Construing biology:
An Ideational Perspective

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Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person where due reference is not made in the text.

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Abstract

This thesis reports on a linguistic study that is concerned with building a discourse semantic framework for exploring knowledge building through language in undergraduate biology. The linguistic theory that underpins this study is systemic functional linguistics (SFL). One particular dimension of SFL, stratification, conceptualises register (field, tenor and mode) as being realised by patterns of discourse semantics, which are in turn realised by patterns of lexicogrammar. Of particular relevance to knowledge building, particularly to what social realism refers to as 'knowledge structure' (Bernstein, 1999), is the register variable field, which is construed through the patterns of ideational discourse semantics. The current modelling of ideational semantics, including the 'ideation base' proposed in Halliday & Matthiessen (1999) and the ideational discourse semantics established in Martin (1992), are currently insufficient for exploring the construal of field. On the one hand, Halliday & Matthiessen's description of ideation base is not clearly dissociated from grammatical functions; on the other hand, Martin's description of ideational discourse semantics is not independent from the description of field. Accordingly, in order to pursue systematically the construal of field, this study aims to develop discourse semantic systems that can take responsibility for both field and lexicogrammar and clarify the stratification relations among register, discourse semantics and lexicogrammar. The exploration of ideational discourse semantics is approached with respect to its construal of two aspects in field – taxonomy and activity sequencing (Martin, 1992).

In order to illustrate the exploration of discourse semantic systems as well as demonstrate the analysis of texts through the framework, this study analyses texts that instantiate knowledge building in biology at the undergraduate level.

This study makes two significant contributions. Firstly it contributes to the development of ideational discourse semantics in an SFL framework. In doing so it clarifies the interstratal relationships across field, discourse semantics and lexicogrammar, and it specifies distinctive terminologies at all strata. Secondly, this work provides a significant ground for exploring knowledge building of all kinds. By focusing on texts produced in undergraduate biology, it contributes to a linguistic understanding of scientific discourse, and points out key characteristics of knowledge building in biology at the undergraduate level.

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List of Symbols and Abbreviations

In this thesis, the symbols and abbreviations used in system networks follow the convention established in Matthiessen & Halliday (2009) and Martin (2013). The following symbols and abbreviations are used in this thesis for structural categories, including labels of classes and functions.

/	conflated categories (e.g. Medium/Goal)
||	clause boundary
[[ ]]	embedded clause
‘ ’	projected idea
“ ”	projected locution
1st Ag	First order Agent
2nd Ag	Second order Agent
Act	Actor
add	addition
Adj	Adjunct
adj	adjective
adv	adverb
adv.gr	adverbial group
Ag	Agent
Attr	Attribute
Att-or	Attributor
app	appreciation
Car	Carrier
Cir	Circumstance
cir.iden	circumstantial identifying process
comp	composition
conc	concession
cond	condition
conj	conjunction
consq	consequence
conx	connexion
dim	dimension
ext.conx	external connexion
Fin	Finite
Go	Goal
Id	Identified
In.Rg	Inner Range
Ini-or	Initiator
int.attr	intensive attributive process
int.conx	internal connexion

int.iden	intensive identifying process
Ir	Identifier
Loc	Location
ling.def	linguistically defined entity
Man	Manner (as Circumstance)
man	manner (as connexion)
mat	material process
Med	Medium
men	mental process
n.gr	nominal group
Out.Rg	Outer Range
ost.def	ostensively defined entity
Par	Participant
Ph	Phenomenon
poss.iden	possessive identifying process
post	position
prep	preposition
prep.ph	prepositional phrase
Pro	Process
purp	purpose
Rg	Range
simul	simultaneous
Sen	Senser
succ	successive
temp	temporal
Tk	Token
v.gr	verbal group
v.gr cplx	verbal group complex
val	valuation
Vl	Value
=, +, x	kinds of expansion in complex units: elaboration extension, and enhancement
1 2 3…	sequence of Arabic numbers showing paratactic relations among elements in structure
α β γ	sequence Greek letters showing hypotactic relations among elements in structure

Sources of examples are given in square bracket before examples. The main types are listed below:

[2.5]	The first number represents the Text number; the second number represents the clause number in the original text. [2.5] means the fifth clause in Text 2

[2.5C] The capital letter C represents that the clause is a congruent realisation of a figure which is unpacked based on the original example [2.5] which is a metaphorical realisation of the figure.

[2.5Ca] When an example is a congruent realisation which is unpacked based on the grammatical metaphor involved in the original example, the congruent realisation may involve more than one clause. The letters in lowercase ‘a’, ‘b’, ‘c’ etc. represent the order of the clauses in the congruent realisation. [2.5Ca] is the first clause in the congruent realisation [2.5C].

[2.5i] The Roman letters ‘i’, ‘ii’, ‘iii’, etc. indicate that the examples are paraphrased based on the original example [2.5].

Chapter 1 Introduction

1.1 A linguistic response to 'knowledge-blindness'

Knowledge shapes society. There is an increasing recognition that the distribution of knowledge in a society is associated with the distribution of power. The building of knowledge is therefore a research interest that attracts scholars from various theoretical backgrounds. In pursuit of democracy and social justice, scholars challenge the unbalanced distribution of knowledge in education systems around the world and appeal for its redistribution (e.g. Bizzell, 1992; Bernstein, 2000; Maton, 2014; McArthur, 2013).

However, researchers interested in exploring 'knowledge' often put more emphasis on concepts related to knowledge rather than on knowledge itself. Maton (2014), writing from the perspective of sociology of education, argues that while knowledge is the basis of much research, ironically the question of 'what is knowledge' has been a blind spot (p. 3 ff.). This 'knowledge-blindness' holds true in research across various theoretical backgrounds. In supporting students' academic success, New Rhetoric studies, for example, acknowledge that academic discourse constitutes knowledge in an academic community; academic writing is thus not just a process of writing, but a process of knowing (Bizzell, 1992; Russell, 1991; Maimon, 1981). However, instead of questioning 'what is known', their research focus has been primarily on the social activity of a 'discourse community' (e.g. Bizzell, 1992). The 'construction' of knowledge is regularly interpreted in terms of the socioeconomic context in which knowledge is produced (Bazerman, 1988; Myer, 1990). Other researchers, who pay more attention to language and texts, such as those from the background of English for Specific Purposes, also recognise the importance of knowledge in relation to academic discourse. Their object of study, however, has been primarily on how knowledge is negotiated in different academic discourse communities. The analyses are often focused on the schematic structures of academic texts (Swales, 1990, 2004; Bhatia, 1993; Dudley-Evans, 1994), and on 'interactional' and 'interactive metadiscourse' (such as 'hedges and boosters', 'self-mention' and 'endophorics' (Hyland, 2005)). Little attention has been paid to 'what knowledge is being negotiated'.

Apart from these studies, there is also a body of cognitive research based on formal linguistic theory, specifically generative grammar, conceptualises knowledge as semantic meanings that reside in minds (Lakoff, 1987; Jackendoff, Cohn, & Griffith, 2012; Levison, Donald, & Lessard, 2012). The exploration of knowledge in this tradition tends to be associated with a human's perception of a world 'out there'; 'knowledge about parts of world' is interpreted in terms of 'mental models' (Johnson-Laird, 1983; Lundquist & Jarvella, 2000).

Many of the various strands of research listed here do recognise the importance of knowledge, but bypass the question of what knowledge really is. This question, however, has been taken seriously for decades in research underpinned by systemic functional linguistics (hereafter SFL). Systemic functional linguistics approaches understanding knowledge from a social semiotic perspective. From this perspective, knowledge is meaning, and meaning is made through a social semiotic which has evolved in our culture. It is from this perspective that knowledge itself becomes an object of study – the question of 'what kind of knowledge is developed' becomes a social semiotic question of 'what meanings are made', and to be more specific 'what systems of meaning are established'. Verbal language and many other modes of semiosis (such as images, gestures and mathematical symbols) are all meaning-creating resources of knowledge.

This thesis adopts SFL as its informing theory. I explore knowledge building by examining one of its key meaning making resources – verbal language. SFL provides a multidimensional theoretical framework for exploring knowledge building through language. A detailed outline of relevant theoretical dimensions in SFL will be provided in Chapter 2. What needs to be highlighted here is the primary concern that motivates this study – that is, to enhance the current SFL framework for exploring knowledge building.

1.2 Foci of the study

1.2.1 A theoretical focus: developing ideational discourse semantics

Systemic functional linguistics (SFL) conceptualises language as a stratified semiotic system, involving (in Hjelmslev's terms) both a content plane and an expression plane (phonology/graphology). The content plane has two meaning-making levels – discourse semantics (Martin, 1992) (or semantics in Halliday & Matthiessen 1999) and lexicogrammar. Discourse semantic meanings are realised by lexicogrammatical meanings. SFL also conceptualises the relationship between language and context as natural and bi-directional – that is, language realises context, and context is realised through language. Such natural relationship is possible since three contextual variables (field, tenor and mode) correspond to the metafunctional organisation of language. Following Halliday (e.g. 1978) field is construed by ideational meanings of language, tenor is enacted by interpersonal meanings, and mode is composed by textual meanings. The model assumed here is presented diagrammatically as in Figure 1.1 below.

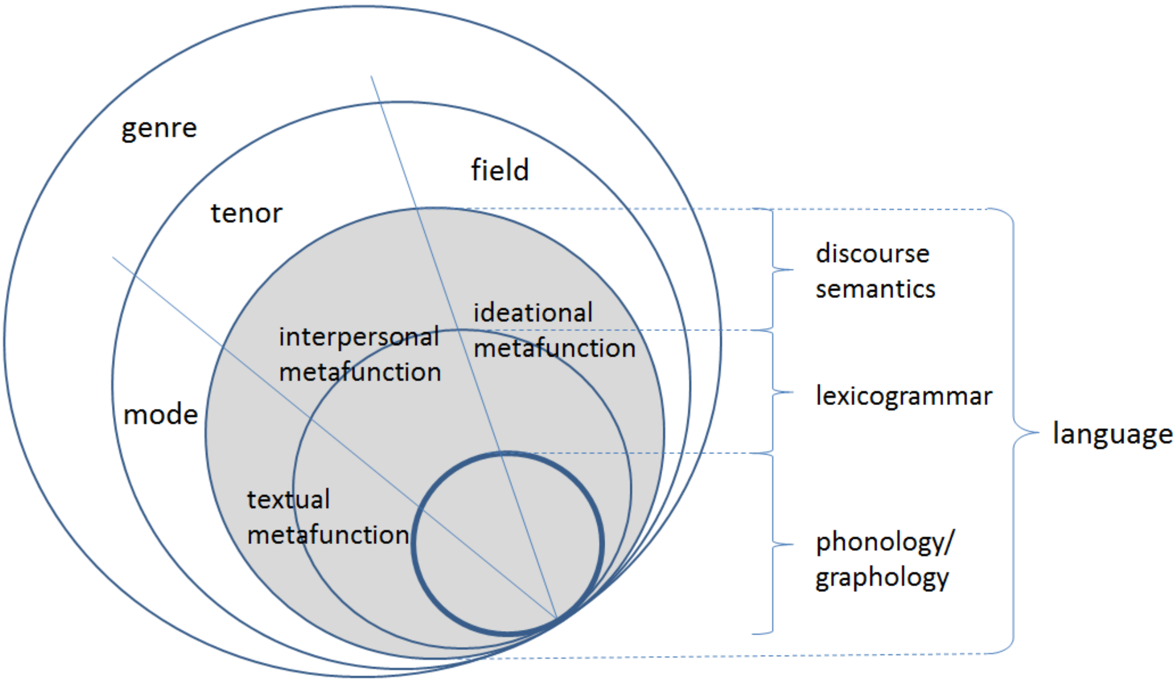


Figure 1.1 Stratification and metafunction in SFL framework

In this framework, knowledge of different kinds (e.g. history, biology, physics, geography) is associated with **field** and realised by ideational meanings of language – since field is about 'what is happening' (Halliday, 1985, p. 12). Martin (1992) defines field as 'sets of activity sequences oriented to some global institutional purpose' (p. 536). In order to explore knowledge building of any kind through language, we are thus concerned with how a field is realised through the ideational discourse semantic meanings of language, which are further realised through lexicogrammar.

However, the current description of the relationships among field, ideational semantics and lexicogrammar in this framework is far less than clear. Halliday's description of grammar is a 'deep' grammar (Halliday, 1966/2002b) which contrasts significantly with traditional and formal grammars. It takes account of both the syntagmatic and paradigmatic organisation of grammatical resources. Under this approach, grammatical structure does involve a 'surface' level (syntagms), including nominal group and verbal group patterns in the traditional sense; importantly however, the more covert syntactic relations between grammatical classes are specified by their functional categories, such as Actor, Goal, Token and Value. Below is an example of grammatical structure at the clause level.

	the boy	*kicked*	*the ball*
function (ideational)	Participant [Actor]	Process: material	Participant [Goal]
class	nominal group	verbal group	nominal group

This approach to grammar is designed as a way to 'bring out the semantic naturalness of grammar' (Matthiessen & Martin, 1991, p. 10). However, one consequence of the natural relationship between semantics and lexicogrammar is that the grammatical function labels are often 'borrowed' to describe semantic meanings – for example Halliday & Matthiessen's (1999) use of participant, process and circumstance in describing semantic units. This 'borrowing' is found in many other SFL publications (e.g. Ravelli, 1988, p. 139; Derewianka, 2003, p. 197). As a result, the distinction between ideational semantics and lexicogrammar is often unclear.

On the other hand, at the level of context, Martin's (1992) description of field has been a seminal development of the notion of field as a register variable, and is a major motivation for the development of ideational discourse semantic descriptions in language (Martin, 1992; Martin & Rose, 2007). Discourse semantic analysis has proven to be a more productive way of identifying, describing, and differentiating fields than analysing grammatical features alone, as illustrated in the work on the discourse of history (Coffin 1996, 2006; Eggins, Wignell, & Martin, 1993), biology (Martin 1993a, 1993c; Humphrey & Hao, 2012), geography (Wignell, Martin, & Eggins, 1993), industry (Rose, 1997, 1998) and administration (Iedema, 1995). However, given the natural relationship between language and context, there is a natural relationship between field and the patterns of ideational discourse semantic meanings. As a result, the description of discourse semantics is not clearly independent from the description of field; for example, the activity/implication sequences and taxonomic relations which are conceptualised as two aspects of field are also often used to characterise discourse semantic features.

As a result, there is a lack of independent categorisation across field, ideational discourse semantics and lexicogrammatical systems. In order to have a linguistically robust exploration of knowledge building of any kind, it is necessary to firstly elucidate the interstratal relationship among the strata, and provide independent descriptive categories for each level.

In pursuit of a model of this kind, this thesis takes Halliday's grammatical description (e.g. Halliday, 1985; Halliday & Matthiessen, 2014) and Martin's field description (Martin, 1992) as the theoretical departure, and then focuses on how to develop an ideational discourse semantic system that can mediate the relation of field to lexicogrammar. The approach to discourse semantics here is thus a trinocular one – looking from 'above' in relation to field, from 'below' in relation to lexicogrammar and 'around' in terms of its relationship to the interpersonal and textual discourse semantic meanings.

1.2.2 An empirical focus: knowledge building in undergraduate biology

A systematic account of ideational semantics is the ground for exploring how knowledge is construed through language in any text – whether a written text, a spoken lesson, or a series of texts that track an apprenticeship over time. In order to illustrate the exploration of ideational discourse semantic systems and also demonstrate how the framework can be used for analysing texts, this study chooses texts that represent knowledge building in biology at the undergraduate level. This focus is based on a research project that was part of the Scaffolding Literacy in Academic and Tertiary Environments (SLATE) project (Mahboob, Dreyfus, & Humphrey, 2010) in which I participated from 2010 to 2011 (Hao, 2010; Hao & Humphrey, 2012; Humphrey & Hao, 2013). One aspect of the research was concerned with how evaluation in the discourse of biology was achieved through the interpersonal discourse semantic resources – particularly the choices of ATTITUDE in the APPRAISAL system. Since the targets of evaluation are ideational meanings, it was often difficult to make distinctions among units of meaning at different strata; it was also difficult to make systematic distinctions between different kinds of ideational discourse semantic meanings, particularly those that have nominal realisations (e.g. 'kinds of entity' in Martin & Rose, 2007, p. 114). My concern with ideational semantics emerged out of this research.

The discourse of biology is a representative discourse of science, involving an uncommonsense field. It has been illustrated in previous studies (e.g. Halliday & Martin, 1993, Halliday, 1998) that scientific discourse is characterised by its use of technicality (Martin, 1993a, 1993c; Wignell et al., 1993) and 'grammatical metaphor' (Halliday, 1985). Sometimes it is also described in terms of abstraction (e.g. 'theoretical abstraction' in Halliday, 1998). The linguistic distinctions between grammatical metaphor and these descriptive terms such as technicality and abstraction have been rather unclear. For example in Martin (1993b), the term 'abstraction' is used to refer to both technical terms found in scientific discourse (e.g. *erosion, deposition, deflation*) and grammatical metaphors in history discourse (e.g. *death*, *destruction*, *increase*). At the same time, in other works (e.g. Martin 1993a; Wignell, et al., 1993; Eggins, et al., 1993) technicality is used to characterise scientific discourse and abstraction is used to describe discourse of history. Apart from these variations, the term 'abstract entity' is used in Martin & Rose (2007) (c.f. Martin, 1997) to include technical (e.g. *inflation, gene*), institutional (e.g. *regulation, policy*), semiotic (e.g. *fact, idea, concept*) and generic terms (e.g. *colour, time, type*), and grammatical metaphors are treated under the heading 'metaphoric entity'. In short, in previous studies the relationships among 'technicality', 'abstraction' and grammatical metaphor are far from clear. An important reason for these confusions is the problem of distinguishing discourse semantic units of meaning from meanings at the levels of lexicogrammar and field. The discourse of biology provides a rich source of data for sorting out these issues.

Of particular interest within the field of biology, I choose to focus on texts produced in undergraduate tertiary education, since it has been found in previous studies that the texts produced at the end of undergraduate apprenticeship share a great number of features with the published research articles written by the experts in the discipline (Hood, 2004; Hao 2010). Knowledge building at undergraduate level thus represents an apprenticeship into a discipline, and this apprenticeship develops as a transition from knowledge 'reproduction' to knowledge 'production' (Bernstein, 1990, 2000). This study explores aspects of this transition. For this purpose, I apply the discourse semantic framework established in the study to analyse texts that are produced at different undergraduate year levels. For the purpose of building ideational discourse semantic systems, selecting texts at different stages of the apprenticeship provides a variety of ideational discourse semantic instances, and instances that can reveal the interactions between discourse semantics and grammar (e.g. grammatical metaphor), as well as the interactions between discourse semantics and field. The selection of texts for the analysis based on their theoretical account will be specified in Chapter 2.

1.3 Significance of the thesis

This thesis makes a number of significant contributions. Firstly, it makes a theoretical contribution to the current model of stratification in SFL. It contributes specifically to

- the development of ideational discourse semantic systems of ENTITY, FIGURE and the understanding of the patterns of sequences;

- the explanation and clarification of the interstratal relationships between the ideational discourse semantic systems and systems in field and in lexicogrammar, with stratally distinct terminology clarified;
- the modelling of stratal tension between discourse semantics and lexicogrammar.

Secondly, the development of ideational discourse semantics provides an analytical framework for a linguistic exploration of knowledge building. By focusing on exploring knowledge building in undergraduate biology, this study provides a further understanding of knowledge building in science. Specifically, it reveals

- the distinction between technicality and grammatical metaphor in scientific discourse;
- the ways in which entities and metaphorical realisations of figures and sequence are orchestrated to build the texture of biology discourse;
- some developmental features of building biological taxonomies across undergraduate years;
- some developmental features of how the disciplinary field of biology is established across undergraduate years.

In addition, the findings in this study have potential pedagogic implications for teaching academic literacy. The features of knowledge building revealed at different undergraduate year levels can be useful for planning literacy support programs. The findings from the linguistic analysis of laboratory reports and research reports, such as the staging structure of the texts and the use of grammatical metaphor to build scientific explanation and argument, can be useful for scaffolding students to construct these types of text.

1.4 Organisation of the thesis

This thesis is organised into five chapters. The current chapter (Chapter 1) has positioned this study as one of appliable linguistics, informed by SFL. The major objective of this thesis is to develop a linguistic framework for the purpose of knowledge building. Specifically, the aim is to develop ideational discourse semantics that can be responsible for construing field, and at the same time responsible for its realisation in lexicogrammar.

Chapter 2 establishes the foundations of the study. This chapter is further divided into two parts. The first part of the foundations (from section 2.2 to section 2.4) outlines the theoretical principles in SFL which are relevant to this study. Section 2.2 introduces SFL architecture, including the dimensions of stratification, metafunction, rank, system/structure complementarity (axis), instantiation and semogenesis. In section 2.3, I associate knowledge building with field, and specify the concern with construing field through discourse semantics. In section 2.4, current SFL semantic frameworks for exploring the construal of field are critically reviewed. The necessity for a further clarification of stratification among field, discourse semantics and lexicogrammar is pointed out. Importantly, this section also provides detailed discussion of the modelling of the stratal relationship between discourse semantics and lexicogrammar. Based on these theoretical concerns, section 2.5 specifies the study's research questions and introduces the research design. The research questions are divided according to the construal of two dimensions of field – that of taxonomy and activity sequence, which are explored respectively in Chapters 3 and 4.

Chapter 3 explores the construal of taxonomy of field via an ideational discourse semantic system termed ENTITY. This chapter consists of two parts. The first part develops the discourse semantic system ENTITY and its associated system DIMENSIONALITY based on the analysis of biology texts. In the second part, the frameworks of ENTITY and DIMENSIONALITY are applied to analyse four student texts ranged at different undergraduate year levels. The analysis reveals some developmental features of taxonomy building.

Chapter 4 explores the construal of activity sequences at the level of field through discourse semantics. In order to do so, this chapter firstly extends the ENTITY system in Chapter 3, and develops a discourse semantic system termed FIGURE at a higher rank (section 4.2). Then in section 4.3 the ways in which figures are related into sequences in the data are explored. The identification of figure and sequence involves teasing out their various metaphorical realisations in the data. The stratal tension between discourse semantic figures and sequence and their realisations in lexicogrammar are modelled in this discussion. In addition, some developmental features of managing grammatical metaphors in the data texts are introduced. In section 4.4, the discussion moves to the construal of activity sequences at the level of field through the discourse semantics sequences. I identify delicate types of activity sequences in the field of undergraduate biology, which reflect subtypes of field. In section 4.5, the instantiations of various types of activity sequences and types of field in the four student texts will be compared.

Chapter 5 concludes this study by firstly summarising the major findings of the study (section 5.2), including its theoretical contributions to the SFL framework, and the findings of knowledge building revealed in undergraduate biology texts. Section 5.3 points out some potential aspects in pedagogy that may be impacted by this study. In section 5.4, the chapter addresses outstanding issues and further directions for research that are opened up in this study.

Chapter 2 Foundations

2.1 Introduction

The aim of this chapter is to establish foundations for a linguistic study of knowledge building. The first part of the foundations introduces the theoretical principles in systemic functional linguistics which are relevant to this study. In the second part, the research questions will be specified, and the design of the research is described.

In reviewing theoretical principles in SFL, section 2.2 firstly introduces several theoretical dimensions of SFL architecture. These theoretical dimensions provide complementary perspectives for our exploration of knowledge building throughout the thesis. In section 2.3, I associate knowledge building specifically with the concept of **field** in SFL. In section 2.4, the current analytical frameworks in SFL for construing field are critically reviewed. It is suggested that a more balanced discourse semantic framework is needed in order to effectively reveal the construal of field. Finally in section 2.5, research questions for this study are specified. These questions are concerned with developing a discourse semantic framework for the linguistic analysis of knowledge building. Section 2.5 also introduces the rationale for the data selection.

2.2 The architecture of systemic functional linguistics

Systemic functional linguistics is a social semiotic theory that is concerned with the study of meaning. Its approach to the study of meaning is a social one, taking into account how meaning is made in context. The use of language is shaped by the social environment in which we are living in. At the same time language plays its part in the evolution of culture. As a kind of meaning-making resource, language is not a random collection of meanings, but has evolved as **a system of meanings** which organises itself in principled ways. Language is by no means the only semiotic system evolved in our culture: systems other than language include images, gestures, music, mathematics (Kress & van Leeuwen, 2006; Painter, Martin, & Unsworth, 2012), and so on. The study of semiotic systems from a systemic functional perspective may be referred to as **systemic functional semiotics** (Martin, 2006). In this study I focus on the linguistic dimension of social semiotics.

Over the last several decades, systemic functional linguistics has developed a comprehensive theoretical architecture (e.g. Halliday, 1985; Halliday & Matthiessen, 1999; Halliday & Matthiessen, 2014; Martin, 1992; Matthiessen, 1995). A number of complementary theoretical dimensions constitute the architecture as a whole. In this section, we review the dimensions which are relevant to this study, including **stratification**, **metafunction**, **rank**, **system/structure complementarity (axis)**, **instantiation** and **semogenesis**.

2.2.1 Stratification

SFL sees language as a stratified semiotic system (e.g. Halliday, 1985, 1994 , following Hjelmslev, 1961). **Stratification** relates different orders of reality on a cline of abstraction. One key relationship in this picture is between language and context. In SFL terms, language symbolises social context; and social context is symbolised by language. By 'symbolising', we mean that our social reality is the "reality that we construe for ourselves by means of language" (c.f. Halliday & Matthiessen, 1999, p.3). The relationship between the two is thus natural and bi-directional. This view of language contrasts significantly to the formal linguistic notion that language is in opposition to human mind or the notion that 'reality' exists dissociated from language. In Hjelmslev's (1961) theoretical terms, language is denotative semiotic and context is connotative semiotic; language as denotative semiotic constitutes the expression plane of context as connotative semiotic. This symbolising relationship between language and context is represented graphically by co-tangential circles as shown in Figure 2.1 below.

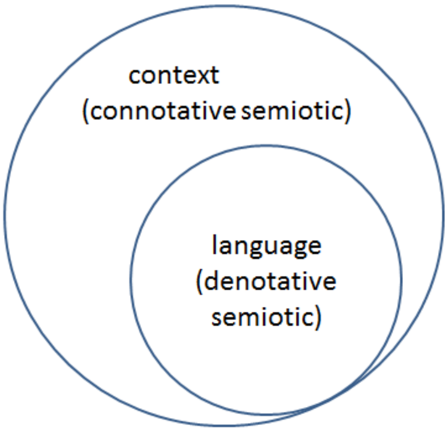


Figure 2.1The relationship between language and context (c.f. Martin, 1999, p. 36)

As a denotative semiotic, language has its own content plane and expression plane. Its expression plane, **phonology/graphology,** interacts with the physical materiality of speech/writing on the expression plane of language. The expression plane is often explained as representing the content plane in an arbitrary way; it has evolved based on the conventions of language users in the culture. For example, the meaning of the colour *red* is symbolised in different cultures with different graphological signs, such as by “red” in English, “红” in Mandarin Chinese, and “rojo” in Spanish. The content plane of language is further organised into two meaning-making levels **- lexicogrammar** (Halliday, 1985/1994) and **discourse semantics** (following Martin, 1992). Lexicogrammar is concerned with making meanings through the clause; discourse semantics is concerned with making meanings in the discourse in whole texts. Unlike the arbitrary relationship between lexicogrammar and phonology/graphology, discourse semantic meanings are realised naturally by lexicogrammar. The three strata of language are represented in Figure 2.2 below, with the arbitrary relationship between lexicogrammar and phonology/graphology is represented by the thickened lines (following Martin, 1999).

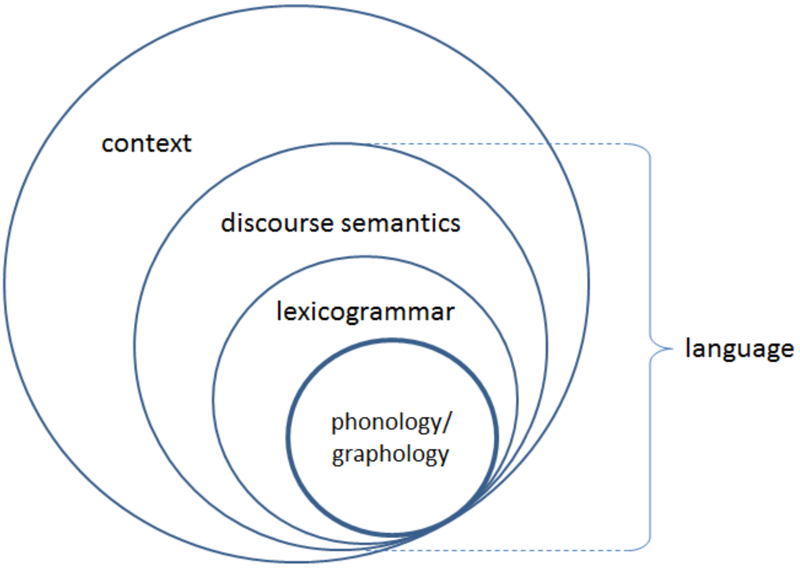


Figure 2.2 Stratification of language (c.f. Martin, 1992, 1999)

At the level of context, a further stratification is also made (following Martin, 1986, 1992). Context is stratified into two connotative semiotics **- genre** and **register**. At the highest order of reality, genre refers to **a system of** ‘staged goal-oriented social processes’ that constitutes our social culture (Martin, 1986, p. 246). Genre is expressed through a lower level of context, register, which is organised into three variables – field, tenor and mode (Martin, 1992, p. 495).

Field is concerned with what is going on in a social activity; tenor is concerned with relationship between interactants; and mode is concerned with the role that language plays in a text (Martin & Rose, 2006, p. 296). As an intermediate stratum between genre and language, these register variables relate the use of language to the social processes in our culture. The hierarchy of stratification across language and context is represented in Figure 2.3 below.

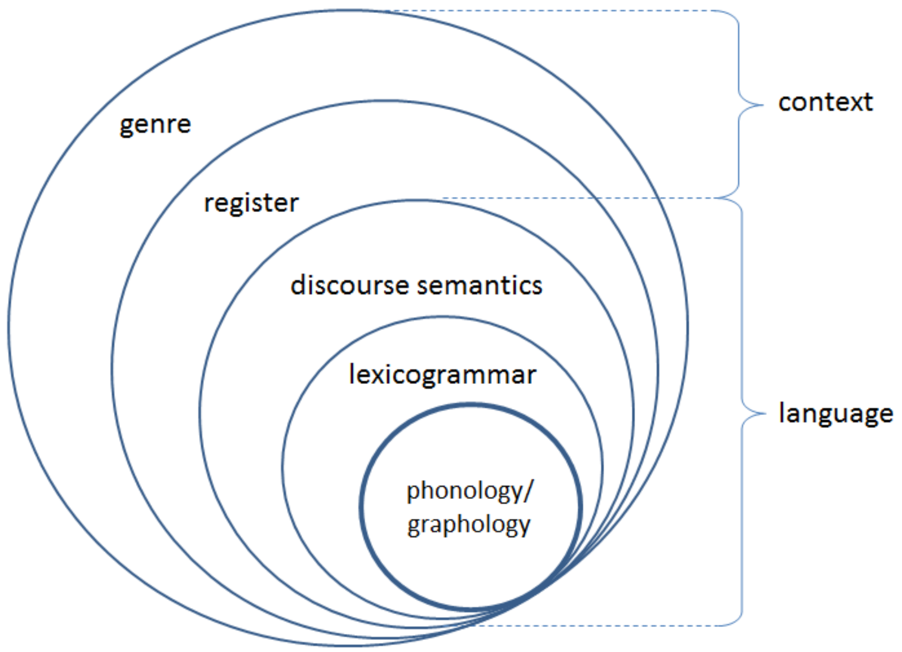


Figure 2.3 Stratification of language and context (c.f. Martin, 1992)

Along the hierarchy of stratification, each stratum of semiotic system **realises** the stratum at the higher level and is at the same time **realised by**[1] the one at the lower level. Critically, the realisations along the cline are not a chain of one-to-one relationships, but a non-linear way of relating **patterns of meaning** at one stratum to another. Lemke's (1984) notion of 'metaredundancy' provides a useful way to articulate the relationships among strata. Put simply, meanings at a higher order stratum are patterns of meaning at the next lower order one. For example, register is concerned with generalisations about discourse semantic patterns, which are themselves patterns of lexicogrammatical patterns (Caffarel, Martin, & Matthiessen, 2004, p. 36). We can model the metaredundant relationship in Figure 2.4 below.

[1] *Realisation* has also been referred to in SFL through the wordings of *construe* (i.e. realise) and *activate* (i.e. realised by) (e.g. Hasan, 1996).

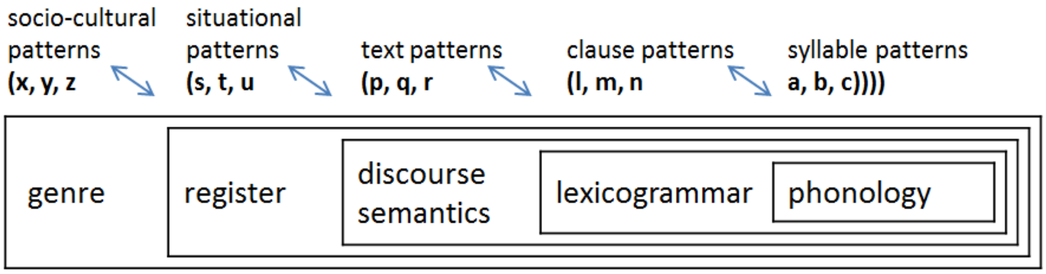


Figure 2.4 Metaredundant relation between strata (c.f. Quiroz, 2013, p. 21)

Note that an alternative model of context is offered by some SFL linguists (e.g. Halliday & Hasan, 1985; Halliday & Matthiessen, 1999, 2014; Hasan, 2009), who treat context as one single stratum. This study follows the model of stratified context, since the interstratal relationship between genre and register provides a productive way of modelling how a social process is achieved linguistically (Martin, 1991, 1992, 1999). As Martin argues,

> "the advantage of the genre perspective is that it provides a more wholistic interpretation of text type which in turn makes it possible to account for the fact that field, mode and tenor variables are never randomly combined but rather settle into a number of relatively stable combinations reflecting the system of social process engendering a speech community" (Martin, 1991, p.131).

Genre as a separate stratum is thus conceptualised as a system of social processes (Martin & Rose, 2008). This approach has been found to be productive not only for the purpose of linguistic description of social context, but also for applying systemic description of language to descriptions of context in literacy education (Rose & Martin, 2012). This will be elaborated further in section 2.3.1 below.

2.2.2 Metafunction

Language is socially functional. As a semiotic system, its social functionality is reflected in the fact that different bundles of systems are oriented to different kinds of meaning, including ideational, interpersonal and textual meanings (Halliday, 1967a, 1967b, 1968; Halliday & Matthiessen, 2014; Martin, 1992). Ideational meanings construe our experience of the external world (doing, happening, being and saying), and our internal world (thinking and feeling). Interpersonal meanings enact our social relationships with people around us. Textual meanings compose ideational and interpersonal meanings in discourse. Ideational meanings are further distinguished into two subtypes, experiential and logical meanings, with the former concerned with configuring what is going on, and the latter concerned with sequencing the goings-on. These different bundles of meaning systems that are oriented to different social functions are referred to as **metafunctions**.

The functional organisation of language has been conceptualised as systematically related to the contextual organisation through register variables (e.g. Halliday, 1978, 1985; Martin, 1991, 1992). This reflects the solidary relationship between language and context. Field is by and large realised through ideational meanings, tenor through interpersonal meanings and mode is realised through textual meanings. The solidary relationship between the functional organisation of register and that of language allows the meanings in text to be predicted from its context, and at the same time allows the context to be understood based on the meanings made in the text. It is the simultaneous functional organisation of language and its associated register variables that realise genres as social processes. The functional diversity can be mapped onto the hierarchy of stratification as in Figure 2.5 below.

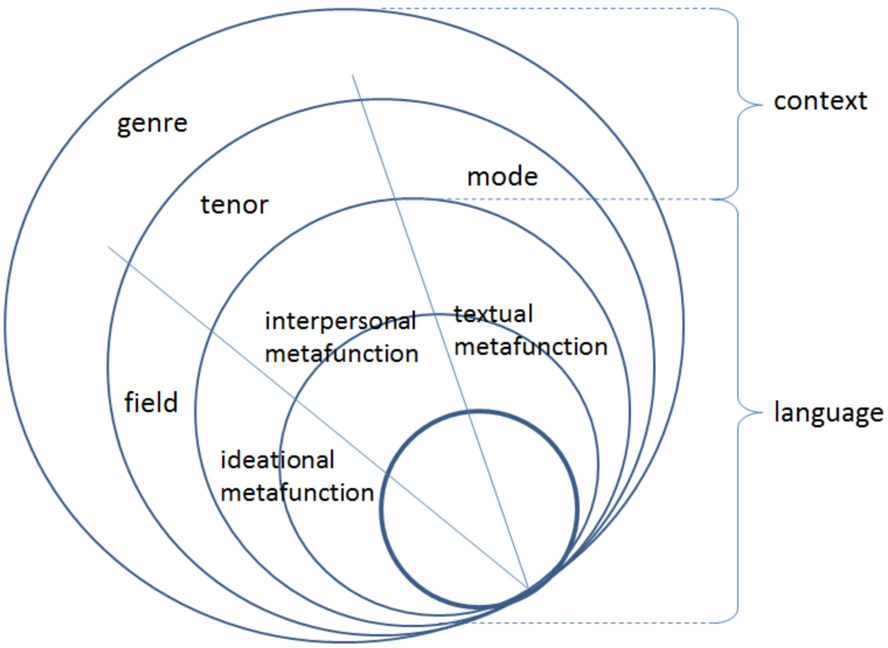


Figure 2.5 Metafunctional relations between language and context

The metafunctional organisation of language is not only reflected in the different bundles of systems, it is also characterised by its different modes of expression (Halliday, 1979). Extending Pike's (1959) discussion of linguistic resources considered from the perspectives of particle, wave and field, Halliday (1979) suggests that ideational meaning is expressed through **particulate** structure (constituent meaning), interpersonal meaning through **prosodic** structure (radiating meaning), and textual meaning through **periodic** structure (waves of meaning). These three types of structure are exemplified at clause rank below:

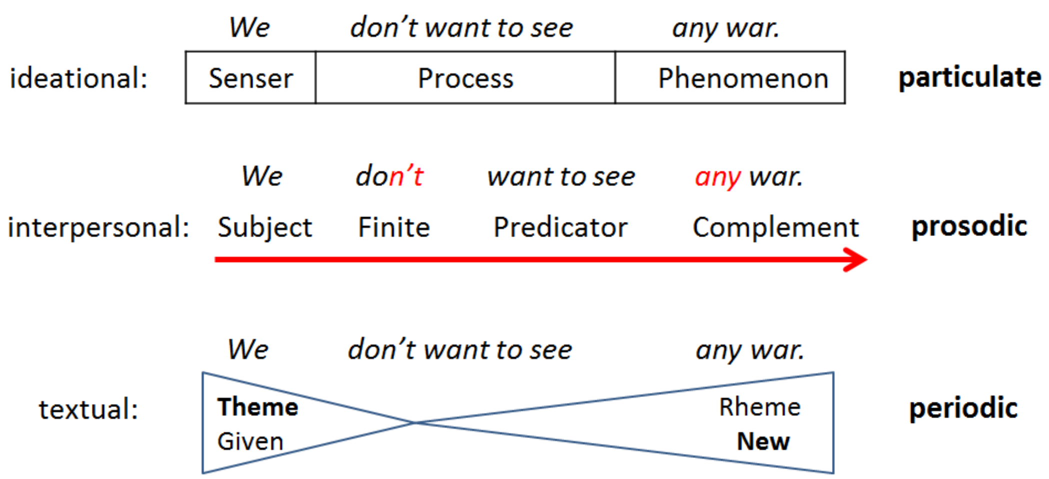


Figure 2.6 Three kinds of meanings associated with three modes of expressions

In another paper where Halliday focuses specifically on grammatical structures (Halliday, 1981), he makes a distinction between multivariate and univariate structures. A multivariate structure is a structure that involves more than one variable; a univariate structure is a structure that involves only one variable. According to Martin (1996), multivariate structure has been used in Halliday (1985) and subsequent editions of his *Introduction to Functional Grammar* to generalise across particulate, prosodic and periodic structures associated with the experiential, interpersonal and textual metafunctions. Univariate structure has been associated with serial structure in the logical metafunction, as outlined in Table 2.1 below.

Table 2.1Types of structure and metafunctions (c.f. Martin, 1996, p. 41)

particulate: part/part	logical		univariate
particulate: part/whole	experiential		
prosodic	interpersonal		multivariate
periodic	textual		

An additional perspective on representing particulate structure, including experiential and logical structures, is through nuclearity (Martin, 1996; c.f. Halliday, 1979). While Halliday (1979) mainly employs linear representation for representing particulate structure of experiential meaning, at the same time he emphasises that there is no particular reason why the constituent representation should be linear. He suggests that "having a nucleus consisting of Process plus Goal with the other elements clustering around it" may be a more appropriate conception and representation (see Figure 2.7).

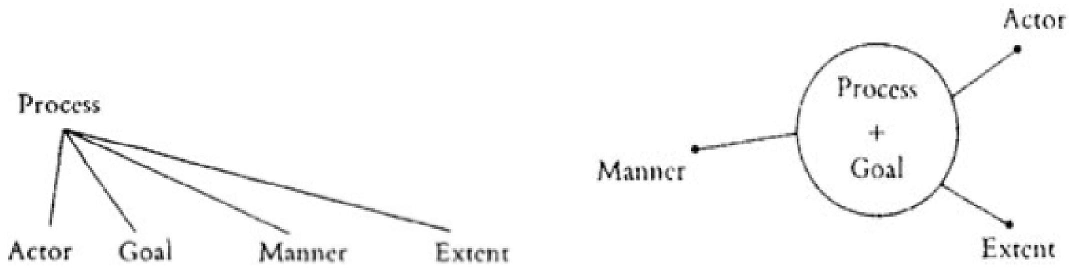


Figure 2.7 Linear and nuclear representation of experiential grammar (Halliday, 1979/2002, p. 203)

This nuclear representation of ideational structure is further developed by Martin (1992, 1996). He approaches the conceptualization of nuclearity from the perspectives of metafunction, rank and strata. Firstly, Martin argues that as far as all three metafunctions are concerned, particulate structure or ‘constituency’ is in fact a reductive representation, since it can be used as a crude way to represent all structures of ideational, interpersonal and textual meanings, yet none of their unique structural characteristics (i.e. nuclearity, prosody and periodic) can be successfully revealed (see Figure 2.8 below). Therefore, it is necessary to dissociate constituency from the structure of any metafunction.

These two approaches	are	supplemented	by a third	
Value	Process		Token	←particle as particle
Mood		Residue		←prosody as particle
Theme	Rheme			←wave as particle

Figure 2.8 Particle, prosody and wave as structures of constituency (from Martin, 1996, p.42)

Ideationally, given the distinction between experiential and logical meanings, Martin (1996) distinguishes the principle of nuclearity into an orbital structure, which is a mono-nuclear configuration, and serial, which is a multi-nuclear structure due to the recursion of elements. These structures are represented in Figure 2.9 below.

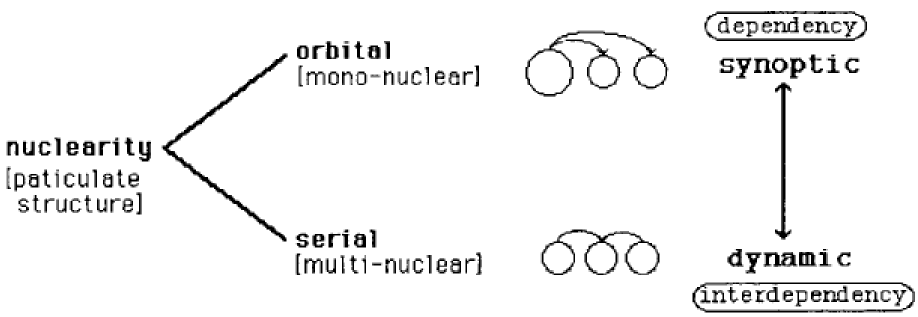


Figure 2.9 Nuclearity as a model of particulate (ideational) meaning (Martin, 1996, p.51)

Similarly, Matthiessen (1995, p. 196) interprets clause structure along a cline of 'nuclearity/peripherality' (see Figure 2.10 below) by drawing on the grammatical functions in the ERGATIVITY system. This cline is ranged across three layers of units, reflecting the degree to which Participants and Circumstances are involved in the process.

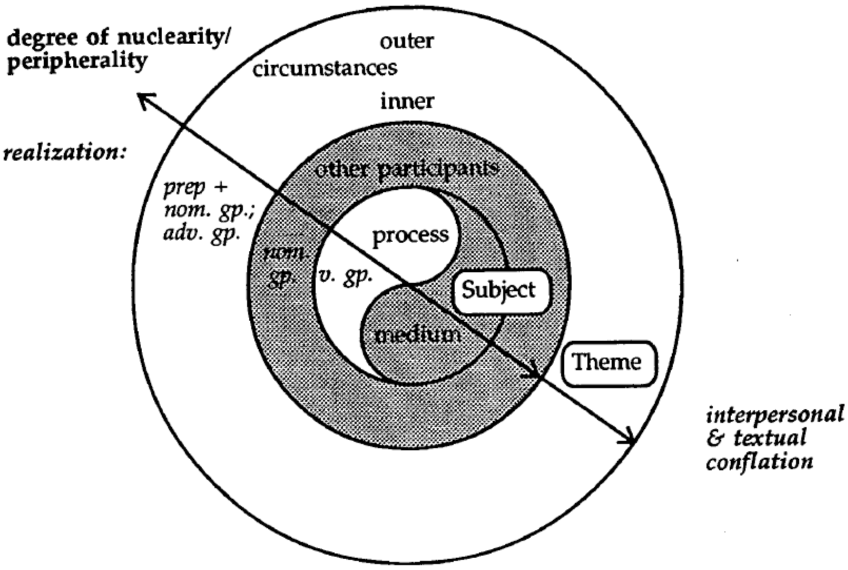


Figure 2.10 Cline of nuclearity/peripherality of involvement (from Matthiessen, 1995, p. 197)

The conceptualisation of nuclearity is not only revealing in terms of representing structures in lexicogrammar, but also across strata such as in genre and discourse semantics. At the level of genre, orbital and serial generic structures are exemplified in spoken and written texts (e.g. Martin, 1996; Iedema, 1995, 1997; White, 1997; Christie, 2002). At the level of discourse semantics, Martin (1992) illustrates nuclear configurations of meaning across a rank scale. This will be reviewed in detail in section 2.4.1.2 below.

In association with different metafunctions, nuclear, prosodic and periodic structures are therefore used to organise meanings across strata. For the discussion of prosodic structure in discourse semantics, see Hood (2008) and Tann (2010); and for the illustration of periodic structures in discourse semantics, see Martin (1992, 1993a, 2009) and Martin & Rose (2007).

2.2.3 System and structure

SFL sees language as a network of relationships. A distinction is made between **paradigmatic** and **syntagmatic** relationships (Halliday, 1966/2002b, following Saussure 1916/1974; Firth, 1957; Hjelmslev, 1961). Paradigmatic relationships are concerned with oppositions of meanings in a system. Syntagmatic relationships are concerned with the unfolding of meanings in a text. Paradigmatic and syntagmatic relationships are also referred to as **system** and **structure.** The complementary relationship between system and structure is called **axis** (Matthiessen & Halliday, 2009; Martin, 2013b). According to Martin (2013b), it is axis that underlies the organisation of strata and metafunction as introduced above (e.g. Halliday, 1967a, 1967b, 1968) as well as the organisation of rank (e.g. Halliday, 1966/2002a), which will be reviewed in section 2.2.4 below.

Paradigmatic relations are **realised**[2] through those which are syntagmatic. SFL uses both function and class labels for syntagmatic structure. An arrangement of classes is referred to as a **syntagm**. Functions specify 'actual syntactic relations into which the classes enter' (Halliday, 1966/2002b, pp. 107-8). Two configurations are thus considered on the syntagmatic axes. The example below demonstrates the structure of a clause, *I kicked the ball*:

	I	*kicked*	*the ball*
function (ideational)	Actor	Process	Goal
class	nominal group	verbal group	nominal group

This clause is configured through grammatical functions (Actor + Process + Goal), which specify its syntagmatic relation. These functions are then realised in the form of classes (i.e. nominal group, verbal group and nominal group), which specify the realisation of functions in terms of the unit next below. The relationship between function and class is not one-to-one. Most grammatical functions can be realised by more than one class, and a given grammatical class can perform more than one function (Martin, 2013b, pp. 36-37). For example, a nominal group can realise a Participant (e.g. *the deadline* [Value] *is **tomorrow*** [Token]) or a Circumstance (e.g. *we will go to the zoo **tomorrow*** [Circumstance: Time]); and a Circumstance can be realised by a nominal group (e.g. *we will go to the zoo **tomorrow*** [Circumstance: Time]), a prepositional phrase (e.g. *we will go to the zoo **in the morning*** [Circumstance: Time]) or an adverbial group (e.g. *we will go to the zoo **happily*** [Circumstance: Manner]). The relationship between paradigmatic and syntagmatic axis is represented in Figure 2.11 below.

[2] Note that while the relationship between system and structure is also typically referred to in terms of realisation, their relationship is not a relationship between different strata (i.e. an **interstratal** relationship), but an **intrastratal** relationship which organises meanings at a given stratum. Apart from axial relations, other intrastratal relationships include the relationship between meanings along the cline of delicacy in a system and the relationship between different ranks (Matthiessen, 1993).

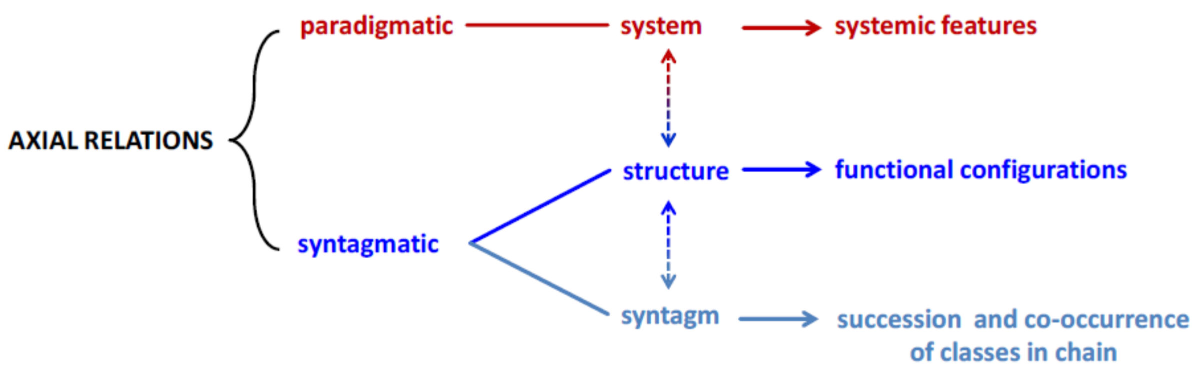


Figure 2.11 Syntagmatic and paradigmatic axis (Quiroz, 2013, p. 55)

Paradigmatic oppositions and syntagmatic organisations are modelled in SFL through **system networks**. Figure 2.12 below is an interpersonal system at the stratum of lexicogrammar.

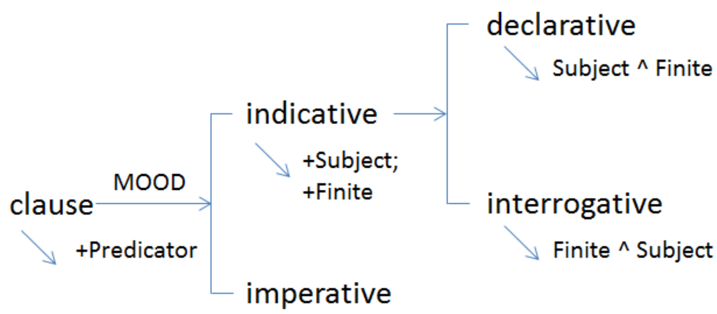


Figure 2.12 A basic system network of MOOD (from Caffarel et al., 2004, p. 25)

Reading from left to right, this system has an entry condition which is a **clause**. The name of the system is written conventionally in small caps (i.e. MOOD). The square bracket specifies a number of features in the paradigmatic opposition, which are written in lowercase (e.g. indicative, imperative). A diagonal arrow under the features reads 'realised by', which relates the paradigmatic oppositions of features to their syntagmatic organisations. Following the arrows, the realisation statements specify a number of functions and their relationships; for example, '+' means 'insert function', '^' means 'followed by' (e.g. in declarative, Subject is followed by Finite). A feature in a system can be an entry condition of another system; for example 'indicative' in Figure 2.12 is an entry condition of another system, with the features 'declarative' and 'interrogative' features conventionally enclosed in square brackets in running text. All the features in a network are ranged on a scale of **delicacy**, from less delicate features on the left to more delicate ones on the right. In Figure 2.12, the relationships between the features are logical 'or' (i.e. either indicative or imperative). We can also include logical 'and' relations in a system network. For example, at clause rank, the experiential system TRANSITIVITY, the interpersonal system MOOD and the textual system THEME constitute the meaning potential of a clause simultaneously. A system network including these three systems is shown in Figure 2.13 below. The brace positions TRANSITIVITY, MOOD and THEME as **simultaneous systems**.

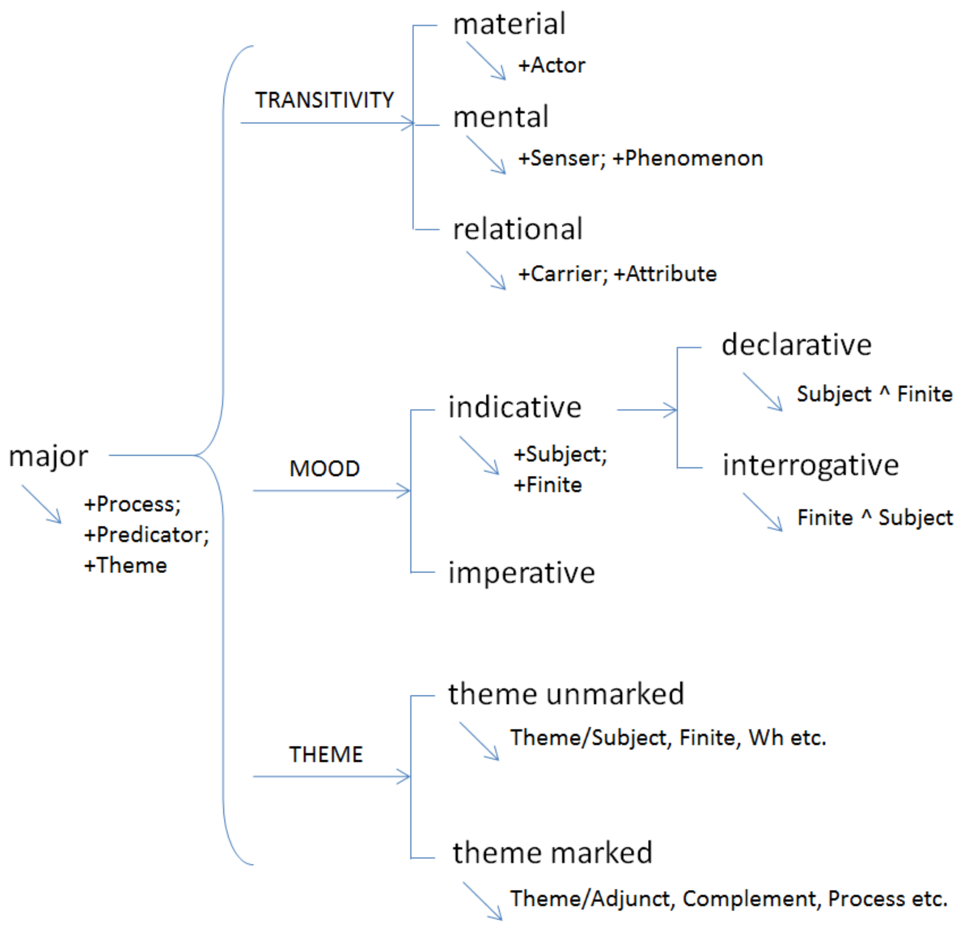


Figure 2.13 Basic TRANSITIVITY, MOOD and THEME systems (from Martin, 1992, p. 9)

In system networks, all features refer to classes (e.g. major clause, indicative clause). Most structures in realisation statements are specified by functions (e.g. Subject ^ Finite). Functions represent 'the syntagmatic role some unit is playing'; classes provide 'the paradigmatic potential of a unit' (Caffarel et al., 2004, p. 34). For detailed account of system networks see Matthiessen & Halliday (2009) and Martin (2013b).

In SFL system networks are used to model paradigmatic and syntagmatic relations at all strata. A system at a given stratum can be usefully related to systems from above, around and below. Taking MOOD system again as an example, when looking from around at the stratum of lexicogrammar, MOOD is associated simultaneously with the experiential system TRANSITIVITY and the textual system THEME.

		I	*kicked*	*the ball*
function	**experiential**	Actor	Process	Goal
	interpersonal	Subject	Finite/Predicator	Complement
	textual	Theme	Rheme	
syntagm		nominal group	verbal group	nominal group

Looking from above, from the discourse semantic stratum, MOOD is associated with the more abstract interpersonal discourse semantic system SPEECH FUNCTION. Separating MOOD and SPEECH FUNCTION is motivated in part by the phenomenon of **grammatical metaphor**, which refers to the possibility of **stratal tension** between discourse semantics and lexicogrammar (Martin, 2008; see section 2.4.3 for a detailed account of grammatical metaphor in the ideational metafunction). As illustrated in Table 2.2 below (Martin, 2013b, pp. 80-81), the different choices in MOOD may construe the same meaning in discourse semantics (i.e. requesting information, or commanding act). A congruent way of requesting information is through [interrogative: wh-]; however the other clause types (e.g. declarative, imperative) can also achieve the same purpose in a less congruent way.

Table 2.2 Demanding information through MOOD choices (from Martin, 2013b, pp. 80-81)

SPEECH FUNCTION	**MOOD**	**relevant function structure**	**example**	**compliant response**
information question	[interrogative: wh-]	Wh/C^Finite^Subject	*What is your name?*	*- Sachin.*
	[declarative]	Subject^Finite	*And your name is...?*	*- Sachin.*
	[interrogative: polar]	Finite^Subject	*Is your name Sachin or Sunil?*	*- Sachin.*
	[imperative]	Predicator (non-finite)	*Tell me your name.*	*- Sachin*
command	[imperative]	Predicator (non-finite)	*Open the door.*	*- OK.*
	[declarative]	Subject^Finite	*The door needs opening.*	*- OK.*
	[interrogative: polar]	Finite^Subject	*Could you open the door?*	*- OK.*
	[interrogative: wh-]	Wh/C^Finite^Subject	*Why don't you open the door?*	*- OK.*

Given the phenomenon of grammatical metaphor, one system/structure cycle at one stratum is not sufficient to model the meaning-making potential of language as a whole. It is necessary to have two system/structure cycles situated at two strata - one at lexicogrammar and the other at discourse semantics (Martin, 2013b, p. 83). The relationship between two strata is referred to as **interstratal relationship**. The interstratal relationship between SPEECH FUNCTION and MOOD is modelled in Figure 2.14 below.

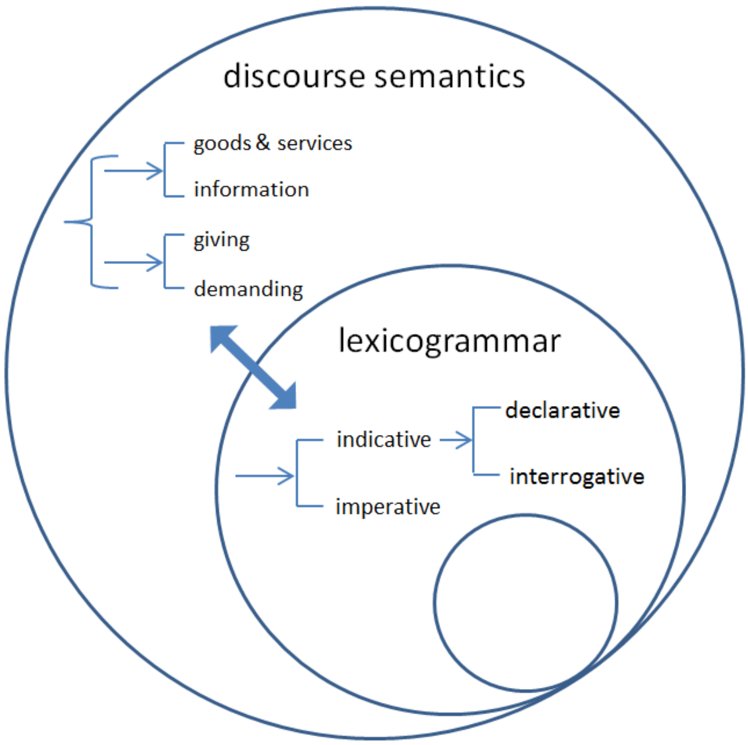


Figure 2.14 Interstratal relationship between SPEECH FUNCTION and MOOD (adapted from Martin, 2013b, p. 83)

Looking from below, at the level of phonology, choices in MOOD can be realised by choices in TONE system (Figure 2.15).

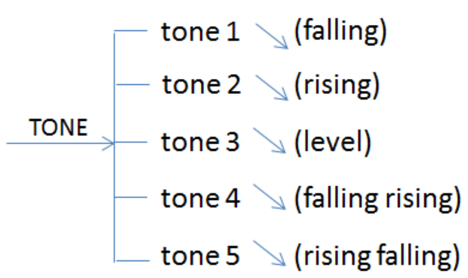


Figure 2.15 TONE system (Martin, 2013b, p. 98)

When the relationship between MOOD and SPEECH FUNCTION is congruent, choices in MOOD are associated with the tones naturally, as outlined in Table 2.3 below.

Table 2.3 Realisation of MOOD choices through tones (from Martin, 2013b, p. 98)

MOOD	TONE
[declarative]	//1 *we played India*//

[exclamative]	//5 *what a ball he bowled*//
[polar interrogative	//2 *did you win*//
[wh- interrogative]	//1 *who got the wickets*//
[imperative]	//1 *play well*//

However, when the relationship between MOOD and SPEECH FUNCTION is marked, a MOOD choice can combine with different tones to achieve different effects of speech functions (Martin, 2013b, Halliday & Greaves, 2008). For example, a request for information may be realised through a declarative clause, which is expressed through a rising tone (e.g. //2 *they played* ***Ind****ia*// (‘*did they play India?*’)). The systems discussed above are mapped across strata in Figure 2.16 below.

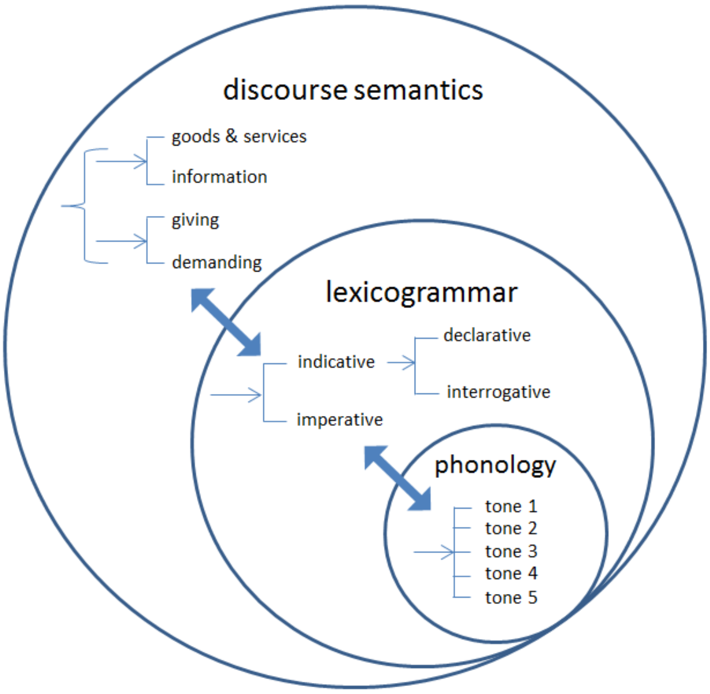


Figure 2.16 Interstratal relationships among SPEECH FUNCTION, MOOD, and TONE (adapted from Matthiessen & Halliday, 2009, p. 39)

The interstratal relationships between interpersonal systems can be further explored at the level of context. For example, POWER (STATUS in Martin, 1992) in tenor as a register variable is construed through the SPEECH FUNCTION in the discourse, which is in turn realised through the choices of PERSON in lexicogrammar (see Martin, 1992, 2013b). The critical point here is that as far as stratification is concerned, a system network at any stratum (except for the highest and lowest ones) is associated simultaneously with systems from the strata above, around and below.

2.2.4 Rank

Alongside the organisation of systems through metafunction and stratum, at each stratum, bundles of systems are also organised onto ranks "according to the size of units they are classifying" (Martin, 2013b, p. 62). Each system thus has its point of origin at a particular **rank**[3]. The compositional hierarchy of ranks in SFL is referred to as **rank scale**.

At the stratum of lexicogrammar, a clause is decomposed into groups/phrases. These are further broken down into words, which may be further broken down into morphemes. The rank scale for clause to word constituency is exemplified in Figure 2.17 below.

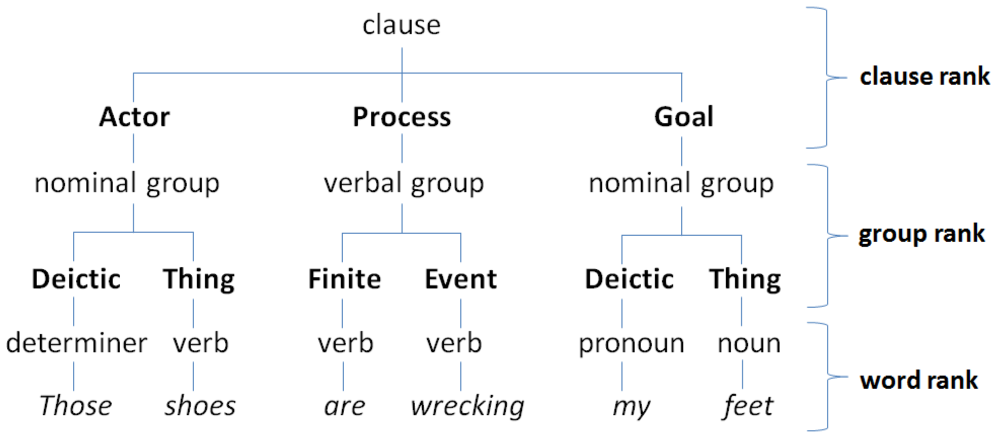


Figure 2.17 An example of rank scale in lexicogrammar (adapted from Martin et al., 2010, p. 16)

As outlined in the tree diagram in Figure 2.17, each rank is represented by one class/function cycle. Clause rank is represented by its functional configuration (Actor + Process + Goal). The classes (e.g. nominal group) that realise the clause-rank functions provide further environments for constituency at group rank, which involves functions of smaller units (e.g. Deictic, Thing, Finite, and Event).

The organisation of rank scale is determined by system networks. Each class is the entry condition of a system at a particular rank, and provides an environment for potential paradigmatic oppositions. For example, the clause is an entry condition of TRANSITIVITY; the nominal group is the entry condition of a nominal group system, as illustrated in Figure 2.18 below.

[3] The conceptualisation of rank in SFL has mainly been associated with constituency, which privileges the particulate structure in ideational metafunction; while Caffarel et al. (2004, p. 32) point out that 'units at each rank can normally be probed for evidence of orbital, prosodic and periodic organisation, and in addition enter into serial complexes'.

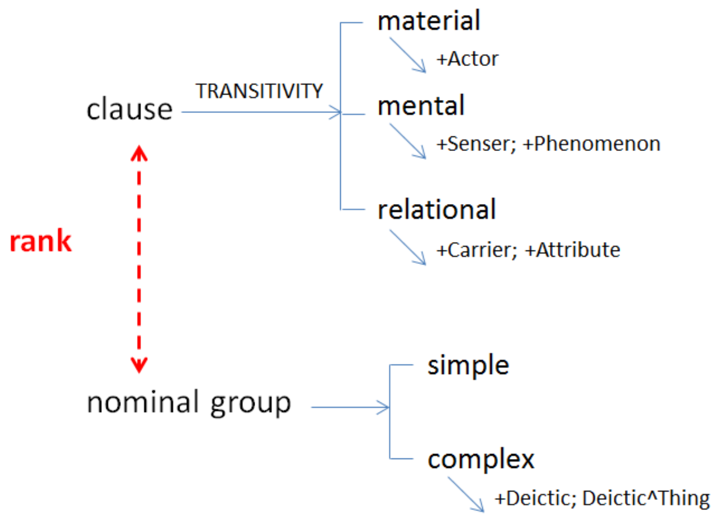


Figure 2.18 Intrastratal relationship between clause and nominal group systems (adapted from Martin, 2013b, p. 62)

The relationship between systems at different ranks of the same stratum is an **intrastratal relationship**. The relationships along the rank scale are determined critically by the function/class cycle on the syntagmatic axis. That is, the class that realises the function at the higher rank is the entry condition of a system at the lower rank. Martin (2013b) models the system/structure cycles along ranks as in Figure 2.19 below.

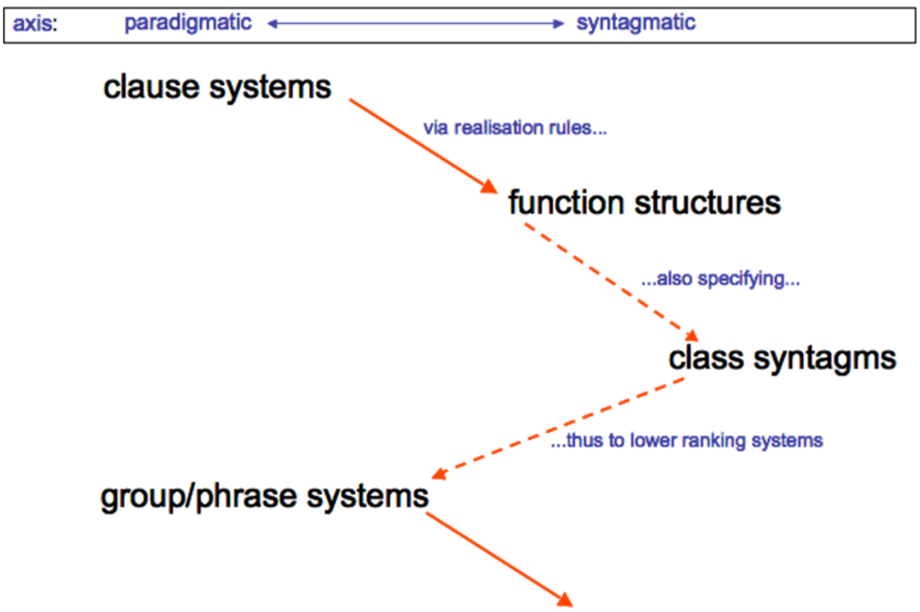


Figure 2.19 Clause and group rank system/structure cycle (from Martin, 2013b, p. 65)

The systemic organisation of rank scale allows us to describe the phenomenon of **rank-shift.** Rank-shift means that units at the higher rank may realise a function at the rank below. The down-ranked unit is also referred to as an **embedded** unit. The example below demonstrates that, instead of being realised by a nominal group, the Actor participant at the clause rank is realised by an embedded clause (i.e. *wearing those shoes*), which has its own clause structure.

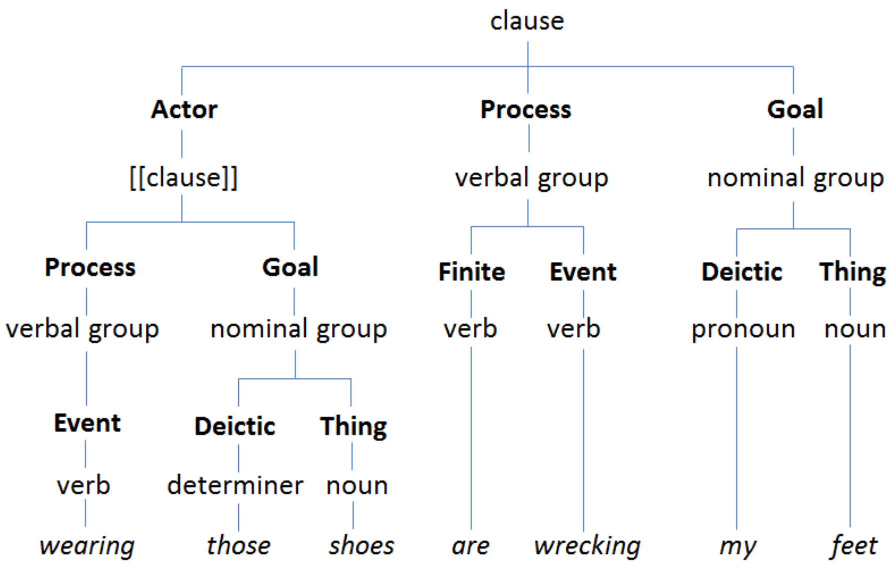


Figure 2.20 Example of embedded clause (adapted from Martin et al., 2010, p. 18)

Rank-shift has the effect of expanding grammatical resources, as the meaning potential of a higher-ranking unit enriches the meanings at the lower rank (Halliday & Matthiessen, 1999, p. 10).

Rank scales are not unique to lexicogrammar. For example, at the discourse semantic level, SPEECH FUNCTION and NEGOTIATION systems are organised at different ranks (Ventola, 1987; Martin, 1992, 2013b). SPEECH FUNCTION accounts for the system at the rank of **move**, and NEGOTIATION accounts for the sequencing of moves at the rank of **exchange**.

At the level of genre, rank allows the constituency of social processes to be described (Martin & Rose, 2008). Genres are identified by their configurations through functional stages, which can further specify a system of phases. Taking the narrative *Shanteun Raaje* in Martin & Rose (2008, p. 84) as an example, the rank scale revealed in this instance of narrative genre is illustrated in Figure 2.21 below.

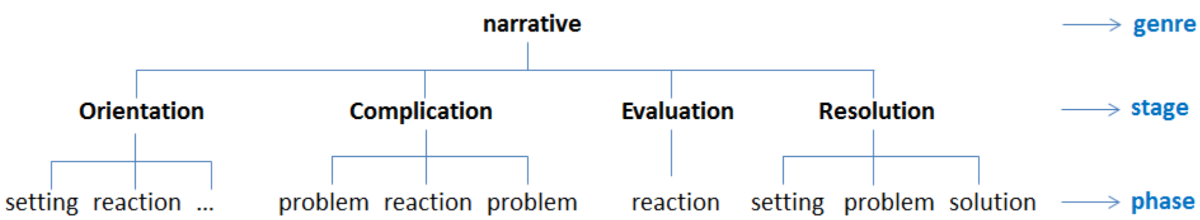


Figure 2.21 Constituency of a narrative Shanteun Raaje (c.f. Martin & Rose, 2008, p. 84)

To consolidate the theoretical dimensions I have so far reviewed, the complementarity of system and structure underlies the organisation of systematic functional model of language. A system can be associated simultaneously with a system at another stratum, a system at another rank, and a system in another metafunction. Martin & Matthiessen (1991) represent these simultaneous theoretical dimensions as in Figure 2.22 below.

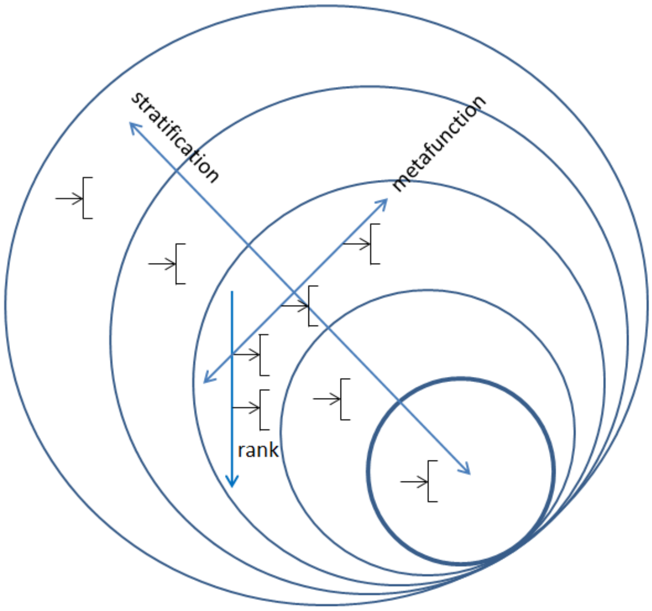


Figure 2.22 Simultaneous dimensions of stratification, metafunction and rank (adapted from Martin & Matthiessen, 1991, p. 350)

2.2.5 Instantiation

Systems and structure underline the organisation of strata, metafunction and rank. Through system networks, what is shown is 'how it is possible for meanings to be made' (Halliday, 2008, p. 120). The meaning-making potential of a language is instantiated in individual texts. The relationship between language as systems and as texts is referred to in SFL as **instantiation** (Halliday & Matthiessen, 2014, p. 27). Instantiation is a cline of generalisation. At the most generalised pole, we can locate language as system (the meaning potential of a language); and the meaning potential can be instantiated as particular instances in the form of a text. A useful analogy Halliday uses to explain such complementarity is the relationship between weather and climate:

> "Weather and climate are not two different things, they are the same thing, which we call *weather* when we are looking at it close up, and *climate* when we are looking at it from a distance. The weather goes on around us all the time; it is the actual instance of temperature and precipitation and air movement that you can see and hear and feel.

The climate is the potential that lies behind all these things; it is the weather seen from a distance, by an observer standing some way off in time." (Halliday, 1991/2007, p.276)

When approaching texts, we are concerned with the actual instances and generalised systemic potential at the same time. Our observation of what a speaker 'actually says' has to be interpreted in association with what she/he 'can say' (Halliday, 1978, p. 40). It is often necessary to shunt back and forth, making generalisation on the basis of instances, and at the same time identifying instances according to systemic potential.

As far as the systemic interlocking of stratification, metafunction and rank is concerned, the process of instantiation relates system to instance at any given stratum, at any given rank and in any given metafunction, as modelled in Figure 2.23 below.

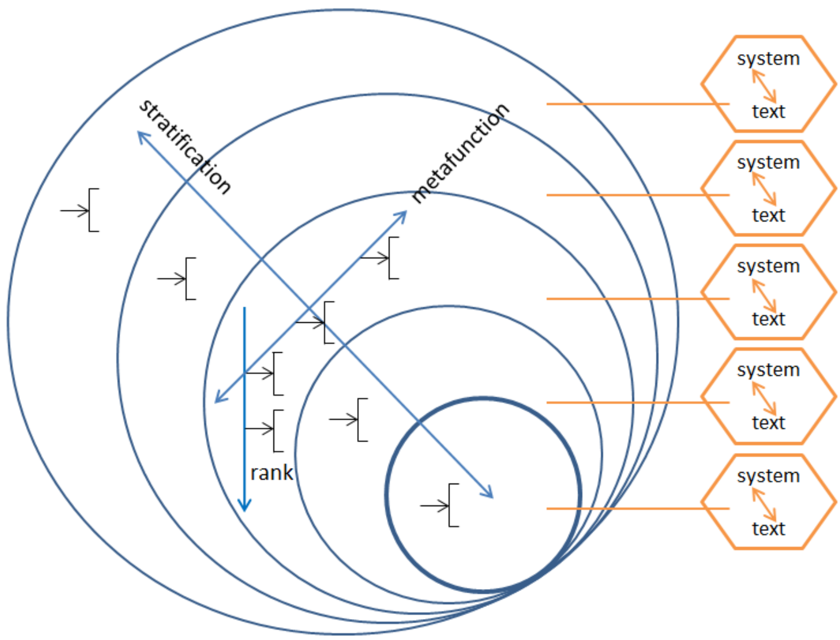


Figure 2.23 Realisation in relation to instantiation (adapted from Martin, 2010, p. 22)

2.2.6 Semogenesis

Semiotic systems are not static, but rather constantly changing. Semiotic change (**semogenesis**) is modelled in SFL according to three time scales. The relatively short timescale is concerned with the unfolding of text, called **logogenesis**. Logogenesis involves the 'instantial construction of meaning in the form of a text'; the instantiation of meaning is 'continually modified in the light of what has gone before' (Halliday & Matthiessen, 1999, p. 18). A relatively longer timescale, **ontogenesis,** is concerned with the development of the individual speaker, referring to the process through which a child develops the mother tongue (Painter, 1999). The longest timescale of semiotic change is concerned with change of culture, known as **phylogenesis.** Through these processes, meanings are 'continually created, transmitted, extended and changed' (Halliday & Matthiessen, 1999, p.18). Meanings made within the smaller timeframe allow the meanings in the bigger timeframe to emerge; and the meanings in the bigger timeframe condition the choices of meaning made in the smaller one. The relationships between these semiotic changes are represented in Figure 2.24.

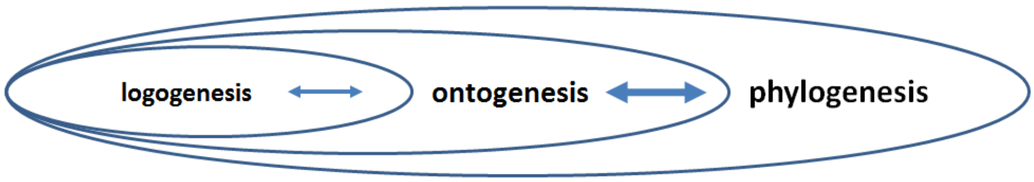


Figure 2.24 Time frames and semogenesis (adapted from Martin & Rose, 2007, p. 318)

2.2.7 Summary

To summarise, SFL conceptualises language as a meaning creating resource. Language is modelled as a system of meaning in a given culture which is organised into different metafunctions, strata and ranks. The systems of meanings are instantiated in texts. For discourse analysts, the study of instances of meaning in a text can never be dissociated from the systemic potential of the meanings. Additionally, language is constantly changing; any observation of language has to be situated in a particular timeframe.

The theoretical principles reviewed in this section are drawn on throughout this thesis. In the next section, I interpret knowledge building through the various theoretical principles, especially stratification.

2.3 A systemic functional linguistic view of knowledge building

As far as knowledge building is concerned, the key question is 'what is knowledge'. It has been noted in the previous chapter that many theorists outside SFL conceptualise knowledge and language as separate phenomena; language is often seen as the expression of knowledge (e.g. Jackendoff, 2012; Lakoff, 1987). Halliday's (e.g. 1998/2004) position, however, is that instead of just being a means of expressing knowledge, language creates knowledge. The relationship between knowledge and language is articulated by Halliday as below:

> "Language is not the means of knowing; it is the form taken by knowledge itself. Language is not **how we know** something else, it is **what we know** [original

emphasis]; knowledge is not something that is encoded in language – knowledge is made of language...” (Halliday, 1988/2007)

From this point of view, knowledge and language are not two different phenomena. The process of developing language is at the same time the process of developing knowledge. Children start developing their language at birth and there is ‘continuity between home, neighbourhood and schools as environments for learning’ (Halliday, 1990/2007, p. 360). Three crucial changes of language development are the move from protolanguage (Halliday, 1975/2003; Painter, 1984) to language in the second year of life when children start to develop grammar (Painter, 1999); the move from everyday spoken language to written language when they enter into school around age five; and the move from written language to the language of subject disciplines, when they enter into secondary school (Halliday, 1998/2004, p. 27). These three critical moments of development are rephrased by Halliday in terms of knowledge – that is, the moves into ‘commonsense knowledge’ (age 1-2), into ‘educational knowledge’ (age 4-6) and into ‘technical knowledge’ (age 9-13) (see Figure 2.25 below); but this is an alternative, not a supplementary formulation.

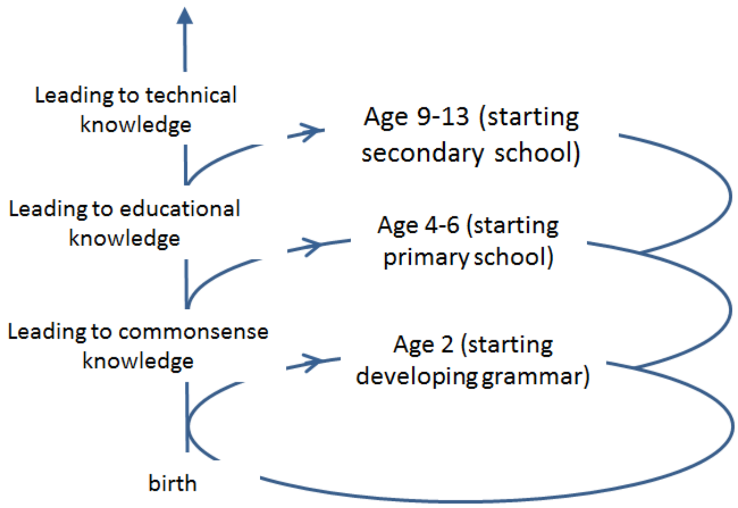


Figure 2.25 Three critical moments of knowledge development of an individual (c.f. Halliday 1998/2004)

The specialisation of ‘technical knowledge’ introduced at primary and secondary school is also recognised by some educational linguists (e.g. Christie & Derewianka, 2008; Rose & Martin, 2012; Schleppegrell, 2004). Various subject areas are introduced to students, such as English (Rothery, 1994; Rothery and Stenglin, 1994a, 1994b, 1997), history (Coffin, 1996, 2006; Matruglio, 2014), geography (Humphrey, 1996), science (Veel, 1993, 1997, 1998), mathematics (Veel, 1999; O’Halloran, 2005) and music (Weekes, 2014). In terms of building scientific knowledge that is the concern for this thesis, it has been found that the basic scientific knowledge starts to be developed around year 7; more discipline-specific knowledge such as physics, biology and chemistry starts to be developed at year 9; and training to professional science starts at undergraduate level (Rose et al., 1992; Martin & Rose, 2008, p. 226; Zhao, 2012). A spiral outlining the development of science through education is presented in Figure 2.26 below.

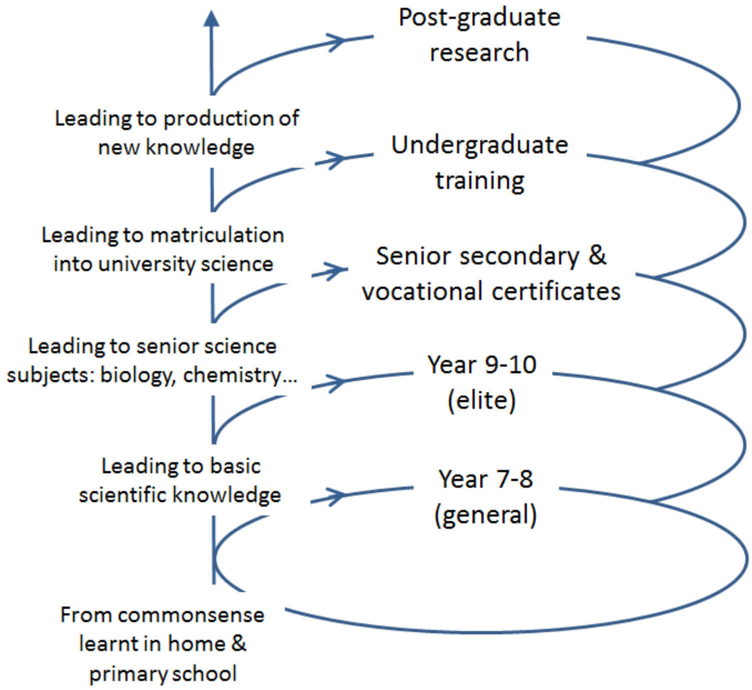


Figure 2.26 Stages in science education (c.f. Rose et al., 1992, p. 84)

Knowledge introduced in secondary school in disciplines is ‘recontextualised’ knowledge (Bernstein, 2000) – that is, the ‘the results of what scientists and historians have done’ (Wignell, 2007, p. 51). The recontextualised knowledge continues to be developed in greater depth in undergraduate training. Researchers who have focused on disciplinary knowledge at tertiary level (Hood, 2004; Humphrey, 2013a; Humphrey & Hao, 2013; Humphrey & Dreyfus, 2012) have reported the distinct challenges across different subject areas such as biology, linguistics, education and communication. While the knowledge developed at tertiary level is also largely recontextualized knowledge, it has been also found that at the final stage of undergraduate training, the research report (sometimes called dissertation) shares similar features with the published research articles produced by discipline experts, despite their equally significant differences.

The question of ‘what is the knowledge in a discipline apprenticed at the tertiary level’ is essentially the question of ‘what is the language *of* that discipline’ at this level. That is to say, drawing on SFL theoretical framework, the linguistic exploration of **language** in undergraduate biology can be approached with respect to all theoretical dimensions, including stratification, metafunctions, instantiation and semogenesis. The sketch above of knowledge development from home towards tertiary education draws on the ontogenetic perspective on language development. In terms of metafunction, we may consider whether the building of knowledge emphasises technicality in the discipline (Halliday & Martin, 1993), or it emphasises values that are negotiated in a community (Martin, Maton & Matruglio, 2010), or the integration of knowledge in a text (see Martin, forthcoming). From the perspective of instantiation, we may consider the instances of knowledge in a particular text in relation to the systemic potential of the discipline. The question of ‘how knowledge is construed’ is associated particularly with stratification. As far as verbal language is concerned, in this study I explore disciplinary language in terms of its discourse semantic patterns, which realise register and genre, and are realised through lexicogrammatical patterns. In the following sections, I will further review work on stratification.

2.3.1 Knowledge as social processes (genres)

As introduced earlier, genres are a system of staged, goal-oriented social processes in a culture. They are identified by their recurrent configurations of meanings that enact the practices of a given culture (Martin & Rose, 2008, p. 6). Before I get into the detail of genre in relation to educational knowledge, it is useful to draw on Bernstein’s sociological notion of ‘coding orientation’ (Bernstein, 1977) in relation to social context. Bernstein argues that social subjectivities are distinguished by differing orientations to meaning (i.e. different coding orientations); and these are manifested as ‘relations between’ and ‘relations within’ social contexts. When individuals’ coding orientations vary, it can lead to their ‘different capacity of recognising one type of context from another’ (Martin & Rose, 2008, p. 17). Such social phenomenon of unequal access to contexts resonates with the inequality of accessing to genres from SFL perspective.

As Martin & Rose (2008) point out, ‘since the privileged genres of modernism had evolved within the institutions of academia, science, industry and administration, that relatively few members of the culture had access to, relations between these and other genres reflected the structures of social inequality’ (p. 18). That is to say, access to the privileged knowledge (i.e.

‘technical knowledge’ in Halliday’s terms) is the access to the genres of the knowledge. Genre theorists recognise that while control of the privileged genres is apprenticed at the tertiary level (Rose & Martin, 2012), the access to this level is in turn dependent on learning genres at school (e.g. Rothery, 1994; Rose et al., 1992; Veel, 1997; Unsworth, 1995, 1997; Coffin, 1996), where disciplinary knowledge is first introduced to students. Identifying the genres in school is therefore the first critical step towards making knowledge explicit and accessible to students. Having this educational purpose in mind, genre theorists have identified a range of school genres in the 80s and 90s. The survey ranged across subject areas such as English, geography, history, mathematics and science. These genres are mapped into a system network according to the similarities and differences of their social purposes in Figure 2.27 below. Three primary categories are identified according to the shared functions of engaging, informing and evaluating; within each group, more delicate genres are categorised.

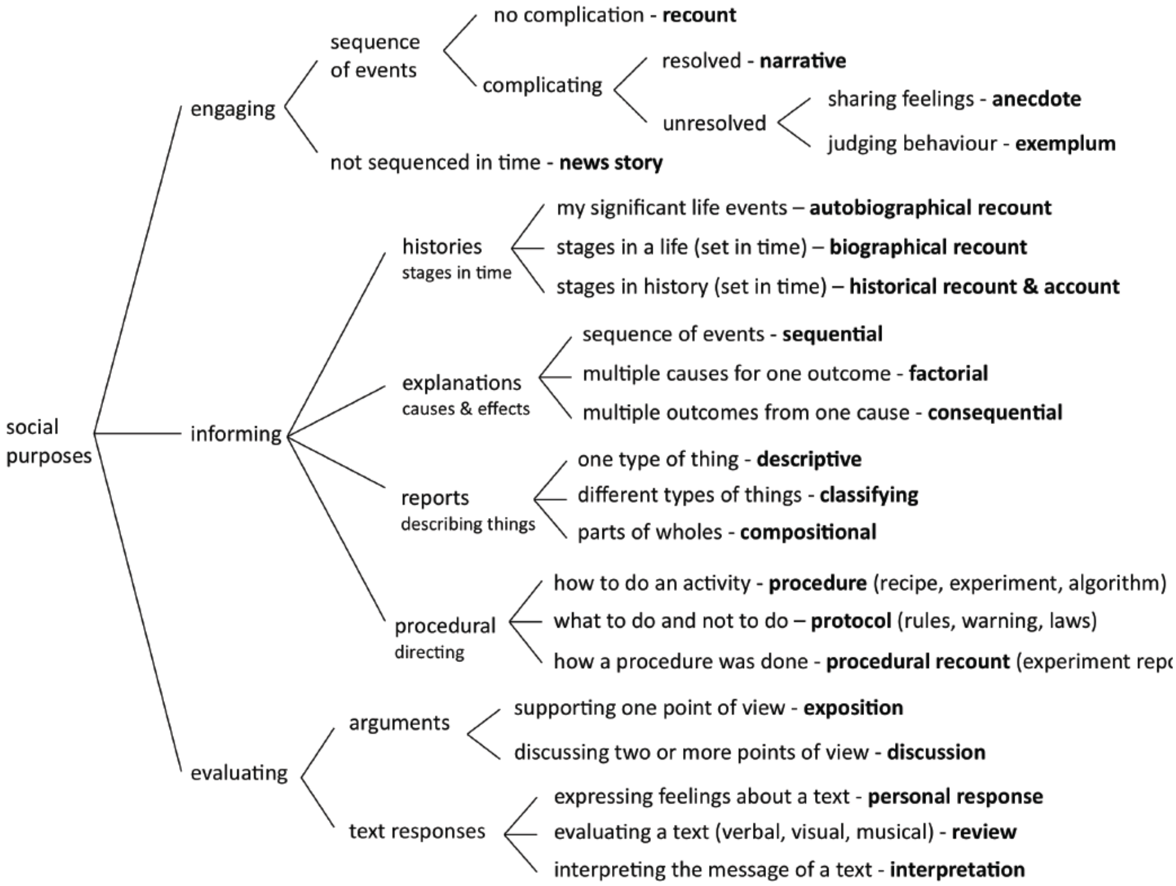


Figure 2.27 Map of genres in school (Rose & Martin, 2012, p. 128)

Through exploring genre across disciplines, it is found that same social purposes may be shared by different subject areas. For example, arguing for a position (i.e. exposition genre) is one of the social purposes in English (Humphrey, 2013b), history (Coffin, 2006, Matruglio, 2014), and science (Veel, 1997, 1998). At the same time, each subject area involves multiple genres. Science, which is our particular concern here, has several social purposes. As Martin & Rose describe,

> "Science semioticises the natural world by generalising about things and processes in four regular ways: by classifying and describing phenomena, by explaining how processes happen, by instructing how to observe phenomena (e.g. in experiments), and by recounting and interpreting what was observed. So four families of genres that characterise science are **reports** that classify and describe, **explanations** of cause and effects, **procedures** for observing and experimenting, and **procedural recounts** for reporting on observations and experiments." (Martin & Rose, 2008, p. 141)

Within these four genre families, more delicate genres may be distinguished. For example, three types of reports can be identified, according to their more delicate ways of describing a phenomenon in descriptive report, classifying a phenomenon in classifying report and decomposing a phenomenon in compositional report. Each of these reports, like all genres, can be broken down into goal-oriented stages, according to the recurrent ways in which it unfolds. Achieving the social purpose of a descriptive report for example requires a stage of Classification of the phenomenon before providing the Description of the phenomenon.

An overview of genres and their stages found in science subjects is presented in Table 2.4 below. Note that apart from the four main genre families identified in science, exposition and discussion are also accounted for (Martin, 1993b; Veel, 1997, 1998).

Table 2.4 Genres in sciecce (c.f. Martin & Rose, 2008; Veel, 1997)

Genre		Social purpose	Stages
procedure		to enable scientific activity, such as experiments and observation, to occur.	Aim^ Materials^ Steps
procedural recount (including experiment reports and research articles)		to recount in order and with accuracy the aim, steps, results and conclusion of a scientific activity.	Introduction^ Method^ Result/Investigation^ Discussion/Conclusion
report	**descriptive report**	to classify a phenomenon and then describe its features	Classification^ Description
	classifying report	to subclassify a number of phenomena with respect to a given set of criteria	Classification system^ Types
	compositional report	to describe the components of an entity	Classification of entity^ Components

explanation	**sequential explanation**	to explain simple sequence of causes and effect	Phenomenon identification^ Explanation sequence
	factorial explanation	to explain multiple causes	Phenomenon identification ^ Factor [1-n]
	consequential explanation	to explain multiple effects	Phenomenon identification ^ Effects [1-n]
	conditional explanation	to explain the effects which vary depending on variable conditions	Phenomenon identification^ Explanation sequence
	theoretical explanation	to introduce and illustrate a theoretical principle and/or to explain events which are counter-intuitive	Phenomenon identification/Statement of theory ^ Elaboration [1-n]
	exploration	to account for events for which there are two or more viable explanations	Issue^ Explanation 1^ Explanation [20n]
exposition		to persuade the reader to think or act in particular ways	Thesis^ Arguments 1-n^ Reinforcement of thesis
discussion		to persuade the reader to accept a particular position on an issue by considering more than one perspective	e.g. Issue^ Dismissal of opponent's position^ Arguments for own position^ Recommendation

Genres are not only mapped typologically, but a topological perspective is also taken, which emphasises their similarities alongside differences (Martin & Matthiessen, 1992; Martin & Rose, 2008, p. 138). This form of classification is particularly useful in education since it facilitates 'the development of learner pathways' which allows students to 'move smoothly from control of one genre to another' (Martin, 1997, p. 16). Based on the configuration of meanings analysed in the genres of school science, Veel (1997) proposes an ideal knowledge path, from procedures and recounts to various types of explanations, as shown in Figure 2.28.

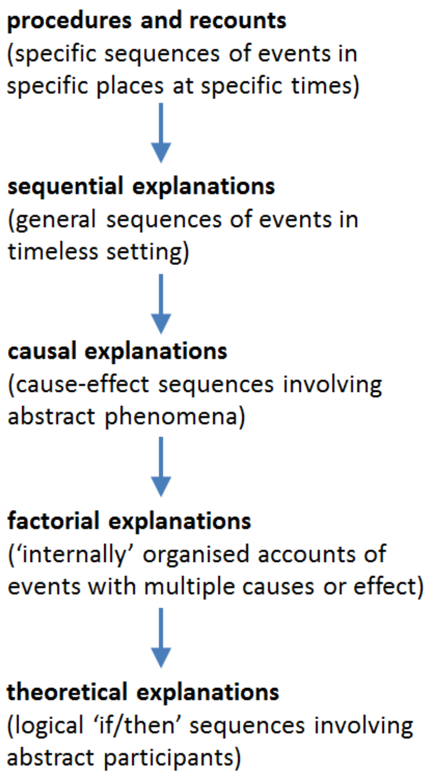


Figure 2.28 An idealised knowledge path in school science (c.f. Veel, 1997, p. 189)

Various elemental genres in the system may be instantiated in a single text and organised logogenetically. The instantiation of multiple genres in a text may be structured in various ways. Firstly, the instantiated genres in a text may be related to each other through logical semantic relation of expansion or projection – a text of this kind is termed a macro-genre (Martin, 1994, 1995; Martin & Rose, 2008 p. 218). Macro-genres have a univariate structure. Martin (1994) suggests that a macro-genre is to a clause complex as a genre is to a clause:

macro-genre: clause complex::
genre: clause

An example of a macro-genre is a chapter of geography textbook exemplified in Martin & Rose (2008, p. 218 ff.). Each genre instantiated in the text is interdependent on other ones.

A second way of instantiating multiple genres to a text is through embedding (Martin, 1994, Szenes, forthcoming). Here the genre as a whole has a multivariate structure. That is to say, an embedded genre is to an embedded clause as a genre is to a clause.

embedded genre: embedded clause::
genre: clause

Embedded genres are instantiated in a text in which they function as generic stages within a genre as a whole. Martin (1994) illustrates the embedding of genre through an example of macro-proposal. A news story is embedded in the first stage of the macro-proposal, functioning as an Involvement[4].

It has been found in previous studies that pedagogic texts and assessment tasks are often combinations of various elemental genres, either in the form of macro-genres or embedded genres. For example, Humphrey (2013a) reports on the challenges in reading macro-genres in biology, including both web-based and print textbook chapters. In terms of genre embedding, Hood (2004) argues that the Introduction to student's research report can consist of a Descriptive report on the object of study, a Descriptive report on others' research and a Description of the writer's own study (p. 55). Similarly, in Drury's (2006) observation of 'short-answer' tasks produced at the first year undergraduate biology, she finds that several elemental genres can be identified in even a short answer text, including reports, explanations and expositions. What has been highlighted in these studies is that the texts produced at the tertiary level typically demonstrate a far more complex configuration of meanings in comparison to the genres identified at the school level.

It is important to note here that while verbal language is focused on in this study, genres are regularly configured through multiple semiotic modes (Bateman, 2008). In scientific genres, semiotic modes such as images, graphs, tables and symbols of mathematics often interact with verbal language to compose a genre (van Leeuwen & Humphrey, 1996; Martin & Rose, 2012; Unsworth, 2001; Guo, 2004).

2.3.2 Knowledge structures and fields

So far I have been using the wordings 'subjects' and 'disciplines' loosely in referring to disciplinary knowledge, (i.e. 'technical knowledge' in Halliday's term). My concern has to do with 'what knowledge is construed', which has been referred to by Bernstein (1999) as 'knowledge structure'. Theoretically speaking, knowledge structure is associated with the register variable field (e.g. Martin, 2007). As Martin explains,

[4] Note that Christie (1997) does not distinguish genre embedding from genre complexing (i.e. macro-genre). The curriculum genre illustrated there can also be treated as an example of genre embedding.

> "In the stratified model of context, the register variable field provides a social semiotic perspective on knowledge structure; and knowledge is by and large realised through, construed by, and over time reconstrued through ideational meaning (via the modalities of language and image). So exploration of knowledge structure is treated linguistically as exploration of field of discourse." (Martin, 2007, p. 34)

A field is defined as 'sets of activity sequences oriented to some global institutional purpose' (1992, p. 536). Field is modelled through system networks, as a 'system of activity' (Martin, 1997). Martin suggests the relationship between various fields as in Figure 2.29 below.

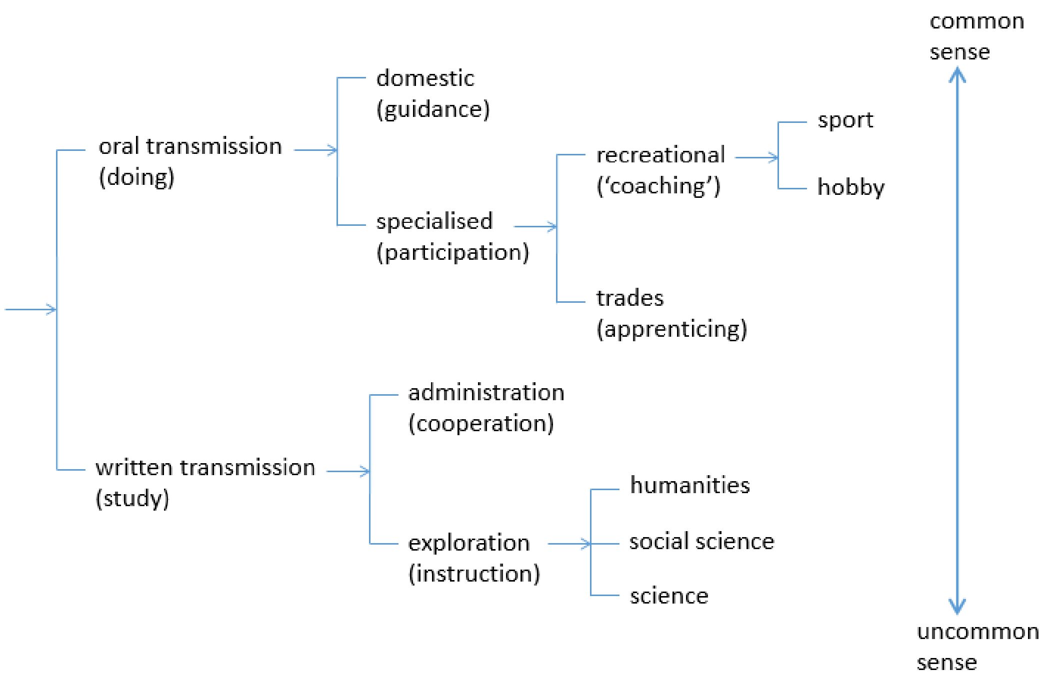


Figure 2.29 A provisional classification of fields (Martin, 1992, p. 544)

In Figure 2.29, a primary distinction is made between the fields that are transmitted orally, and fields that are necessarily documented in writing. Martin stresses that fields also need to be viewed topologically, since like all semiotic categories, fluid boundaries among fields 'is essential for meaning to evolve' (1992, p. 292). As annotated by the cline on the right hand side in Figure 2.29, fields are scaled from those which are relatively commonsense to those which are relatively uncommonsense. The most uncommonsense fields on this scale are **exploration fields**, including humanities, social science and science.

Martin's field typology in some sense resonates with Halliday's identification of the development of knowledge that we have reviewed above (Figure 2.25). In particular, domestic fields can be associated with knowledge that is accessed at home before the age of 5; exploration fields can be associated with both educational knowledge introduced in primary school and technical knowledge as that developed further in secondary school and beyond.

The field typology in Figure 2.29 also resonates with Bernstein's (e.g. 1999) sociological identification of knowledge structure. Bernstein makes a primary distinction between commensense knowledge and uncommensense knowledge as horizontal and vertical discourse. Horizontal discourse is one which is 'segmentally organised, context specific and dependent', and it is likely to be 'oral, local, context dependent and specific'. A vertical discourse is one which has a form of 'coherent, explicit and systematically principled structure' or 'takes the form of a series of specialised language with specialised modes of interrogation and specialised criteria for the production and circulation of texts' (p. 159). In Martin's field terms, the distinction between horizontal and vertical discourses sets up the opposition between the fields involving oral transmission (i.e. domestic and specialised fields) and those depending on written transmission (i.e. administration and exploration fields). Bernstein makes a further distinction within vertical discourse – that is between horizontal and hierarchical knowledge structures. A horizontal knowledge structure is defined as 'a series of specialised language with specialised modes of interrogation and criteria for the construction and circulation of texts' (p. 162), which occur typically in the disciplines of humanities. A hierarchical knowledge structure is 'a coherent, explicit and systematically principled' and 'hierarchically organised' structure (p. 159), which is often exemplified in the disciplines such as physical science. The distinction between horizontal and hierarchical knowledge structure resonates with the delicate distinctions among science and humanities within exploration fields.

Drawing on the distinction between hierarchical and horizontal knowledge structure, Wignell (1998, 2007) explores the nature of knowledge structure in social science. Through a detailed linguistic analysis of texts in various areas in social sciences including sociology, economics and political sciences, Wignell finds that the language of social science has evolved as a hybrid of the language of physical sciences and the language of humanities. The knowledge structure of social sciences, therefore, configures meaning associated with both hierarchical and horizontal knowledge structures. Following Bernstein, a hierarchical knowledge structure is represented by a triangle and horizontal knowledge structure is represented by a series of segmented languages (L); accordingly the hybrid knowledge structure of social science is thus represented as segmented triangles (Wignell, 2004 in Martin, 2011). The relationship among fields with different knowledge structures, specifically exploration fields, is then mapped on a cline as shown in Figure 2.30.

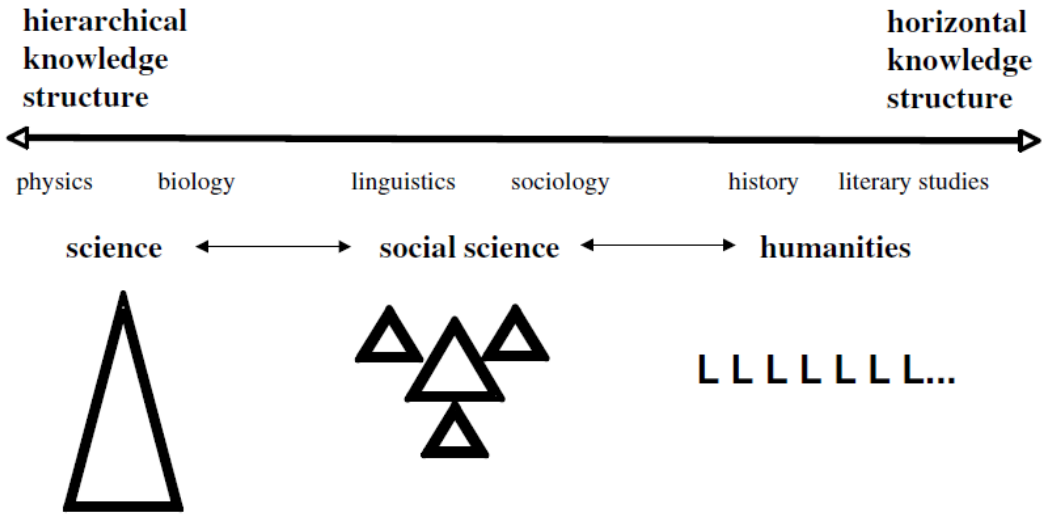


Figure 2.30 Vertical discourse as complementarity and cline (Martin, 2011, p. 43)

While Bernstein's identification of different knowledge structures provides a useful perspective for articulating the differences among different fields, from an SFL point of view, the typological oppositions are essentially motivated by their different types of taxonomy and activity sequencing. For pedagogic purposes, Martin specifies the taxonomy and activity sequences of different fields as in Table 2.5 below.

Table 2.5 Field in relation to activity sequence and taxonomy (Martin, 1992, p. 545)

	activity sequences	**taxonomies**
domestic (guidance)	implicit	'natural'
specialised (participation)	manuals	utilitarian (tools)
administration (cooperation)	procedures	pragmatic (subjects)
exploration (instruction)	implication sequence	technical (things)

Martin draws on Barthes' (1975) notion of 'sequence' to describe activity sequences in a field. Several features of activity sequences can be summarised here. For Barthes, sequences are ordered and unfolded through time, for example the sequence of 'order a drink, obtain it, drink it and pay for it'. Secondly, steps in a sequence involve both 'expectancy' and 'risk'. Recognition of an activity sequence implies an expectation that one of its events will follow another. It is always possible for expectations to be countered – that is the 'risk', which creates the context for concessive conjunctive relations; counter-expectation has an instrumental role to play in narrative genre.

In Martin's work, there is a distinction between an activity sequence in which one event is probably followed by another and an implication sequence in which one event is absolutely determined by the other (p. 324). He draws on the notion of modality (Halliday, 1994) to make the distinction between the two – associating expectancy sequences with modalisation and implication sequences with modulation. These two types of sequence relations can be made explicit in language as temporal (*and then*) and causal (*if…then…*) logical relations respectively. Expectancy relationships occur typically in story genres, such as narrative, recount, and procedure; whereas causal relationships are a significant feature in scientific explanations. Wignell et al. (1993) introduce the term 'implication sequence' for sequences involving if/then causal relations. They suggest that implication sequences contrast with what they call expectancy sequences since they 'explain how things are, or come to be the way they are'; and they indicate 'a more ordered connection among sequences' (pp. 174-5). An opposition between expectancy and implicational relations between field activities is therefore set up, as shown in Figure 2.31.

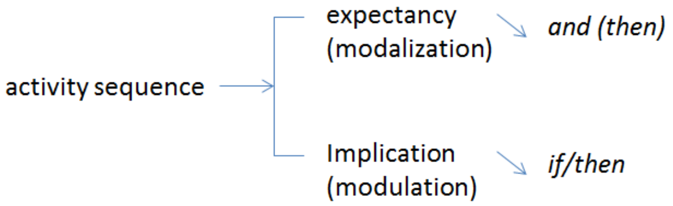


Figure 2.31 Activity sequence relations (Martin, 1992, p. 324)

A third characteristic of activity sequences is that they can be named. Naming allows activity sequences to be arranged in taxonomies in terms of part/whole relations. Martin gives an example of this from tennis where a *point* has one or more *shots* as its parts, and the *point* is itself part of a *game*, which is part of a *set*, which may be part of a *match*, which may be part of a *round* in a *tournament.*

The other dimension of field, taxonomy, refers to 'action, people, places, things, and qualities', which are organised based on classification and composition. Classification maps taxonomies in terms of subclasses (and co-subclasses); composition relations map taxonomies based on the relation of parts (and co-parts) to a whole. Martin notes that both classification and composition can organise taxonomies of people, places and things in a given field. Actions in a field are more commonly organised in terms of part/whole relations, reflecting a compositional perspective on activity sequences. Qualities are only organised by classification, and involve relatively shallow taxonomies (pp. 295-297).

Martin's identification of activity sequences and taxonomies in a field allows for a linguistic distinction among fields. We may label fields as 'science', 'social science' and 'humanities', each of which may be divided further into more delicate categories such as physics, biology, sociology, history, etc.; however, when exploring fields as a semiotic system, it is their organisation with respect to taxonomy and activity sequences that determines the ways in which fields are similar to or different from each other.

Drawing on Martin's definition of field, Hood (2010) identifies fields in Introductions to academic research articles (i.e. research warrant genre). She finds that the taxonomies and activity sequences in this genre are oriented to two types of field: one is 'the set of phenomena (entities and/or activities) that constitute the object of study'; the other is 'the construction of the process of research itself, the entities and activities to do with the process of enquiry and knowledge building' (p. 121). Hood also notes that these fields in academic research articles can be described along with the cline of delicacy – i.e. 'at different levels of generality' (p. 117). At a micro level we can be very specific in describing the fields construed in an individual text, for example 'research into student satisfaction in a context of expanding demand for online learning in higher education' (p. 119). At the same time such a field may be generalised to a broader field of education, which can be further generalised to a disciplinary field as social sciences. Among the texts of academic research articles, the field of the object of study shows greater delicacy and variation in comparison to the field of research.

The field oppositions identified by Martin and Hood, which distinguish fields with the respect to taxonomy and activity sequences, both provide useful frameworks for exploring disciplinary fields at the tertiary level.

2.3.3 Summary

In this section, I have reviewed work on field in SFL from the perspectives of genre and field. It has been stressed that from an SFL perspective knowledge is construed through language, and it is construed in texts.

On the hierarchy of stratification, field is construed through language. As suggested by Halliday (1978), field is by and large construed through ideational meaning; tenor tends to be enacted through interpersonal meaning; and mode is composed through textual meaning. To reveal the means through which the field of undergraduate biology is construed, my focus is then on the ideational meanings of language in undergraduate biology – that is the patterns of ideational discourse semantics which are further realised through the patterns of lexicogrammar. It is therefore necessary to take a further step, reviewing the theoretical principles of ideational discourse semantics in an SFL framework.

2.4 Construing field through ideational discourse semantics

In order to explore the discourse semantic patterns through which a field is construed, in this section I review ideational (discourse) semantics. Two key models of ideational (discourse) semantics are available in SFL theory - they are Martin's (1992) IDEATION system and Halliday & Matthiessen's (1999) ideation base. I will review these two models below, focusing on the ways in which units of meaning are identified and the interstratal relationships among field, (discourse) semantics, and lexicogrammar.

2.4.1 Ideational discourse semantic systems

Martin (1992) sets up discourse semantics as a more abstract stratum of meaning, which is organised metafunctionally. Ideational discourse semantic meanings are organised as two systems – IDEATION and CONJUNCTION. IDEATION is by and large realised through the patterns of experiential grammar; CONJUNCTION is associated with the grammar of logical meanings. Interpersonal discourse semantic systems include APPRAISAL and NEGOTIATION. Textual systems are IDENTIFICATION and PERIODICITY. Discourse semantic systems of different metafunctions interact with each other to create the texture of discourse. The discourse semantic systems and their key contributors are summarised in Table 2.6 below.

Table 2.6 A metafunctional organisation of discourse semantic systems

discourse semantic systems		Key references
ideational	IDEATION	Martin, 1992; Martin & Rose, 2007
	CONJUNCTION	Martin, 1992
interpersonal	APPRAISAL - ATTITUDE - GRADUATION - ENGAGEMENT	Martin, 1997; Martin & White, 2005; Hood, 2004, 2010; Hood & Martin, 2007
	NEGOTIATION (discourse as dialogue)	Ventola, 1987; Martin, 1992

textual	IDENTIFICATION	Martin, 1992; Martin & Rose, 2007
	PERIODICITY	Martin, 1992; Martin & Rose, 2007

As far as the ideational metafunction is concerned, we focus on IDEATION and CONJUNCTION systems. The IDEATION system is concerned with lexical relations at the level of discourse; it is broken down into three aspects – taxonomic relations, nuclear relations and activity sequences. I review each of these dimensions below.

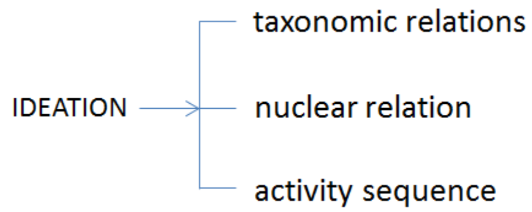


Figure 2.32 IDEATION system

2.4.1.1 Taxonomic relations

According to Martin (1992), field taxonomies are construed in discourse through the broad categories of classification and composition. Classification has to do with hyponymy, co-hyponymy and hyperonymy (i.e. class-member and co-class). For example, *marriage* is a co-hyponym of *friendship*, and *marriage* and *friendship* are both hyponyms of *relationship*. Composition refers to relationships between parts and wholes (e.g. *arm* is part of the *body*), as well as relationships among co-parts (e.g. *hands, arms* and *legs* are co-parts of a *body*). Apart from classification and composition, other types of taxonomic relation are also found in discourse, for example synonym, repetition, antonyms and series. The various kinds of taxonomic relations are summarised in Martin & Rose (2007, cf. Martin, 1992), reproduced in Figure 2.33.

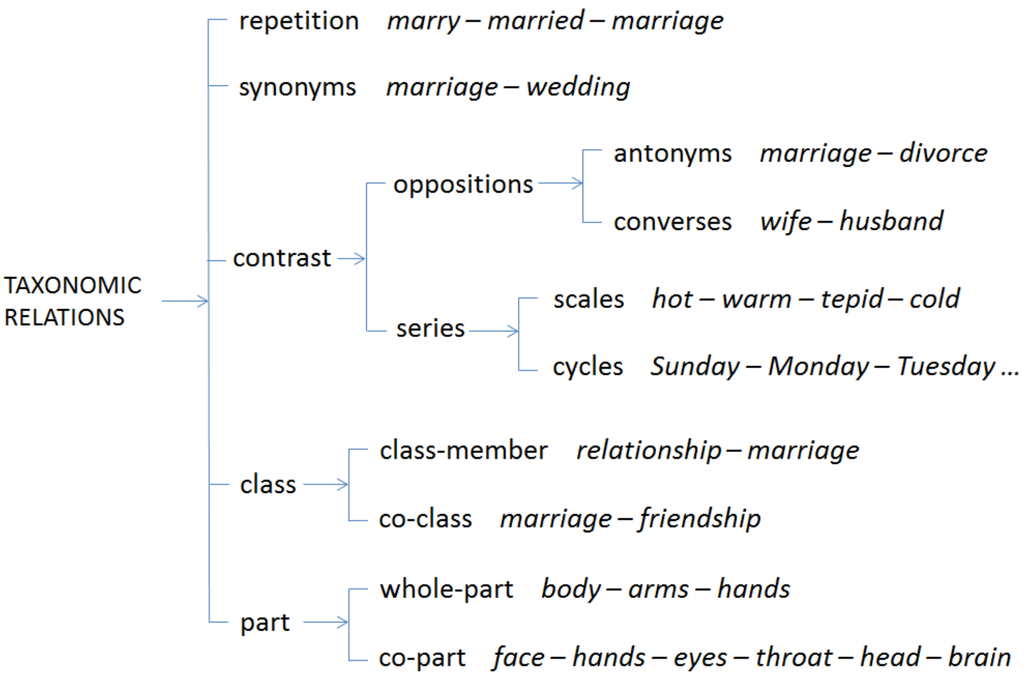


Figure 2.33 Taxonomic relation system (Martin & Rose, 2007, p. 81)

Developing taxonomic relations in the discourse relies on the discourse semantic unit of meaning - named as **message part** in Martin (1992). Martin defines a message part as a unit of meaning that realises 'the features taxonomising people, places and things' in a given field; or 'one of the actions configuring with people, places and things and entering into activity sequences'; or 'one of the qualities associated with people, places, things and actions' (p. 293). Critically, it is the message part that realises 'people, places and thing' that builds taxonomic relations in a field. This type of message part is typically realised nominally. In Martin & Rose (2007), the message parts that build taxonomies are named as **entities** (c.f. 'things' in Martin, 1997). According to Martin & Rose, entities in the discourse are not always tangible and 'concrete'; in some discourse, taxonomic relations can be established around 'abstract' entities such as *marriage*, *abduction*, *torture*, and *human rights*. In order to reveal the nature of entities in relation to fields, they categorise entities as in Table 2.7 below.

Table 2.7 Kinds of entities (Martin & Rose, 2007, p. 114)

indefinite pronouns		*some/any/nothing/one*
concrete	everyday	*man, girlfriend, face, hands, apple, house, hill*
	specialised	*mattock, lathe, gearbox*
abstract	technical	*inflation, metafunction, gene*
	institutional	*offence, hearing, applications, violation, amnesty*
	semiotic	*question, issue, letter, extract*
	generic	*colour, time, manner, way, kind, class, part, cause*
metaphoric	process	*relationship, marriage, exposure, humiliation*
	quality	*justice, truth, integrity, bitterness, security*

As shown in Table 2.7, the general categories of entities include **concrete**, **abstract** and **metaphoric** ones. Martin & Rose suggest that the distinction between concrete and abstract ways of meaning reflects a fundamental division among fields of activity in modern cultures – between the 'everyday activities of family and community', and the 'uncommon-sense fields of technical professions and social institutions such as law, medicine or education'. Concrete entities are all ostensively defined – that is, they can be learned by pointing to them and using them. Among the concrete entities, some belong less in everyday activities than in specialised occupations. In contrast to concrete entities, technical entities refer to 'abstract concepts', which occur in professional occupations, such as economics, linguistics or biology; they are usually learned in educational settings. The other types of abstract entities, semiotic and generic ones, can be found in 'all kinds of field'. The third general category, metaphoric entities, refers to the instances of grammatical metaphor in the discourse.

While these types of entities provide a way of exploring field in relation to lexical items in texts, this categorisation is problematic in a number of ways. Firstly, the typological distinction among everyday, specialised, technical and institutional entities is motivated primarily from above at the level of field. These categories go hand in hand with the types of field (see Figure 2.29 above). This one-to-one relationship between field types and entity types leads to uncertainty in discourse analysis when we try to determine whether the identification of entities is the identification of discourse semantic features or it is essentially the identification of field types.

Secondly, the distinction between 'concrete' and 'abstract' is unclear. Based on Martin & Rose's description, concrete entities are tangible and they can be ostensively defined. However, 'abstract: technical' entities such as *birds* and *sea urchins* may also be 'concrete' – the *birds* seen in the park by layman and the *sea urchins* that are found on the beach are not the same types of entities as the *birds* and *sea urchins* observed by biologists – although they are visible to both. The fact that the same word may refer to phenomena in different fields has also been pointed out by Wignell et al. (1993). The system of entities, as it stands, is not able to reveal such distinctions.

Thirdly, the metaphoric entities noted in Table 2.7 are treated as instances of grammatical metaphor. Grammatical metaphor by definition involves tension between the stratum of discourse semantics and lexicogrammar (Halliday, 1985; Martin, 2008). In other words, instances of grammatical metaphor are not instances of meaning at the level of discourse semantics. Examples such as *security, truth, exposure* etc. can be unpacked into relative congruent forms in the discourse (i.e. *it is secure/insecure, it is true, it is exposed*), and so lexicogramamtically construe either discourse semantic messages, or an event or quality as a message part. The discussion of grammatical metaphor as stratal tension will be elaborated in section 2.4.3.1.3 below.

To summarise, message parts are identified as a unit of meaning that construes taxonomic relations. The categorisation of entities is largely motivated from above, which creates the uncertainty across the level of field and the level of discourse semantics. And there is some confusion of levels as far as the stratal tension engendered by grammatical metaphor is concerned.

2.4.1.2 Nuclear relations

Nuclear relations by definition reflect the ways in which actions, people, places, things and qualities configure as activities in activity sequences. They are concerned with relationships between message parts. Martin adapts logical semantic relations (Halliday, 1985) to categorise nuclear relations. Elaboration is treated as a relationship within one message part. For example, what is realised grammatically as a Classifier=Thing[5] configuration (e.g. *paper bag*) construes one message part. Extension and enhancement, on the other hand, establish relationships between different message parts. Based on the different logical semantic relations, units of meaning are identified in relation to the scope of nuclearity, including centre, nuclear, margin and periphery. The elaborating structure of Classifier=Thing noted above is situated in the centre; the nucleus extends the meaning in the centre; the margin extends and at the same time enhances a given unit; and the periphery further enhances a given unit. Nuclearity is modelled across grammatical ranks, as in Table 2.8 below. At clause rank, a Process or the elaborating structure Process=Range:process is centre; centre can be extended through a Medium in the nucleus (e.g. *play + the ball*); and it can be extended and enhanced through Agent (e.g. *Jon* +x *plays + the ball*), and further enhanced through an Circumstance in the periphery (e.g. *Jon* +x *plays + the ball* x *in the backyard*). At the nominal group rank, an elaborating structure Classifier=Thing (e.g. *paper=bag*) is seen as the centre, which can be extended by an Epithet (e.g. *big + paper=bag*) or enhanced by

[5] The annotations of logical semantic relations within a message part and among message parts follow the annotations in Martin (1992).

Numerative (e.g. *three* +x *big* + *paper=bags*) and Qualifier (e.g. *three* +x *big* + *paper=bags x from the supermarket*). A comparable principle is applied to the verbal group.

Table 2.8 A model of nuclearity (adapted from Martin, 1992, p. 319)

structure / rank	CENTRE	NUCLEUS	MARGIN	PERIPHERY
clause	Process = Range:process	+ Medium + Range: entity	+x Agent +x Beneficiary	x Circumstance
nominal group	Classifier = Thing	+ Epithet	(+x Numerative)	x Qualifier
verbal group	Event = Particle	+ Event (event complex)	(+x causative)	x Manner adverb

This model of nuclear relations has been more recently represented visually in Martin & Rose (2007) as in Figure 2.34 below.

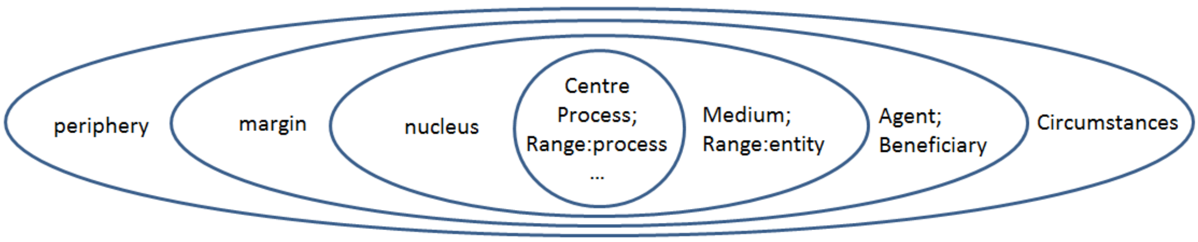


Figure 2.34 Nuclearity in the clause (Martin & Rose, 2007, p. 95)

Notice that the identification of nuclear relations, particularly at clause rank, reflects an ergative perspective on experiential clause grammar (i.e. TRANSITIVITY). Such a model of nuclearity does provide an insightful way of modelling units of meaning which are more abstract than grammatical units. However, since the labelling of discourse semantic units, in both Martin (1992) and Martin & Rose (2007), relies on an ergative analysis of grammatical functions (i.e. Medium, Process, Agent, etc.), the problem of separating discourse semantic phenomena and lexicogrammar reappears.

2.4.1.3 (Discourse semantic) activity sequence

The notion of activity sequence in IDEATION, in contrast to its use at the level of field, is concerned with the ways in which activities in a field are realised in discourse semantics. Discourse semantic activity sequences are associated closely with the system of CONJUNCTION (Martin, 1992, Chapter 4). A message is treated as a basic unit that can constitute an activity sequence. According to Martin, 'message is realised as a ranking clause that is neither a projection, nor a hypotactically dependent elaborating clause' (1992, p. 235). Clauses that are locutions and ideas, elaborating β clauses and all embedded clauses are treated as realisations of message parts instead of messages, as summarised in Table 2.9 below.

Table 2.9 Realisations of message parts through grammatical clauses (Martin, 1992, p. 235)

locution	*He said **he'd won**.*
idea	*He thought **he'd won.***
= β	*He said he'd won, **which he had**.*
[[fact]]	*It pleased him **that he'd won.***
[[act]]	*I saw **him win**.*
[[relative clause]]	*The guy **who won** ended up losing.*
[[wh clause as Head]]	***Whoever won** ended up losing.*

Messages are related to each other in the discourse through conjunctions. The system network of CONJUNCTION involves three simultaneous systems: types of logico-semantic relation, the opposition between internal and external logical relations, and the opposition between explicit and implicit one – as shown in Figure 2.35 below.

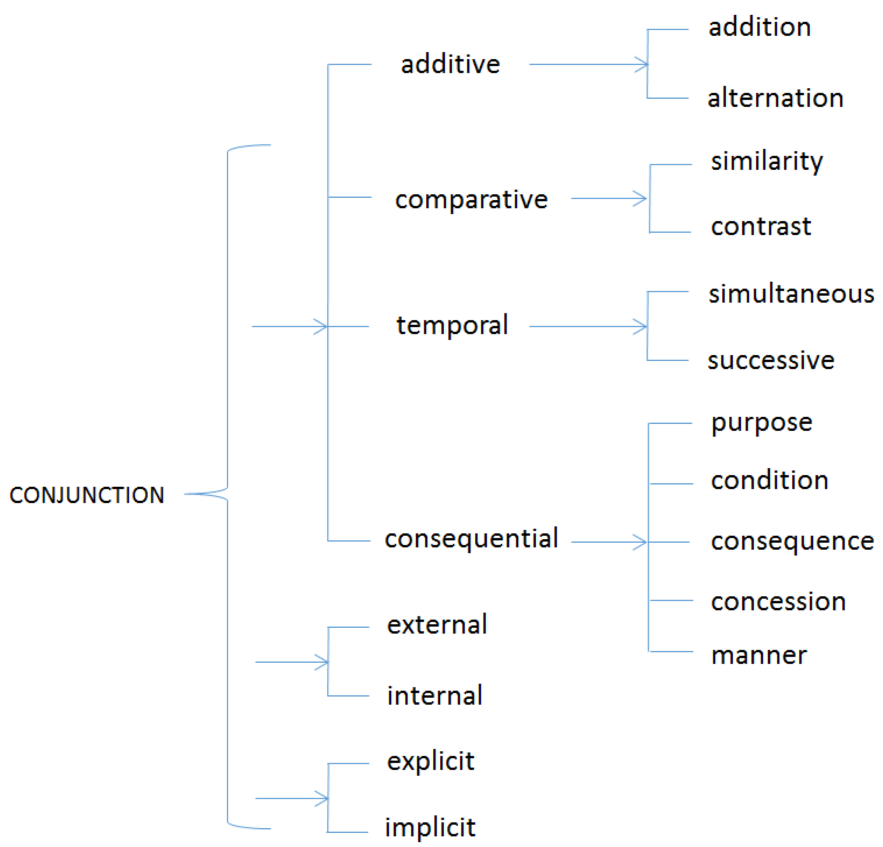


Figure 2.35 System of CONJUNCTION (cf. Martin, 1992)

Among various types of logical relations, the external temporal and consequential conjunctions are 'oriented to the activity sequences constituting field' (Martin, 1992, p. 193). Martin makes the distinction between types of logical relations from an interpersonal perspective – drawing again on modality (e.g. Halliday, 1985). Events in temporal relations are 'unmodulated'; they simply involve one event preceding another. Through consequential relations, events are seen to be 'modulated'; that is to say, one event is *enabling* or *determining* the other (p. 193). The notion of modality is developed further to identify the delicate types of consequential relations, as demonstrated in Figure 2.36 below. By means of manner relations, the relationship between events is modulated through "potentiality". This is in opposition to the causal relations by means of which events are modulated through 'obligation'. Alongside being modulated through obligation, causal relations may be 'modalised' (p. 193). The consequence relation is unmodalised; but the condition and purpose relations are modalised. Through the logical relations of purpose and condition, Effect is irrealis; that is to say, 'there is a possibility, a probability or a certainty that it will be determined by the Cause' (p. 193). Additionally, purpose distinguishes itself from condition since it contains 'an additional modulation of inclination', since the Effect is desired.

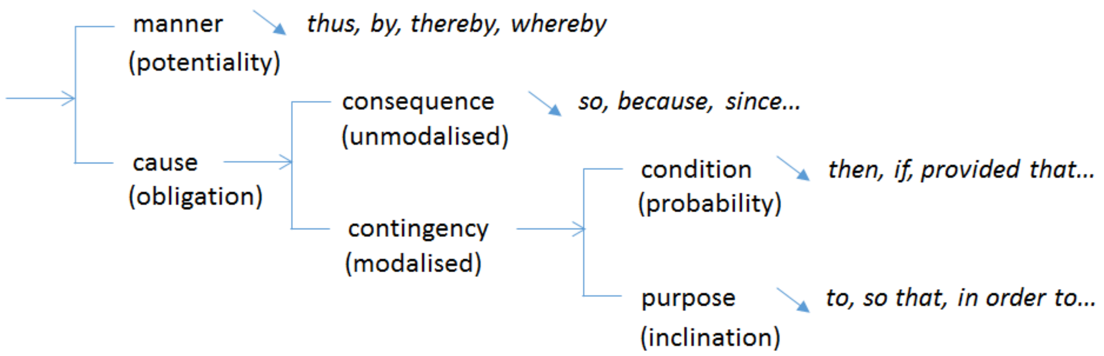


Figure 2.36 Consequential relations (Martin, 1992, p. 195)

The distinction between temporal and consequential relations is closely associated with the distinction between activity sequences and implication sequences proposed by Martin at the level of field. In explaining implication sequences, Martin argues that 'whereas in most fields probability *modalises* the relation between activities (one is likely to follow another), in science an attempt is made to construct reality in such a way that one activity implies another (the relationship between the two is causally *modulated*) [my emphasis]' (p. 323). The types of activity sequences shown in Figure 2.31 above, are reproduced in Figure 2.37 below.

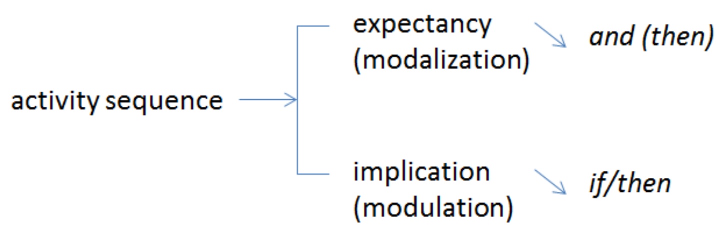


Figure 2.37 Activity sequence relations (Martin, 1992, p. 324)

This approach to consequential relations in discourse semantics and activity sequences in field is problematic in several ways. Firstly, modalisation and modulation are employed twice as the criterion differentiating between types of activity sequences at the level of field and types of logical relations in discourse semantics. This can mistakenly imply that all consequential relations in the discourse construe implication relations in field. It will be shown in Chapter 4 that this is certainly not the case. The second issue has to do with labelling: at the level of discourse semantics, while the configurational units in the discourse which construe field activities are referred to by Martin (1992) as messages, the discourse semantic sequence units are named as 'activity sequences' (both in Martin, 1992 and Martin & Rose, 2007), the same term used at the level of field. As a result, the interstratal relationship between activity sequences in field and discourse semantic 'sequential units' is unclear.

2.4.1.4 Summary

In summary, discourse semantic IDEATION and CONJUNCTION systems open up a more abstract level of meaning-making resources than the stratum of lexicogrammar. However, their interstratal relationships to lexicogrammar and to field need clarification. Taxonomic relations organising entities in the discourse semantics are not motivated independently of field typology; the same term 'activity sequence' is used at levels of discourse semantics and field; and the criteria for nuclear relations is dependent on ergative functions in lexicogrammar.

2.4.2 Ideation base

An alternative model of ideational semantics is proposed in Halliday & Matthiessen (1999). The modelling of ideational semantics there, named as **ideation base**, is approached by moving 'upwards from the grammar' (p. 2). According to Halliday & Matthiessen, the ideation base "controls the ideational systems in the grammar: primarily, that of transitivity in the clause and those of projection and expansion in the clause complex" (p. 11). In this section, my review of their ideation base will focus on three issues – i) the ways in which units of meaning are identified; ii) the use of logico-semantic meanings; and iii) the conceptualisation of sequential meanings (i.e. sequence). These dimensions are relevant to the review of Martin's IDEATION and CONJUNCTION systems above. I will comment on similarities and differences at various points.

2.4.2.1 Identification of units of meaning

Three primary units of meaning are established in ideation base - elements, figures and sequences. These units are distinguished according to different levels of 'complexity of the phenomena of experience' (Halliday & Matthiessen, 1999, p.48). A sequence consists of figures, which consist in turn of elements. The three primary types of elementary units are 1) the **process** (action/event, process of consciousness, or relation); 2) **participant/s** in that process, and 3) **circumstance/s** (p. 59). An additional meaning **relator** that construes logico-semantic relations of expansion between figures in a sequence is also included as an elementary unit. A system of phenomenon is shown in Figure 2.38 below.

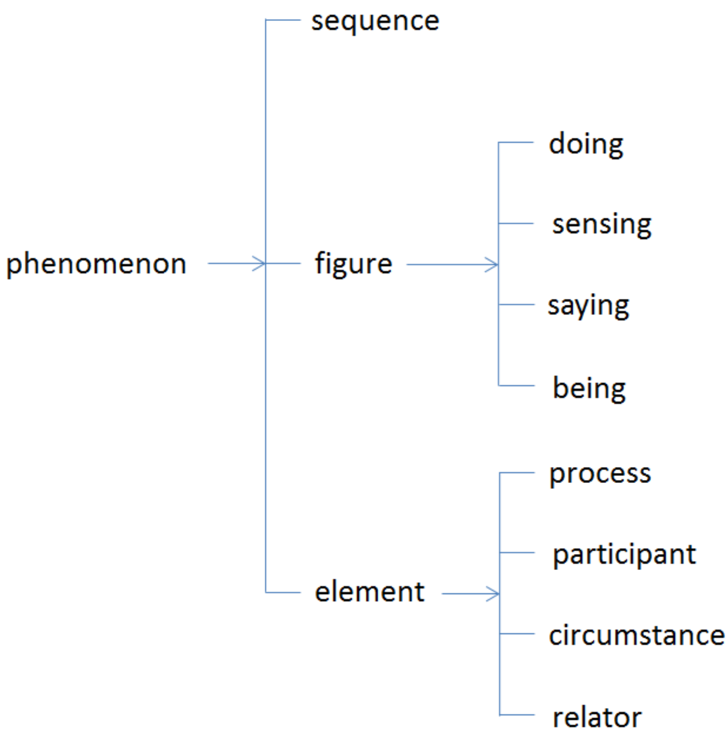


Figure 2.38 Types of phenomenon (Halliday & Matthiessen, 1999)

Semantic sequences, figures and types of elements are realised through various grammatical units. Sequences are congruently realised through clause complexes, and figures are congruently realised through clauses; elements are realised through various grammatical units within clause, as summarised in Table 2.10 below.

Table 2.10 Realisations of ideational semantic elements in lexicogrammar in Halliday & Matthiessen (1999)

semantic units		lexicogrammatical realisation
sequence		clause complex
figure		clause
elements	process	verbal group
	participant	nominal group
	circumstance	adverbial group; prepositional phrase
	relator	conjunction group

I discuss below the identification of each of these semantic units.

2.4.2.1.1 Elements

To begin with elementary units, Halliday & Matthiessen suggest that types of elements are realised congruently in lexicogrammar by different 'classes of units' (1999, p. 99) – i.e. the process is realised by the verbal group, the participant by nominal groups, and circumstances by adverbial groups or prepositional phrases. This realisation relationship is articulated by Halliday & Matthiessen as the relationship between 'two sides of the sign' (p. 19). As they explain,

> "Our 'sign' is not the Saussurean sign: we are not talking about the relationship between a word and its phonological representation (between content and expression, in Hjelmslev's terms). The relationship is *within* [original emphasis] the content plane, between a meaning and a wording – the non-arbitrary relationship between the system of semantics and the system of lexicogrammar" (p. 20)

The distinction that Halliday & Matthiessen make here implicates two types of interstratal relationships – one is a natural relationship within the content plan of language and the other is an arbitrary relationship between lexicogrammar in the content plane and phonology/graphology in the expression plane. As noted earlier, apart from the interstratal relationship between strata, each stratum has its own intrastratal organisation with respect to axis and rank (see footnote 2). It is important to stress that in SFL 'realisation' has been loosely used in referring to both interstratal and intrastratal realisations, and sometimes confused with instantiation (Martin, in press). Setting instantiation aside, the potential use of 'realisation' in relation to strata is summarised in Table 2.11.

Table 2.11 Various ‘realisation’ relationships in SFL framework

	‘realisation’ relationships	examples
interstratal relationship	arbitrary interstratal relationship between expression plane and context plane of language: graphology/phonology realising lexicogrammar	the meaning of ‘red’ is realised by the graphological sign “红” in Mandarin Chinese
	non-arbitrary (‘natural’ or solidary) interstratal relationship between semantics and lexicogrammar	a semantic ‘entity’ *paper bag* is realised by a grammatical configuration Classifier (*paper*)^Thing (*bag*)
intrastratal relationship	function/class relationship on syntagmatic axes: grammatical class realises grammatical Function	Actor *a little boy* in *a little boy kicked the ball* is realised by a nominal group
	paradigmatic and syntagmatic relation at one stratum	the choices of material clause within PROCESS TYPE is realised by the configuration of Actor + Process + Goal (e.g. *a little boy* [Actor] *kicked* [Process] *the ball* [Goal])

While it appears that Halliday and Matthiessen are trying to set up a non-arbitrary interstratal relationship between the stratum of semantics and lexicogrammar, and they contrast this with the arbitrary interstratal relationship between pholonology/graphology and lexicogrammar, I would argue that the ‘realisation’ relationship they actually establish, such as that between the Process and a verbal group, or between a Participant and nominal group, is in fact an intrastratal relationship between function and class on the syntagmatic axis. While it might be argued that it is simply an issue of labelling semantic units with what are normally lexicogrammatical functional terms, evidence for their grammatical status can be seen by examining Halliday & Matthiessen's reasoning about elements ‘from around’ – through the metafunctional perspective of their ideation base. The paradigmatic distinction among the elements ‘participant’, ‘process’ and ‘circumstance’ is partly motivated in relation to interpersonal MOOD and textual THEME. In relation to MOOD, they note that ‘participants’ can serve as Subject; whereas circumstances and process cannot. In relation to THEME, they note that ‘participants’ and ‘circumstances’ can both play the role of Theme, but that a process can only be Theme in an imperative clause (p. 99).

2.4.2.1.1.1 Things

We now take one further step in relation to ‘things’ as a delicate type of participant in the ideation base, since things are comparable to taxonomic relations in IDEATION in Martin (1992) and Martin & Rose (2007).

Halliday & Matthiessen identify a thing as one type of participant, in opposition to quality, as shown in Figure 2.39 below.

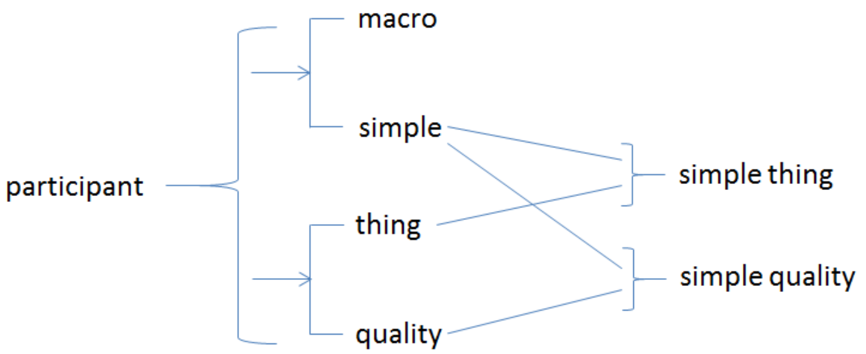


Figure 2.39 Network of participant (Halliday & Matthiessen, 1999, p. 60)

Both thing and quality can be either simple or macro. A macro thing involves grammatical metaphor. This has to do with the modelling of grammatical metaphor in ideation base, which I will discuss in section 2.4.3.1 below. It is the simple thing and quality that concerns us here. According to Halliday & Matthiessen, participants are interpretable as expansions of things – they are things with added qualities. They exemplify this expansion as in Figure 2.40 below.

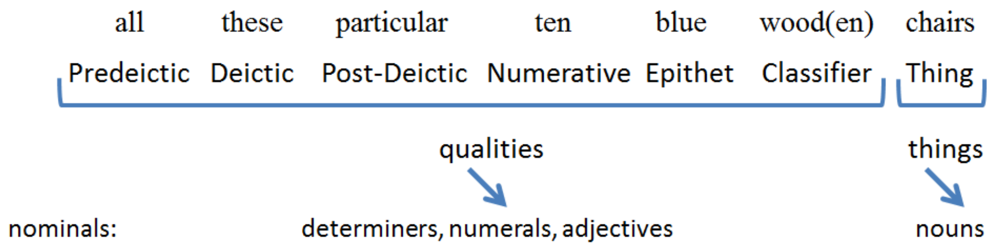


Figure 2.40 Qualities and things in the nominal group (Halliday & Matthiessen, 1999, p. 184)

While thing and quality are identified as two paradigmatic features of participants, they are at the same time treated as syntagmatic units within a participant. Halliday & Matthiessen suggest that participants are 'made of both things and qualities'; and 'the cut-off point between things and qualities is between the Classifier and the Thing' (p. 184). This seems to suggest that a semantic thing is essentially realised by Thing in the nominal group. This identification contrasts to the identification of discourse semantic unit entity (a message part in Martin, 1992), where an entity can be realised by either Thing or the elaborating configuration Classifier=Thing. For Halliday & Matthiessen, "Classifiers are qualities of the 'class' type" (p. 184), a strongly grammatical perspective.

Halliday & Matthiessen categorise types of things as shown in Table 2.12 below. These categories are suggested to be grammatically responsible, based on their participant roles in process types. For example, conscious things are identified according to their role in figure of sensing [Senser], of saying [Sayer] and of doing [Actor in middle clause]; object (material) type of thing is identified based on their role as 'impacted participant in figure of doing [Goal]' (p. 191).

Table 2.12 The criteria for ordering of things (Halliday & Matthiessen, 1999, p. 194)

			(i) role potential in figure:			(ii) internal organization of participant:		
			Senser:	Sayer:	Actor (in effect-ive):	pron:	general noun:	number: count/ mass
conscious			√	√	√	s/he/ they	person &c	count
non-conscious	mater-ial realm	animal			√	it/ they	creature, animal	count
		natural force			√	it/ they	—	count
		object (material)				it/ they	thing, object	count
		substance				it	stuff	mass
		abstraction (material)				it	—	mass
	sem-iotic realm	human collectives	√	√	√	it~they/ they	—	count
		institution	√	√	√	it~they/ they	place, show, set-up	count
		objects (semiotic)		√		it/ they	—	count
		abstraction (discrete)				it/ they	(see note)	count
		abstraction (non-discrete)				it	—	mass

Each of the thing type can be developed further in delicacy. It is suggested that this delicacy illustrates the principle of 'lexis as most delicate grammar' (p. 198). The identification of things and qualities further indicates the dependency of elementary semantic units on definitions of grammatical units.

2.4.2.1.2 Figure

The conflation of semantic units with lexicogrammatical units is also evident in the identification of figures in the ideation base. In Halliday & Matthiessen (1999), a figure is defined as ‘a representation of experience in the form of a configuration, consisting of a process, participants taking part in this process and associated circumstances’ (p. 53). In Matthiessen (1995), a figure is explicitly associated with grammar – it is referred to as a name of ‘a macro-phenomenon that is represented by a clause; and the representational resources of a clause is TRANSITIVITY’ (p. 196). Four primary types of figures are identified - figures of doing, sensing, saying, being & having. Among these, saying and sensing figures may project other figures as secondary order, semiotic reality. The projecting and projected figures, for Halliday & Matthiessen (1999), constitute a kind of sequence. The types of figures and their syntagmatic configurations are summarised in Halliday & Matthiessen (1999) as in Table 2.13 below.

Table 2.13 Types of figure and participant roles (Halliday & Matthiessen, 1999, p. 129)

		Process			projection
doing	Actor		Range		
	she	*is playing*	*the piano*		
	Actor		Goal		
	she	*is polishing*	*the piano*		
	Actor		Goal	Recipient	
	she	*is giving*	*a book*	*to her brother*	
	Actor		Goal	Client	
	she	*is building*	*a house*	*for her brother*	
sensing	Senser		Phenomenon		
	she	*knows*	*his father*		
	Senser				
	she	*knows*			*that his father has arrived*
saying	Sayer		Verbiage	Receiver	
	she	*says*	*a few words*	*to her brother*	
	Sayer			Receiver	
	she	*says*		*to her brother*	*that his father has arrived*
being & having	Carrier		Attribute		
	she	*is*	*a lawyer*		
	Token		Value		
	she	*is*	*his lawyer*		

As shown in Table 2.13, it is clear that the syntagmatic structures of figures consist of units which are grammatical functions (e.g. Actor, Goal, Sayer, Senser, etc.). Through a system/structure cycle, the paradigmatic oppositions of figures motivated by the grammatical configurations are in fact clause types at the level of grammar – that is the system of PROCESS TYPES, including the choices of material, verbal, mental, behavioural and relational processes. From the axial point of view, the types of figures in Table 2.13 do not seem to reveal more abstract meanings than experiential grammar.

2.4.2.1.3 Sequence

A sequence is identified in Halliday & Matthiessen (1999) as 'a series of related figures' (p. 50), which is realised through a clause complex. Two primary types of sequence are distinguished – involving projection or expansion. Projecting sequences "construe figures of sensing and saying on two levels, the level of sensing/saying itself and the level of the content of sensing/saying" (p. 129). Within an expanding sequence one figure is related to another figure at the same order of reality through a relator (p. 117). Three types of relations between figures are identified, according to three types of logico-semantic expansion - elaboration, extension and enhancement.

Sequences of expansion and projection in Halliday & Matthiessen's ideation base are considered as units of meaning at the same rank. They can be associated with the units of meaning in Martin's IDEATION introduced above. However, a sequence of expansion is comparable to an activity sequence in discourse semantics – that is a series of messages; whereas sequence of projection is comparable to a single message. A similar identification of semantic message is also proposed in Hasan (e.g. 1996). For both Martin and Hasan, the 'projected figure' is treated as a message part instead of an individual message (see Table 2.10 above). Halliday & Matthiessen associate their semantic rank scale more closely with grammatical systems. Martin and Hasan identify units of meaning that are more dissociated from grammar, as meanings in the discourse in their own right.

Note that while Halliday & Matthiessen set up sequence, figure and elements along a rank scale, they also argue that the relationship between figure and sequence may be treated as one of delicacy (p. 92) – "there is not a sharp line between a figure and a sequence of figures: a **quantum of experience** is not defined before it is construed, and the grammar rather sets up *a cline from sequence to simple figure* [original emphasis]" (p. 118). For example, the figure 'someone caramelises sugar' can be interpreted as the sequence of figures 'someone heats sugar until it melts and turns golden'. It is argued that "a single figure at a fairly high degree of delicacy may be 'blown up' as a sequence of figures at a lower degree of delicacy" (p. 92). I would argue however that what is going on here is not an delicacy issue, but an interstratal relationship between field and (discourse) semantics – that is between a field activity (i.e. ‘someone caramelising sugar’) which may be realised in language either through a sequence consisting of a series of figures (*someone heating sugar until it melts and turns golden*), or through one figure (*someone caramelising sugar*). The series of figures and the individual figure are an agnate pair semantically with respect to the field activity that they construe. This interstratal relationship between figure/sequence in the discourse and activities in field will be explored in Chapter 4, section 4.4.

In summary, Halliday & Matthiessen (1999) approach the modelling of ideation semantics largely from the perspective of lexicogrammar. Their identification of semantic sequences, figures and elements relies strongly on grammatical units. The stratification of semantics and lexicogrammar thus remains unclear.

2.4.2.3 Identification of logico-semantic relations

As we have seen, logico-semantic meanings have been employed as organising principles in both Martin’s IDEATION and in Halliday & Matthiessen’s ideation base. However the two models demonstrate different ways in which logico-semantic relations are identified.

2.4.2.3.1 A nuclear perspective on figures

Similar to the nuclearity perspective established in Martin (1992), Halliday & Matthiessen also apply logico-semantic meanings in exploring the degree to which units of meanings are involved in a figure. Drawing also on the grammatical configurations, specifically the ERGATIVITY system (Halliday & Matthiessen, 2014, p. 332 ff.) of a clause, they propose that Process and Medium is a complementarity – which as a whole is referred to as a ‘clause nucleus’. It is suggested that the clause nucleus ‘is made manifest in the grammar of a clause’, and that it semantically ‘construes the centre of gravity of a figure, the focal point around which the system of figures is organised’ (p. 156). Other participants (Range, Agent, and Beneficiary) and circumstances are external to this nucleus. Logico-semantic relations of projection and expansion are applied to reveal the relationship between the nucleus and other participant roles and circumstances. Both participants (e.g. Range:process and Attributes) and circumstances (Role and Manner:quality) can elaborate the nucleus. Participants (e.g. Agent, Client, and Recipient) and circumstances (e.g. Cause, Manner and Location) can enhance the nucleus. Circumstances such as Angle can project the nucleus, and circumstances of

Accompaniment extend the nucleus. The involvement of units of meanings in a figure is modelled as a spectrum in Figure 2.41 below.

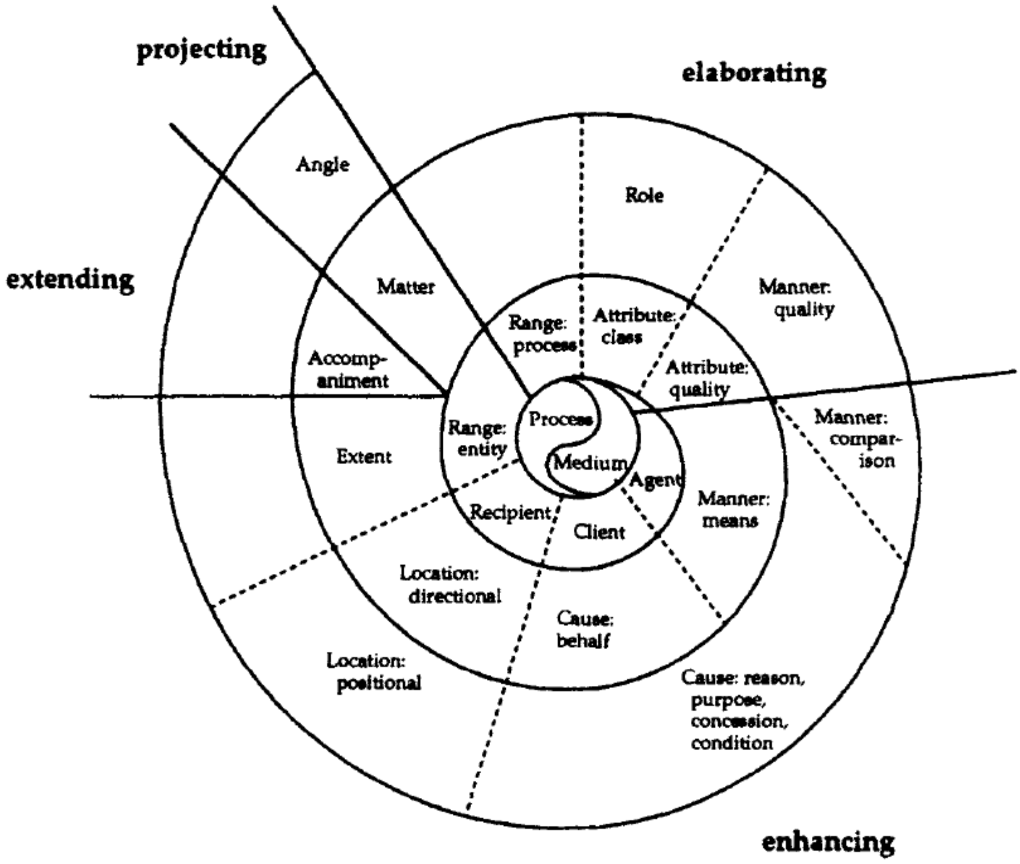


Figure 2.41 The degree of the involvement of participants and circumstance in a figure (Halliday & Matthiessen, 1999, p. 174)

This model can be compared to and contrasted with the nuclearity model in the IDEATION component of Martin's discourse semantic model in a number of ways. While in both models logico-semantic relations are employed to reveal the relationship of participants and circumstances to the nucleus, significant differences can be revealed. Firstly, in Halliday & Matthiessen's ideation base, the Medium and Process complementarity as a whole is treated as the centre of a figure (i.e. nucleus); in IDEATION, while Medium and Process are closely bonded with each other in a nucleus, the 'central' unit of a message is identified as the Process, potentially elaborated by a Process Range. Secondly, for Halliday & Matthiessen, elaboration, along with extension and enhancement, indicates a boundary between two different semantic units; whereas in IDEATION elaboration is a relationship within one unit. For example, while in both models examples such as *sing a song, ask a question, play tennis* are treated as a Process being elaborated by a Range, in Martin (1992), the elaborating structure Process=Range:process as a whole construes one discourse semantic meaning;

whereas in Halliday & Matthiessen (1999), two semantic units are identified – a process and a participant. Thirdly, Martin identifies a more fine-grained set of logico-semantic relations: extending at the same time enhancing, annotated as +x; for example Agent extends and enhances the nucleus of a clause (e.g. *Jon +x plays + the ball*), whereas such relationships are treated as enhancement in Halliday & Matthiessen (1999).

2.4.2.3.2 Expansion and projection of things

Logico-semantic relations are also employed in Halliday & Matthiessen (1999) to make delicate distinctions among things. Logico-semantic projection is used to identify 'things of projections' (named as semiotic abstractions), which according to Halliday & Matthiessen refers to 'a grammatical class under the heading of fact nouns'. Based on various types of fact projections, semiotic abstractions are further categorised into case (e.g. *case, fact, idea*), chance (e.g. *chance, hypothesis, possibility*), proof (e.g. *confirmation, evidence, proof*) and need (e.g. *need, duty, obligation*) (p. 203). The types of semiotic abstractions are comparable to semiotic entities in Martin & Rose (2007), but with greater delicacy. Logico-semantic expansion is also used to explore the delicacy of things, including things of elaboration (e.g. *type, kind, example*), things of extension (e.g. *part, element, side, unit, addition*) and things of enhancement (e.g. *period, reason, purpose, may*) (p. 204). Notice that in IDEATION elaboration sets up taxonomic relations including both classification and composition. In contrast, in Halliday & Matthiessen's ideation base, elaboration is associated only with classificatory taxonomic relation; the logical relationship of composition is treated as extension. Things of expansion are comparable to generic entities in Martin & Rose (2007). Chapter 3 develops a different description of taxonomic relations construed by resources of these kinds.

2.4.2.4 Semantic units and texts

A further significant difference between IDEATION and Halliday & Matthiessen's ideation base has to do with the conceptualisation of semantic units and text. This difference is the result of the different conceptualisation of context in these two models.

For Halliday & Matthiessen, figure, sequences and texts are of 'the same order of abstraction'; they are 'semantic phenomena' (p. 122-3). The conceptualisation of text as a unit of meaning is also found in Hasan (1995, 2009) and Cloran (1994). Text and message are treated as two units of meaning along a rank scale. For Hasan, a message is 'the smallest semantic unit which is capable of realising an element of the structure of a text' – that is, a unit of meaning that is part of a text. Cloran identifies an intermediate unit in between message and text, named a rhetorical unit. Both rhetorical units and texts are constituted by sequences (i.e. a series of messages). Sequences in Halliday & Matthiessen (1999), messages in Hasan (1996) and rhetorical units in Cloran (1994) are all at the same order of abstraction as texts – i.e. at the level of semantics.

By contrast, for Martin (1992) messages and (discourse semantic) activity sequence are ideational discourse semantic units of meaning, instead of generic components of a text. In this study, I follow Martin's identification of discourse semantic units of meaning; and treat texts as instantiation of systems at all strata, metafunctions and ranks.

2.4.2.5 Summary

This section has reviewed the identification of semantic units of meaning in Halliday & Matthiessen's ideation base – element, figure and sequence. It has been made clear that their ideation base is strongly motivated from below (i.e. lexicogrammar), which results in an unclear division of labor between their strata of semantics and lexicogrammar.

Halliday & Matthiessen's ideation base is associated with the discourse semantic IDEATION in several ways. For example, Halliday & Matthiessen's types of thing are predicated on taxonomic relations; the spectrum of meanings involved in a figure is comparable to nuclear relations; and sequences are comparable to activity sequences. Three types of meanings along the rank scale are identified in both models – elementary, configurational and sequential. However, the theoretical conceptualisations of these units of meaning and their relationships are significantly different. Halliday & Matthiessen's ideation base is largely motivated from below; IDEATION is more motivated from above. In Chapters 3 and 4 of this thesis I will develop a model of ideational semantics that balances the perspectives from above, around and below.

2.4.3 Grammatical metaphor

For Halliday and Matthiessen, and for Martin, grammatical metaphor is a critical motivating factor for the stratification of the content plane of language. In reviewing the two models of ideational semantics above, I have not yet discussed the different ways in which grammatical metaphors are conceptualised. In this section, I focus on the modelling of grammatical metaphor in SFL literature.

As noted there is a consensus in previous studies that grammatical metaphor is a critical motivation for stratifying semantics as a more abstract content plane (Halliday, 1985; Martin, 1992; Halliday & Matthiessen, 1999). As Halliday (1998) argues, 'there would be no metaphor without stratification' (p. 192). It has been illustrated above that the relationship between lexicogrammar and discourse semantics is a solidary one; and it is this solidary relationship that grounds understanding even when grammatical metaphor is involved. As introduced in section 2.2.3 above, different choices of discourse semantic SPEECH FUNCTION, such as a command '*open the window*', can be realised by marked MOOD choices (e.g. through the interrogative "*could you open the window please?*"). When the command is realised metaphorically, the solidary relationship between the two strata allows us to respond in two ways – either responding to the literal reading of the question ("*No, I cannot*"), or responding to the 'figurative' meaning (Halliday, 1985), i.e. the command ("*Ok*"); of course in order to facilitate the negotiation we will tend to respond to the discourse semantic meaning of command (Martin, 1991). The mapping of command *'open the window'* to the imperative clause is the congruent mapping of command; the interrogative clause is considered a metaphorical realisation. Halliday comments on recognition of grammatical metaphor as follows:

> 'As speakers of a language we are aware of what is the congruent mode of encoding any feature, and we use this as a kind of base line: for example, however rarely we may actually use an imperative in giving orders, we have a feeling that it is in some sense the unmarked way of doing so' (1984, p. 14).

It is important to stress that a metaphorical means of realisation is understood in relation to its congruent means of realisation, and that there can be more than one grammatical metaphor by which a similar meaning is realised – for example "*could you please open the window?*" and "*it's pretty hot here, isn't it?*" can realise the same command '*open the window*'.

Grammatical metaphor is of two types[6], ideational metaphor and interpersonal metaphor (Halliday, 1985/1994). Each type is exemplified through a pair of examples below.

[6] Note that textual metaphor is identified in Martin (1992) (e.g. *reason, factor, point*). In this thesis, instances accounted for by Martin as textual metaphors are not treated as grammatical metaphor involving stratal tension, but as semiotic entities based on the role they play in PERIODICITY (see Chapter 3, section 3.2.2.2.2).

interpersonal metaphor:
[congruent] Open the window.
[metaphorical] Could you open the window, please?

ideational metaphor:
[congruent] In the evening the guests ate ice cream and then swam gently.
[metaphorical] The guests' supper of ice cream was followed by a gentle swim. (Halliday 1994, p. 345)

Both interpersonal and ideational metaphors are significant in vertical discourse: interpersonal metaphors are found to be useful for negotiating knowledge through heteroglossic engagement (Martin & White, 2005; Hood, 2010, 2011), and ideational metaphors are more associated with 'the kind of knowledge being negotiated', which is our concern here. I thus focus specifically on ideational metaphor for the purpose of exploring knowledge building.

In the following sections, I firstly review the different ways of modelling ideational metaphor in previous studies, before considering how ideational metaphors can be identified in texts; I will then discuss the functions of ideational metaphor, which bears on the concern with disciplinary discourse.

2.4.3.1 Modelling ideational metaphor

In the literature, various conceptions of ideational metaphor are available. We can group them roughly into three categories – grammatical metaphor as i) a variation in grammatical expression (e.g. Ravelli, 1985/1999), as ii) involving a semantic compound or semantic junction (e.g. Halliday & Matthiessen 1999) and as iii) stratal tension (Halliday, 1998; Martin 1991, 1992, 2008; Tavernier, 2014).

2.4.3.1.1 Ideational metaphor as variation in grammatical expression

Halliday (1985/1994) firstly describes grammatical metaphor in relation to the traditional view of metaphor as lexical metaphor. For Halliday, lexical metaphor refers to 'variation in the meanings of a given expression' – for example *flood* as the congruent expression of either 'a moving mass of water', or a metaphorical expression of 'a moving mass of feeling or rhetoric' (Halliday, 1994, p. 342). Halliday argues that in contrast to lexical metaphor, grammatical metaphor is 'variation in the expression of a given meaning' (p. 342). A given semantic configuration can have a realisation in lexicogrammar that is considered to be congruent, and various other realisations that are considered to be metaphorical.

Halliday (1994) compares congruent and metaphorical wordings in grammar through their different configurations in process types. The comparison is represented as in Table 2.14 below. The congruent realisation consists of a clause complex with two material processes; whereas in the metaphorical realisation, we find a single relational identifying process. The corresponding cells in Table 2.14 reveals that the meanings realised congruently through the material clauses are realised metaphorically through participants Identified and Identifier; and the temporal meaning *and then* realised congruently through a conjunction is realised metaphorically through a Process (i.e. *was followed by*).

Table 2.14 Representation of grammatical metaphor (Halliday, 1994, p. 347)

<table>
<tr><td>‘the guests’</td><td>‘ate</td><td>in the evening’</td><td>‘ice cream’</td><td>‘and</td><td>then’</td><td colspan="2">‘gently’</td><td>‘swam’</td></tr>
<tr><td>Actor</td><td>Material</td><td>Time</td><td>Goal</td><td></td><td>Time</td><td colspan="2">Manner</td><td>Material</td></tr>
<tr><td>the guests’</td><td colspan="2">supper of</td><td>ice cream</td><td colspan="2">was followed by</td><td>a</td><td>gentle</td><td>swim</td></tr>
<tr><td colspan="4">Identified</td><td colspan="2">Relational Process: (Circ.: Time/Identifying)</td><td colspan="3">Identifier</td></tr>
<tr><td colspan="4">nominal group</td><td colspan="2">verbal group</td><td colspan="3">nominal group</td></tr>
<tr><td>Modifier/Deictic: Possessive</td><td colspan="2">Head/Thing</td><td>Modifier/ Qualifier: Appositive</td><td colspan="2"></td><td></td><td>Modifier /Epithet</td><td>Head/ Thing</td></tr>
</table>

The representational principle here, according to Halliday, is to ‘match the elements vertically as closely as possible’ (1994, p. 347). This form of representation is effective in demonstrating the contrast between the functional configurations in the two different realisations (see also Thompson, 2004, p. 220 ff.).

Ravelli (1985/1999) conceptualises grammatical metaphor as variation of the expression of a meaning, as modelled in Figure 2.42 below. One point this modelling suggests is that the congruent and metaphorical expressions in the lexicogrammar are semantically equivalent (Ravelli, 2003, p. 41).

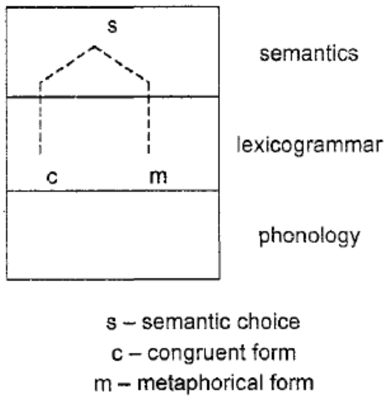


Figure 2.42 Grammatical metaphor interpreted as realisation choice (Ravelli, 1985/1999, p. 55)

2.4.3.1.2 Ideational metaphor as semantic compound/junction

The conceptualisation of grammatical metaphor as metaphorical expression in Ravelli (1985) is revised in Ravelli (1988). She argues here that it is not true that the meaning realised by congruent and metaphorical expressions are the same, since ‘the grammatical category itself has a feedback effect into the semantics, and alternative lexicogrammatical realisations may omit or include different parts of the message’ (p. 137). Under this notion, grammatical metaphor is rearticulated as “a combination of semantic features’, as shown in Figure 2.43 below. The multiple meaning choices combines together in the semantics and then the semantic compound ‘gives rise to a metaphorical realisation in the lexicogrammar’ (p. 137).

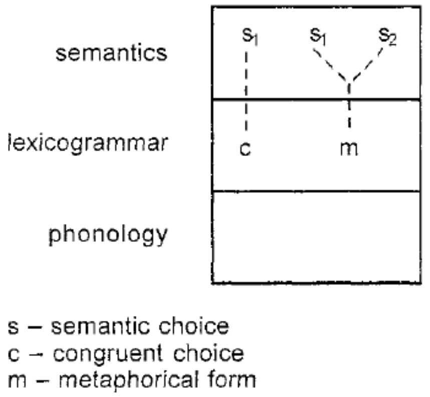


Figure 2.43 Grammatical metaphor interpreted as ‘semantic compound’ (Ravelli, 1988, p. 137)

An advantage of this model, Ravelli proposes, is that it is possible ‘to pinpoint the meaning difference between the two forms’. While she goes on to suggest that based on this model, it is ‘necessary to represent the level of semantics with system networks as for the lexicogrammar’ (p. 138), no semantic system network is established. As a result, in her categorisation of grammatical metaphors, as shown in Table 2.15 below, the labelling of semantic choices draws on grammatical function labels, since they are 'terms with which we are familiar' (p. 138).

Table 2.15 Categories of grammatical metaphor (Ravelli, 1988, p. 139)

No. semantic choice	**metaphorical realisation**	**congruent realisation**	**example**
	Function/class	**class**	
1 process	Thing / nominal group	verbal group	*the* ***appointment*** *of an ambassador*
2 process	Epithet, Classifier / adjective	verbal group	***incoming*** *Soviet missiles*
3a quality of a Thing	Thing / nominal group	adjective	*peace through* ***strength***
3b quality of a process	Epithet, Classifier / adjective	adverb	*its* ***intrinsic*** *worth*
3c quality of a process	Thing / nominal group	adverb	*a sense of* ***security***
4a modality	Epithet / adjective	(modal) adverb	*the* ***possible*** *outcome*
4b modality	Thing / nominal group	adjective, passive verb	*first strike* ***capability***
5a logical connection	Thing / nominal group	conjunction	*for that* ***reason***
5b logical connection	Process / verbal group	conjunction	*the arms race* ***contains*** *the threat*
6 circumstance	Process / verbal group	prepositional phrase	*night* ***follows*** *day*
7a participant	Classifier / adjective	nominal group	***economic*** *development*
7b participant	Thing / nominal group	nominal group	*the art of* ***generalship***
8a expansion	Relative Act, clause / embedded clause	ranking clause	*WWIII is more likely than [[****peace breaking out****]]*
8b projection	Fact / embedded clause	ranking clause	*[[****all it can do****]] is [[to retaliate]]*
9 circumstance	Epithet, Classifier / adjective	prepositional clause	***historical*** *experience*

A significant point revealed in Table 2.15 is that when a semantic choice is realised congruently, its semantic meaning can be deduced by the grammatical functions that realise the meaning, whereas when it is realised metaphorically, both grammatical function and class need to be considered.

The view of grammatical metaphor as a compound of semantic meanings is further developed in Halliday & Matthiessen (1999); there grammatical metaphor is considered to involve 'semantic junction'. As they explain, metaphoric elements are junctional in that 'they embody a junction of two semantic categories' (p. 244). The junctional elements are in contrast to the elements that 'could be assigned to a single category: process, thing, quality etc.', which are referred to as 'ordinary' elements (p. 244). Types of semantic junctions are summarised in terms of a 'higher rank syndrome' and a 'lower rank syndrome' (Halliday, 1998). Metaphors at the higher rank involve the shift from figure to element; from sequence to figure; and from figure with process to figure with process as thing. At a lower rank, metaphors are identified as a junction of elementary units such as ‘process thing’, ‘circumstantial quality’ and ‘relator process’ (p. 244).

The conceptualisation of semantic junction is of interest in two ways. Firstly, it seems that grammatical metaphor is treated as something happening at the level of semantics, which is then mapped onto a grammatical realisation. This is evident in the system network of semantic elements established in Halliday & Matthiessen (1999). In the system of participants (as a semantic element) in their ideation base, choices of thing and quality can be either macro or simple (see Figure 2.44 below). The macro thing and macro quality refer to grammatical metaphors – that is to say, grammatical metaphors are identified as semantic choices. Macro participants are then junctions of ‘thing’ or ‘quality’ with some other semantic elements.

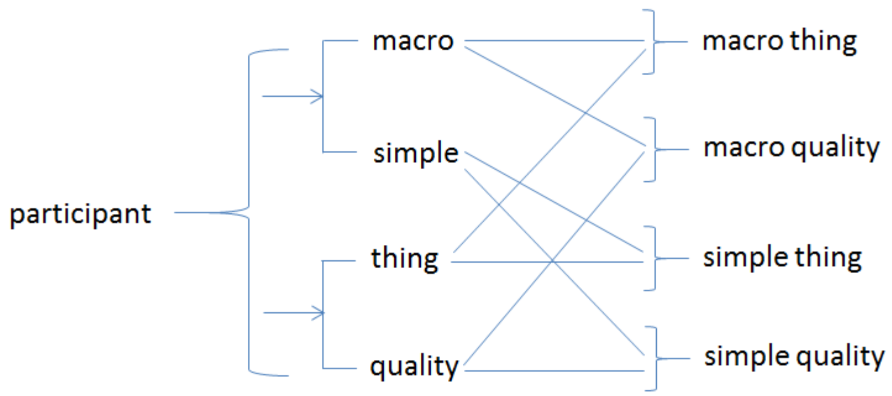


Figure 2.44 Types of participant (c.f. Halliday & Matthiessen, 1999, p. 60)

A second point of interest in Halliday & Matthiessen’s conception of grammatical metaphor has to do with their conceptualisation of ideation base. It has been suggested earlier (section 2.4.2.1) that semantic elements in their ideation base are not clearly dissociated from grammatical functions. It is thus important to question whether the junction of elements in their semantics is in essence the junction of grammatical functions. Below is an example provided in Halliday & Matthiessen (1999) demonstrating a ‘shift’ of construing a sequence to construing a figure (p. 253):

> They shredded the documents before they departed for the airport =>
> Their shredding of the documents preceded their departure for the airport.

Their analysis of the semantic junction is shown as in Table 2.16.

Table 2.16 An analysis of metaphorical syndrome (Halliday & Matthiessen, 1999, p. 253)

			sequence		
figures:	elements:		figure *They shredded the document* [process + participant + participant]	relator *before*	figure *they departed for the airport* [process + participant + circumstance]
figure	participant	thing	(process => thing) *shredding*		(process => thing) *departure*
		quality	(thing => expansion of thing: possessive) *their*		(thing => expansion of thing: possessive) *their*
		quality	(thing = expansion of thing: qualifying) *of the documents*		(circumstance => expansion of thing: qualifying) *for the airport*
	process			(relator => process) *precede*	
	circumstance				

What seems to be going on in Table 2.16 is that two grammatical analyses are undertaken – one for the congruent realisation, shown horizontally as ‘figure [Participant + Process + Participant] + relator + figure [Process + Participant + Process]’, and one for the metaphorical realisation, shown vertically as ‘Participant + Process + Circumstance’. It is the conflation of the functions of the metaphorical realisations with the functions of the congruent realisations that reveals the ‘semantic junctions’.

‘Semantic junction’ in Halliday & Matthiessen (1999) not only makes the semantics take all the responsibility for making meanings in modelling grammatical metaphor; important also is the fact that due to the conflation of terminology for semantic units and grammatical functions, semantic junctions are essentially the doubling of grammatical functions.

2.4.3.1.3 Ideational metaphor as stratal tension

Another approach to grammatical metaphor involves treating grammatical metaphor as a tension between the strata of discourse semantics and lexicogrammar (Halliday, 1998; Halliday & Martin, 1993; Martin, 1992; Martin, 2008; Taverniers, 2014).

Halliday (1998) articulates grammatical metaphor along these lines in a paper where he explains that it is ‘a realignment between a pair of strata: a remapping of the semantics on to the lexicogrammar’ (p. 192). Martin (2008) suggests that this ‘realignment’ and ‘remapping’ of the realisational relationship between the two strata is a principle through which language's meaning potential is indefinitely extended. A critical point here is that grammatical metaphor is about the relationship between the two strata; it does not in itself refer to a unit of meaning on one stratum or the other. In a model with a stratified content plane, both semantics and grammar make meanings; their relative congruent and metaphorical interstratal relationships are determined by the extent to which the meanings at two levels match each other.

Taverniers (2014) provides a more recent articulation of stratal tension from a syntagmatic perspective. She defines grammatical metaphor as a 'doubling of semiosis'. Drawing on metafunctional modes of expression, as 'wave, field and particle' (Halliday, 1979), the ideational metafunction is interpreted as 'a bundle of building blocks, realising a configurational meaning'. Taverniers uses the example *the restructuring of the economy was followed by a major crisis* to model this doubling effect, as shown in Figure 2.45 below. We can unpack this ideational metaphor as *the economy was restructured, and then there was a major crisis*. Congruently, the figure *the economy was restructured* is realised through the configuration Participant + Process + Participant; metaphorically, this figure is mapped onto a Participant (i.e. *the restructuring of the economy*) in another clause. Two figures are then 'bundled' together, realised in one clause through the metaphorical realisation. As Taverniers puts it, 'in ideational metaphor there are two layers of configuration for figures'.

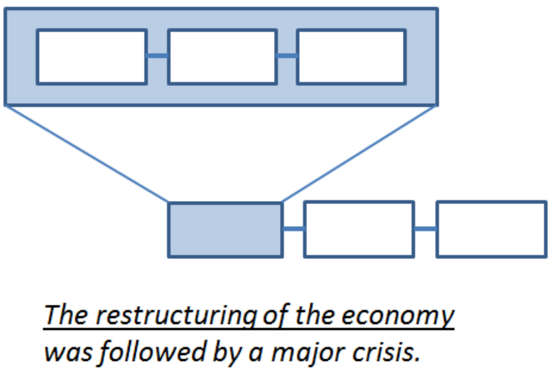


Figure 2.45 Grammatical metaphor as doubling of bundling (from Taverniers, 2014)

In representing stratal tension, much early works deploys the labels for grammatical functions in naming semantic units -- with grammatical units named through class labels. Consider for example the way stratal tension is modelled in Martin (2011) – as Figure 2.46 below.

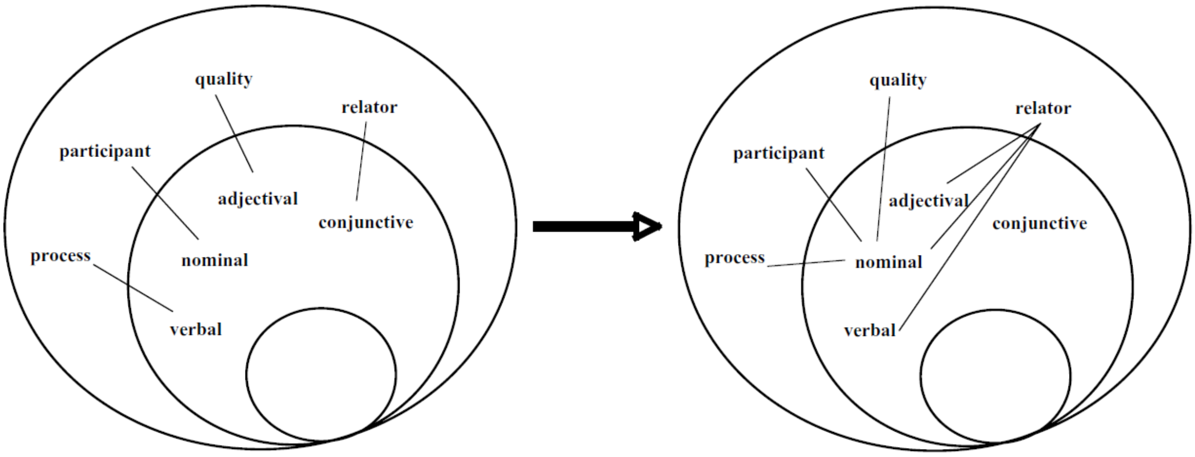


Figure 2.46 Modelling of congruence and grammatical metaphor (Martin, 2011, p. 48)

While this way of representing stratal tension demonstrates the 'scrambling' effect of the metaphor across strata, it is misleading in the sense that the grammatical representation simply involves a syntagm (i.e. a sequence of classes). In more recent work, Martin & Matruglio (2013) model grammatical metaphor by using a distinct discourse semantic labelling (sequence, figure, entity, event, setting) for the semantics. Congruently then, a sequence is realised through a clause complex, a figure is realised through a clause, an entity is realised congruently through a Participant, an event is realised congruently through a Process, and a setting is realised congruently through a Circumstance. Metaphorically, a figure can be realised through a Participant, or a Circumstance. Their examples are reproduced in Table 2.17.

Table 2.17 Analysis of grammatical metaphor (Martin & Matruglio, 2013)

discourse semantics	entity	event	[figure]	setting
	Wealthy families	*controlled*	***the manufacture of garum***	*in Pompei*
lexicogrammar	Participant	Process	Participant	Circumstance

discourse semantics	entity	event	quality	[figure]
	Some families	*became*	*wealthy*	*through **the manufacture of garum***
lexicogrammar	Participant	Process	Participant	Circumstance

By adopting discourse semantic labels, the analyses more transparently displays meaning being made at both levels simultaneously.

To summarise, while there is a consensus in the literature that grammatical metaphor plays a critical role in motivating the stratification of discourse semantics and lexicogrammar, there are various ways in which grammatical metaphors are modelled, including treating grammatical metaphor as variant expression, as semantic junction, and as stratal tension. The different ways of conceptualising grammatical metaphor result in part from the different ways in which semantics is modelled. In this study, grammatical metaphor will be developed in terms of a relationship between discourse semantics and lexicogrammar involving stratal tension, since it is the stratal tension model that allows for meaning to be made at both the levels of discourse semantics and of lexicogrammar and it is one of the concerns of this thesis to develop distinctive terminology for modeling meaning on these two strata. In the next section, we consider how ideational metaphor can be identified in texts.

2.4.3.2 Identifying ideational metaphor

Since grammatical metaphors are incongruent ways of mapping discourse semantics and lexicogammar, the remapping has various grammatical effects which help us identify grammatical metaphors in texts. Two typical grammatical effects for ideational metaphors are transcategorisation and rankshift. The examples [b] and [c] below demonstrate these two effects in comparison to [a] (example adapted form Martin, 1992, p. 17).

> [a] congruent: Zaphod was delighted so that Trillian celebrated.
>
> [b] metaphorical: grammatical metaphor involving transcategorisation:
> Zaphod's **delight** resulted in Trillian's **celebration**
>
> [c] metaphorical: grammatical metaphor involving rankshift:
> metaphorical: Zaphod's delight resulted in **[[Trillian celebrating the day]].**

Below I explain how grammatical metaphors are reflected in grammar as transcategorisation and rankshift. I then draw on the concept of agnation and enation (Gleason, 1965) to illustrate how we can not only identify but also distinguish grammatical metaphors of different types.

2.4.3.2.1 Transcategorisation, derivation and grammatical metaphor

The remapping of a semantic meaning onto lexicogrammar is typically reflected at the grammatical level as a shift from one grammatical function in a congruent realisation to another in a metaphorical realisation. As shown in examples [a] and [b] above, the meanings mapped congruently onto a Process and Attribute (*is delighted*) and Process (*celebrate*) in [a] are remapped metaphorically onto Participants (*Zaphod's delight; Trillian's celebration*) in [b]. Given that different grammatical functions are usually (though not always) associated with different classes (e.g. Process in the form of verbal group, Participant in the form of nominal group), the shift of grammatical functions is often marked by a shift from one word class to another (such as the shift from the adjective *delighted* to the noun *delight* or from the verb *celebrate* to the noun *celebration* as annotated in the examples below). This process of shifting word classes is referred to as transcategorisation.

> [a] congruent: Zaphod was **delighted** [Attribute/adjective] so that Trillian **celebrated** [Process/verb].
> [b] metaphorical: Zaphod's **delight** [Thing/noun] results in Trillian's **celebration** [Thing/noun]

In Indo-European languages such as English, transcategorisation often involves a morphological change, known as derivation. In the above examples the transcateogisation of *celebra**tion*** from *celebrate* involves derivation. While derivation may be used as an indicator for transcategorisation; not all transcategorisation involves derivation. Consider for example:

> [d] congruent: He wants to **dance** [Process/verb] with her.
> [e] metaphorical: The **dance** [Participant/noun] with her made him happy.

The transcategorisation of *dance* as a verb to *dance* as a noun involves no morphological change. In some languages, such as in Mandarin Chinese, transcategorisation never involves derivation (for example the shift from adjective 公平 (*fair*) to noun 公平 (*fairness*) (Yang, 2011; Fawcett, 2013).

While transcategorisation is useful sometimes in indicating instances of grammatical metaphor, it is important to stress that they are two very distinct phenomena. Transcategorisation is a resource for 'extending the lexical resources of a language' (Martin 2008, p. 829) at the level of lexicogrammar. Not all instances of transcategorisation indicate a metaphorical relationship between semantics and lexicogrammar as grammatical metaphor. Compare the examples below:

> [f] congruent: the **runner** [Participant/noun] wins the game.
> [g] congruent: we will **run** [Process/verb] for thirty minutes.

Runner in [f] is a noun that is transcategorised and derived from the verb *run.* However, *runner* functions as Participant in a clause, construing a human entity (e.g. *the runner won; the runner said; the runner was tired*) (Martin, 2008, p. 828). That is to say, the discourse semantic entity and the Participant/nominal group have a congruent relationship. Such transcategorisation therefore does not indicate grammatical metaphor. However, compare another pair of examples below:

[h] congruent: The world was **transformed** [Process/verb] in 19th century.

[i] metaphorical: The **transformation** [Participant/noun] took place in 19th century.

In example [i], stratal tension is involved. The noun *transformation*, which is derived from the verb *transform*, functions as a Participant realised by the class nominal group; instead of being mapped onto an discourse semantic entity, it may be mapped onto a discourse semantic figure as in [h] (*(the world) is transformed*). In order to determine the mapping and remapping of meanings at two levels, distinctive modelling of discourse semantic and lexicigrammatical meaning is crucial.

In a nutshell, transcategorisation, derivation, and grammatical metaphor are strongly associated with each other; they however describe different linguistic phenomena. Table 2.18 below summarises their different features. Derivation at the most surface level can indicate transcategoriation (though not all transcategorisation involves derivation), which suggests the possibility of grammatical metaphor. Some suffixes in derivation are more likely to be associated with grammatical metaphor than others (such as '-ment', '-ion', '-ing', '-ity/-ty', etc.); some usually indicate transcategorisation but not grammatical metaphor, such as '-er/or' (Ravelli, 1985/1999, p. 63).

Table 2.18 Derivation, transcategorisation and grammatical metaphor

linguistic phenomenon	features
derivation	1) change of word class, reflected in morphology; 2) indicator of transcategorisation (e.g. verb *transform* -> noun *transformation;* verb *run* -> noun *runner*; verb *sleep* -> adj. *sleepy*)
transcategorisation	1) change of word class; 2) may or may not involve derivation (e.g. *transform* -> *transformation; run* -> *runner*), but not always (e.g. *an excellent **cook*** -> *I **cook***); 3) may indicate grammatical metaphor (e.g. *transform* -> *transformation*), but not always (e.g. *run* -> *runner*);
grammatical metaphor	1) stratal tension between discourse semantics and lexicogrammar (e.g. an discourse semantic event *transform* is mapped onto a Participant in grammar *transformation*); 2) involves transcategorisation, which may or may not involve derivation.

However we need to be careful. In previous studies, grammatical metaphors realised through nominal groups have received significant attention, under the heading **nominalisation**. It needs to be stressed here that nominalisation by definition is a type of transcategorisation; it is a class-shift towards the noun (e.g. verb to noun, adjective to noun, conjunction to noun). And just as not all transcategorisation involves stratal tension, not all nominalisations indicate grammatical metaphor. Compare the examples below:

> congruent: The new **government** does not have popular support.
> metaphorical: The last year of their **government** was completely disastrous.

In both examples, *government* are instances of nominalisation (transcategorised from verb *govern* to noun *government*); however, only the second nominalisation can be read as involving stratal tension. In the first example, *government* refers to a discourse semantic entity (i.e. a group of people who govern a country or a state). In the second example, *government* can be read as referring to the act of managing a country; we can unpack the metaphor as *they governed the country last year, and it was completely disastrous.* Mapping *government* congruently to a discourse semantic entity is particularly common in the discourse of news media and administration.

2.4.3.2.2 Rankshift and ideational metaphor

Apart from shifting word class, a second indication of a remapping of discourse semantic meaning to lexicogrammar is rankshift, specifically when there is a shift of meaning at clause rank to the rank of nominal group. Compare the pair of examples below:

> [a] congruent: Zaphod was delighted so that Trillian celebrated.
> [b] metaphorical: Zaphod's delight caused **[[Trillian celebrating the day]].**

In this pair, the clause *Trillian celebrated* in the clause complex in [a] is shifted to the nominal group rank in [b] – *[[Trillian celebrating the day]]*, functioning as Thing/Head in a nominal group, which realises the Value in a relational clause. The structure of clause [c] is displayed as below.

	Zaphod's delight	*caused*	***[[Trillian celebrating the day]]***
Function	Token	Process: relational identifying	Value
class	nominal group	verbal group	nominal group

Notice that while both *Trillian celebrated* and *[[Trillian celebrating the day]]* construe a discourse semantic figure realised by a clause, by shifting ranks the embedded clause functions as a Participant (a Value). That is to say, the congruent mapping of a figure onto a clause is remapped as a Participant at group rank. This remapping co-occurs with the remapping of discourse semantic meanings of another figure ('*Zaphod was delighted*') onto a Participant (i.e. *Zaphod's delight*) and their logical relationship ('*so*') onto the Process (*resulted in*).

Of course not all embedding indicates grammatical metaphor; for example, clauses embedded as Qualifiers in nominal groups (e.g. *He doesn't agree with the fact [[that the earth has been getting warmer]]*), or which function as a fact in relational processes (e.g. *The fact [[that the earth has been getting warmer]] is undeniable*) are not in themselves indicators of grammatical metaphor. Typically, where rankshift reveals stratal tension, it does so as part of a syndrome of remapping meanings (as in [c] above). For a fuller account of grammatical metaphor involving rankshift, see Chapter 4 (section 4.3.2) where grammatical metaphors in the data texts are explored.

2.4.3.2.3 Agnation, enation and ideational metaphor

As illustrated above, looking for derivation, transcategorisation and rankshift can be useful steps towards identifying grammatical metaphor. Importantly, we need to ask 'how this resource may or may not evolve to affect the relationship between discourse semantics and lexicogrammar' (Martin, 2008, p. 828). The concepts of **agnation** and **enation** identified by Gleason (1965) have been drawn on to explore this potentiality (Ravelli, 1985/1999; Heyvaert, 2003).

Gleason (1965) defines agnation and enation as 'two kinds of relations existing between sentences or other constructions and basic to the grammatical system of the language' (p. 196). Two sentences may be enate if they have identical structures (p. 199); pairs of sentences with the same major vocabulary items, but with different structures are agnate if the relation in structure is regular and systematic (p. 202). Agnation and enation are not isolated relations but mutually defining (Heyvaert, 2003; Davidse, 1998). When groups of sentences are found to be agnate to each other, within each group the sentences are enate. Gleason illustrates this through the examples below (1965, p. 202).

He saw it. ⇔ *It was seen by him.*
III III
He heard it. ⇔ *It was heard by him.*
III III
He felt it. ⇔ *It was felt by him.*

The structures *he heard it, he felt it* and *he saw it* 'can only be identified as enate because they share certain agnates' (Heyvaert, 2003, p. 71) – all of them can, for example, have receptive voice.

Gleason also points out that agnate structures need not be 'on the same grammatical level' (1965, p. 211). For instance, the clause *the boy runs* is seen as agnate to its nominalised equivalent *the boy's running*.

The boy runs. ⇔ *The boy's running.*

Agnation is also 'not limited to sentences or constructions of smaller size' (Gleason, 1965, p. 212). Gleason illustrates this by an agnate pair of a sentence and a sequence of sentences:

The passer-by who found the purse got a reward. ⇔
The passer-by found the purse. He got a reward.

Ravelli (1985/1999) draws on the notion of agnation to identify grammatical metaphors. She points out that if a realisation is identified to be metaphorical, it has 'an agnate form of different word class or of a different rank' (1985/1999, p. 65). In a sense, agnation is used as a technique to identify transcategorisation and rankshift. As she exemplifies, the metaphorical realisation of a 'process meaning explode', *the explosion,* has as its verbal agnate *explode.* Heyvaert (2003) argues that exclusive attention has been paid to agnation in studying grammatical metaphor but that in order to identify grammatical metaphor systematically, it is crucial to consider both agnation and enation. She stresses that if we do not link up the congruent agnates with their enate structures, they 'fail to pick up on the more fundamental, systemic choices that are realised by the lexicogrammar of a construction', but merely function as 'paraphrases' (p. 71). The complementarity of agnation and enation is therefore important in our identification of grammatical metaphor; specifically, they help distinguish one metaphorical way of mapping meanings from another. I now explain the principles of identifying and making distinctions between grammatical metaphors in this study by drawing on agnation and enation.

Firstly, through agnation, we can determine whether instances of transcategorisation may involve a stratal tension. If there is an agnate form, we can unpack the stratal tension into its congruent mapping, as exemplified by the agnate grammatical structures in [a, b] below (congruent on the left and metaphorical on the right).

Zaphod was ***delighted*** *so Trillian* ***celebrated*** ⇔ *Zaphod's* ***delight*** *resulted in Trillian's* ***celebration*** [a, b]

The agnate clauses construe similar semantic meanings; the clause on the right indicates one metaphorical way of mapping meanings. As has been clarified, both discourse semantics and lexicogrammar make meanings, and in order to determine whether one way of mapping meaning is the same as another, meanings at both levels need to be considered. Presumably, we have two discourse semantic configurations [A] and [B] mapped respectively on the grammatical configurations [a] and [b]:

discourse semantic configuration [A] ⟷ (map onto) grammatical configuration [a]

discourse semantic configuration [B] ⟷ (map onto) grammatical configuration [b]

If both discourse semantics configurations [A] and [B] and grammatical configurations [a] and [b] are enate, their ways of mapping meanings are the same. If their mapping is metaphorical, they are the same type of grammatical metaphor. When it comes to analysing texts, and we find an instance which indicates grammatical metaphor, the question is how to reveal its discourse semantic configuration in order to further compare its way of mapping with others. The criteria used in this thesis is this: once the grammatical metaphor is unpacked into a congruent mapping (based on the criteria of agnation and transcategoriation just illustrated above), its semantic configuration will be reflected more or less literally on its grammatical realisation (this point will be clarified later in the thesis once the discourse semantic units are established in Chapter 3 and 4). The agnate pair of the two grammatical realisations can thus be used to reflect meanings at two levels - one is a discourse semantic configuration, the other a metaphorical grammatical configuration.

congruent realisation [A]
(discourse semantic configuration) ⇔ metaphorical realisation [a]

If the agnate pair [A] and [a] is enate with another pair – i.e. enate both in terms of their discourse semantic configurations and grammatical configurations, then the same way of mapping meanings at two levels (i.e. same grammatical metaphor) can then be identified.

congruent realisation [A] (discourse semantic configuration)	⇔	metaphorical realisation [a]
III		III
congruent realisation [B] (discourse semantic configuration)	⇔	metaphorical realisation [b]

However, if the configurations at either level are not enate, as modelled below, then they are not the same way of mapping meaning - i.e. different grammatical metaphors.

congruent realisation [A] (discourse semantic configuration)	⇔	metaphorical realisation [a]
III		X
congruent realisation [B] (discourse semantic configuration)	⇔	metaphorical realisation [b]

congruent realisation [A] (discourse semantic configuration)	⇔	metaphorical realisation [a]
X		III
congruent realisation [B] (discourse semantic configuration)	⇔	metaphorical realisation [b]

This principle will be followed in Chapter 4 when ideational metaphors in the data texts are explored. What needs to be emphasised here is that building discourse semantic units of meaning is the basis for effectively exploring ideational metaphor; and in order to distinguish different types of ideational metaphor, unpacking ideational metaphors in the data texts is an important step.

Transcategorisation, derivation, rankshift, agnation and enation are useful for identifying grammatical metaphors. However, the 'metaphorical' status of some instances may be still ambiguous when it comes to analysing texts, particularly in vertical discourse. Since language is constantly evolving, some metaphorical ways of mapping meanings may gradually become so conventionalised as to lose stratal tension; they would then lose their metaphorical sense, becoming a 'dead' grammatical metaphor in a particular instance (Halliday, 1998; Martin, 2008), such as the example of *government* introduced earlier (e.g.

The new government does not have popular support). In semantic terms what started life as a semantic figure ends up as a semantic entity.

Both 'live' and 'dead' metaphors are powerful ways of building field in vertical discourse. In the next section, I review their functions in relation to field – as building technicality and creating logical reasoning.

2.4.3.3 Functions of ideational metaphor in vertical discourse

Ideational metaphors have been studied previously in relation to a range of registers. In enacting tenor, ideational metaphor has been found to be associated with the evaluative resources of APPRAISAL (Martin & White, 2005; Hood, 2004, 2010), both in terms of forming a target for an evaluation (e.g. *unsuccessful* ***marriage***) or as an evaluative resource in itself (e.g. *a huge* ***disappointment***). Ideational metaphor can also function as a mode-oriented resource, since it can help compose information flow in a text, with respect to managing Given + New in relation to Theme + Rheme at the clause level (e.g. Halliday 1998), as well as organising layers of hyper- and macro-thematic and information at higher level periodicity in a text (Martin, 1993a, p. 265 ff.). In terms of construing field, in particular in vertical discourse, ideational metaphor has been found to play two significant roles – i) it contributes to developing technicality and ii) it manages logical reasoning (e.g. Halliday, 1988/2004, 1998; Martin, 2007; Wignell et al, 1993). As Martin (2007) suggests,

> "(ideational metaphor) names the process which engenders vertical discourse…failure to access this resource entails exclusion from hierarchical and horizontal knowledge structures" (p. 51-55).

Below I focus the discussion on its function as 'field-oriented' resource.

2.4.3.3.1 Ideational metaphor and technicality

Technicality is defined as 'terms or expressions (but mostly nominal group constituents) with a specialised field-specific meaning' (Wignell et al., 1993, p. 161). Technicality functions as a 'field-creating process', which allows us to 'set up and taxonomise areas of human interest' (Wignell et al., 1993, p. 182).

Technical terms are mostly realised through nominal groups, usually things or Classifier^Thing compounds. As pointed out by Halliday, the 'nominal group has, in its grammar, the potential for organising a large quantity of lexical material into functional configurations'; meanings construed by nominal groups are 'more stable elements on the experiential scene which tend to persist through time, and are more likely to be subcategorised, than processes – e.g. there are more classes of leaves than classes of falling' (1998, p. 197). Wignell et al. (1993) summarise the various nominal group configurations through which a technicality may be realised, as shown in Table 2.19 below.

Table 2.19 Grammatical configurations of technical terms (c.f. Wignell et al., 1993)

Grammatical configurations	**Examples**
a) a single nominal or thing	*mesas, buttes, consumers*
b) nominal group compound – Classifier^Thing, in which Classifier is usually an Epithet in vernacular usage	*physical environment, raw materials*
c) Classifier^Thing in which Classifier represents the agent in an implication sequence	*relief rainfall, frontal rainfall*
d) **nominalisation**	***condensation, transpiration***
e) technical nominal group compound with a Classifier^Thing, where the Classifier is a **nominalisation** representing the agent from an implication sequence	***convection** currents*

As shown in Table 2.19, nominalisation is a critical resource for creating technicality, summarised as type d) and e). A technical term in the form of nominalisation is usually developed via grammatical metaphor. The process of turning a nominalisation as grammatical metaphor into a technicality is a process of 'distillation' (Martin, 1993b, p. 191). During the process of distillation, providing a definition of the technical terms in a particular field is a critical step to 'distil' it as a technical term. A definition of a technical term is realised through a Token/Value relational identifying process (Wignell et al., 1993), which 'translates' common sense meaning into technical meaning in vertical discourse. Wignell et al. found that in all the scientific texts they examined, 'the technical term always realises the function of Token, and that what is thought of as the definition realises the role of value'. Nominalisation, such as *diffusion* is defined as below (example adapted from Martin, 1993b, p. 201).

term		definition
diffusion	*is*	*the process whereby a substance in high concentration moves to a place of low concentration*
Token	Process [intensive identifying]	Value

Once a nominalisation such as *diffusion* is defined in this way, it is no longer necessary for it to be unpacked in the discourse; the phrase becomes a 'dead' metaphor (Halliday, 1998, p.

222). Importantly, it functions now as a 'technical entity' in the discourse semantics. Sometimes a technical term may be even named or renamed. The names of technical terms in English are derived frequently from Latin and Greek (White, 1998), for example the Latinised term *osmosis* (from Latin *osmose*), which is a kind of *diffusion*.

term		definition
osmosis	*is*	*the diffusion of water across a semi-permeable membrane*
Token	Process [intensive identifying]	Value

Relational identifying processes are only one of the ways in which a technical term can be defined. Wignell et al. (1993) suggest that the elaborating relationship linking Token and Value can be generalised to various other grammatical realisations, which are summarised in Table 2.20 below. According to this summary, only one of the definitions is not agnate to the elaborating Token/Value structure in relational identifying process – namely when a phenomenon is defined by an accumulation of attributes through a possessive attributive process. Note that while not all the examples provided in Table 2.20 are nominalisations, these grammatical structures provide various ways in which a nominalisation as grammatical metaphor may be distilled as technical terms.

Table 2.20 Various ways of definition (c.f. Wignell et al., 1993)

Ways of definition	**Examples**
identifying relational clause	*An **ecosystem** is = <u>that home or place in which a community or group of interacting plants and animals lives</u>.*
'translating' process	*In geography, **the biome** is = <u>the living part of the ecosystem</u>.*
elaborating technical terms through embedded clauses (defining relative clauses)	*When water evaporates it changes into <u>an invisible gas</u> = called **water vapour**.*
elaborating nominal groups	*at <u>the lowest level</u>, = **trophic level 1** at <u>the next lowest level</u>, = **trophic level 2**…*
elaborating conjunctions (group/clause)	***trophic level 1**, = <u>that is where life forms are the simplest</u>*
anaphoric reference	*until eventually all the species of plants and animals in the ecosystem live in **a balanced state**. = This means <u>that they depend upon one another and live in harmony unless disturbed.</u>*
possessive attributive process	*(A **desert** has<u>): lack of water; very slow humidity; long drought followed by deluge; minimum cloud and maximum sunshine; very hot days and very cold nights; a great daily range of temperatures</u>.*

(key: technical terms are in bold; definitions are underlined)

Distilling ideational metaphor into a technical term has been found to be particularly significant in science (Halliday & Martin, 1993; Halliday, 1998). Once nominalisations of ‘qualities’ and ‘events’ are distilled into technical terms, they can be further categorised, described and measured.

In comparison to technicality in science, in the discourse of the humanities, in particular the history discourse that has been explored in previous studies, technical terms as nominalisations were found to be less common (Martin, 1993c). The technical terms that are there, which typically taxonomise phases of time, often involve proper names (e.g. *the French Revolution, the Long March, the Renaissance*) (Martin, 2007). More recently, Martin et al. (2010) find that more technical terms occur in the discourse of history than previously thought. The technical nominalisations with ‘-ism’ in Modern History (e.g. *conservatism, feminism, liberalism, communism, nationalism*) are particularly significant. As a derivational suffix ‘-ism’ is ‘something that turns a proper name or adjective into a principle, belief or movement’; as technical terms, they build up the ‘system of values and attitudes’ with taxonomic oppositions (such as *individualism vs communism, capitalism vs socialism, nationalism vs colonialism*) (p. 443). Martin (2013a) illustrates that alongside their taxonomic oppositions, these -isms may be ‘axiologically charged’ (Maton, 2014) in opposition to one another or other terms. For example *communism* is taxonomically opposed to *capitalism*, but axiologically it may be read as in opposition to *Christianity*. Martin (2013a) refers to such weakly classified but highly axiologically charged terms in discourse of humanities as ‘flexi-tech’; their ‘flexibility’ is based on the fact that ‘their meanings tend to be adapted from text to text according to scholars’ particular interpretative needs’.

In summary, ideational metaphor is an important step as far as building technicality is concerned. Once in the form of nominalisation, a meaning can then be defined and taxonomised, entering into a range of relations as a technical term in a given field.

2.4.3.3.2 Ideational metaphor and logical reasoning

The second function of ideational metaphor in relation to field is developing logical reasoning. As Halliday suggests, “technicality by itself would be of little value unless accompanied by a discourse of reasoning” (1998, p. 201). According to the observation of science and history in previous studies (e.g. Wignell et al., 1993; Eggins et al., 1993; Martin, 1993a, 1993c, 2007), logical reasoning is often realised metaphorically in order to ‘carry forward the momentum of the argument’ (Halliday, 1998, p. 202). However different discourses have demonstrated different preferences of ideational metaphor in building logical relations.

According to his observation of scientific texts, Halliday found that in explaining and interpreting scientific phenomena, external and internal logical relations can be realised in various ways. External relations are concerned with what is going on in the field, whereas internal ones are about our interpretation of what is going on in the field. He summarises these resources schematically as in Figure 2.47 below.

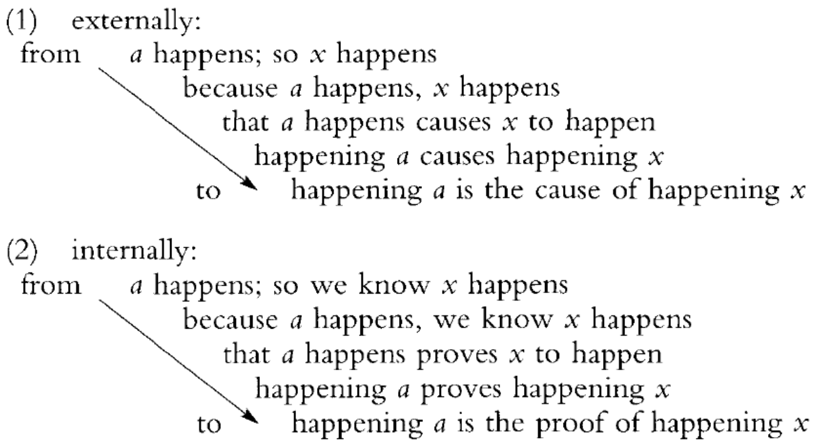


Figure 2.47 Realisations of external and internal logical relations (Halliday, 1988/2004, p. 155)

As demonstrated in Figure 2.47, instead of being mapped onto conjunction (e.g. *so*), external and internal relations can be mapped metaphorically onto Processes realised by verbal group complexes (e.g. *a happens* ***causes*** *x to happen; a happens* ***proves*** *x to happen*), and Participants realised by nominal groups (e.g. *cause, proof*). Another significant feature shown here is that mapping logical relations metaphorically necessarily creates a syndrome of grammatical metaphor – that is, some other meanings are also mapped metaphorically onto grammar. For example, a discourse semantic going-on ('a happens') is mapped on to a Participant (e.g. *That the rain occurs is caused by the condensation of water*) or Qualifier within a Participant (e.g. *That the rain occurs is the result of [the condensation of water]*). Similarly in Martin (2007), various grammatical realisations of logical reasoning are found, as summarised in Table 2.21.

Table 2.21 Causal relations realised inside a clause in science discourse (c.f. Martin, 2007; Halliday, 1998)

grammatical resources	**examples**
Participant / noun	*the rising air becomes cooler for the* ***reasons****…*
Epithet / adjective	*the* ***resulting*** *clouds are usually of the cumulous type…*
Minor Process / preposition	*much of the rain that falls in Australia occurs as a* ***result*** *of the uplift and condensation of water*
Process / verbal group	*a could front* ***causes*** *uplift and condensation in a water*

According to Martin's observation, in explaining scientific phenomena, the prominent logical relations are external ones, which develop implication sequences in scientific fields. Unsworth (1995) found that in pedagogic texts, internal causal relations are also used in order to relate implication sequences to one other (which he refers to as 'domains'). For example in an explanation of tides, internal relations were used to deal with the inter-relationship among the implication sequences of 'the earth's orbit around the sun, the moon as a satellite of the earth, and the consequent variation in the relative positioning of the sun and the moon with respect to earth, etc.' (p. 71).

In history, construing logical reasoning through grammatical metaphors is also significant[7]. History particularly favours the mapping of causal relations onto a Process. A significant reason for this is that the lexical range of verbal groups in English grammar has the capacity to open up an indefinite number of ways of relating one event to another (Martin, 2007, p. 47), such as *give rise to*, *determine*, *improve*, *contributes to*, as exemplified in Table 2.22.

[7] Note that in previous studies, ideational metaphors for the purposes of building logical relations have also been referred as 'abstraction' (Martin, 1993c, 2007; Wignell, 2007). However, in this study, this descriptive term is not followed in describing discourse, since abstraction has been used in SFL framework to characterise levels of stratification (e.g. field is more abstract than discourse semantics, which is more abstract than lexicogrammar).

Table 2.22 Causal relations realised inside a clause in science discourse (c.f. Martin, 2007; Halliday, 1998)

grammatical resources	**examples**
Process/ verbal group	***The outflow*** *of Vietnamese boat people throughout the region* ***gave rise to*** *great moral dilemmas in* ***the implementation*** *of government policies.*
	The Howard government's ***unwillingness*** *to apologise* ***determined*** *the nature of its* ***response*** *to other recommendations contained in Bringing them home.*
	the ***over-reliance*** *on the government's own records* *grossly* ***distorts*** *Windschuttle's* ***understanding*** *of the* ***realities*** *of frontier life…*
	very considerable ***difficulties*** ***arise from*** *the* ***insufficiency*** *of stationary*
	Government ***record keeping*** ***improves*** *somewhat* *with the* ***arrival*** *of Sorrell in 1817*
	The ***detention*** *in remote places* ***were contributing to*** *more regular bad* ***decision making*** *at the primary stage*

(key: experiential metaphors are in bold; logical metaphors are in bold and underlined)

These more fine-tuned types of cause are significant resources for relating historical events in building knowledge of history. In science, on the other hand, simple cause/effect relations are preferred. As Martin puts it, 'fuzzy cause would be a problem for scientists, not a solution' (2007, p. 47)

Note that the ideational metaphors that are involved in developing logical reasoning contrast with the 'dead' metaphors which are distilled as technicality in the field – they are 'alive'. Halliday (1998) refers to such ideational metaphors as 'instantial' ones, in opposition to the 'systemic' ones deployed in building technicality. He emphasises that the two types of metaphor are in fact not as oppositional as they might appear; as he explains:

> "(if we view discourse) in the longer term, we can observe the instantial *becoming* the systemic. Technical terms are not, as a rule, created outright, in isolation from the discourse; they emerge discursively, as the 'macro-text' of the discipline unfolds. In this respect they are just one manifestation of the general phenomenon whereby instantial effects flow through into the system – because there is no disjunction

> between system and instance: what we call the 'system' of language is simply the potential that evolves over time." (Halliday, 1998, p. 221)

This brings us again to the fluid boundary between 'live' and 'dead' metaphors (such as *government* as the act of 'governing', or *government* as a group of people). In order to draw the line between these two, one criterion followed in this thesis is to determine whether they are linguistically defined in the field. Insofar as they are provided with definition in the field, they are treated in the analysis as technicality rather than ideational metaphor. Linguistic definitions of technical terms will be discussed in Chapter 3.

2.4.3.4 Summary

In this section, I have firstly reviewed the various ways in which ideational metaphors are conceptualised. As illustrated, it is the stratal tension model that takes responsibility for meaning making in both discourse semantics and lexicogrammar. Secondly I have illustrated several ways in which ideational metaphor may be identified in texts. The contributions made by ideational metaphor to knowledge building in vertical discourse have also been outlined – namely, creating technical terms and building logical reasoning. As far as the construal of field in undergraduate biology is concerned, the identification of both phenomena is critical in the analysis.

2.5 Exploring the field of undergraduate biology

I have reviewed above the theoretical foundations in SFL which are relevant to this study. In this section, I associate these theoretical principles with the specific focus of this study – namely a linguistic exploration of how the field of biology at undergraduate level is construed through language. I will firstly specify the research questions; and then explain the rationale for the selection of data texts, and the principles in data analysis.

2.5.1 Research questions

As introduced in Chapter 1, the major motivation for this study is to explore knowledge building through language. I have specified in this chapter that, drawing on an SFL framework, the linguistic concern with knowledge building is associated primarily with exploring the ways in which field as a register variable is construed through the patterning of discourse semantics, which is in turn construed through the patterning of lexicogrammar.

As far as discourse semantic patterning of language is concerned, I have outlined the current models of (discourse) semantics in SFL. However, in current modelling, as has been reviewed critically in section 2.4, neither the ideational discourse semantics (IDEATION and CONJUNCTION systems) established in Martin (1992) (later in Martin & Rose, 2007), nor the ideation base presented in Halliday & Matthiessen (1999), is sufficient to model a stratum that is balanced in relation to lexicogrammar and field. It is therefore necessary in this study to further develop the ideational discourse semantic systems to clarify their relationships with the systems at the stratum above, around and below. Only then we can draw on the discourse semantic systems to analyse the discourse semantic patterning of texts to further reveal the building of field. Two objectives in this study are then posited – one theoretical and the other empirical:

1) to develop discourse semantic systems that are responsible to meanings on the stratum above, around and below;
2) to illustrate the construal of field in undergraduate biology by drawing on the systems developed in this study.

It has been outlined that field is constituted along two dimensions - taxonomy and activity sequences. These two aspects of field are manifested in different discourse semantic meanings. That is to say, specific issues in relation to the different aspects of field need to be addressed:

➢ In relation to taxonomy:
1) developing discourse semantic systems that can construe field taxonomies;
2) illustrating the construal of field taxonomies in undergraduate biology through their discourse semantic patterning in the data.

➢ In relation to activity sequences:
1) developing discourse semantic systems that can construe activity sequences in field;
2) illustrating the construal of activity sequences in the field of undergraduate biology through their discourse semantic patterning in the data.

To achieve these research objectives, my exploration starts by developing relevant discourse semantic systems in relation to each aspect of field. Multiple systems in SFL are drawn on in the analysis to reveal their interactions with ideational systems, including the discourse semantic systems APPRAISAL, CONJUNCTION, IDENTIFICATION and PERIODICITY (Martin, 1992; Martin & White, 2005; Martin & Rose, 2007), and the grammatical system TRANSITIVITY, alongside nominal group systems (Halliday & Matthiessen, 2014). In the second stage, a set of texts are selected to illustrate the instantiation of ideational discourse semantic systems.

2.5.2 Selection of data

In order to develop discourse semantic systems, the primary concern in this study is the systemic potential of meaning-making resources. That is to say, along the cline of instantiation, this study is more oriented towards the system pole. The data texts serve to reveal which systems are foregrounded. That is to say, it is important to select texts which are representative as far as instantiating systemic resources is concerned. At the same time, dealing with the complexity of the interaction among systems across strata, metafunctions and ranks necessarily limits the amount of data that are explored. It is therefore critical to carefully select data that can balance the complexity of exploring systems as well as the productivity of qualitative analysis.

For the purpose of developing discourse semantic systems, a set of data texts are selected, including both student texts and pedagogic texts at the undergraduate level. The student texts consist of laboratory reports and research reports collected from the School of Biology, the University of Sydney. These texts are produced for assessment in the core subjects across different year levels. Pedagogic texts consist of laboratory manuals (see reference list) and a major textbook in the field that is used in the core subjects - *Biology* (Campbell & Reece, 2005). The reasons for selecting these data are explained as follows.

Firstly, laboratory reports and research reports are selected since they are representative as far as demonstrating the literacy demands of biology at an undergraduate level is concerned. Based on the genre systems established in Martin & Rose (2008), laboratory reports and research reports are the subtypes of procedural recount (p. 200). The stages identified in the texts include (Abstract ^) Introduction ^ Method(s) ^ Results ^ Discussion (^ Conclusion), as summarized in Table 2.23. The genre analysis in this study also indicates a variety of phases (Martin & Rose, 2008, p.82), which, as defined by Martin & Rose, are sub-stages of a genre. For the annotation of stages and phases in the selected student texts, see Appendix A. The phases identified in the data can be usefully compared with the embedded genres that are identified in Hood (2010). I will return to the issue of phases, stages and genres in Chapter 5.

Table 2.23 Stages and instantiation of elemental genres in laboratory report and research report

	lab report	**research report**
stages	❑ Introduction ❑ Method ❑ Results ❑ Discussion ❑ Conclusion	❑ Abstract ❑ Introduction ❑ Methods ❑ Results ❑ Discussion

Apart from the student texts, references to laboratory manuals and textbooks are also important since they are relevant to different phases in student texts. For example, an experimental procedure can be related to a phase in Method stage of a lab report or research report, and an explanation of biological phenomenon can be related to a phase in their Discussion stage. Another particular significant reason for referring to the textbook is that it provides definitions and taxonomic relations of technical terms, which are the linguistic evidence for the distillation of technical language which are instantiated in student texts.

For the purpose of illustrating the discourse semantic analysis drawn on the systems developed in this study, four texts produced by one undergraduate student are selected, as summarised in Table 2.24 below.

Table 2.24 Texts selected for illustrating discourse analysis

text type	**level**	**subjects**	**word count**
laboratory report	first year 2008, semester 1	Concepts in Biology	842
laboratory report	second year 2009, semester 1	Molecular Biology	778
research report	second year 2009, semester 2	Vertebrates and their Origins	1,976
research report	third year 2010, semester 2	Fungi in the Environment	2,826

These texts have several characteristics. Firstly, they represent selections at different year levels. For the purpose of beginning to explore knowledge building as a dynamic semiotic process across time, the texts provide four snapshots of field building at different points in the undergraduate student's apprenticeship. Their comparisons thus potentially point to some developmental features of the field. Secondly, the texts are high-graded as assessment tasks by the subject instructors (above 75%). This consideration is relevant to the potential pedagogic implications of the analysis. Making explicit how the meanings are made satisfactorily is necessary for providing effective modelling and scaffolding in teaching academic literacy. I will return to the pedagogic implications of the thesis in Chapter 5.

2.6 Concluding remarks

In this chapter, I have situated this study in relevant dimensions of an SFL theoretical framework. The concern to explore knowledge building has been specified in terms of exploring how field is construed through the discourse semantic patterning of language. In order to achieve this, the current discourse semantic system needs to be developed further to be responsible to both field and lexicogrammar. Distinctive terminology and distinctive systems on each level will be clarified.

In the following chapters, the exploration of field is developed according to two aspects of field – taxonomy and sequencing of activities, which are discussed respectively in Chapter 3 and Chapter 4. In each chapter, the theoretical framework for the analysis will be firstly developed before being employed in analysing the data texts.

Chapter 3 Construing taxonomy

3.1 Introduction

In this chapter, I explore the construal of field from the perspective of taxonomy building. The construal of taxonomy in field is investigated through entities at the level of discourse semantics. The student texts chosen as data for the illustration reveal that at different stages of the apprenticeship distinctive ‘things’ are focused on in the texts. We begin with a glimpse of two excerpts, one from a first year laboratory report, the other a third year research report. It can be seen that the entities (underlined) that occur in the texts are rather different.

Table 3.1 Excerpt from Text 1

Text 1.
Introduction Calibration of a pipette allows the relationship between theoretical volumes and those actually obtained to be determined…. In this experiment a Finnpipette, ranged 200 – 1000uL, and a Bio-Rad P200 pipette were calibrated by using three methods – weight-of-water, spectrophotometry and radioactivity…
Method Set amount of water was pipetted into a container, and the weight of the water dispensed was measured and recorded. …
Result Weight-of-water method showed close correlation between the theoretical pipette and experimental values… suggesting the pipette to be both accurate and precise throughout its range (0-200uL). …
Discussion While the weight-of-water method appeared to provide the best calibration of the pipette, there were a number of limitations associated with it. Firstly, the sensitivity of the balance was limited, with its only measurements larger than 1mg detected …
Conclusion The different methods used in pipette calibration contained varying degrees of accuracy. Although the use of the weight-of-water method was simple and inexpensive, it did not provide an accurate representation of the accuracy and precision of the pipette. …

Table 3.2 Excerpt from Text 4

Text 4.

Introduction A complex interaction exists between insects and the health and diversity of fungal communities. These interactions may be beneficial to both insects and fungi, for example symbiotic relationships between termites and cellulase-producing gut fungi (Slater, 1992)… We propose a model … This model was tested, using dung fungal spores and examining their passage through the gut of the Australian plague locust, Chortichocetes terminifera. …
Method Species of Penicillium, Podopspora, Absidia, Isaria and Phycomyces were isolated from possum faeces. The fungi were cultured on 3.5% Potato Dextrose Agar (PDA). …
Results A positive result for spore viability after ingestion determined when the target fungi was isolated... Additional growth on treatment plates was compared to non-target fungal growth present on control plates …
Discussion Penicillin, Isaria and Absidia spores retained viability after ingestion by and passage through the gastrointestinal tract of both second and fifth instar C. terminifera. In comparison, the larger spores of Podospora (14-20um) did not retain their viability… So it stands to reason that larger fragments would be more susceptible to be damaged by mandibular action (Clissold, 2008). …

Text 1 contains a number of entities referring to utilitarian tools, such as *pipette* and *container*, as well as methods, such as *weight-of-water* and *spectrophotometry*. A few nominalisations can be seen, such as *limitations*, which may be taken as an instance of 'abstraction' (Martin & Rose, 2007; Wignell, 2007). Some 'generic' terms (Martin & Rose, 2007) such as *value*, and *range* are also relatively abstract. We can get a sense from Text 1 that the reported experiment employs more than one method and involves certain tangible tools and instruments. In Text 4, few experimental tools are found, but a number of biological phenomena are mentioned, such as *insects* and *fungi*. Certain biological phenomena are given their scientific names, such as *Penicillium, Podopspora, Absidia*, etc. We also find some nominalisations which are likely to be technical terms, such as *viability*, *ingestion*, and *mandibular action*. Based on this primary analysis, it is not difficult to suggest that Text 1 is more 'concrete', with some 'abstractions', and Text 4 is more 'technical', or involving more 'theoretical/technical abstraction' (Halliday, 1998, p. 199). However, the questions that I am concerned with at this point are: what do we mean by 'concrete', 'technical' and 'abstract'? What are the linguistic features of entities in Text 1 or Text 2 that make them 'concrete', 'technical' or 'abstract'? How are they differentiated from each other typologically? Importantly, how can we systematically identify all these entities in text? With respect to their grammatical realisation, should entities be identified by class as being realised in nominal groups, or by function, as the Thing within nominal groups? As far as field is concerned, how are we able to conclude now that Text 4 construes a 'technical field' when the entities are mostly 'technical'?

It is these queries that motivate the exploration of discourse semantic entities in this chapter. These questions are concerned with the responsibilities assumed by different strata of analysis – including field, discourse semantics and lexicogrammar. In order to answer these questions, it is necessary to establish a discourse semantic system which is clearly stratified with respect to the grammar of nominal groups, and which can take on its share of descriptive responsibility for construing taxonomies in field. Apart from the consideration of stratification, complementarity across metafunctions also needs to be considered.

In the first section of this chapter (3.2), a typology of entities revealed in the data texts will be proposed. In the second section (3.3), it will be argued that, while the typology of entities can distinguish one type of entity from another, the relationship between entities of the same type also needs to be taken into account. In relation to the relationships between entities, a system of dimensionality will be proposed. In the third section (3.4), the frameworks of entity type and dimensionality will then be applied to the analysis of entities in the four student texts produced at different undergraduate years. The purposes of the analysis are to illustrate the ways in which the systems of entity and dimensionality can be used in analysing texts; to reveal the construal of taxonomy in field in undergraduate biology; and to point out some developmental features of taxonomy building from an ontogenetic perspective.

3.2 Towards a system of ENTITY

3.2.1 Motivation from field

As discussed in Chapter 2, Bernstein (1999) makes a distinction between horizontal and vertical discourse, and among the fields of vertical discourse, which includes the disciplines of the humanities, social sciences and science, a distinction is made between horizontal and hierarchical knowledge structures. In knowledge building, a hierarchical knowledge structure subsumes previous knowledge, as exemplified in science, whereas a horizontal knowledge structure develops by proposing new perspectives, as exemplified in the humanities. Biology can then be seen as a scientific field that involves a hierarchical knowledge structure. Bernstein's sociological identification of disciplinary fields complements Martin's (1992) linguistic perspective on field agnation. Among the fields classified by Martin (1992, p. 544, reproduced in Figure 3.1 below), science is seen to be related to humanities and social science as a field of exploration.

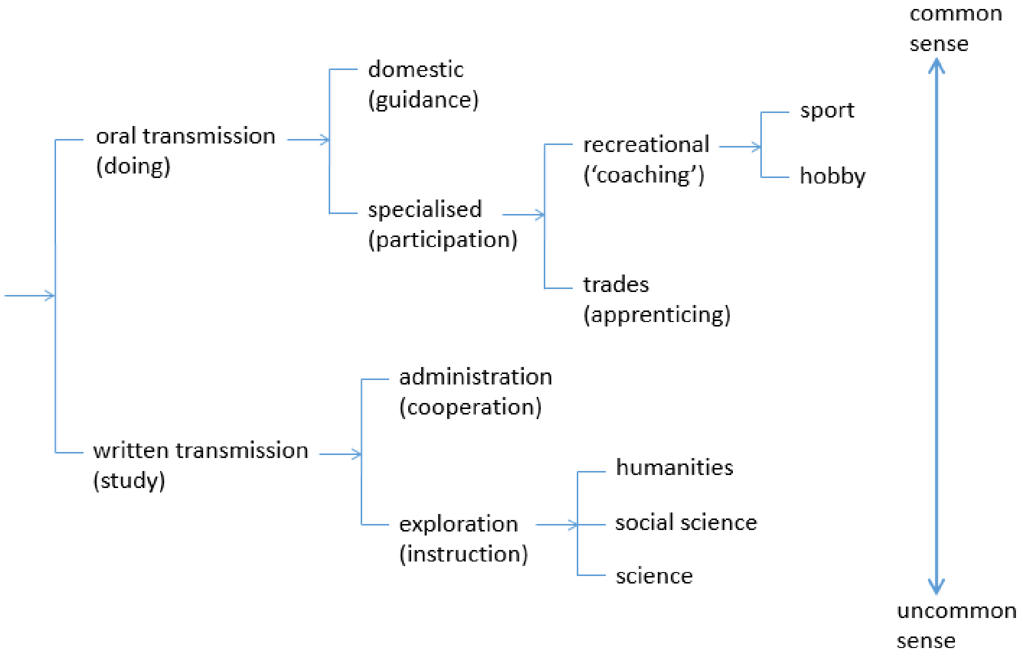


Figure 3.1 A provisional classification of fields (Martin, 1992, p. 544)

Exploration fields distinguish themselves with respect to implication sequences and technical taxonomies. The way in which technical taxonomies contribute to hierarchical knowledge building in exploration fields is through the classification and composition types of taxonomic relations (Martin, 2013a).

While Martin's field agnation is helpful to articulate the general distinction between intellectual fields (exploration) from the other fields, this perspective of seeing a scientific field (such as biology) as an exploration field is different from seeing biology as a disciplinary field. Drawing on Hood's distinction of the field of object of study and field of research in the disciplinary field, Martin's articulation of scientific field is largely focused on science as an 'object of study'. However, in this study participation in doing biology was also shown to be significant. The data texts demonstrate that apprenticeship into the discipline of biology at the tertiary level concerns not only the accumulation of biological knowledge about living organisms, but also the ability to conduct experiments. Experimental methods for doing experiments are construed in all student texts, including both laboratory and research reports. That is to say, conducting laboratory experiments by following laboratory manuals, employing tools and apparatus, recording data, interpreting data, and reporting findings are crucial activities in the apprenticeship into biology (Janovy, 2004). According to Martin's (1992) field categories, the presence of such activities sequences and utilitarian tools constitutes a specialised field.

The distinction between specialised and exploration fields is reflected in their distinct lexicogrammatical preferences. Investigating lexis in the discourse of science and technology, White (1998) points out that lexis in science and technology is differentiated morphologically. This is shown by science's preference for non-native forms derived from Greek and Latin (e.g. *cytoplasm, halophile, isotope, aqua*), compared with technology's preference for nominal groups elaborated by Premodifiers drawn from the vernacular lexicon (e.g. *disk operating system, floppy disk*) and acronyms derived from these complex groupings (e.g. *CD-ROM, DOS, RAM*). In addition, scientific terms clearly articulate taxonomic space with respect to the relations between co-hyponyms, and between hyponym and superordinate, whereas taxonomies in technology emphasise the functionality of tools and the composition of the entities these tools construct and maintain. Nonetheless, science and technology are closely bonded in modern society, since science relies on technology to assist experimentation, and technology relies upon science to provide the theoretical basis for its development. In investigating the system of apprenticeship in the technology industry, Rose (1998) finds that technology as a specialised field is particularly evident at the early stage of the apprenticeship, as reflected in the genres of simple procedure, conditional procedure, technological explanation and co-operative procedure (see also Martin & Rose, 2008). At the later stage of the apprenticeship, scientific knowledge is required, as reflected in the science industry genre, which he refers to as technical notes.

The opposition between the exploration field and specialised field in Martin (1992) and that between the field of object of study and field of research in Hood (2010) provides two complementary perspectives on articulating field. In order to capture the goings-on in biology as a discipline, the field of biology can thus be seen as being constituted by both specialised and exploration fields; and at the same time constituted by both the field of object of study and field of research. From the perspective of exploration/specialised fields, the specialised field functions in the service of the field of exploration. As far as apprenticeship into the discipline is concerned, early on there is a balance between specialised and exploration field, but later there is a shift towards specialised activities in the service of exploration.

biology as a disciplinary field		
specialised exploration	→	exploration specialised
utilitarian tools; methods; results; writer's or others' studies; biological phenomena		

As far as investigating field taxonomies is concerned, the system of discourse semantic entities proposed here will be responsible for two aspects of field. Firstly, entity categories will be responsible for realising elements in the field of object of study and the field of research such as biological phenomena (e.g. *cell*, *fungi*, *sea urchin*), utilitarian tools (e.g. *balance*, *microscope*), methods (e.g. *DNA sequencing method*), and studies (e.g. *experiment*, *research*). Secondly, the entity system will take responsibility for construing the intrinsic differences between the exploration fields and specialised fields. Their typological difference, as suggested by Martin (1992), is based on distinctive patterns of meaning transmission. The specialised fields tend to depend on oral transmission, along with visual images, gestures, etc. (Gamble, 2001), whereas exploration fields rely heavily on written transmission in institutionalised contexts of learning. Therefore, field agnation suggests entities need to be explored from two perspectives, potentially indicating two simultaneous systems. In the following sections, each perspective will be developed in order to explore the system of entity. The motivations for entity categories, from 'below' (lexicogrammar), and from 'around' (discourse semantics), will be discussed.

3.2.2 Entity – what meanings are construed?

3.2.2.1 Motivation from below

Because of the natural relation between lexicogrammar and discourse semantics in a model of language with a stratified content plane, it has proved useful to explore entity types in relation to experiential lexicogrammatical systems. A number of the most significant patterns will be briefly reviewed here in relation to an emerging classification of entity types.

Nominal group grammar is an obvious place to begin, because of the congruent mapping of entities onto nominal groups. As noted in Chapter 2, this mapping has been approached in various ways in the literature: with entities realised by a clause Participant; by the group function Thing; or by Classifier^{n}=Thing structures. Here I will follow on from Martin's (1992) discussion of nominal items entering into lexical cohesion in the discourse. According to Martin's conceptualisation, a message part, specifically an entity that is concerned here, can be realised congruently by (Classifier^n)=Thing (*regular sea urchin*), Focus=Thing (*a kind of sea urchin*), possessive Deictic=Thing (*the rainforest's canopy*) structures[8] and elaborating nominal group complexes. It needs to be noted here that in elaborating nominal group complexes, a (Classifier^n=)Thing structure may be used to subsume its elaboration, which may itself realise one or more entities: as in 1 *B-galactosidase,* $^=$2 *an enzyme which breaks down lactose.* Following the types of paratactic elaborating relationship identified at clause rank in Halliday & Matthiessen (2004, p. 397 ff.) – exposition, exemplification and clarification – a more delicate elaborating relationship in nominal group complexes can also be identified. A summary of the realisations of entity through elaborating nominal group structures is provided in Table 3.3.

Table 3.3 Realisations of entity through nominal group structures

Realisation of entity			**Examples**
hypotactic elaboration	(Classifier =) Thing		(β *regular* =) α *sea urchin*
	Focus = Thing		β *a kind of* = α *sea urchin*
	possessive Deictic = Thing		β *rainforest's* = α *canopy*
paratactic elaboration	elaborating nominal group complex	exposition *that is* [i.e.]	1 *B-galactosidase,* = 2 *an enzyme which breaks down lactose*
		exemplification *such as* [e.g.]	1 *molecular sequencing methods,* 2 = *such as DNA sequencing*
		clarification *in fact* [viz.]	1 *most players,* 2 = *in fact everyone on the team, played well*

At clause rank, the nominal group realising entities can additionally be explored in relation to different Participant roles and Circumstances. For example, one of the distinctive features of behavioural and mental processes is that they involve at least one conscious participant, Behaver or Senser. In my data these conscious entities, e.g. *biologists*, tend to be implied in the use of receptive clauses, rather than explicitly realised:

conscious entity (implied as Senser):

[3.47] No motile zoospore-like structures **were observed** [Process] (by me/us [Senser])

[3.52] both prokaryotic and eukaryotic organisms **were seen** [Process] (by me/us [Senser])

[3.94] Members of the Neocallimastigomycota **are** well **known** [Process] for inhabiting the rumen of ruminant grazers (by us/biologists [Senser])

[8] Note that the ownership type of possessive Deictic ^ Thing such as *its wheels* and *his kittens* construes a logico-semantic relation of enhancement rather than elaboration (a part/whole taxonomic relation) (Martin 1992, p. 314). Such structure does not construe one entity, but two.

The Phenomenon in mental processes of this kind typically realizes a non-conscious thing, such as *zoospore-like structure*, *prokaryotic and eukaryotic organisms*, and *members of the Neocallimastigomycota* above. I will come back to the discussion of things of this kind later. At this point, we can take a step forward with the conscious entity.

Turning to verbal processes, we can find that they also typically involve a conscious person, but in this case, one that is typically realised explicitly.

> conscious entity realised by Sayer:
> [4.29] <u>We</u> [Sayer] **propose** [Process] a model whereby smaller fungal spores are more likely to retain integrity and viability
> [4.105-106] <u>We</u> [Sayer] **propose** [Process] that size also becomes a determining factor in fracture initiation where fungal spores are concerned

In addition the data reveals that other types of Sayer are possible:

> [3.23] <u>Thorsen (1999)</u> [Sayer] **reported** [Process] the presence of Chytridiomycota in the digestive system of the irregular urchin, *Echinocardium cordatum*.
> [1.28-29] <u>Radioactivity method</u> [Sayer] **suggested** [Process] that the accuracy of the pipette was quite high throughout its range.
> [4.93] The <u>results</u> [Sayer] **suggest** [Process] that mandibular manipulation of ingested material determines the level of damage…

Reference to publications such as *Thorsen (1999)* will be referred to as publication entities. In addition to realization as Sayers (so-called ‘integral’ citation (Swales, 1990)), publications can be realized by Circumstances of Angle, although these are very rare in my data: *according to Thorsen (1999).* Much more commonly, they appear as ‘non-integral’ sourcing, realized not as part of grammatical structure, but rather appended at the end of the clauses:

> [3.57] The presence of microbial activity in both regular and irregular sea urchins **has been demonstrated** [Process]… (da Silver et. al. (2006), Sawabe et. al. (1995), Temara, De Ridder & Kaisin (1991), Thorsen (1999)).

As exemplified in [1.28-29] and [4.93] above other types of Sayer are also possible, i.e. *radioactivity method* and *results*. We also find that these non-conscious entities can occur in relational process, in which a figure is realised metaphorically (see section 4.2.5 in Chapter 4 for a discussion of these ideational metaphors).

[1.32] The weight-of-water method [Token] suggested **high levels of accuracy and precision throughout the pipette's range** [Value].

[4.125] other results [Token] corroborate **the loss of viability** [Value].

Non-conscious entities of this kind can be realised as Goal in material processes, along with the implication of conscious people realised by Actors, as in [1.6] and [1.76] below.

[1.6] …(we [Actor]) **using** [Process] three methods – weight-of-water, spectrophotometry and radioactivity [Goal]

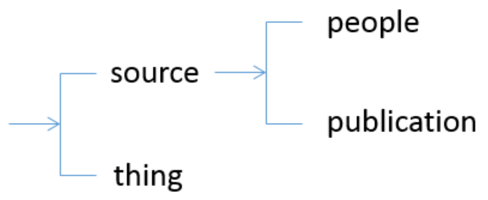
[1.76] … results [Goal] that were easily and efficiently **obtained** [Process] (by us [Actor])

Accordingly, while publications might be considered as topologically close to entities such as *method* and *result*, given their realisations by Sayers, a publication entity is not the entity that is enacted upon, but rather the one that initiates the enactment.

Thorsen (1999) [Actor] uses [Process] three methods [Goal]…

* Thorsen (1999) [Goal] is **obtained/used/done** [Process]

In this thesis, publications and people (*biologists, students*) are thus categorised under the general category of source[9], as outlined below. The network below also includes the entity type thing, as construed in the Phenomena in [3.47], [3.52] and [3.94] above.



While the entities realised as *method* and *results* can both function as Sayers in verbal processes and as Tokens in metaphorical relational processes, they are typologically different. Entities such as *result* can be used to symbolise a proposition as Token in a Token^Value structure, whereas this is not possible for entities such as *method.*

[4.93] The results [Sayer] **suggest** [Process] that mandibular manipulation of ingested material determines the level of damage.

[9] The differentiation between people and publication is less explicit in the discourse of humanities and social science than in that of science. For the discussion of the realisation of explicit and implicit knowers in discourse, see Hood (2011).

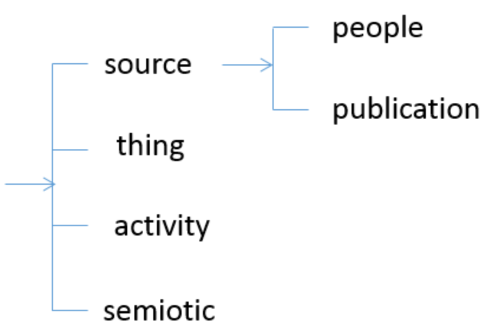
[4.93i] The <u>results</u> [Token] are [[that mandibular manipulation of ingested material determines the level of damage]] [Value]

[1.28-29] <u>Radioactivity method</u> [Sayer] **suggested** [Process] that the accuracy of the pipette was quite high throughout its range
[1.28-29i] * <u>Radioactivity method</u> [Token] is [[that the accuracy of the pipette was quite high throughout its range]] [Value]

What *can* be symbolised by entities like *method* is an act (Halliday & Matthiessen, 2014, p. 252), usually realized by a material process.

[1.28-29ii] <u>Radioactivity method</u> [Token] is [[to use spectrophotometer to test the calibration of pipette]] [Value]

Following Halliday & Matthiessen, we can distinguish here between acts (macrophenomena) and facts (metaphenomena): entities such as *method* name acts, while entities such as *results* name facts. Names of metaphenomena will be treated as semiotic entities; and names of macrophenomena will be treated as activity entities. I have now introduced two additional entity types into our description, semiotic entities and activity entities, as outlined below.



Alongside semiotic entities realized as names of facts we also need to make room for names of the other metaphenomena - locutions and ideas. These are exemplified below, first for ideas and then for locutions.

semiotic entity [idea] and mental process:
[2.30] This confirmed previous <u>knowledge</u> [[that lactose induces B-galactosidase activity]].
[cf. We <u>know</u> || that lactose induces B-galactosidase activity.]

semiotic entity [locution] and verbal process:
[3.70i] The <u>suggestions</u> [[that these organisms could be chytrid zoospores]] were further

reinforced by the study.

[cf. The result suggests || that these organisms could be chytrid zoospores.]

A summary of the nouns that typically realise semiotic entities (including facts, locutions and ideas) is provided in Halliday & Matthiessen (2014, p. 536), and reproduced as Table 3.4 below.

Table 3.4 Nouns of locution, idea and fact (adapted from Halliday & Matthiessen, 2014, p. 536)

			projection nouns	**fact nouns**
propositions	stating	locutions	statement; report, news, rumour, claim, assertion, argument, insistence, proposition, assurance, intimation	(1) 'cases' (nouns of simple fact): fact, case, point, rule, principle, accident, lesson, grounds
		ideas	thought, belief, knowledge, feeling, notion, suspicion, sense, idea, expectation, view, opinion, prediction, assumption, conviction, discovery	(2) 'chances' (nouns of modalization): chance, possibility, likelihood, probability, certainty, offchance, impossibility (3) 'proofs' (nouns of indication – caused modalization): proof, indication, implication, confirmation, demonstration, evidence, disproof
	questioning	locutions	question; query, inquiry; argument, dispute	(1') 'cases': issue, problem, conundrum (2') 'chances': uncertainty
		ideas	doubt, question	
proposals	offering	locutions	offer, suggestion, proposal, threat, promise	
		ideas	intention, desire, hope, inclination, decision, resolve	
	commanding	locutions	order, command, instruction, demand, request, plea	(4) 'needs' (nouns of modulation): requirement, need, rule, obligation, necessity, onus, expectation, duty
		ideas	wish, desire, hope, fear	

As can be seen in these categories, more delicate types of fact are further identified, including cases, chances, proofs and needs. The proof type, specifically, construes causality. My data demonstrate that the causality revealed by semiotic entities can be categorised into two subtypes: 'result' which refers to the perceived consequence; and 'proof' which refers to the interpreted consequence, exemplified in [4.167] and [4.149] below.

semiotic entity [fact: result]

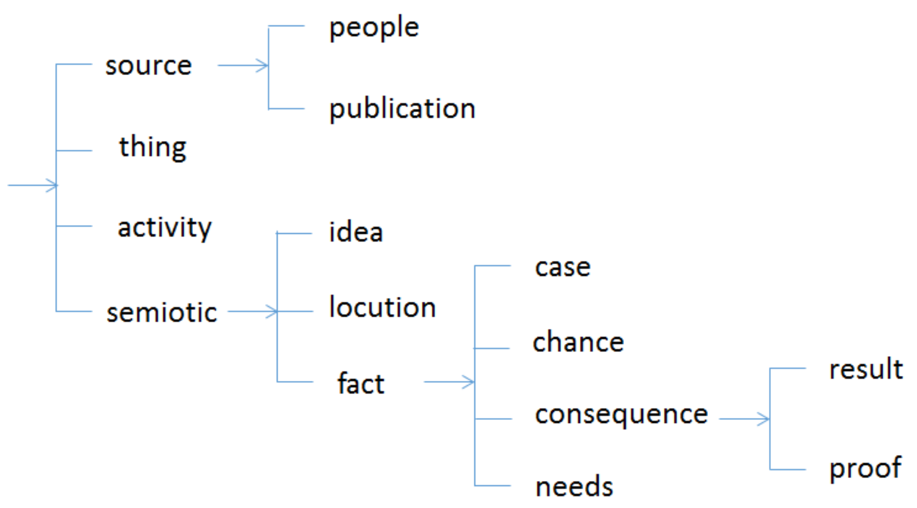
[4.167] The results of this investigation contribute to a growing body of literature documenting the role of insects in transporting fungal spores.

semiotic entity [fact: proof]

[4.149] The literature provides evidence that the compound is fungicidal.

This more delicate distinction is also suggested by Davidse (1991, p. 352). She distinguishes fact nouns that indicate causation between 'external causation' and 'internal causation', drawing on Halliday (1988/2004)'s distinction between external and internal causation realised by conjunctions. This suggests that semiotic entities that express causality can be distinguished into two subtypes. We can name the general category 'consequence', and then make a distinction between a **result type** and a **proof type**.

As we can see, the nouns representing facts, locutions or ideas are closely associated with nominalisations of conjunctions and of lexical verbs realising mental and verbal processes. This raises the question of whether nominalisations such as *suggestion, hypothesis, knowledge, evidence* construe a semiotic entity, or is a metaphorical realisation of other discourse semantic meaning in a nominal form. I will return to this issue in section 3.2.2.2 below, where the interactions of such nouns with the discourse semantic systems of CONJUNCTION and PERIODICITY are concerned. At this point, we can add the system of semiotic entities to our description.



We return at this point to the activity entity type introduced above, taking into account entities such as *method, experiment, study, project.* These entities refer to the activities of doing biology. These names of acts are typically configured in material processes with entities representing people who use the method, do the experiment or conduct the study. Within these, a further distinction can be made, according to their different realisations in Circumstances: entities such as *experiment* and *study* tend to be realised in Location; whereas entities such as *method* tend to be realised in Manner; various names of particular methods, such as *culturing method, dissection method, phylogenetic analysis*, can be found. For example (Circumstances are in bold, entities are underlined):

activity entity realised in Circumstance [Location]

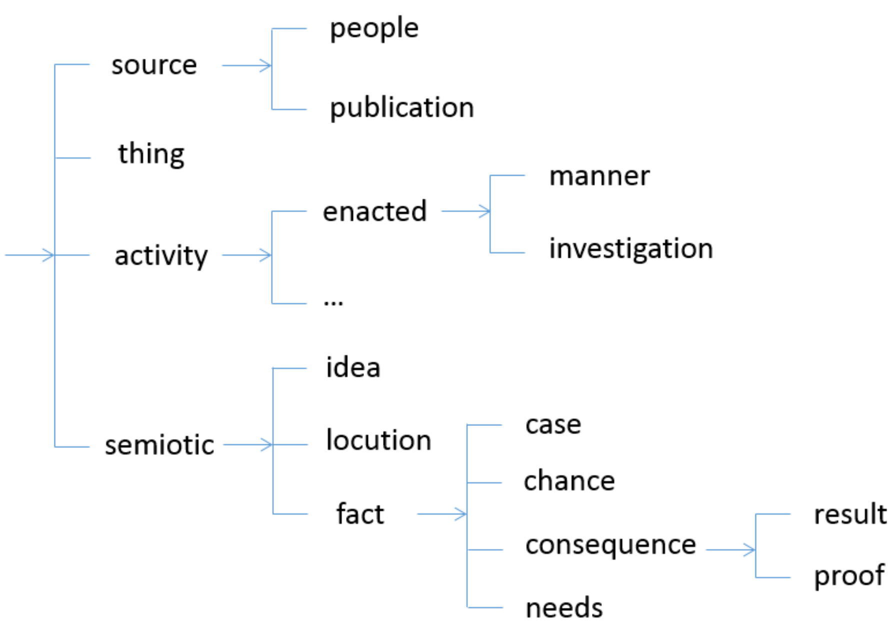
[1.5] **In this <u>experiment</u>** a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated

[4.108a] …the small but not large spores survived **in this <u>study</u>**…

activity entity realised in Circumstance [Manner]

[3.29] It also aimed to provide some evidence for the presence of chytrids within sea urchins, **through microscopic observation and <u>culturing methods</u>**.

These sub-types of activity entity can be distinguished as manner versus investigation. These research activities carried out by biologists contrast with activities observed by them (e.g. *gene expression, colonisation, maceration*), which will be discussed later. We can now expand our classification of entity types as follows.



Note that the category of enacted activity entities allows for entities that name the activity conducted in a particular field, which may also be realized in discourse semantics by sequences of figures setting out what goes on step by step: for further discussion of this point see section 4.4 in Chapter 4.

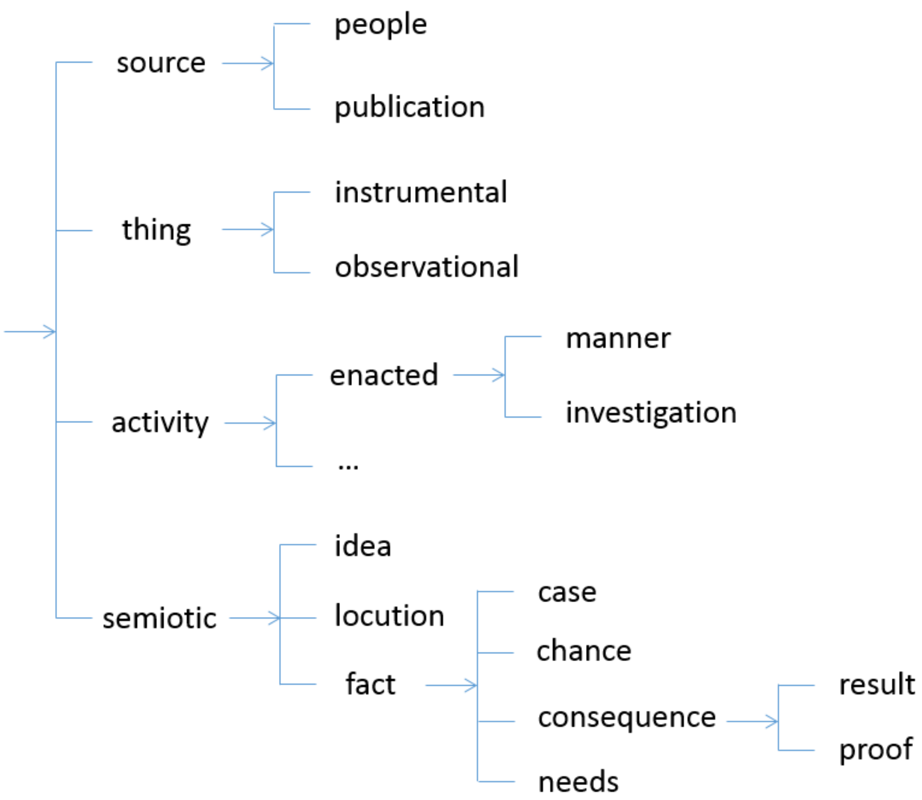
At this point we will take a further step in classifying the non-conscious thing entities introduced above as Phenomena in mental processes:

> thing entity realized by Phenomenon:
> [3.47] No motile <u>zoospore-like structures</u> [Phenomenon] **were observed** [Process] (by me/us [Senser])
> [3.52] both <u>prokaryotic and eukaryotic organisms</u> [Phenomenon] **were seen** [Process] (by me/us [Senser])

Thing entities can also be realised as Goals in material processes, with people entities realised as Actors (typically implicitly in receptive clauses).

> thing entity realized by Goal:
> [1.5] In this experiment a <u>Finnpipette</u> and a Bio-Rad P200 <u>pipette</u> [Goal] **were calibrated** [Process] (by <u>us</u> [Actor]).
> [2.12] <u>E. coli bacteria</u> [Goal] **were cultured** [Process] in a glycerol medium (by <u>us</u> [Actor]).

Thing entities realised by Goals in material processes are associated in the data with the tools and apparatus that are deployed in the laboratory to assist in the observation of scientific phenomena. In contrast, thing entities realised by Phenomena in mental processes refer to biological phenomena that are observed during laboratory experiments. Thus two types of thing entities can be distinguished as instrumental versus observational.



Instrumental entities can also be realised in Circumstances, either as Location or Manner:

instrumental entity realised in Circumstance [Location]

[1.8] set amount of water was pipetted (by us) **into a <u>container</u>** [Location]

[2.12] E. coli bacteria were cultured (by us) **in a <u>glycerol medium</u>** [Location]**.**

instrumental entity realised in Circumstnace [Manner]

[2.23] The reaction was stopped (by us) **with <u>sodium carbonate</u>** (6.9mM) [Manner]

We can also note that both instrumental and observational things are found in Focus^Thing configurations, but involving different types of Focus group (the identification of types of Focus group follows Martin et al., 2010, p. 170). Instrumental entities tend to involve measurement of the things:

the weight of water;
the volume of pipette;
the range of pipette.

Observational things, in contrast, are not just measured, but are associated with Focus structures that add classifying, re-counting or partitive meanings:

members of the phylum,
species of sea urchin

the number of spore;
the amount of B-galactosidase
the size of fungal spores,

part of the normal flora,
a section of the gut,
the same stage of their lifecycle,

We can see from these examples that instrumental entities are focused on measurement, while observational entities, in contrast, are oriented to construing taxonomic relations.

We now return to the activity entity that was introduced above. I have identified the enacted activity entity type which names a series of goings-on carried out by biologists. This type of activity entity is opposed to the other type, the observational activity entity, which names a series of goings-on observed by biologists. The distinction between the two is that the agents of enacted activities (manner and investigation) are people entities, whereas the agents of observational activities are observational things. The instigation of activities by observational things can be found either in a Thing^Qualifier or Classifier=Thing structure, as exemplified below. Note that the Thing^Qualifier structure can construe two entities (since Qualifier enhances the Thing instead of elaborating it), both the observational activity and observational thing; whereas in the Classifier=Thing structure, the observational thing is subsumed in the activity entity by the Classifier.

observational thing and observational activity realised in Thing^Qualifier:
[4.30] smaller spores more easily avoid maceration by insect mouthpieces…
[4.150] The alternative explanation for the absence of colonization by *Isaria*…

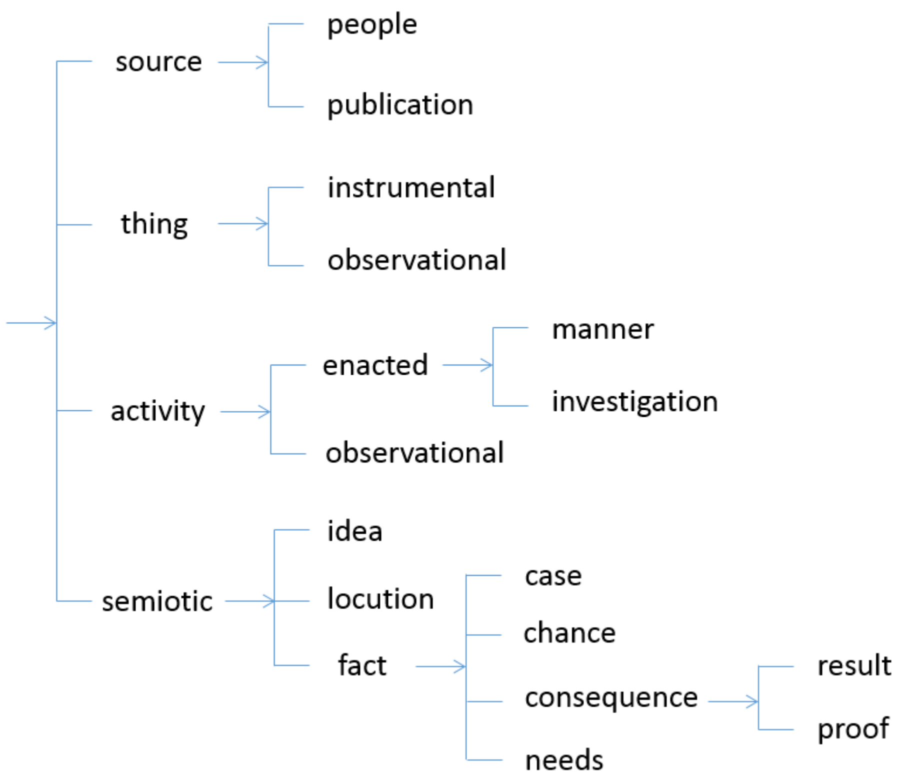
observational activity realised by Classifier=Thing:
[4.58] …by spraying a fresh PDA plate with spore solution and monitoring spore germination
[4.148] A number of invertebrate hosts have been shown to aid fungal spore dispersal

We can see from these examples that the realizations of observational activities rely heavily on nominalizations (*maceration, colonization, dispersal, germination*). As has been discussed in Chapter 2 (section 2.4.3.2), not all nominalizations are grammatical metaphors that create stratal tension between lexicogrammar and discourse semantics. These nominalisations exemplified above do not entail stratal tension because they are discourse semantic entities, not events. As entities, these instances construe taxonomies in the field. Their status of being an entity is typically established through field-specific defining Token^Value structures (the ways of defining entities will be discussed in detail in section 3.2.3 below). For example, *dispersal* is defined in the biology textbook as follows (Campbell & Reece, 2005, p. 1084):

The movement of individuals away from centre of high population density or from their area of origin	*is called*	*dispersal*
Value	Process	Token

Defined in this way, the goings-on construed in the Value can be distilled as the entity *dispersal*. Part of the pay-off of naming goings-on through nominalisations is taxonomising, since in English grammar, nouns have more potential to be classified than verbs (Halliday, 1998; Wignell et al., 1993). This allows activity entities to enter into taxonomic relations with other activity entities. For example, once *dispersal* is an entity, it can be categorized into different kinds through Classifiers (e.g. *spore dispersal* and *seed dispersal*); and within *seed dispersal*, a further classification can be made between *autochory seed dispersal* and *allochory seed dispersal*. Therefore, through nominalizations, series of goings-on in the field can be named and defined as entities for the purpose of taxonomy building in the field.

We can now add the category of observational activity into our entity types below.



To this point, four primary entity types in the data texts have been identified: source, thing, activity and semiotic. Two other entity types, place and time, are also found in the data:

place entity realised in Location:

[3.30] Three species of regular sea urchin were collected from the rocky-intertidal region **at <u>Chowder Bay</u>** [Cir. Location]**.**

[3.14] Chytridiomycota are found **in <u>aquatic and terrestrial habitats</u>** [Cir. Location].

time entity realised in Time:

[3.36] Samples taken from *E. heliocidaris* and *P. phyllacanthus* were stored at four degrees Celsius **for a <u>week</u>** [Cir. Time].

[4.72] The plates were observed **over a period of 4-14 <u>days</u>** [Cir. Time].

Place and time occur less frequently in the data, and their realisations tend to be restricted to Circumstances; we can compare their realization by Participants in other fields, including everyday field and exploration fields such as geography, geology, and history:

<u>place entity</u> realized by Participant in everyday conversation:

The <u>park</u> in our neighbourhood is full of ginkgo trees.

place entity realized by Participant in geography text (from Wignell et al., 1993):
Desert streams usually drain down into the lowest portions of nearby desert basins which are called bolsons.

time entity realized by Participant in everyday conversation (from Painter, 1999, p. 123):
S: How come it's a bigger day when it's summer?

time entity realized by Participants in history text:
The Year 200 BC was a year of the pre-Julian Roman Calendar.

An overview of the entity categories identified so far from below is displayed in Figure 3.2 below.

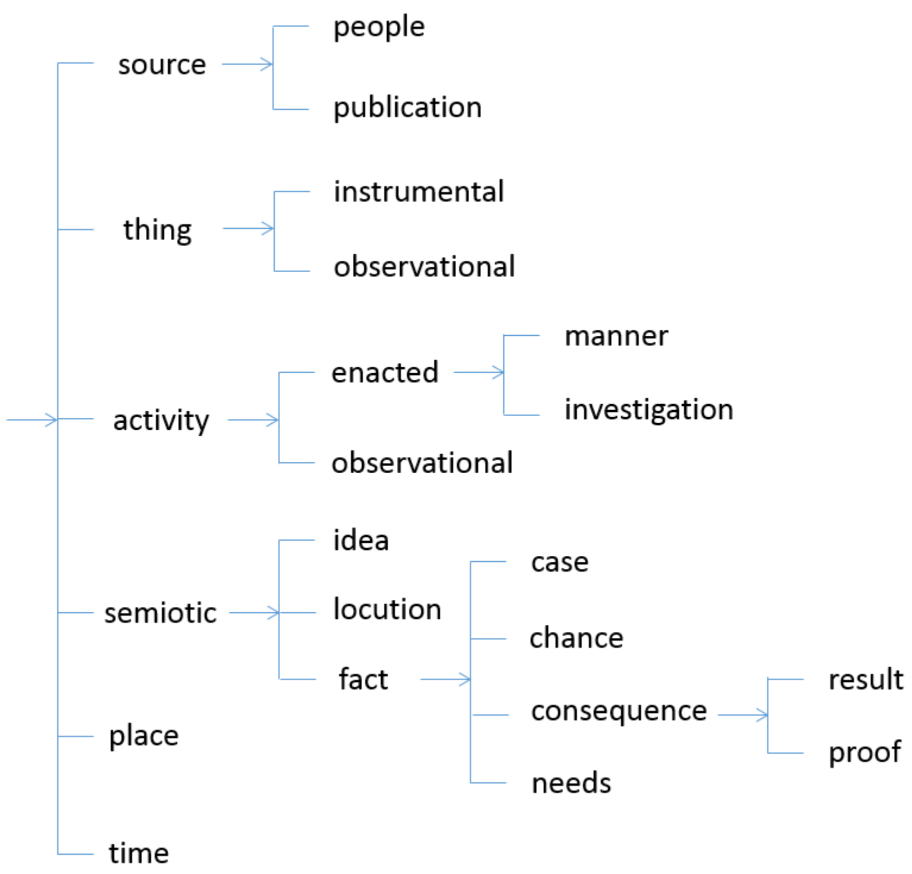


Figure 3.2 ENTITY TYPES in biology

3.2.2.2 Entities at discourse semantics

In the last section, I explored entity types by looking from below in terms of their realisations in the experiential grammar. In this section, entities are investigated by looking from roundabout at the level of discourse semantics. The interactions between entities and other discourse semantic systems sheds light on the categories of entities.

3.2.2.2.1 Entity and ATTITUDE

In investigating the attitudinal resources in the discourse of biology from an interpersonal perspective, Hao & Humphrey (2012) found that the appreciation type of ATTITUDE (Martin & White, 2005) is a particularly significant interpersonal resource to persuade readers of the legitimacy of a study. Extending the typology of appreciation established in Martin & White (2005), Hao & Humphrey (2012) suggest that a more fine-grained categorisation of appreciation in their data is necessary according to the various couplings between the interpersonal resource of appreciation and ideational resources such as biological phenomena, method and study in their data. Their categorisation of appreciation in the discourse of biology is shown in Table 3.5 below.

Table 3.5 Appreciation in the discourse of biology (from Hao & Humphrey, 2012)

Appreciation in Biology		**inscribed (positive)**	**inscribed (negative)**
valuation	Prominence *Is it prominent?*	*significant, basic, core, main, substantial, remarkable, key, major, well-known, integral, play a role…*	*minor, less, not enough…*
	Social/environmental Benefit *Is it beneficial?*	*beneficial, advantageous, favourable, harmless, significant, vital, essential…* *(v.) improve, cure, treat, strengthen, relieve, protect, contribute to…*	*harmful, problematic, alarming, disadvantageous, damaging, dangerous, unsafe, poor…*
	Necessity *Is it necessary?*	*needed, necessary, useful, required, helpful, urgent…*	
	Worthiness *Is it worthwhile?*	*worthy, profound, helpful, promising, expected …*	
	Effectiveness *Is it effective?*	*effective, reliable, proper…*	
composition	Efficiency *Is it efficient?*	*efficient, inexpensive, productive…*	*time-consuming, expensive unproductive, deficient, laborious…*
	Completeness *Is it complete?*	*detailed, comprehensive, thorough, conclusive, holistic, systematic…*	*preliminary, unknown, partial, inadequate, unanswered…*
	Clarity *Is it clear?*	*clear, explicit, obvious…*	*obscure, unclear…*
	Complexity *Is it easy to be dealt with?*	*simple, easy, convenient…*	*complex, complicated, difficult, indistinguishable, inconvenient…*
reaction	Interest *Is it interesting to study?*	*interesting, fascinating…*	

Drawing on these appreciation categories, we can explore how the types of entity are combined with evaluation in my data. Starting from thing entities, we can find that observational things are combined with the valuation subtypes of prominence and social/environmental benefit.

observational thing + **valuation** [prominence]
[3.15] Members of this phylum are **ecologically important**,
[4.100] Mandibles **play a crucial role** in the digestive process of the locust by fragmenting ingested plant material

observational activity + **valuation** [benefit]
[4.17] insect-fungi interactions may also be **detrimental** to both groups

In contrast to observational things, the other subtype, instrumental things, tend to be evaluated through the resources of composition.

instrumental thing entity + **composition** [complexity]
The equipment was **easy to use**.

The different kind of bonding with valuation versus composition can thus be seen to interact systematically with the typological distinction between the two sub-types of things.

Apart from evaluating instrumental things, resources of composition can also be used to evaluate semiotic entities. In particular, the sub-type of completeness, which is concerned with whether the entity is complete and thorough, and the subtype of clarity, which is concerned with whether the entity is explicit and clear, are commonly combined with semiotic entities.

semiotic entity + **composition** [clarity]
[1.60C] The data in this experiment are highly **variable**.
[1.76] the spectrometer provided results that were **easily and efficiently obtained**.

semiotic entity + **composition** [completeness]
[4.94] Such findings are **consistent** with current understanding of food processing by members of the Acrididae…
[3.71] Such findings in regular sea urchins **have not been reported previously**.

I have shown in the previous section that semiotic and enacted activity entities are closely related topologically, given that both types can be realized by Sayers in verbal processes, and both can be configured with metaphorically realized figures in relational processes. The closeness between the two is further reflected by their combination with similar attitudinal resources. For example, it is found that both semiotic and activity entities can be combined with composition [completeness], such as the evaluation of semiotic entities *findings* in [4.94] and [3.71] above, and the evaluation of the enacted activity *research* in [3.129] below.

> enacted activity + **composition** [completeness]
> [3.129] there has been **limited** research on both the identification and role of microbes…

While semiotic and enacted activity entities can be evaluated in a similar way, enacted activities can also be evaluated with various evaluative resources other than composition [completeness]. For example:

> enacted activity + **valuation** [worthiness]
> [4.36]…making such a study **ecologically realistic and important**

> enacted activity + **composition** [efficiency][10]
> [1.47] This method was **time consuming**

We can also see that at a more delicate level, the subtypes of enacted activity, investigation and manner, are oriented to different types of attitude. As the examples below show, investigation entities can be evaluated through composition [completeness] and valuation [worthiness]; while manner entities can be evaluated through composition [efficiency]. These different couplings thus confirm our typological distinction between the two types of enacted activity.

> enacted activity [investigation] + **valuation** [worthiness]
> [4.36]…making such a study **ecologically realistic and important**

> enacted activity [investigation] + **composition** [completeness]
> [3.129] there has been **limited** research on both the identification and role of microbes…

[10] Note that according to Hao & Humphrey (2012), effectiveness and efficiency are at the border between valuation and composition. Since the distinction between valuation and composition is that between perception and cognition (Martin & White, 2005, p. 57), effectiveness, which is oriented to the cognition type of mental process (i.e. we think it is effective), is treated as subcategory of valuation; whereas efficiency, which usually requires measurement, is oriented to the perception type of mental process (i.e. we can see it is efficient).

enacted activity [manner] + **composition** [efficiency]

[1.47] This method was **time consuming**

[1.51] This method could prove **more efficient** in calibrating tools

In my data, no evaluations of time and place entities are found. This is not surprising since time and place are not salient entity types in the discourse of biology.

From an interpersonal perspective, the investigation of how entity types interact with attitudinal resources then reinforces the typology of entities put forward above.

3.2.2.2.2 Entity and PERIODICITY

I move next to the textual metafunction, to look at how entities interact with the system of PERIODICITY (see Martin & Rose, 2007, Chapter 6). Periodicity is concerned with the way in which discourse semantic meanings are packaged in text in order to construct the information flow in a way that makes it accessible for readers. The information in a text may be predicted by higher level Themes, i.e. hyperTheme or macroTheme, and consolidated in higher level News, i.e. hyperNew or macroNew. In the current data, higher level Themes and News often involve semiotic entities.

As discussed in section 3.2.2.1 above, semiotic entities include subtypes of fact, locution and idea; and more delicate categories of fact nouns, including case, need, chance and consequence, can also be identified (c.f. Halliday & Matthiessen, 2014, p. 536). These semiotic entity types are exemplified in Table 3.6 below.

Table 3.6 Semiotic entity types

locution			*statement, report, news, question, argument, proposition*
idea			*thought, belief, knowledge, feeling, idea, doubt, desire, hope*
fact	case		*fact, case, point, principle, problem, limitations*
	chance		*chance, possibility, probability, certainty*
	need		*need, requirement, rule, obligation, duty*
	conseq.	result	*result, findings, consequence*
		proof	*proof, evidence, indication, implication, confirmation*

Following this framework, I will briefly exemplify the correspondence between higher level Themes and News and different kinds of semiotic entities in my data. Firstly in terms of using semiotic entities to organise higher level Themes, examples [3.118 ff.] and [3.128 ff.] below demonstrate that entities [case] and [proof] function to preview the subsequent texts.

interaction between hyperTheme and semiotic entity [case]:

[3.118 ff.]

hyperTheme There were a number of **<u>aspects</u>** which were unaddressed in this report and should be accounted for in future studies
Firstly, it remains unclear whether the zoospore-like structures were chytrids, or if they belonged to another fungal group... Secondly, the components of the digestive tract and coelom of sea urchins vary greatly, with each section having differing roles and environmental conditions – including variation in pH, chemical composition, oxygen concentration and toxicity...

interaction between hyperTheme and semiotic entity [fact: proof]:

[3.128 ff.]

hyperTheme The identification of microorganisms within sea urchins, and attempts to understand their role in such a relationship is significant for a number of **<u>reasons</u>**.
(Firstly,) as there has been limited research on both the identification and role of microbes within the Echinodermata... Secondly, the Chytridiomycota are a polyphyletic taxon, which are characterised by the presence of flagellated zoospores... Furthermore, symbiotic microorganisms, including anaerobic fungi, have been shown to increase the efficiency of nutrient uptake, and may be necessary for herbivory...

The case entity *aspects* in [3.118 ff.] is used to name a number of subsequent propositions. These propositions are organised in the text in order of succession through the internal conjunctions *firstly*, *secondly*, etc. Similarly in [3.128 ff.], the proof entity *reasons* is used to name several propositions in the subsequent text. These propositions are not only organised successively in the text, but at the same time are related causally to the hyperTheme. The semiotic entities *aspects* and *reasons* therefore allow the propositions in the texts to be previewed in the hyperThemes.

Secondly, semiotic entities involved in higher level News can also be found, as in excerpt [1.77 ff.] below: the case entity *disadvantages* and the need entity *needs* attend to the organisation of the macroNew in the text. The student writer labels this stage of the text as Conclusion.

interaction between macroNew and semiotic entities [case & need]:

[1.77 ff.]

... **(Discussion)** ...
macroNew **(Conclusion)** The different methods used in pipette calibration contained varying degrees of accuracy. Although the use of the weight-of-water method was simple and inexpensive, it did not provide an accurate representation of the accuracy and precision of the pipette. Similarly there were **disadvantages** associated with the radioactivity method including high costs and elaborate preparation. Instead, spectroscopy provided results that balanced the **need** for high levels of precision and accuracy with safety, speed and efficiency.

The semiotic entities *disadvantages* and *need* in the macroNew are used to refer to what has gone before: they name, respectively, the proposition 'how the radioactivity method is disadvantageous', and the proposal 'what is required in the experiment', both of which have been discussed in the preceding text. The semiotic entities in the higher level News thus help to encapsulate the propositions and proposals in the preceding text.

Semiotic entities can thus play a useful role in organising texts. We need to note that, in some texts, nominalisations such as *disadvantage, need, limitation, reason* may need to be treated as ideational metaphors instead of entities. One criterion I draw on in this thesis to distinguish between semiotic entities and ideational metaphors has to do with whether the fact, locution or idea nouns positioned in higher level Themes and News function to preview and review pieces of text. There could of course be ideational metaphor within higher level Themes and News, but it would be working *inside* the hyperTheme and hyperNew, rather than relating the hyperTheme and hyperNew to subsequent and preceding texts. Therefore, nominalisations that organise discourse through periodicity will be treated as a discourse semantic resource – i.e. semiotic entities; they do not create stratal tension between discourse semantics and lexicogrammar.

In addition, the use of the Focus group *a number of* in [3.118 ff.] and [3.128 ff.] above suggests that *reasons* and *aspects* can be quantified, which is one of the systems associated with entities. This point will be discussed further in section 3.3 below.

In several texts in the data, semiotic entities are used as subheadings to name chunks of text, including *Introduction, Method, Results, Discussion* and *Conclusion.* These subheadings can be treated as field-specific semiotic entities which refer to propositions construed by systematic linguistic patternings. These semiotic entities are employed in laboratory and research reports as a shared metalanguage in organising texts.

From the perspective of the logogenetic unfolding of text, periodicity can shed light on the identification of semiotic entities. It provides useful criteria to distinguish semiotic entities from ideational metaphors.

3.2.2.2.3 Entity and CONNEXION

To this point we have looked at the interactions between entities and ATTITUDE, and between entities and PERIODICITY, I now move on to the logical metafunction to explore the interaction between entities and the system of CONJUNCTION (hereafter CONNEXION)[11].

Connexions function in the discourse to relate figures into sequences, and sequences further construe activity and implication sequences in a field. In the CONNEXION system, a primary distinction is made between external and internal logical relations (Halliday & Hasan, 1976; Martin, 1992). Martin (1992, p. 180) explains that the external relations are oriented to what is going on in the field, whereas the internal relations attend to the organisation of text itself. He identifies a simultaneous system of additive, comparative, temporal, and consequential connexions. Within external consequential connexions, he also recognises choices of manner, consequence, condition, purpose and concession (see Figure 3.3 below).

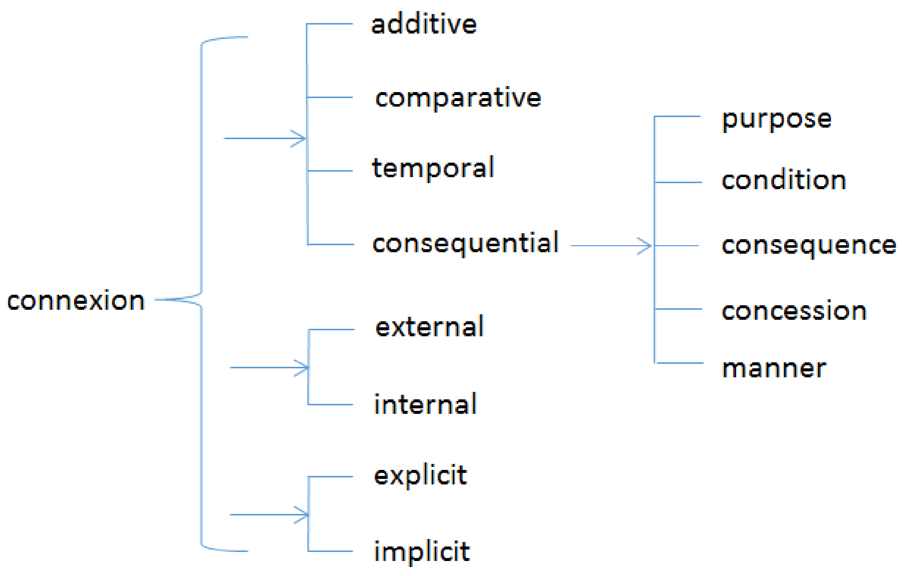


Figure 3.3 CONNEXION system (c.f. Martin, 1992)

[11] In this thesis, the logical relations that connect goings-on at the level of discourse semantics are renamed **connexion** instead of conjunction (see Chapter 4), in order to avoid the terminology confusion with the lexicogrammatical system of CONJUNCTION (e.g. Halliday & Matthiessen, 2004/2014).

Analysing the data in relation to this connexions framework, it is found that consequential connexions, both external and internal ones, can be related to certain fact-type semiotic entities with respect to the similar work they do in construing field, that is, both connexions and semiotic entities can construe causal relations in an implication sequence (for a detailed discussion of the realisation of implication sequences in discourse, see Chapter 4).

In the discourse semantics, this brings us to the borderline between semiotic entities and logical metaphors. One strategy for distinguishing semiotic entities from logical metaphors, as was discussed in the previous section, is by considering their role in higher level Themes and News. In [3.128 ff.] the word *reason* predicts three sections of discourse motivating the author's claim about the significance of a biological relationship. The reasons are themselves related to one another through internal temporal and additive connexions.

<u>semiotic entity [fact: proof]</u>: **internal connexion** [consequence]

[3.128 ff.]

hyperTheme The identification of microorganisms within sea urchins, and attempts to understand their role in such a relationship is significant for a number of **<u>reasons</u>**.
(Firstly,) as there has been limited research on both the identification and role of microbes within the Echinodermata, Secondly, the Chytridiomycota are a polyphyletic taxon, which are characterised by the presence of flagellated zoospores... Furthermore, symbiotic microorganisms, including anaerobic fungi, have been shown to increase the efficiency of nutrient uptake, and may be necessary for herbivory...

In examples such as these, a term like *reasons* functions as the name for the causes predicted by the higher level Theme (e.g. *reasons = there has been limited research… etc*.). Note the contrast with the meaning of *reason* in the following example, where it encodes the causal relationship between two figures (for the detailed discussion of figures, see section 4.2 in Chapter 4):

The **reason** for the fact [[that the identification of microorganisms is significant]] is [[that there has been limited research on this topic]]

c.f. It is significant to identify microorganisms **because** there has been limited research

In this example a sequence is realised by the clause. One of the figures, which is named as a fact (i.e. *the identification of microorganisms is significant*), refers to the effect of the other figure (*there has been limited research*). The causal relation between the figures is realised metaphorically by the noun *reason.*

discourse semantics	sequence		
	figure + connexion		figure
utterance	*The reason for the fact [[that the identification of microorganisms is significant]]*	*is*	*[[that there has been limited research on this topic]]*
lexico-grammar	Vl/Id	Process: inten.ident.	Tk/Ir

It can be suggested that, when functioning as semiotic entities, the terms in question are names for figures which function as causes or effects, but when functioning in grammatical metaphors, the terms in question encode a conjunctive relation between figures.

In this section, by looking around at the level of discourse semantics, I have explored the ways in which entities interact with interpersonal, logical and textual discourse semantic resources. This has helped confirm the validity of the entity typology at the level of discourse semantics. In addition, the interactions between entities and other discourse semantic systems have helped us develop a strategy for distinguishing between semiotic entities and grammatical metaphors.

3.2.3 Entity – how are meanings transmitted?

In the last section, I focused on the entity types which enable some meanings in fields to be construed, for example utilitarian tools, methods, biological phenomena, and so on. As has been pointed out earlier, when looking from above, we can take a second perspective to reveal the nature of field: that is, to look at how these meanings are made in different modes. In distinguishing fields, Martin (1992) has suggested that one distinction between exploration fields and commonsense/specialised fields is their different modes of meaning transmission. His observation is that meanings in exploration fields tend to be transmitted in the written mode, whereas meanings in commonsense and specialised fields tend to be transmitted through the spoken mode, in combination with visual images, gestures, etc. (see also Gamble, 2001). Therefore, in order to further understand the distinction between exploration and specialised fields, in this section I will focus on how meanings of entities are transmitted in different modes. In order to do so, I will draw on spoken texts from Painter's (1999) study of pre-school language development, as well as written texts from Wignell et al.'s (1993) study of geography textbooks. The biology textbook (Campbell & Reece, 2005) which is used in the student's core subjects will be also referred to. The specific focus here is on the ways in which entities are defined and organised as taxonomies.

I consider definitions of entities from the perspectives of discourse semantics and lexicogrammar. The discourse semantic systems IDEATION (Martin, 1992, Chapter 5; Martin & Rose, 2007, Chapter 3) and IDENTIFICATION (Martin, 1992, Chapter 3; Martin & Rose, 2007, Chapter 5) are particularly relevant to the investigation. The relevant IDENTIFICATION systems are displayed in Figure 3.4 below.

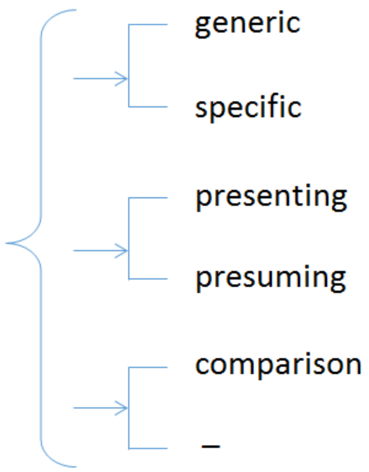


Figure 3.4 Three central IDENTIFICATION systems (from Martin, 1992, p. 105)

At the level of lexicogrammar, the TRANSITIVITY system is drawn on to analyse how definitions are realised grammatically. In the following sections, I will discuss the definitions of entities in spoken mode before moving on to explore the written mode.

3.2.3.1 Entities in spoken transmission

Painter (1999) reports on the ontogenetic development of child language from the age of 2 to 5. Introducing entities to Stephen occurs at very early stages of his language development through naming tangible objects in his world. Here is an example recorded when Stephen was at the age of 2 years (Painter, 1999, p. 84):

(S watching M dress)
S: What are **these**?
M: Nipples.
S: Nipples.

S: What's **that**?

M: **That**'s my belly button.

In this example, Stephen verbally refers to specific things (i.e. *nipples, belly button*) by using the exophoric reference *these* and *that.* These things are observable to Stephen and his mother in the material context of situation. His mother assigns the names to the specific things also using exophoric reference. Grammatically, this naming process is realised by the encoding type of intensive identifying clause.

exophoric

discourse semantics	presuming & specific: exophoric pointing to the thing		entity [thing] specific
utterance	*That*	*is*	*my belly button*
lexicogrammar	Vl/Id	Process: int. iden. (encoding)	Tk/Ir

Following Martin (2007), these definitions can be seen to involve ostensive definition – that is, defining an entity by pointing exophorically to an object. This type of entity is referred to here as an **ostensively defined** entity.

At a later stage of Stephen's language development, entities are introduced differently. In the following episode (Painter,1999, p. 124), the entity *order* is introduced to Stephen. The linguistic definition of *order* offered by mother is in bold.

S: Mummy, it's a question that you don't eat porridge with your fingers. (pause) It's a question that you don't eat porridge with your fingers.

M: That's not a question it's an order.

S: What's an order?

M: **It's something that you tell somebody and they have to do**.

S: I meant an order.

In this dialogue, *order* is firstly named by *it's an order*, and so distinguished from a *question.* However, naming the situation is inadequate to fully define the meaning *order*. The mother then offers a definition of order using an intensive identifying process *an order is something that you tell somebody and they have to do*. Note that *order* is presented as a generic entity, rather than a specific one like *my belly button*.

discourse semantics	entity [semiotic] generic		
utterance	*it (an order)*	*is*	*something [[that you tell somebody and they have to do]]*
lexicogrammar	Tk/Id	Process: int. iden. (decoding)	Vl/Ir

The definition of *order* in this example is distinct from the ostensively defined entities (e.g. *nipples*, *belly button*) illustrated above, since it relies solely on linguistic resources. This type of entity will be referred to as a **linguistically defined entity** (c.f. Martin, 2007).

While both ostensive definition, e.g. the *nipples* and *belly button* example, and linguistic definition of an entity, e.g. the *order* example, are found in the spoken mode, they can be distinguished in a number of ways. Firstly, grammatically, the ostensively defined entity is realised through an encoding type of intensive identifying process, whereas the linguistically defined entity is realised through a decoding type (for the grammatical distinction between encoding and decoding types, see Halliday, 1968, 1994 and Davidse, 1991). Secondly, in terms of their identification, the ostensively defined entity is very likely to be specific, given the exophoric reference to a tangible thing in the material situation; whereas the linguistically defined entity tends to be generic.

entity	identification	process type	example
ostensively defined	exophora	intensive identifying [encoding]	*That is my **belly button.***
linguistically defined	generic	intensive identifying [decoding]	*An **order** is something that you tell somebody and they have to do.*

We can thus identify two types of entity according to their distinct definitions.

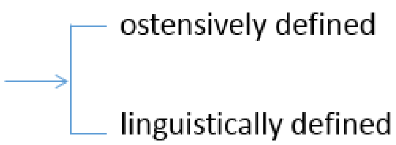


Figure 3.5 DEFINITION system of entities

While linguistic definitions are useful when the entity is not ostensively present, e.g. *order*, it is sometimes challenging to define an entity linguistically for young children in the spoken mode. In this episode below (Painter, 1999, p. 120), the mother uses a material process to provide an explanation of ‘what electricity does’ rather than using an identifying process to give a definition of ‘what electricity is’ (see also the example of *council* in Painter, 1999, p. 119).

> (M warns S not to play with wall socket)
> M: It’s a switch for electricity.
> S: (? But what is it?)
> M: It’s for electricity.
> S: But I don’t know what it looks like.
> M: No, well, you can’t see it. **The electricity makes things go**…

As Painter points out, the answer to *what it is* would require locating the entity in terms of its taxonomic relations to other entities (p. 120). For example, *electricity* needs to be explained in relation to entities such as *energy, electrons, currents*, and so on, which are not part of domestic life. To provide a satisfactory definition of an entity such as *electricity* requires institutional training in a field-specific subject.

3.2.3.2 Entities in written transmission

In the pedagogic texts discussed in Wignell et al. (1993), as well as in the students’ biology textbook (Campbell & Reece, 2005), new terminologies are predominantly introduced linguistically. In contrast to a linguistically defined entity (e.g. *an order is something you tell somebody and they have to do*) in the spoken mode, those in the written mode have distinctive features at the levels of both lexicogrammar and discourse semantics.

Grammatically, the definition of an entity in the biology textbook can also involve an intensive identifying process. Both the decoding and encoding subtypes of intensive identifying process are evident. In the decoding type, exemplified in [a] below, the entity is situated in the Theme position and its meaning is ‘unpacked’ through other entities.

> [a] A lysosome is a membranous sac of hydrolytic enzymes that an animal cell uses to digest all kinds of macromolecules (Campbell & Reece, 2005, p. 107)

utterance:	*a* ***lysosome***	*is*	*a membranous sac of hydrolytic enzymes that an animal cell uses to digest all kinds of macromolecules.*
lexicogrammar	Tk/Id	Process: int. iden. (decoding)	Vl/Ir

In contrast, an entity defined in the encoding type has the opposite coding direction. It is a ‘naming process’, used to label what the scientific phenomenon *is called*:

[b] The entire region between the nucleus and the plasma membrane is called the cytoplasm (Campbell & Reece, 2005, p. 98).

utterance:	*the entire region between the nucleus and the plasma membrane*	*is called*	*the **cytoplasm***
lexicogrammar	Vl/Id	Process: int. iden. (encoding)	Tk/Ir

In both the decoding ('unpacking') and encoding ('naming') types of intensive identifying process, the defined entities are realised by Tokens, and their definitions are realised by Values. Wignell et al. (1993) point out that the Token/Value relationship in identifying clauses is just one kind of grammatical structure that realises the general relationship of '*x* defines *y*'. They found that this elaborating relationship can be realised in various grammatical forms, including embedded defining relative clauses, elaborating nominal group complex, and elaborating conjunctive relations within a clause; as well as involving anaphoric reference (e.g. *this*) to encapsulate meanings that are realised in one or more preceding clauses (Wignell et al., 1993, pp. 167-168). These various ways of defining entities are exemplified below; the definitions are highlighted in bold, and the elaborating relationships are marked by '='.

[c] defining an entity through elaborating nominal group complex; term elaborated by definition
All cells have **ribosomes, = tiny organelles [[that make proteins according to instructions from the genes]]**

[d] defining an entity through elaborating nominal group complex; definition elaborated by term
Within the membrane is **a semifluid substance, = cytosol**…

[e] defining an entity through embedded clause
Mature plant cells generally contain a large central vacuole enclosed by **a membrane [[= called the tonoplast]]**.

[f] anaphoric reference to an entity
You have probably learned the meaning of the term **transpiration** in your science lesson. **=** **In this process**, **plants lose water in the form of vapour through their leaves, this water is replaced with water containing plant food collected by the plant roots...** (Wignell et al, 1993, p.168)

As realisations of elaboration, these various forms are agnate to intensive identifying processes, either the encoding or decoding type. We can reconstruct the examples just presented as intensive identifying processes at the clause rank, as exemplified below.

utterance [c]	***ribosomes***	*are*	*tiny* ***organelles*** *[[…]]*
lexicogrammar	Tk/Id	Process: int. iden. (decoding)	Vl/Ir
utterance [d]	*…a* ***semifluid substance****, (which)*	*is called*	***cytosol***
lexicogrammar	Vl/Id	Process: int. iden. (encoding)	Tk/Ir
utterance [e]	*a* ***membrane****, (which)*	*is called*	*the* ***tonoplast****.*
lexicogrammar	Vl/Id	Process: int. iden. (encoding)	Tk/Ir
utterance [f]	***transpiration***	*is*	***a process*** *[[whereby…]]*
lexicogrammar	Tk/Id	Process: int. iden. (decoding)	Vl/Ir

In students' laboratory and research reports, few entities are defined through intensive identifying processes at the clause rank. However, several linguistic definitions at the group rank via nominal group complexes are evident, occurring particularly in the Introduction sections. For example in [2.4] below, the entity *B-galactosidase* is defined through unpacking, and the entity *Echinocardium cordatum* in [3.23] is defined through naming.

> [2.4] In this experiment the activity of B-galactosidase [Tk/Id], = an enzyme which breaks down lactose [Vl/Ir], was studied.

> [3.23] Thorsen (1999) reported the presence of Chytridiomycota in the digestive system of the irregular urchin [Vl/Id], = Echinocardium cordatum [Tk/Ir]

This preference for defining entities at the clause rank may be due to the fact that the purpose of laboratory and research reports is to demonstrate prior knowledge, rather than, as in pedagogic texts, to introduce new knowledge.

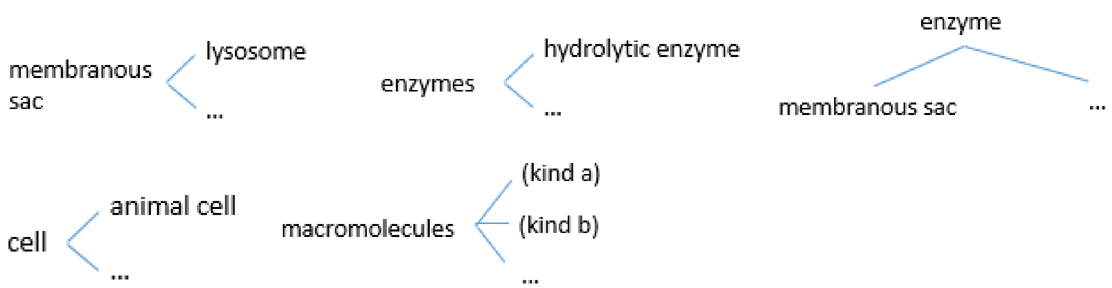
To summarise our analyses so far, we have found that ostensively defined entities are characteristic of the spoken mode, whereas linguistically defined entities have been found in both modes (see Table 3.7). Grammatically, both the decoding and encoding types of intensive identifying processes can be used to define entities in these modes.

Table 3.7 Definition of entities in spoken and written mode

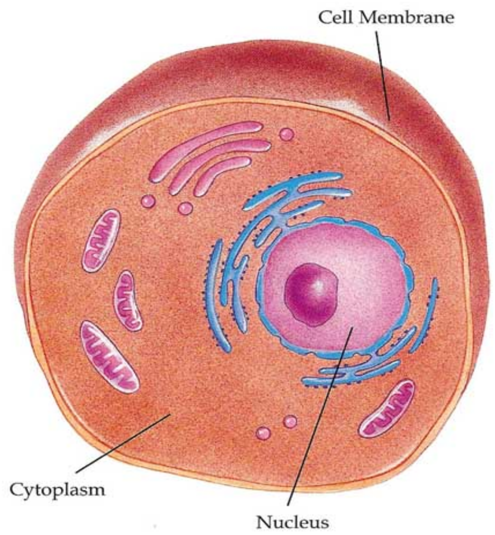
	ostensively defined entity	**linguistically defined entity**
spoken mode	**encoding**: *That is my belly button.*	**decoding**: *An order is something that you tell somebody and they have to do.*
written mode		**decoding**: *A lysosome is a membranous sac of hydrolytic enzymes that an animal cell uses to digest all kinds of macromolecules*
		encoding: *A semifluid substance is called cytosol.*

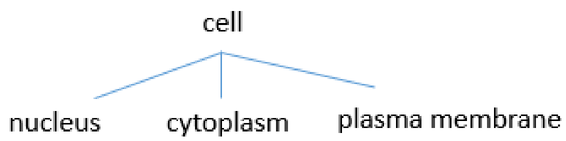
Note in Table 3.7 that the linguistic definition of entities in both speaking and writing can be realised by the decoding type of intensive identifying process. The distinction between the two is therefore not revealed through experiential grammar. However, in the discourse semantics the definitions in written mode reveal distinct ideational features from those in the spoken mode.

The data show that a linguistic definition of an entity in the written mode may explicitly construe taxonomic relations between entities. Consider example [a]: *a lysosome is a membranous sac of hydrolytic enzymes that an animal cell uses to digest all kinds of macromolecules.* In this definition, a classification relation is first established between the defined entity *lysosome* and *membranous sac.* The entity *membranous sac is* then related to *hydrolytic enzyme* by a Thing^Qualifier structure – *a membranous sac of hydrolytic enzymes*, which suggests a taxonomic relation of composition: that is, *membranous sac* is part of *hydrolytic enzyme*. The Classifier in *hydrolytic enzymes*, *hydrolytic*, suggests that this particular type of *enzyme* is differentiated from other types of *enzymes*. Apart from these taxonomic relations, an embedded clause is used to elaborate *hydrolytic enzymes.* In this clause, more entities are involved, including *animal cell,* and *(all kinds of) macromolecules,* both of which are classified through the Classifier *animal* and through the Focus group [classifying] *all kinds of*. The complex taxonomic relations revealed in this definition are displayed in the diagrams below.



Taxonomic relations between entities are also revealed in the encoding type of linguistic definitions, such as example [b] *the entire region between the nucleus and the plasma membrane is called the cytoplasm.* The entities *nucleus, plasma (cell) membrane* and *cytoplasm* are related to one another in terms of the composition of a cell (see the image of cell below)[12].





Therefore, the definition of entities in written transmission contributes significantly to establishing taxonomic relations of classification and composition among entities. These are critical ideational characteristics that can distinguish definitions in the written mode from those in the spoken mode. We thus distinguish entities that are taxonomised in their linguistic definitions, such as the examples above, from those that are not (e.g. *An order is something that you tell somebody and they have to do*). Entity type choices can thus be expanded as in Figure 3.6 below.

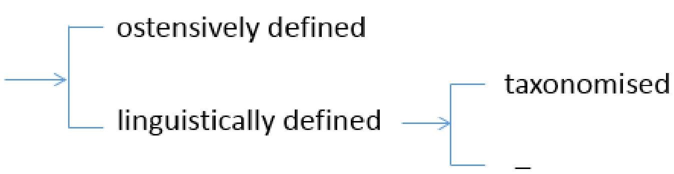


Figure 3.6 Expanded DEFINITION system of entities

It is important to note that taxonomising is not restricted to scientific fields, it is a characteristic of all fields, including exploration, specialised and commonsense fields:

[12] Source of the image:
http://www.daviddarling.info/childrens_encyclopedia/Genetic_Engineering_Chapter1.html

different fields construe the world in divergent taxonomies (Wignell et al., 1993), while not all field taxonomies are realised in the discourse through a linguistic definition which is concerned with building taxonomic relation. In other words, what characterises the linguistically defined entities in a scientific field is that their definitions are especially concerned with building up taxonomic relations.

Bringing together the entity systems that have been identified so far, including the system of CATEGORISATION and the system of DEFINITION, the entity system can be expanded as Figure 3.7 below. The entities in CATEGORISATION can be simultaneously ostensively defined or linguistically defined.

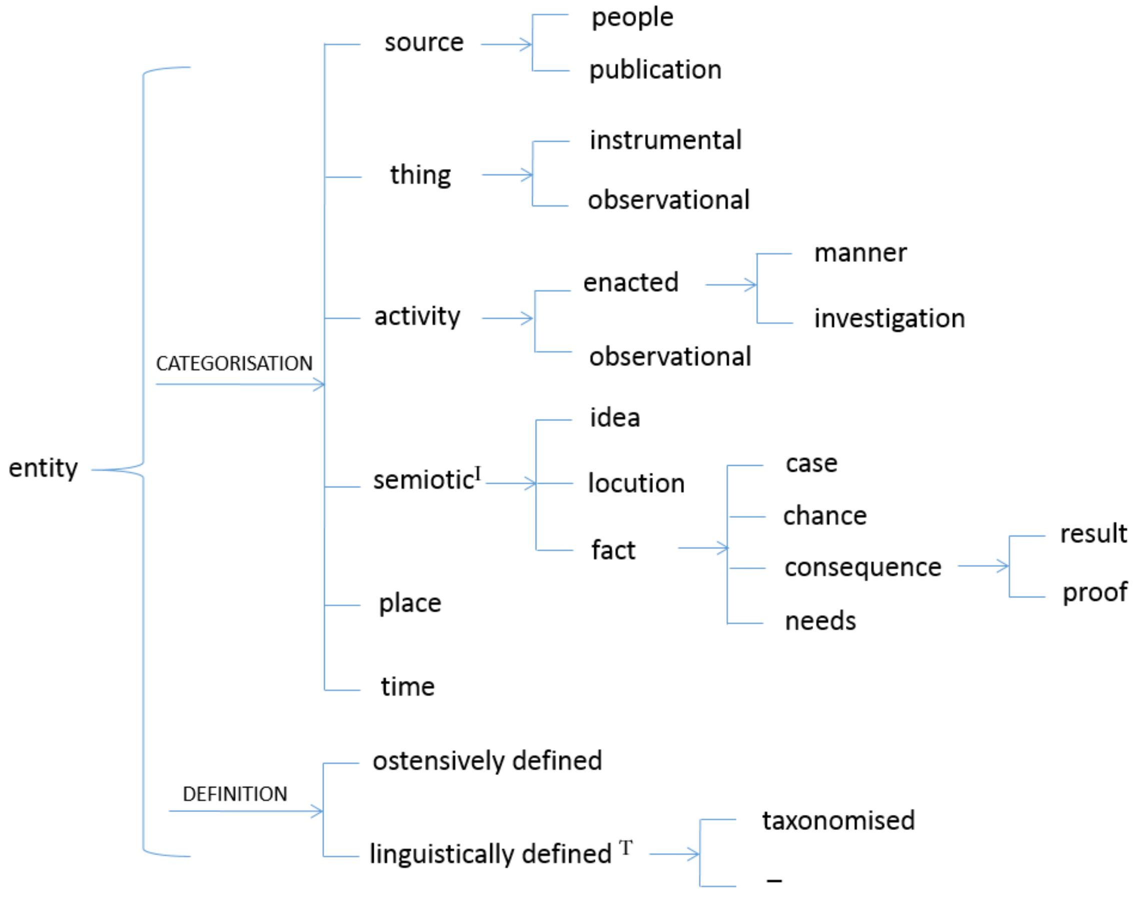


Figure 3.7 Expanded ENTITY TYPES in biology

The [I/T] convention in the system shows that semiotic entities are by nature linguistically defined entities, since semiotic entities are the names of facts, ideas and locutions which are brought into existence by language. Other entities can be either ostensively defined or linguistically defined. Linguistically defined people can occur in a field such as medicine (e.g. *neonate*) and administration (e.g. *general manager, council*); linguistically defined places can occur in fields such as geography and geology (e.g. *continent, tropics*); linguistically defined time can occur in a field such as history (e.g. *BC, AD*). As far as the field of biology is concerned, linguistically defined entities are primarily concerned with things and activities.

To this point I have taken into account of two distinct aspects of entity types with respect to their construal of taxonomies in field. In the next section, I take a further step to explore field specific entities in biology according to different means of scientific observation.

3.2.4 Linguistically defined entities in biology - what are the means of observation?

Observations of linguistically defined biological phenomena focus on things and activities. Based on the nature of different biological phenomena, various observational techniques are required in the field. This provides us a further basis on which to categorise field-specific observational entities.

In the discourse, the scientific observation of an entity is revealed through the configuration of the entity with other entities in a going-on. Let us begin with a few examples. The linguistically defined observational entities (underlined and bolded) in the examples below are configured in the different goings-on with people entities (i.e. *SCUBA*, and implied *me/us*), and also instrumental ones (i.e. *a light microscope, sodium carbonate*).

> [3.31-32] **Specimens of the irregular urchin, *Echinocardium cordatum* (heart urchin),** were also collected from within the oceanic sediment at Watsons Bay by SCUBA. These were then dissected (by me/us)…
> [3.33] Samples were then taken from **the coelomic cavity and digestive tract of the sea urchins** and were viewed (by me/us) at 10 and 40 times magnification using a light microscope…
> [2.23] The **(cellular) reaction** was stopped (by us) with sodium carbonate (6.9mM)

These examples suggest that the observational entities are handled by scientists in three distinct ways. Firstly in [3.31-32], the observational thing *specimens of the irregular urchin, Echinocardium cordatum (heart urchin)* is physically manipulated (i.e. *collected* and *dissected*) by the student group (i.e. *SCUBA*) and the student writer who is conducting the experiment. The physical activities are realised by material processes (i.e. *collected* and *dissected*). Secondly, in [3.33], the observational things (i.e. *the coelomic cavity and digestive tract of sea urchins*), were observed by people, suggested by their realisation in the mental process *were viewed*. The instrumental thing *light microscope* facilitated the observation.

And thirdly, in [2.23], an observational activity entity *cellular reaction* is *stopped* by people using an instrumental thing *sodium carbonate*, which is a chemical solution. Therefore, we can see that there are different means of biological observation, which require the assistance of different sets of instrumental things. Based on these differences, fine-grained distinctions among observational entities can be established.

In [3.31-32], the physical manipulations involved in the collection and dissection of *sea urchin* suggest that *sea urchins* have a tangible presence which can be perceived. Based on their systematic perceptible differences with respect to shapes and colours, sea urchins can be categorised into the categories *heart urchin, purple sea urchin, regular urchin* or *irregular urchin* (see Figure 3.8 below).

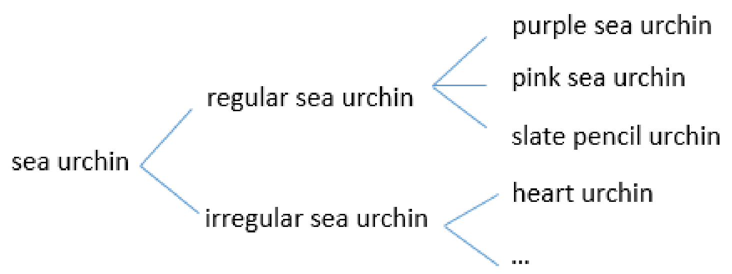


Figure 3.8 Taxonomies of sea urchin based on shapes and colours

Note that by pointing to the different colours of purple sea urchin and pink sea urchin, we could potentially define them ostensively and so distinguish one from the other in commonsense terms. However, it is also possible to define them linguistically, and position them in uncommonsense taxonomies in a pedagogic text (e.g. *A purple sea urchin is a spiky, aquatic echinoderm that resides on rocky sea floors…*)

For biologists who have trained in the field, a *sea urchin* is linguistically identified as a species that belongs to the phylum *Echinodermata*. It is distinguished from other members of the same phylum, such as *sea stars*, *sea cucumbers*, *brittle stars* and *crinoids*, based on their biological similarities and differences. Biologists categorise *sea urchins* scientifically into subclasses not only based on their physical appearance, but also on other less directly observable features such as their evolution, habitat, biological construction, physiological system, and so on. The scientific taxonomies of sea urchins are displayed in Figure 3.9 below (Kroh & Mooi, 2012). Almost all the terminology is borrowed from Greek (e.g. *Cidaroida, Atelostomata, Diadematoida*).

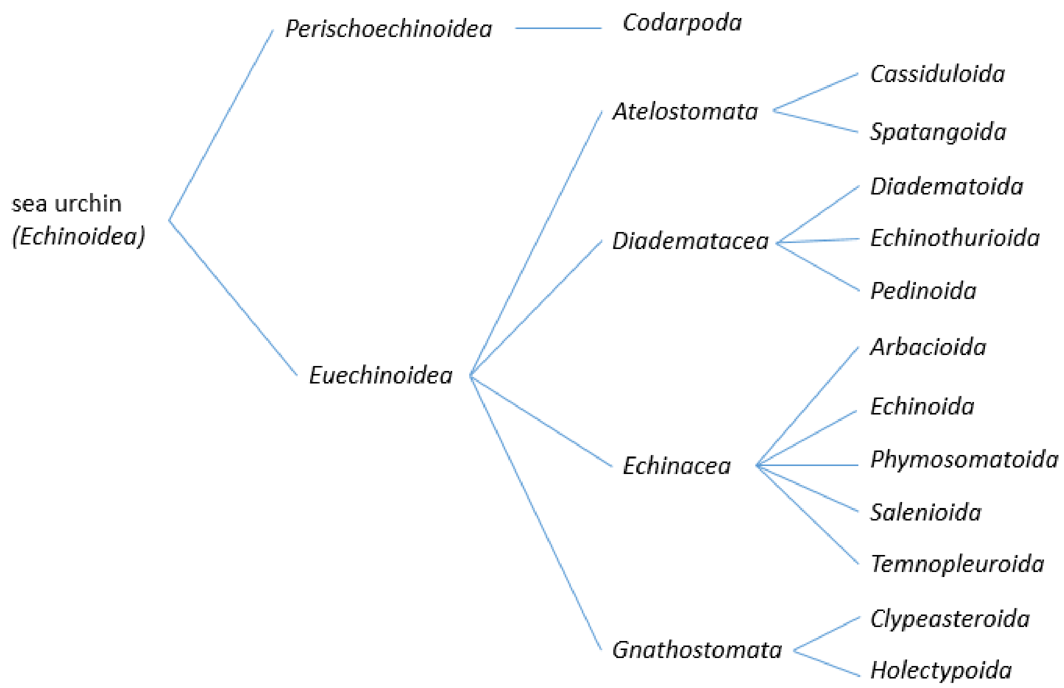


Figure 3.9 Scientific taxonomies of sea urchin

While what entity *sea urchin* in Figure 3.9 refers to can be observed through naked eyes, to scientifically differentiate one type of *sea urchin* from another requires each entity to be linguistically defined with respect to the taxonomic relations to the others (e.g. *Euechinoidea (class Echinoidea) is a sub-class of sea urchins in which the nominally rigid test is composed of five ambulacra and five interambulacra, each made up of two columns of plates.*). Given their observable nature as well as scientific categorisation of *sea urchin* in Figure 3.9, these entities can be named as **trained gaze entities**. Wignell et al. (1993, p. 155 ff.) provide similar exemplification of *birds of prey* that are taxonomised in different fields. In the specialised field, the birdwatchers' taxonomy of *birds of prey*, which relies solely on observable physical characteristics, are the ostensively defined entities; whereas in the exploration field the scientific taxonomy of *birds of prey*, which draws further on their biological similarities in chromosomes and genes, are the trained gaze entities.

In example [3.33], observational things are configured with people as well as an instrumental thing, the technological instrument *microscope*. Modern technology plays a significant role in scientific observation. The invention of microscopes in 1590 and their technological development in the 17th century extended the limits of human senses as far as biology is concerned. The new technology allowed biological phenomena to be observed at an ever more microscopic level. Additional examples of observing phenomena through microscope can be seen in [3.29] and [3.67].

> [3.29] **Microscopic observation** of the coelomic fluid of *E. Heliocidaris* and *P. phyllacanthus* showed bacterial species, protists – such as *Paramecium* –, sea urchin haemocytes and other eukaryotic cells.
> [3.67] however the **microscopic resolution** obtained was not enough to allow the presence of single or multiple flagella to be observed.

Like trained gaze entities, these entities observed through microscope are also tangible in a sense that they can be perceived. However, the perception can only be achieved with the assistance of technology, rather than through the naked eye. We can therefore name entities that can **only** be observed by means of technology as **technologically enhanced gaze entities** (**tech-enhanced gaze** for short). Note that the instrumental things enabling the observation, such as *microscope*, tend to be ostensively defined, since the procedure of manipulating the apparatus can be modelled physically, or be shown in the manual (which may contain both verbiage and image). To linguistically define an instrumental thing through a Token/Value structure does not necessarily provide an adequate explanation of how the instrument is used.

Furthermore, the example [2.23], *the* ***cellular reaction*** *was stopped (by us) with* *sodium carbonate*, reveals that the instrumental thing *sodium carbonate* used by people is not technological but chemical. The use of *sodium carbonate* inhibits a *cellular reaction,* which involves chemical elements inside the cell. The understanding of chemical phenomena at stake here is beyond what can be observed under the microscope. In my data, entities construing chemical elements are mostly configured with tech-enhanced gaze entities in goings-on realised by material processes. For example, in [3.58] and [3.111], the tech-enhanced gaze entities *bacteria* and *Chytridiomycota* are realised as Agents, which 'produce' the chemical phenomena *fatty acids, enzymes,* etc., realised as Goals.

> [3.58] It is likely that bacteria present may produce fatty acids… as well as enzymes which aid degradation of ingested material
> [3.111] Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates, including cellulose, keratin and chitin

Observational things such as *fatty acids, enzymes,* and *cellulose* are at the lowest level of biological organisation, at which point there is a blurry boundary between what is biology and what is chemistry. The phenomena that are beyond the observation of microscope tend to be differentiated from one another based on their chemical and physical structures. For example, *fatty acids* differ from other acids, e.g. *amino acids*, based on the different number of carbons, hydrogen atoms and oxygen in their structure. During the apprenticeship into biology, these entities are not directly observed and perceived by students, but are inferred from chemical reactions by using chemical solutions. We can gloss them as **inferable entities**. It is important to note that while such entities are usually inferred in biological experiments, in chemistry they can be shown through technology such as the sophisticated imaging instrument PET scanner, which can monitor chemical processes). That is to say, the distinction between tech-enhanced gaze entity and inferable entity in a field is determined by the different technology employed.

So far I have differentiated observational entities based on their different means of observation. We need to note that observational activities can also be differentiated on this basis. For example, *bird migration* can be observed through the trained gaze; *cell division* can be observed under the microscope; and *enzymic digestion* can be detected through chemical reaction. The cross-classification between observational things and activities and field specific observations is exemplified in Table 3.8 below.

Table 3.8 Cross-classification between observational entities and types of field-specific observations

	linguistically defined: trained gaze	**linguistically defined: tech enhanced gaze**	**linguistically defined: inferable**
thing: observational	*locust, Australian plague locust (Chortichocetes terminifera), Desert Locust (Schistocera gergaria)*	*fungal spore, dung fungal spore, Penicillium, Podopspora, Absidia, Isaria, Phycomyces*	*enzyme, antifungal enzyme, digestive enzyme*
activity: observational	*bird migration mandibular maceration, digestive sequence, peristalsis, physiological response*	*cell division, fungal spore ingestion, spore suspension, spore germination*	*enzymic digestion,*

To summarise, this section has illustrated that the linguistically defined entities in my data can be broken down into three subtypes according to their different means of observation: trained gaze, tech-enhanced gaze, and inferable entities. We can now expand the entity system further by taking into account the system of OBSERVATION, with choices of delicate types of linguistically defined entities as shown in Figure 3.10.

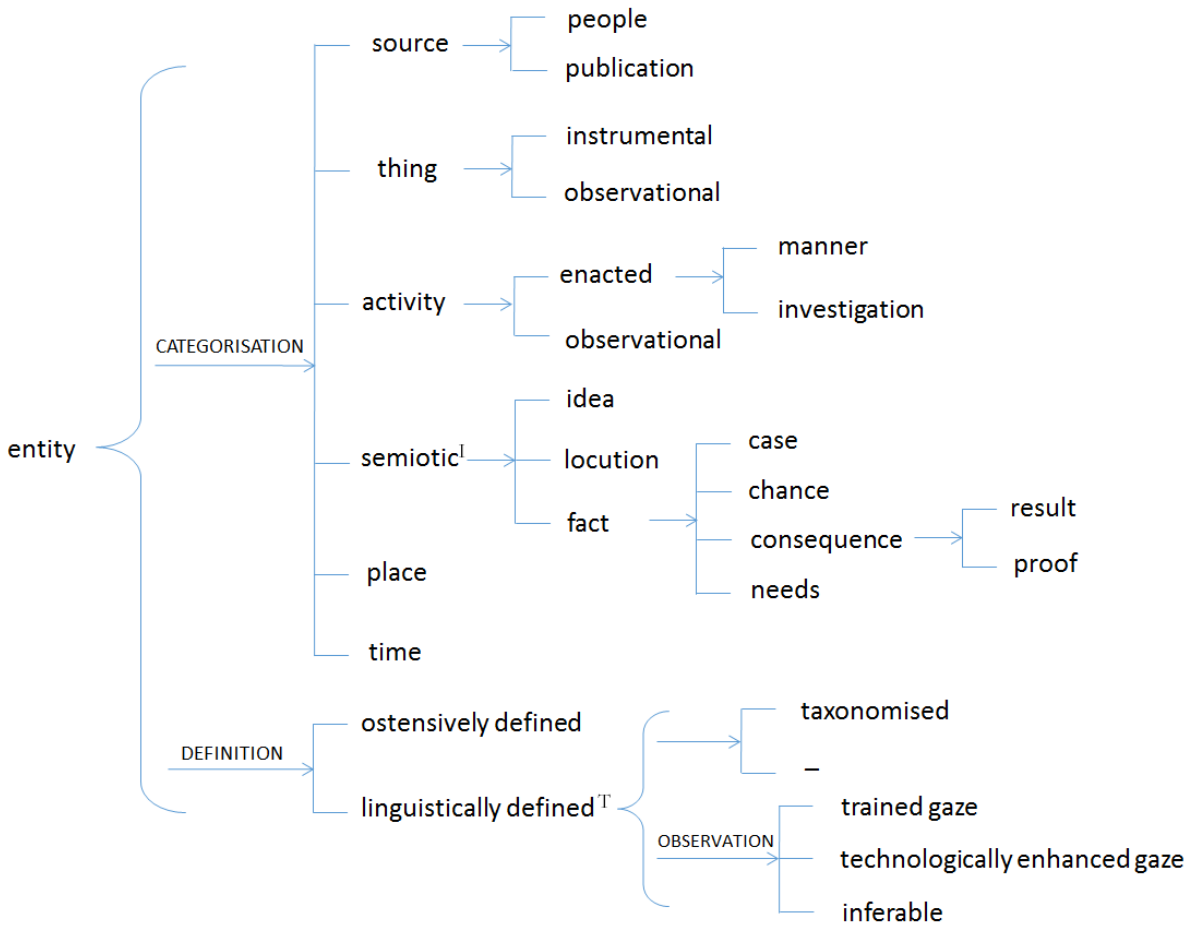


Figure 3.10 Expanded ENTITY TYPES *in biology texts*

The cross-classification implied in the system network, however, overgeneralises entities beyond the discourse of biology, such as linguistically defined people and time. The ways in which people, place, time are defined and observed in other disciplinary areas are outside the scope of this study. In order to avoid cross-classifications that are inapplicable here, a summary of the entities in my data is shown in Table 3.9.

Table 3.9 ENTITY TYPES *in biology texts*

types of entity				**examples**
thing	instrumental	ostensively defined		*tap water, plate, container, microscope, container, pipette, vial, automatic dispenser, gloves, fume-cupboard, cuvette, balance, spectrophotometer,*
		linguistically defined: trained gaze		*Potato Dextrose Agar, Triton-X solution, glycerol medium, sodium carbonate,*
	observational / ling. defined	trained gaze		*insects, gut, sea urchin, gastrointestinal tract, mouthpiece, Australian plague locust, mandible, herbivore*
		tech enhanced gaze		*fungal spore, eukaryotic cells, sporangium, flagella,*
		inferable		*pathogen, fungal entomopathogen, enzyme, cytoplasm,*
activity	enacted	investigation		*study, project, experiment*
		manner		*method, dissection method, culturing methods, treatment,* *biocontrol, autodissemination, environmental management*
	observational / ling. defined	trained gaze		*physiological response, maceration, peristaltic movement,*
		tech enhanced gaze		*fungal suspension, germination, growth, fungal spore dispersal*
		inferable		*enzymic digestion, gene expression*
place	osten. defined			*Chowder Bay, Watsons Bay,*
	ling. defined			*aquatic habitat, terrestrial habitat, temperate zone, rocky-intertidal region,*
semiotic / ling. def.	fact	case		*fact, problem, limitations*
		chance		*possibility, chance*
		needs		*purpose, needs*
		consq.	result	*result, findings, consequence,*
			proof	*evidence, confirmation, implication, reasons*
	idea			*concern, knowledge,*
	locution			*literature, explanation, suggestion, report, information, hypothesis*
source	people			*we, student, biologist*
	publication			*Smith (1999)*

3.3 Dimensionality

Taxonomy building in a particular field involves both naming phenomena, and building up taxonomic relations among phenomena. In the previous section I identified entity types in the discourse of biology. While this entity typology is helpful in distinguishing one entity type from another, it is not sufficient to describe the relationship between entities of the same type. For instance, we have seen that entities of the same type can be associated with each other taxonomically in a field, such as the taxonomy of *sea urchins* (i.e. *purple sea urchin, slate pencil urchin, irregular sea urchin,* etc.). However, their entity type alone does not reveal the nature of the taxonomic relations between them. It is therefore necessary to further explore how relationships between entities of the same type are construed in the discourse. We will see that entities can be elaborated in the discourse in various ways. It is these discourse semantic elaborations that differentiate one entity from another and that establish relationships among them. The discourse semantic meanings associated with the elaboration of entities are treated here as the **dimensionality** of an entity.

3.3.1 Elaboration of entities

Dimensionality of entities is discourse semantic elaboration of an entity. I begin with two examples. In [1.8-9] and [2.30-31] below, the entities are underlined and their elaborations are highlighted in bold.

> [1.8-9] Set **amount** of water was pipetted into a container, and the **weight** of the water was measured and recorded.
>
> [2.30-31] Three **species** of regular sea urchin were collected from the rocky-intertidal region. **Specimens** of the irregular urchin were also collected…

In [1.8-9], *amount* and *weight* do not relate taxonomically to the instrumental thing *water*, but rather elaborate *water* in terms of how it can be measured. Similarly in [2.30-31], *species* elaborates the entities *regular/irregular sea urchin* in terms of how they are categorised. These dimensionalities of entities are realised grammatically through an elaborating Focus=Thing structure in the nominal group. The elaborations of entities are named – e.g. *amount, weight,* and *species* – by the Thing in each of these groups.

Apart from Focus=Thing, there are many other ways to realise the dimensionality of an entity in the grammar, both at group rank and clause rank. In particular, elaborating structures in grammar (Martin, 1992, p. 314; Wignell et al., 1993) are the critical resources. At the group rank dimensionality of an entity can occur in the structure that realises an entity (see section 3.2.2.1), including hypotactic elaboration through Classifier^{n}=Thing, or possessive Deictic=Thing, as well as paratactic elaboration through various types of elaborating nominal group complex, e.g. exposition, exemplification and clarification.

I illustrated earlier in section 3.2.3.2 that certain elaborating nominal group complexes, in particular the exposition type, can be used to define entities through naming and unpacking. These are agnate to the Token/Value relationship in an intensive identifying process. However, there are other instances of exposition nominal group complex in the data that are agnate not to intensive identifying processes, but rather to intensive attributive processes and possessive identifying processes, for example [2.41] and [1.5-6] below.

> elaborating nominal group complex [exposition] in relation to intensive attributive process:
> [2.41] The flask containing lactose and <u>1 glucose, = 2 a preferred simpler food source</u> demonstrated a lower level of B-galactosidase activity.
> cf. Glucose [Carrier] is [Process] = a preferred simpler food source [Attribute].

> elaborating nominal group complex [exposition] in relation to possessive identifying process:
> [1.5-6] In this experiment a Finnpipette and a Bio-Rad P200 pipette were calibrated, using <u>1 three methods 2 = – weight-of-water, spectrophotometry and radioactivity.</u>
> cf. The three methods [Token] include [Process] = weight-of-water, spectrophotometry and radioactivity [Value].

These different agnation types suggest that more delicate exposition types in the elaborating nominal group complex need to be identified. The various ways of realising dimensionality of entities through elaboration at the group rank can therefore be summarised in Table 3.10 below.

Table 3.10 Elaboration of entity realised at group rank

	Realisation of entity			Examples
hypotactic elaboration	Classifier=Thing			β *regular* = α *sea urchin*
	Focus =Thing			β *a kind of* = α *sea urchin*
	possessive Deictic=Thing			β *rainforest's* = α *canopy*
paratactic elaboration	elaborating nominal group complex	exposition *that is* [i.e.]	naming *is called*	*Chytridiomycota were present in the digestive system of* 1 *the irregular urchin,* = 2 *Echinocardium cordatum.*
			unpacking *is defined as*	1 *B-galactosidase,* = 2 *an enzyme which breaks down lactose, was studied.*
			categorising *is categorised as*	*The flask containing lactose and* 1 *glucose,* = 2 *a preferred simpler food source demonstrated a lower level of B-galactosidase activity.*
			including *including*	*In this experiment a Finnpipette and a Bio-Rad P200 pipette were calibrated, using* 1 *three methods* 2 = *– weight-of-water, spectrophotometry and radioactivity.*
		exemplification *such as, for example* [e.g.]		*Further analysis could be performed using* 1 *molecular sequencing methods,* 2 = *such as DNA sequencing.*
		clarification *in fact, indeed* [viz.]		1 *Most players,* 2 = *in fact everyone on the team, played well.*

In the Classifier=Thing structure, *regular* elaborates the entity *sea urchin* in terms of its particular subtype. In the possessive Deictic=Thing structure, *rainforest's* elaborates the entity *canopy* by specifying its whole. Among the various elaborating nominal group complexes, the entity construed by the secondary nominal group elaborates the one construed by the primary one by making reference to its taxonomic relations. We can in fact explicitly name these various elaborations through Focus groups, such as *regular sea urchin is a kind of sea urchin; rainforest's canopy is a part of rainforest*. These at the same time imply: *sea urchin is a superordinate of regular sea urchin; rainforest is a whole of rainforest's canopy*.

The dimensionality of an entity can also be realised at the clause rank. As has been illustrated above, their realisations through elaborating nominal group complexes are agnate to various types of relational process, which can thus also be used to realise the dimensionality of entities.

It is the region of discourse semantic meaning that elaborates an entity which is conceptualised here as the dimensionality of the entity. As we can see, dimensionality in discourse can be lexicogrammaticalised, either with or without making explicit reference to the elaboration via naming through a Focus group. Given that among its various lexicogrammatical realisations, a Focus=Thing structure allows the dimensionality involved to be explicitly named, types of Focus group established in Martin et al. (2010, p. 170) (reproduced in Table 3.11 below) provide a useful starting point for exploring the typology of dimensionality.

Table 3.11 Types of Focus nominal groups (from Martin et al. 2010, p. 170)

Focus subtypes	examples Head:	
perspective	*side, top, front, back, foot, peak, summit, root, start, end, picture, painting, photo, drawing*	*Oscar saw [the top of] the mountain; Oscar drew [a picture of] Dorian.*
re-counting	*cup, glass, jug, tank, pound, yard, metre, gallon, litre, set, collection, group, crowd, school, herd, flock, gaggle, pod, swarm*	*Oscar drank [a glass of] wine; Oscar attracted [a crowd of] admirers.*
partitive	*bit, part, piece, component, leg, arm, branch, stem, chapter, section, member*	*Oscar finished [a chapter of] the book.*
selecting	*three, four, some, none, hundreds, thousands, bigger, smaller, largest, smallest, first, third, last, next*	*Oscar won [three of] the awards; he preferred [the smaller of] the two cakes.*
dimensional (descriptive quality)	*size, shape, colour, height, weight, length, texture, taste, smell, nose, aroma, feel, look, sound*	*Oscar felt [the texture of] the cloth.*
evaluative	*bastard, bitch, fuck, pig, dingbat, fool, bugger, saint, darling, angel, genius*	*It was [a bugger of] a day.*
classifying	*kind, type, class, category, brank, make, form, variety, species*	*This is [a tasty kind of] beer.*

However, it is important to note that while elaborating structures in the lexicogrammar is a useful place to start the exploration of dimensionality, I found that dimensionality can be realised in discourse through various other ways. Below I will begin with the examples of each type of dimensionality with the realisations that involve lexicalisation of the dimension, and then explore other possible grammatical manifestations of each dimensionality type.

3.3.2 Types of dimensionality

3.3.2.1 Classification

Firstly, we have seen above that an entity can be elaborated in terms of classification. The Focus group that names the classification is the Focus [classifying], such as *other members of the geofungi* in [3.87].

Focus [classifying] realises classificatory dimensionality of entity

[3.87] other members of the geofungi may also be present within sea urchins…

The entity *geofungi* in [3.87] is elaborated by *other members of*. This elaboration names the relationship between *geofungi* and its subtypes through the wording *members of*. In the discourse, both entities (*geofungi* and its types) are then assigned a dimensionality along which the entities can be classified. The dimensionality of *geofungi* can be named as a **hyperonym (/superordinate)** of other kinds of *geofungi*, which are in turn the **hyponym (/subtype)** of *geofungi*. Other typical examples of classificatory dimensionality named in Focus groups include *a type of guitar, a kind of beer, a class of nouns* and *a breed of dogs.*

One important area in the field of biology is concerned with categorising living species. Apart from naming a classification through terms such as *type of* and *kind of* which can also be used in other fields, biologists have established a biological classification system in terms of field-specific dimensionality. This biological system, initially established by Linnaeus in the mid-eighteenth century, consists of nine categories: *life*, *domain, kingdom, phylum, class, order*, *family, genus*, and *species.* They may be realised through a Focus group, such as in [3.30].

[3.30] Three species of regular sea urchin were collected…

Alongside the field neutral dimensionalities (e.g. *type of; kind of*), these nine biological categories are identified by biologists based on the scientific criteria such as evolution of species, characteristics of DNA, different components of cells, and so on. Their field-specific status is suggested by the fact that they are typically introduced in pedagogic texts through linguistic definitions (e.g. *a phylum* [Token] *is* [Process] *a taxonomic rank below kingdom and above class* [Value]). Note that these categories are field specific dimensionalities, not entities. For instance, while the trained gaze entity *sea urchin* belongs to the category named *class,* it is not a hyponym of *class* (**a sea urchin is a kind of class*); rather it is a hyponym of the trained gaze entity *Echinoderm* which belongs to the higher level category named *phylum* (*a sea urchin is a kind of Echinoderm*).

Note here that while the elaboration of an entity through a field-specific dimensionality can be realised by a Focus=Thing structure (e.g. *the species of regular sea urchin*), sometimes in my data dimensionality can be realised as the Thing in a Classifier=Thing structure. For example, the dimension *species* in [3.40] below is realised by the Thing in the Classifier=Thing structure *the regular and irregular sea urchin species*.

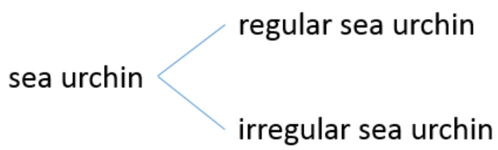
> [3.40] Dissection of both the regular and irregular sea urchin species was successful,

Such Classifier=Thing structures should be distinguished from the Classifier=Thing structure that realise types of entities, such as *regular and irregular sea urchins* in [3.57].

> [3.57] The presence of microbial activity in regular and irregular sea urchins has been demonstrated...

The data reveal that classification taxonomies tend to be built up initially through Focus=Thing structures such as *three species of regular sea urchin* in [3.30] and then assumed through Classifier=Thing structures such as *the regular sea urchin species* in [3.40], or Classifier=Thing structures involving no naming of the dimensionality (i.e. *species*) such as *regular sea urchins* in [3.57].

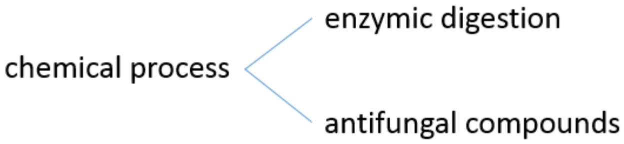
The actual classification of entities into different categories, not just the naming of the relationship involved, is realised by various other grammatical structures both at the group rank and clause rank. At the group rank, the Classifier=Thing structure just exemplified in [3.57] is a typical realisation of such classification in the data. The elaborating relationship between the Classifiers *regular* and *irregular* and the Thing *sea urchin* indicates an classificatory dimensionality – i.e. *regular* and *irregular* ones are hyponyms of *sea urchin.*



The Thing^Qualifier nominal group structure can also be used to construe classificatory dimensionality. For example, in [4.22], the Qualifier *including enzymic digestion or antifungal compounds*[13] indicates that *chemical process* is being classified into two subtypes.

> [4.22] Chemical processes [including enzymic digestion or antifungal compounds] could cause spores to lose their viability.

[13] Note that *including* is treated here as a preposition.



As has been noted above, classification can also be construed by entities realised through various types of elaborating nominal group complex. As has been shown in Table 3.3 above, most of the elaborating nominal group complexes that occur in the data are in fact concerned with the classification of entities. The exposition, e.g. *we used 1 three methods 2 = – weight-of-water, spectrophotometry and radioactivity*, and exemplification, e.g. *further analysis could be performed using 1 molecular sequencing methods, 2 = such as DNA sequencing*, types are particularly relevant.

At clause rank, classificatory dimensionality can be realised through various types of relational process. The data show that classification realised through relational processes is agnate to the subtypes of exposition in the nominal group complex. The agnate pairs can be summarised in Table 3.12 below.

Table 3.12 Realisation of elaboration: exposition

exposition subtypes	**realisation**	
	group rank: NG complexing	**clause rank: relational process**
naming	*Chytridiomycota were present in the digestive system of 1 the irregular urchin, = 2 Echinocardium cordatum*	**intensive identifying process [encoding]:** *The irregular urchin* [Vl/Id] *is called Echinocardium cordatum* [Tk/Ir].
unpacking	*1 B-galactosidase, = 2 an enzyme which breaks down lactose, was studied.*	**intensive identifying process [decoding]:** *B-galactosidase* [Tk/Id] *is an enzyme which breaks down lactose* [Vl/Ir].
categorising	*The flask containing lactose and 1 glucose, = 2 a preferred simpler food source demonstrated a lower level of B-galactosidase activity.*	**intensive attributive process:** *Glucose* [Ca] *is a preferred simpler food source* [Att].
including	*In this experiment a Finnpipette and a Bio-Rad P200 pipette were calibrated, using 1 three methods 2 = – weight-of-water, spectrophotometry and radioactivity*.	**possessive identifying process:** *The three methods* [Tk/Id] *include weight-of-water, spectrophotometry and radioactivity* [Vl/Ir].

Alongside experiential resources, the classificatory dimensionality can also be reinforced through comparative reference, as in [2.8] and [3.87] below.

[2.8] …(we) adding glucose, and **alternative** food sources to lactose.

[3.87] …Cladosporium and Alternaria may also be present within sea urchins and **other** marine invertebrates

The comparative reference item *alternative* in [2.8] makes explicit that *glucose* is a kind of *food source* among many other food sources, and *other* in [3.87] suggests that *sea urchins* are a kind of *marine invertebrate* among many other types of marine invertebrates.

While various grammatical realisations of classificatory dimensionality are found in the data, it needs to be pointed out that sometimes the classification of the entity is not realised explicitly through either clause or nominal group structures, but may be revealed in the discourse in other ways. For example in [2.1-5] below, the relationship between the entities *protein* and *B-galactosidase* can be suggested by the Circumstance of Location *in this experiment.* The use of the Circumstance situates the biological phenomenon in relation to a specific experiment, implying that *B-galactosidase* is a hyponym of *protein.*

[2.1-5] The activity of proteins can be controlled… In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied.

This implicit realisation of classificatory dimensionality is not uncommon in the data. In fact, taxonomic relations among biological phenomena may be simply assumed in the discourse as shared knowledge between the writer and readers. This will be discussed further in section 3.4 when I interpret the texts. A general tendency is that the higher the level of the text (i.e. produced in later undergraduate years), the more implicit the realisation of taxonomic relations in the discourse may become, as the texts assume prior learning.

To summarise, entities can be elaborated in discourse along the dimensionality of classification, which can be realised through various lexicogrammatical resources at both group rank and clause rank. It has also been found that in the discourse of biology field-specific classificatory dimensionality elaborates linguistically defined entities.

3.3.2.2 Composition

A second type of dimensionality reflected in the Focus group is the composition of an entity. In the data, the compositional dimensionality is largely named by Focus [partitive], e.g. *a section of the gut* in [3.125].

Focus [partitive] realises compositional dimensionality of entity:

[3.125] Such variation was not considered within this preliminary work, with samples taken from a section of the gut.

In this example, through the Focus [partitive] *a section of* a compositional taxonomic relationship is named between the whole of the entity (*gut*) and a part of it (/meronymy).

Apart from Focus [partitive], the concept of compositional dimensionality will be extended here to include Focus [perspective], whereby the nominal group provides an angle on a whole. In [4.155] *a crucial aspect of* elaborates the activity entity *autodissemination* by assigning a perspective to it.

[4.155] Understanding spore viability in an entomopathogen/host context is a crucial aspect of autodissemination…

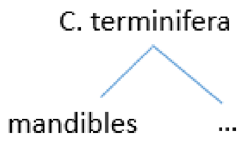
Like classificatory dimensionality, the compositional dimensionality of an entity can be revealed by various grammatical structures at both group rank and clause rank. At the group rank, its realisation through a Thing^Qualifier structure is possible, as in [3.33].

[3.33] Samples were then taken from the coelomic cavity and digestive tract of the sea urchins

In this example, the entities *coelomic cavity* and *digestive tract* realised by the Things are parts of the whole *sea urchin* realised by the Qualifier.

At clause rank, compositional dimensionality may be realised through possessive attributive processes such as in [4.37], where the entity *mandible*, realised by the Attribute, is part of the whole *C.terminifera,* realised by the Carrier.

[4.37] different developmental stages of C. terminifera [Carrier] have mandibles of different sizes [Attribute]



Various lexicogrammatical resources can then be used to construe the dimensionality of an entity in relation to its classification or composition. These are two regions of meaning that construe taxonomic relations among entities. We can group these dimensionalities under a general category - taxonomic relation.

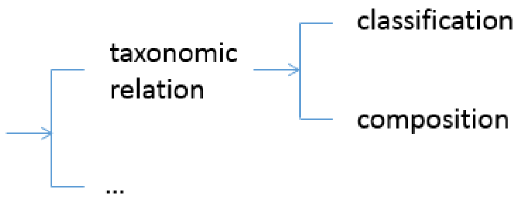


Figure 3.11 DIMENSIONALITY of entity (a)

3.3.2.3 Measurement

A third way in which an entity can be elaborated has to do with how it is measured. The measurement of an entity may be reflected in its realisation through Focus [re-counting] (i.e. Pre-Numerative in Halliday, 1985 and Martin, 1992). For example:

> Focus [re-counting] realises measurement of entity
> [1.17] and <u>5mL of **scintillant**</u> were added.
> [3.44] <u>A number of **round cells**</u> were also observed

In these examples, the underlined nominal group as a whole construes an entity which is measured. Depending on the 'countability' of an entity, Focus can "count" a Thing that is inherently uncountable, e.g. *a bottle of beer*, and "uncount" a Thing that is inherently countable, e.g. *flock of geese* (Martin, 1988, pp. 253-254). Focus [re-counting] construes the **quantification** of an entity. Note that the quantification can be more or less specific: for example, in [1.17] *5mL* provides a specific quantity through numeration; whereas examples such as *a number of* (i.e. *several*) and *a bottle of* provide a rough quantification.

Alongside the Focus [re-counting], the measurement of an entity may be also indicated by a Focus [descriptive quality], such as *set amount of*, *the weight of* and *levels of* in the examples below.

Focus [descriptive quality] realises measurement of entity

[1.8] set amount of water was pipetted into a container.

[1.9] The weight of the water dispensed was measured and recorded.

[2.1-2] The activity of proteins can be controlled through influencing levels of gene expression

In contrast to quantification realised through Focus [recounting], measurements such as *amount of*, *weight of* and *level of* do not specify the quantity of the measurement, rather they name measurements of different kinds. There is an encoding relationship between the measurement type and the quantity that is measured which can be realised through an intensive identifying process. In such clauses, quantity is realised as the Token, and measurement type is realised by the Value.

The amount of water [Value] is [Process] **one litre** [Token].

The number of round cells is **about one million**.

The length of the fabric is **5 metres**.

The speed of the car is **35mph**.

As pointed out above, quantification is not necessarily specified through numeration. A rough quantification can also be provided, such as through some instances of Focus [re-counting], e.g. *a number of* in [3.38] above. Another way of providing a general quantification is through an Epithet, e.g. *small, large, long, short,* etc., either at the clause rank or within the Focus group:

The amount of water is **large/small**: a **large/small** amount of water::

The number of round cells is **large/small:** a **large/small** number of round cells::

The length of the fabric is **long/short**: the **long/short** length of the fabric::

The speed of the car is **low/high**: the **low/high** speed of the car

In addition, quantification of an entity can be comparative:

a **large(r)/small(er)** amount of water;

a **long(er)/short(er)** length of the fabric;

a **bigg(er)/small(er)** size of the shirt;

a **high(er)/low(er)** speed of the car;

It can be seen that the type of measurable dimensionality – *amount, number, length, size, speed* etc. – is determined by the nature of the entity. Different kinds of measurement are likely to be concerned with different measurable units, e.g. *metre*, *litre*, *mL*, and achieved with the assistance of different utilitarian tools and mathematical symbols. The measurable dimensionality of an entity is therefore associated simultaneously with the measurement type and its quantification, although the type may not be necessarily named explicitly in the text. The typology of dimensionality can now be expanded as in Figure 3.12 below.

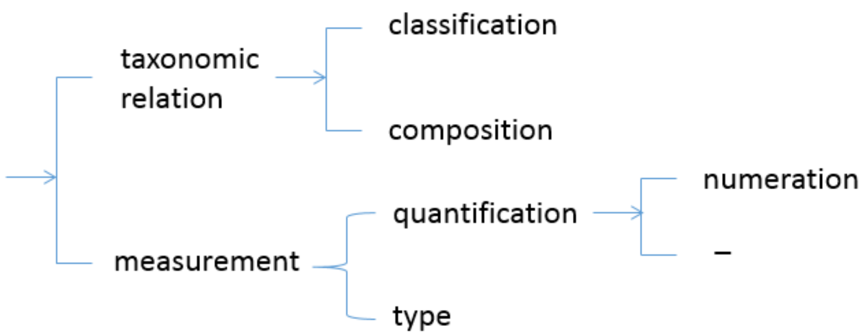


Figure 3.12* DIMENSIONALITY *of entity (b)

The measurable dimensionality of an entity is frequently realised in biology texts. Apart from field-neutral realisations such as *size, weight, amount*, a large number of measurable dimensionalities are field-specific in biology: for example, *the activity of protein* and the *susceptibility of the spores* in the examples below.

> [2.1-5] The activity of proteins can be controlled… In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied.
> [4.113] intrinsic structural differences such as the constituents of the spore wall could increase susceptibility of the spores to antifungals and digestive enzymes of the locust gut.

The measurement *activity* is usually associated in biology with inferable entities such as *enzymes*. As a nominalisation, *activity* is derived from the adjective *active* which construes a quality. However, in my data *activity* is in fact a field specific measurement which is linguistically defined in textbooks: e.g. "The activity of enzyme - how efficiently the enzyme functions - is affected by general environmental factors, such as temperature and pH" (Campbell & Reece, 2005, p. 154). *Activity* in this sense is defined by a mathematical equation of quantification:

> Activity of enzyme = moles of substrate concerted per unit time = rate x reaction volume.

The nominalisation *activity* is thus not treated as a 'live' grammatical metaphor, but rather a field specific measurable dimensionality of linguistically defined entities, specifically, inferable entities in biology. Similar to a field-specific classificatory dimensionality such as *species*, *genus*, or *phylum*, the field-specific measurable dimensionality can be realised in the data texts either through Focus=Thing ([2.1-5] and [4.113] above) or through Classifier=Thing structures such as in [4.19] and [4.139] below.

> [4.19] Loss of fungal spore integrity and viability after ingestion and passage through the insect gastrointestinal tract…
> [4.139] Varying spore concentrations would have affected the chances of a spore being plated from the serial dilutions.

It is important to note that while the measurable dimensionality of entity can be realised through the Thing in a Classifier=Thing structure, the Classifier does not construe a classification of the measurement. That is to say, *fungal spore integrity and viability* and *spore concentrations* are not subtypes of measurements of *integrity*, *viability*, and *concentration.* The measurement can be reworked as a Focus=Thing structure, e.g. *the integrity of fungal spores, concentration of spore*, *activity of B-galactosidase*. Realisation through a Classifier=Thing structure usually occurs in order to fit into the logogenetic unfolding of the text: it tends to appear after the initial Focus=Thing structure has been introduced in the preceding text. As exemplified in the excerpt below, the measurement *activity* is realised through the Focus group (i.e. *the activity of protein; the activity of B-galactosidase*), before it is realised through Thing in the Classifier=Thing structure (i.e. *B-galactosidase activity*).

> [2.1-7] The activity of protein can be controlled through including levels of gene expression or their activation/deactivation when already present in the cytosol. In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied. It is known that in the presence of lactose, B-galactosidase activity increases.

3.3.2.4 Perception

A further type of dimensionality of entity is indicated by Focus [descriptive quality]. As has been illustrated above, Focus [descriptive quality] can name the measurement of different types (e.g. *amount, size, level, length*), but certain instances of Focus [descriptive quality] (e.g. *shape, colour, texture, taste*) included in Martin et al. (2010, p. 170) can construe an elaboration of entity in a way that is less likely to be a measurement, since they do not require utilitarian tools and quantification through mathematics. Such dimensionalities of entities are more likely to rely on observation through human senses such as seeing, smelling, hearing and touching. Wignell et al. (1993, p. 155) exemplify such observable features through the *colour*, *markings*, and *sound* of *birds of prey*. These elaborations of birds can be realised through a Focus=Thing structure (e.g. *the colour of the bird*). We can identify this type of dimensionality as **perception**. Some other typical examples of the dimensionality of perception include *shape, texture, taste, smell* and *look*. Perceptive dimensionality is an important elaboration of ostensively defined and linguistically defined trained gaze entities. As I have discussed in section 3.2.4, definitions of both ostensively defined entities and of linguistically defined trained gaze entities rely critically on their observable characteristics.

In my data, a few realisations of perceptive dimensionality are found, e.g. in the form of possessive Deictic^Thing, as in *their shape* in [3.68-69].

> [3.68-69] The combination of their motility and their **shape** suggests that these organisms could be chytrid zoospores.

Note that while perceptive dimensionality may be realised by a Thing as *shape* in [3.68-69], they are in fact the names of the attributes of an entity by which the entity can be differentiated from another. For instance, the entity *chytrid zoospores* in [3.68-69] is differentiated from other *organisms* by the reference to its shape. In addition, *their shape* can be recovered from the co-text as Focus=Thing *the shape of the organism*.

Four types of dimensionality have now been identified. The classificatory and compositional dimensionalities establish relationships *between* entities, while the measurable and perceptive dimensionalities characterise entities through the measurable and perceptible attributes which allow entities to be differentiated from one another. In a sense, measurement and perception name the criteria for taxonomising entities as opposed to naming the dimensionalities of the taxonomic relation at risk. Measurement and perception can be therefore grouped under the category of attribution of the entity. The system of DIMENSIONALITY is further expanded in Figures 3.13. I have included one system to account for the fact that dimensionality can be either field specific or not. In my data, field-specific classification and measurement have been found to be significant variables.

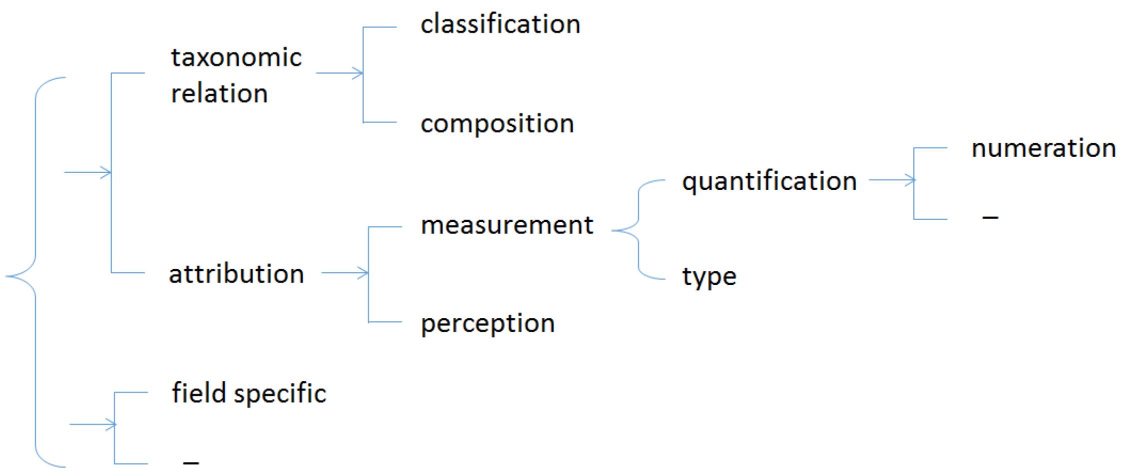


Figure 3.13 DIMENSIONALITY of entity (c)[14]

I have now established a typology of entities, along with their elaborations via dimensionality. This framework provides us with useful tools to investigate how field is construed taxonomically. In the next section, drawing on these systems of ENTITY and DIMENSIONALITY, the four student texts from different undergraduate year levels will be analysed. I will investigate how field taxonomies are construed in each text, and whether these texts reveal a pattern of ontogenetic development in relation to field.

3.4 Taxonomy building through entities in the undergraduate biology texts

In this section, entity types and dimensionality of entities are analysed in the four student texts. As was explained in Chapter 2, the texts are high-graded biology laboratory reports and research reports produced at different undergraduate year levels. Some general issues are considered in the analysis across the four texts. These include:

- What types of entity occur in the text?
- Are the entities elaborated by dimensionality?
- What is the depth of the taxonomies instantiated?
- What characteristics of field are construed by the entity types?

[14] Note that there may be a grammatical ambiguity in terms of whether measurement and perception dimensionality is realised in the Focus [descriptive quality]^Thing or Thing^Qualifier structure. This grammatical distinction needs to be further explored. Nonetheless, at the level of discourse semantics, it is the elaboration of the entity that is construed.

In the following sections, the interpretation of the four texts is organised according to the order in which they appear in the undergraduate program.

3.4.1 Entities and dimensionalities in Text 1 - first year laboratory report

Text 1 reports on a laboratory experiment in the first undergraduate year. The aim of the experiment was to compare three different methods for calibrating a pipette, which is a tool used in laboratories to transport measured liquid. During the experiment, the student was required to enact the three calibration methods, each of which required a different set of apparatus and tools. Based on the experimental results, the student was asked to determine the most suitable method among the three. In this text, four primary entity types – activity, thing, semiotic and source – can be identified.

3.4.1.1 Enacted activity

The use of enacted activity entities is significant in Text 1. Both subtypes, investigation and manner, are evident. Firstly, since Text 1 concerns the testing of methods, the manners referring to these methods, i.e. *weight-of-water, spectrophotometry*, and *radioactivity*, can be identified: these are outlined in [1.5] below. Through an elaborating nominal group, these different manner activities are identified as hyponyms of *method*.

> [1.5] In this experiment a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated, using <u>three methods – weight-of-water, spectrophotometry and radioactivity</u>

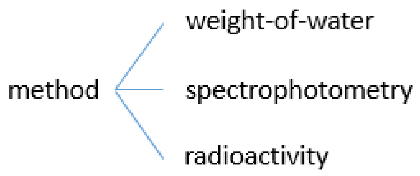


Figure 3.14 Classification of method in Text 1

The other subtype of activity, investigation, is suggested by a single instance, *experiment*, as realised in the Circumstance *in this experiment* in example [1.5] above. It indicates a localised activity in the laboratory.

3.4.1.2 Thing - instrumental

A large number of thing entities occur in Text 1. These things are predominantly instrumental ones, as suggested by their realisation through Goal and Location in material processes, such as those underlined in the examples below (the Location circumstances are in bold).

> [1.8] set amount of water was pipetted **into a container**
>
> [1.10] set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted **into 1mL cuvettes**
>
> [1.16] set amounts (0, 20, 50, 100, 150 and 200uL) of radioactive C-14 glucose were pipetted **into vials**

Different sets of instrumental entities are associated with the different manners of investigation outlined above. The correspondence between these two entity types is summarised in Table 3.13 below.

Table 3.13 Manner and instrumental things in Text 1

entity: manner	entity: instrumental thing
weight-of-water	*pipette, water, container, balance*
radioactivity	*pipette, dye, cuvettes, solution, spectrophotometer*
spectrometry	*pipette, C-14 glucose, vials, scintillant, gloves, fume-cupboard, spectrophotometer*

Most instrumental things can be defined ostensively in the setting of the laboratory, in particular those that are associated with *weight of water* and *radioactivity* methods. Among the entities involved in *spectrometry*, a few instances may require a linguistic definition, such as *C-14 glucose*. While in Text 1 *C-14 glucose* refers to a colourless liquid instrument which can be stored and measured, ostensively pointing to the *C-14 glucose* would not distinguish it from other colourless liquid instruments. It is taxonomically related to the entity *glucose*, which is linguistically defined in the textbook as follows: "glucose ($C_6H_{12}O_6$) is the most common monosaccharide"; *monosaccharide* is in turn defined as "the simplest carbohydrates which include both sugars and the polymers of sugars" (Campbell & Reece, 2005, pp. 10-11). *C-14 glucose*, identified by its specific chemical constitution, is a hyponym of *glucose*. The entity *C-14 glucose* is therefore treated as a linguistically defined instrumental thing.

In terms of the dimensionality of instrumental things, elaboration through measurement is significant. The measurement is often named, such as *amount*, *weight* and *range* in the examples below.

dimensionality [measurement] of instrumental thing

[1.8] set amount of water was pipetted into a container.

[1.9] the weight of the water dispensed was measured and recorded.

[1.25] this accuracy decreased towards the larger end of the pipette's range

[1.17] and 5mL of scintillant was added.

Instances of field specific measurement are also found, such as *absorbance* in example [1.13-15].

[1.13-15] Each solution was mixed, and absorbances were read, using a spectrophotometer, l=445nm.

Absorbance is defined in chemistry as a measurement of radiation transmitted through a material. It is therefore no longer a 'live' grammatical metaphor, in spite of its nominalised form. The entity that is elaborated by *absorbances* in [1.13-15] occurs in relation to the co-text *each solution was mixed*, which implies that it is the *absorbances of solution* which were read.

Apart from measurement, classification of instrumental things can also be found. The entity *pipette* is classified into the hyponyms *Finnpipette* and *Bio-Rad P200 pipette* in [1.5], both of which incorporate proper names (i.e. *Finn-*, *Bio-Rad P200*).

[1.5] In this experiment a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated

Figure 3.15 Classification of pipette in Text 1

3.4.1.3 Thing - semiotic

Several semiotic entities can be identified in Text 1, including particularly the subtypes of fact semiotic entities. A few instances of fact [result], which names a perceived consequence, in opposition to an interpreted consequence such as *proof*, are exemplified below.

[1.76] the spectrometer provided results that were easily and efficiently obtained.

[1.81] spectroscopy provided results that balanced the need for high levels of precision and accuracy with safety, speed and efficiency.

Two other types of semiotic entity, *case* and *need*, are found to help compose the periodicity of the text: e.g. the case entity *limitations* in [1.41] that previews the subsequent passages in a hyperTheme, and the need entity *needs* in [1.81] that consolidates the preceding text in a hyperNew.

case entity & hyperTheme

[1.41] there were a number of limitations associated with it. (Firstly… Secondly…)

need entity & hyperNew

[1.81] …the results balanced the needs for high levels of precision and accuracy with safety, speed and efficiency.

3.4.1.4 Thing - source

A further entity type to be commented on is that of source [people] entities. People in Text 1 are configured in the goings-on alongside the instrumental things and enacted activities throughout the text. However, their 'presence' is not explicit, but rather implied through the use of receptive and non-finite clauses, as shown in [1.6] and [1.8] below. These implied people refer to the students who conducted the experiment.

[1.6] (we) using three methods – weight-of-water, spectrophotometry and radioactivity

[1.8] set amount of water was pipetted (by us) into a container

3.4.1.5 Overview of entities and dimensionalities in Text 1

The salient entity types in Text 1 include activity, thing, semiotic and people. An overview of these entity types and their dimensionalities is shown in Table 3.14 below.

The instrumental entities are elaborated through measurement. Both field-specific and field-neutral measurements are identified. The field-specific measurements suggest that some knowledge of chemistry is required in the experiment. Both instrumental things, e.g. *pipette*, and enacted activities, e.g. *method*, are classified, and each of them are mapped onto two taxonomic levels.

Table 3.14 Types of entity and dimensionality in Text 1

types of entity		ostensively defined	linguistically defined	dimensionality		
				measurement		classification
				field neutral	field specific	
activity	investigation	*experiment,*				
	manner	*method, weight-of-water method, spectrophotometry*				classification of *method*
thing [instrumental]		*container, pipette, vial, gloves, cuvette, balance, spectrophotometer, water, dye, solution*	*radioactive C-14 glucose*	*the weight of water, the volume of pipette, the range of pipette,*	*experimental value, theoretical value absorbance;*	classification of *pipette*
semiotic: fact	consq.		*result*			
	case		*limitations*	*a number of limitations*		
	needs		*needs*			
source [people]		*students*				

The taxonomies instantiated in Text 1 indicate that the operation of experimental tools is significant at the early stage of the apprenticeship, and limited knowledge of biological phenomena has also been demonstrated. While some knowledge of scientific measurement is involved, it is associated with the operation of tools. Apprenticeship into biology at this stage resembles the level of 'trade certificate or equivalent' along the industrial hierarchy in the specialised field, as described by Rose (1998). The activities at this level involve 'selecting and using appropriate techniques and equipment required to perform tasks of some complexity' (NTB in Rose, 1998, p. 243). The field construed in Text 1 therefore has the characteristics of a specialised field.

3.4.2 Entities and dimensionalities in Text 2 - second year laboratory report

Text 2 is a laboratory report which was produced for the assessment of a core subject in the first half of the second undergraduate year. It reports on an experiment that tests how an enzyme reacts to five different biochemical treatments carried out during the experiment. Each treatment requires a different set of materials. The aim of the analysis below is to compare the nature of the taxonomy building in Text 2 with that of Text 1, in terms of both the expansion of entity types and the depth of taxonomies.

3.4.2.1 Things

It was shown in Text 1 that instrumental things are significant in construing taxonomy at the beginning of the first year. In Text 2, the instrumental and observational subtypes of things are both identified.

3.4.2.1.1 Instrumental things

Similar to the instrumental things in Text 1, those in Text 2 are identified through their realization as Goals, Location and Manner in the procedure part of the experiment, i.e. the Method stage. In the following examples, the entities are underlined and the Circumstances are in bold.

> instrumental thing realized by Goal
> [2.8] …(we) adding glucose, and alternative food source to lactose.
>
> instrumental thing realized in Circumstance [Location]
> [2.12] E. coli bacteria were cultured (by us) **in a glycerol medium** (pH7).
>
> instrumental thing realized in Circumstance [Manner]
> [2.23] The reaction was stopped (by us) **with sodium carbonate** (6.9mM)

Most of the instrumental things in Text 2 are linguistically defined. Given their tangibility and linguistic definition, they can be identified as trained gaze things. For instance, the instrumental thing *glycerol medium* above can be ostensively referred to in the setting of laboratory. At the same time, it is linguistically defined in the textbook: "glycerol is an alcohol with three carbons, each bearing a hydroxyl group" (Campbell & Reece, 2005, p. 75).

A number of trained gaze instrumental things can be identified in the discourse. For example in [2.8], the comparative reference *alternative* suggests *glucose* is one of the hyponyms of *food source* among many others. In the immediate co-text [2.13], those 'alternative' food sources are introduced, including *IPTG, lactose, 5-FU,* and *chloramphenicol*.

> [2.8] …(we) adding glucose, and **alternative** food sources to lactose…
> [2.13] One of the following six treatments was added (by us): IPTG (0.48mM); lactose (0.41mM); Lactose (0.41mM) and Glucose (5.4mM); Lactose (0.4mM) and 5-FU (0.02mg/ml); Lactose (0.40mM) and chloramphenicol (0.02mg/ml); no treatment.

Food source is thus categorized into five hyponyms.

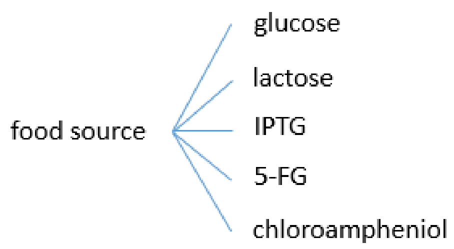


Figure 3.16 Classification of food source in Text 2

Alongside trained gaze instrumental things, ostensively defined instrumental things are also found in Text 2. In contrast to the linguistically defined ones, the ostensively defined instruments and their operation are not introduced in the procedure. For example in [2.27], *control flask* was not introduced in the Method, but assumed in the Result. It refers ostensively to the object in the laboratory setting through the exophoric reference *the*.

> [2.27] The <u>control flask</u> with nothing added demonstrated a basal level of B-galactosidase activity

A second way of assuming an ostensively defined instrumental thing is through a Circumstance of Manner in the form of an adverbial group. For example in [2.25], the use of *spectroscopically* suggests the instrument *spectrophotometer* is used.

> [2.25] Concentration of O-NP, and hence B-galactosidase, was measured <u>spectroscopically</u> [Cir: Manner].

These ways of assuming ostensively defined instrumental things indicate that, in Text 2, the task of operating instruments has shifted focus from ostensively defined instruments to linguistically defined ones.

3.4.2.1.2 Observational things

Apart from instrumental things, the other thing type, observational thing, is also found in Text 2 in the form of metaphenomena projected by mental processes, as exemplified in [2.5-6] and [2.7C].

> [2.5-6] It is known [Process: mental] || that in the presence of <u>lactose</u>, <u>B-galactosidase activity</u> increases

[2.7C] …to determine [Process: mental] || whether gene expression produces enzyme, so B-galactosidase is induced, or the enzyme which already exists is activated, so B-galactosidase is induced.

Observational things such as *galactosidase* and *enzyme* belong specifically to the category of linguistically defined inferable things. Given their intangibility, they are detected in chemical reactions which are initiated by using trained gaze instrumental things, such as *glucose* and *lactose*, in the experiment.

Both classification and measurement of inferable things are instantiated in the discourse. Classification is exemplified in [2.1-5].

[2.1-5] The activity of proteins can be controlled… In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied.

The elaborating nominal group complex (*the activity of B-galactosidase, an enzyme [[…]]*) suggests that *B-galactosidase* is a kind of *enzyme.* Secondly, the Circumstance [Location] *in this experiment* implies that *B-galactosidase* is a specific type of *protein* applied in this particular experiment. The taxonomy *protein, enzyme* and *B-galactosidase* can thus be seen to be organised at three levels.

Figure 3.17 Classification of protein in Text 2

Inferable things are also elaborated through measurement. Both field-specific measurement (e.g. *the amount of* in [2.19]), and field-neutral measurement (e.g. *the activity of* in [2.1-5]), can be identified.

[2.19] An ONPG assay was carried out to determine the amount of B-galactosidase present.
[2.1-5] The activity of proteins can be controlled… In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied.

We can see that in comparison to the thing entities in Text 1, Text 2 focuses more on linguistically defined things, associated with both instrumental and observational things.

3.4.2.2 Activity

The enacted activities in Text 2 demonstrate little difference in comparison to Text 1. Examples of both investigation (e.g. *experiment*) and manner (e.g. *methods* and *treatment*) are found. In addition, the other subtype of activity, the observational, also appears in Text 2. For example,

> [2.36] gene expression controls B-galactosidase activity.

Gene expression names a series of goings-on involving several biological and chemical phenomena such as *DNA*, *protein*, *nucleic acids*, *molecules* etc. It is defined in the textbook as "the process by which DNA directs protein synthesis" (Campbell & Reece, 2005, p. 309). In the explanation part of the Text 2, *gene expression* is broken down into series of steps, as demonstrated in the excerpt below. Some of these steps are named, such as *transcription* and *translation*, each of which can be further decomposed into smaller steps.

> "The process by which DNA directs protein synthesis, gene expression, includes two stages, called transcription and translation. (…) Transcription is the synthesis of RNA under the direction of NDA. Both nucleic acids use the same language, and the information is transcribed, or copied, from one molecule to the other. (…) Translation is the actual synthesis of a polypeptide, which occurs under the direction of mRNA. During this stage, there is a change in language: the cell must translate the base sequence of an mRNA molecule into the amino acid sequence of a polypeptide…" (Campbell & Reece, 2005, pp. 309-311)

Based on this excerpt, we can model the decomposition of *gene expression* as outlined in the diagram below. The activities at the top two levels of the compositional hierarchy are named.

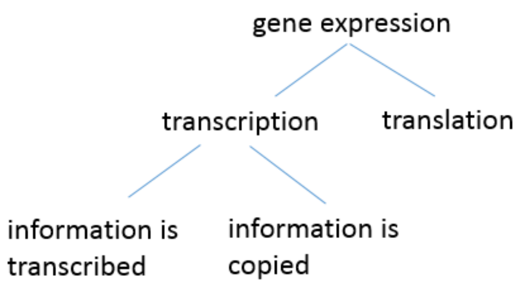


Figure 3.18 Composition of gene expression in Text 2

The student demonstrates her understanding of *gene expression* as an activity and its decomposition through an elaborating nominal group complex in [2.7].

> [2.7] The aim of this experiment was to determine whether the induction of B-galactosidase resulted from the production of the enzyme through gene expression (transcriptional and translational processes) or through activation of the existing enzyme.

Apart from classification, *gene expression* is also elaborated through a measurement, e.g. *levels of* in [2.1-2].

> [2.1-2] The activity of proteins can be controlled through influencing levels of gene expression

The occurrence of observational activities suggests that the knowledge construed in Text 2 is concerned with complex interactions among scientific phenomena.

3.4.2.3 Semiotic

The fact types which occurred in Text 1 – result, case, need – also occur in Text 2. More importantly, another type of semiotic entity – idea – is identified in Text 2, as exemplified by *knowledge* and *hypothesis* in the examples below.

> semiotic entity [idea]
> [2.30] This confirmed previous knowledge [[that lactose induces B-galactosidase activity]].
> [2.37] If the hypothesis [[that activating the already present B-galactosidase induces activity]] was correct…

In these examples, the ideas are elaborated through the goings-on, which involve interactions among inferable things (i.e. *lactose, B-galactosidase*). That is to say, like the observational activities identified above, they name the goings-on as entities.

3.4.2.4 Overview of entities and dimensionalities in Text 2

The investigation of entities in Text 2 has demonstrated some differences that can be interpreted as developmental features in comparison to those identified in Text 1. The comparison between the entity types in these two texts is presented in Table 3.15 below.

Table 3.15 Entity types in Text 1 and Text 2

types of entity			Text 1	Text 2
thing	instrumental / ostensively defined		*container, pipette, vial, automatic dispenser, gloves, fume-cupboard, cuvette, balance, equipment, spectrophotometer, water, dye, solution,*	*control flask, spectrophotometer,*
	ling. defined	instrumental / trained gaze	*radioactive glucose*	*mercaptoethanol, chloroform, glycerol medium, sodium carbonate,*
		observational / inferable		*protein, cytosol, enzyme, lactose, glucose, B-galactosidase,*
activity	enacted	investigation	*experiment*	*experiment*
		manner	*method, weight-of-water, spectrophotometry radioactivity*	*treatment*
	observational / inferable			*gene expression, transcription, translation, induction, bacterial growth*
source	people		*student (implied)*	*student (implied)*
semiotic	fact	case	*limitations*	*fact, mechanism*
		needs	*needs*	*purpose*
		consq.	*results*	*result*
	idea			*knowledge, hypothesis*

Several entity types emerged in Text 2. Firstly observational things and activities, specifically inferable ones, are used to construe taxonomies at the border of biology and chemistry. Secondly, linguistically defined instrumental things are found. They construe the materials, such as chemical solutions, that are used to observe the inferable entities. In addition, semiotic entities are found which name goings-on involving biological phenomena.

The linguistically defined things and activities in Text 2 are elaborated in the discourse through both taxonomic relations and measurement (see Table 3.16 below).

Table 3.16 Dimensionality of entities in Text 2

Text 2: types of entity	dimensionality			
	taxonomic relation:		attribution: measurement	
	class.	comp.	field neutral	field specific

thing	instrumental / ostensively defined		*control flask, repressor, spectrophotometer,*				
	ling. def	instru/ trained gaze	*mercaptoethanol, chloroform, glycerol medium, sodium carbonate,*	types of *food source*			*100mN sodium phosphate buffer, 50mM 2-mercaptoethanol*
		obser. / inferable	*protein, cytosol, enzyme, lactose, glucose, B-galactosidase,*	*protein ->enzyme ->B-gal.*		*the amount of B-galactosidase*	*activity of B-galactosidase,*
activity	enacted		*experiment, treatment*				
	obser. / ling. def		*gene expression, transcription, translation, induction, bacterial growth*		*steps of gene expression*	*levels of gene expression*	
semiotic	fact	case	*fact, mechanism*				
		needs	*purpose*				
		consq.	*result*				
	idea		*knowledge, hypothesis*				

The taxonomies associated with utilitarian tools and materials suggest the field construed in Text 2 has characteristics of a specialised field. At the same time, the taxonomies of the scientific phenomena observed in the experiment suggest that an exploration field is also being established. In comparison to Text 1, the purpose of the experimental activity in Text 2 is to observe a scientific phenomenon, rather than to practice the skills of conducting a procedure. That is to say, the specialised field construed in Text 2 is in service of the exploration field. In addition, the exploration field is characterised by the taxonomies associated with both biology and chemistry, which suggests the significance of chemistry at this stage of the apprenticeship.

3.4.3 Entities and dimensionalities in Text 3 - second year research report

Text 3 is a research report produced at the end of the second undergraduate year. It reports on an investigation of whether the fungi *Chytridiomycota* occur in sea urchins. The investigation of Text 3 will continue to focus on the construal of field through entities. In comparison to Text 2, Text 3 demonstrates a larger variety of entity types as well as a greater depth of taxonomic relations.

3.4.3.1 Thing

Like thing type entities in Text 1 and 2, both instrumental and observational things appear in Text 3. There are no marked differences in relation to instrumental things, but significant differences are found in relation to observational things.

3.4.3.1.1 Observational thing

The observational things in Text 3 are by and large linguistically defined. The more delicate subtypes trained gaze, tech-enhanced gaze and inferable things are all found.

3.4.3.1.1.1 Observational thing: trained gaze

A large number of trained gaze things in Text 3 are associated with *sea urchin*, as underlined in the examples below*:*

> [3.26] The aim of the project would be to confirm the presence of members of the Chytridiomycota within different species of sea urchin
> [3.30-31] Three species of regular sea urchin, *Erythrogramma heliocidaris* (purple sea urchin), *Pyonotilus holopneustes* (pink sea urchin) and *Parvispirus phyllacanthus* (slate pencil urchin), were collected... Specimens of the irregular urchin, *Echinocardium cordatum* (heart urchin), were also collected...

These examples suggest that *sea urchins* are tangible phenomena, based on the reference to their colours (e.g. *purple sea urchin* and *pink sea urchin*) and shapes (e.g. *heart urchin*). Secondly, they are linguistically defined entities, as indicated by their scientific names such as *Erythrogramma heliocidaris* and *Pyonotilus holopneustes.* As has been discussed earlier, scientific names in biology are borrowed from Latin and Greek; they are usually formatted in texts in italics and with initial capitals.

The classification of the trained gaze things is revealed in these examples above. Through Classifiers *sea urchin* is divided into *regular* and *irregular* types, and within each type, further distinctions are made (e.g. *purple sea urchin* and *slate pencil urchin*). The classification is explicitly named, field-specifically as *species*, e.g. *species of regular sea urchin* in [3.30-31]. The field-specific classification is also indicated by their scientific names (e.g. *Erythorogramma heliocidaris*). The first word (i.e. *Erythrogramma*) identifies the genus to which the sea urchin belongs, and the second one (i.e. *heliocidaris*) identifies the species as a smaller category under genus. The classification of sea urchins revealed in [3.30-31] above is displayed in Figure 3.19 below.

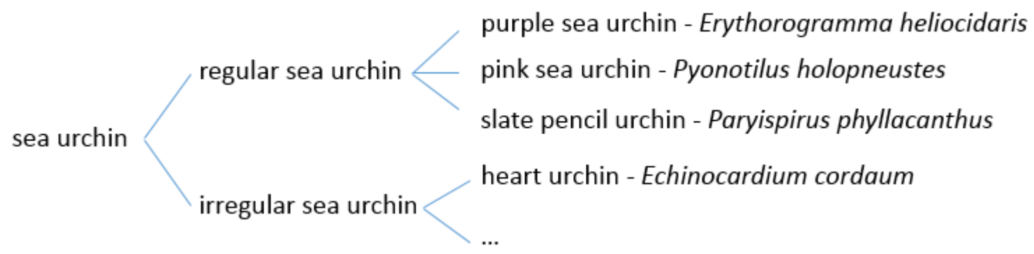


Figure 3.19 Classification of sea urchin in Text 3 (a)

This classification continues to be expanded in the following discourse, e.g. [3.114] and [3.87].

> [3.114] As sea urchins are herbivorous…
>
> [3.87] …*Cladosporium* and *Alternaria* may also be present within sea urchins and other marine invertebrates (Morrison-Gardiner (2002)).

Sea urchins in [3.114] are established as a type of *herbivorous* entity, through an intensive attributive process. In [3.87], through the comparative reference item *other*, *sea urchins* is further positioned as a hyponym of *marine invertebrates.* Note however that the relationship between *herbivorous* and *marine invertebrate* entities is not explicitly realized in the text, but has to be taken as assumed knowledge between the writer and readers in the field: i.e. *marine invertebrate* is a hyponym of *invertebrate*; *invertebrate* is a hyponym of *herbivore*. The classification of sea urchin can now be expanded as in Figure 3.20 below.

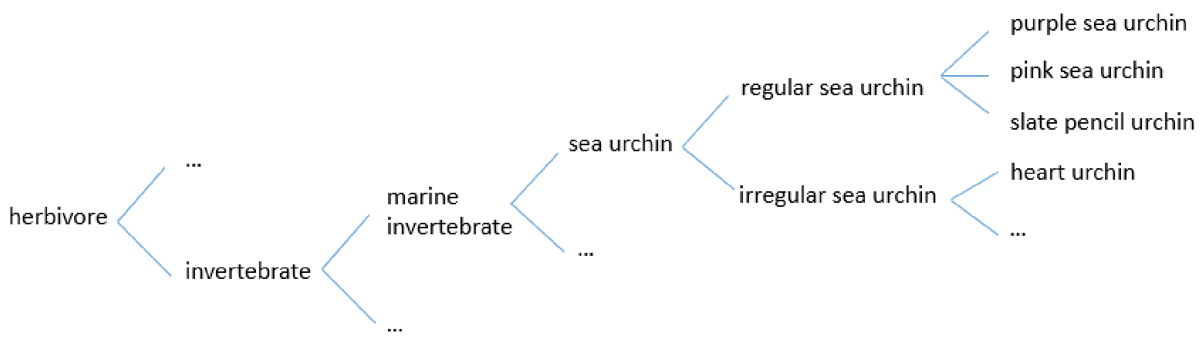


Figure 3.20 Classification of sea urchin in Text 3 (b)

The compositional relationship between *sea urchin* and its parts is also construed. For example in [3.33], the Thing^Qualifier structure indicates that *coelomic cavity* and *digestive tract* are parts of the whole *sea urchin.*

> [3.33] Samples were then taken from the coelomic cavity and digestive tract of the sea urchins

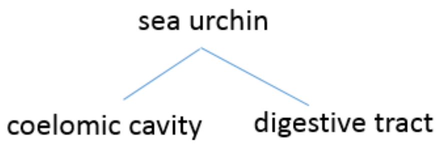


Figure 3.21 Composition of sea urchin in Text 3 (a)

The composition of *sea urchin* is further expanded in [3.103].

> [3.103] the possible presence of chytrids within the coelomic fluid of *P. Phyllacanthus* and *E. heliopneustes* could have resulted from ingestion of algae.

Coelomic fluid is construed as part of the scientifically named sea urchins *P. Phyllacanthus* and *E. heliopneustes.* While the relationship between *coelomic fluid* in [3.103] and *coelomic cavity* in [3.33] is not realised explicitly and relies on the shared knowledge between the writer and readers, the Classifier *coelomic* in each suggests they are related taxonomically. The decomposition of *sea urchin* is expanded as Figure 3.22 below.

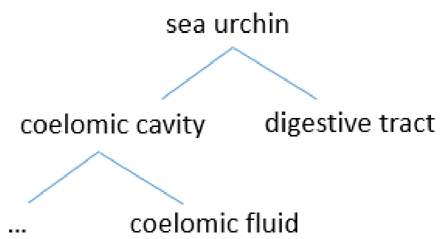


Figure 3.22 Composition of sea urchin in Text 3 (b)

3.4.3.1.1.2 Observational thing: technologically enhanced gaze

Some observational things in Text 3 depend on observation through technology. Most of the tech-enhanced gaze things in this text are associated with the entity *Chytridiomycota (Chytrid).*

Chytrid is linguistically defined at the beginning of the text through an intensive identifying process in [3.11].

> [3.11] The *Chytridiomycota* are considered the most primitive phylum of the fungi.

At the same time, the observation of *Chytrid* through a microscope is realised through the Circumstance of Manner *through microscopic observation* in [3.29].

> [3.29] It also aimed to provide some evidence for the presence of chytrids within sea urchins, through microscopic observation and culturing methods.

Chytrid is elaborated in the discourse through classification. In its linguistic definition in [3.11] above, the relationship between *Chytridiomycota* and *fungi* is named through the Focus group *the phylum of*, which suggests that *fungi* is the superordinate of *Chytridiomycota.*

Figure 3.23 Classification of Chytrid in Text 3 (a)

This classification is expanded in [3.15-16].

> [3.15-16] Members of this phylum are ecologically important, and include plant and animal parasites, as well as the ruminant symbionts

In this example, the relationship between *Chytridiomycota* and its hyponyms (i.e. *plant parasites, animal parasites* and *ruminant symbionts*) is firstly realised through a possessive identifying process. Their relationship is also named through the Focus group *members of.* The classification developed for *Chytrid* entities is presented in Figure 3.24.

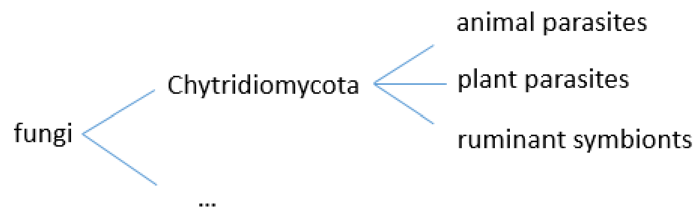


Figure 3.24 Classification of Chytrid in Text 3 (b)

This classification is further expanded as the text unfolds. More entities in [3.83] are associated with *Chytrids.*

> [3.83] …these included filamentous fungi, possibly **species of** *Penicillium* or *Aspergillus* – but not *Chytrids*.

In this example, the entity *filamentous fungi* is firstly realised through a Classifier=Thing structure, indicating the entity *fungi* identified above in [3.11] is classified into different hyponyms: *filamentous fungi* and others. The elaborating nominal group complex as a whole further specifies the hyponyms of *filamentous fungi* – as *Penicillium* and *Aspergillus.* Since the entity *chytrids* is excluded from the category of *filamentous fungi*, a co-hyponym of *filamentous fungi* to which *chytrids* belongs is thus implied. This further expansion of the classification is displayed in Figure 3.25.

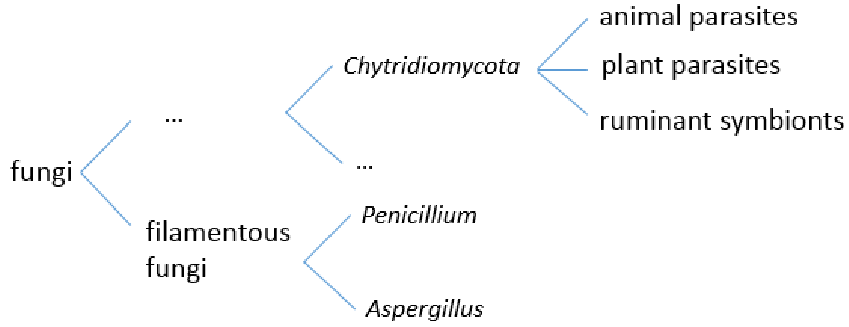


Figure 3.25 Classification of Chytrid in Text 3 (c)

Note that while the hyperonym of *Chytrid* is not specified in the text, the student's understanding of the way in which *Chytrid* is classified is suggested in [3.134] and [3.66].

> [3.134] the *Chytridiomycota* are characterised by the presence of flagellated zoospores.
> [3.66] This motion seemed to suggest the presence of flagella

It can be seen that one criterion distinguishing *Chytridiomycota* from other species, such as the *filamentous fungi* which contain filaments, is the whole/part relationship between *Chytridiomycota* and *flagella*. That is to say, the composition taxonomic relations provide evidence for the classification.

Apart from its classification, *Chytrid* is also elaborated by dimensionality of attribution, such as the measurable dimensionality *motility* and the perceptive one *shape* in [3.68-69]. These dimensionalities provide further criteria for the classification of *Chytrid.*

> [3.68-69] The combination of their motility and their shape suggests that these organisms could be chytrid zoospores.

3.4.3.1.1.3 Observational thing: inferable

While in Text 2 inferable things were salient. in Text 3 they are less significant in comparison to trained gaze and tech-enhanced gaze things. A few instances of inferable things are found, such as *cellulose, keratin,* and *chitin* in [3.111].

> [3.111] Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates, including cellulose, keratin and chitin

In this example, a classification is realized through the Thing^Qualifier structure; this classification is at the same time named through the Focus *a variety of.* The taxonomy construed here is outlined below.

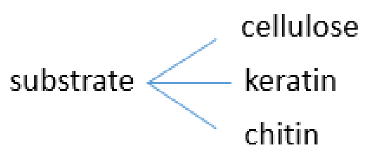


Figure 3.26 Classification of substrates

3.4.3.1.2 Instrumental thing

As in Text 1 and Text 2, instrumental things in Text 3 include both ostensively defined entities and linguistically defined ones. A new feature in comparison to the previous texts has to do with the occurrence of *microscope,* which is associated with the tech-enhanced gaze things identified above. The classification of *microscope* is construed, involving the hyponyms *light microscope* in [3.35] and *scanning electron microscope* in [3.123].

> [3.35] …using a light microscope.
>
> [3.123] …and possibly observation of the gut wall structure using a scanning electron microscope could also aid in identification...

To summarise briefly, in Text 3, the occurrence of trained gaze things and tech-enhanced gaze things is significant. These entity types involve a greater depth of taxonomic relations in comparison to the entities construed in Text 1 and Text 2. Inferable things and instrumental things are comparable to those in the previous texts. So in Text 3 more emphasis is placed on knowledge of biology in comparison to knowledge of technology or chemistry.

3.4.3.2 Activity

Both enacted activity and observational activity entities are identified in Text 3. The main differences in relation to Texts 1 and 2 are associated with the activity [tech-enhanced gaze], and the activity [investigation] entity types.

3.4.3.2.1 Observational activity: Technologically enhanced gaze

The occurrence of observational activities in Text 3 corresponds to the occurrence of a tech-enhanced gaze thing, i.e. *Chytrid*. As shown in [3.107], the biological interaction between *Chytridiomycota* and *Echinoidea* is named as *symbiosis*.

> [3.107] Members of the *Chytridiomycota* may be involved in symbiosis with the *Echinoidea*.

The activity *symbiosis* is taxonomised in relation to other activities in [3.108]. The possessive identifying process realises the classification at two levels, as outlined in Figure 3.27 below.

> [3.108] Host-microbial relationships may include parasitism, commensalism and symbiosis.

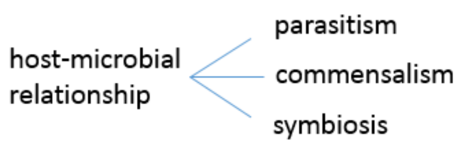


Figure 3.27 Classification of host-microbial relationship

3.4.3.2.2 Enacted activity

Both subtypes of enacted activity, manner and investigation, are found in Text 3. In Text 1 and Text 2 the instances of investigation activities are mostly *experiment*, reflecting the laboratory activity. By contrast, the instances of investigation in Text 3 move beyond a purely experimental level to contextualise this work as part of building knowledge in the field as a whole, e.g. *study* and *project* in [3.27] and [3.77].

> [3.27] This preliminary study aimed to determine the most practical methods to allow this project to be attempted, in particular collection and dissection methods.
> [3.77] Such taxonomic identification would be followed closely in future studies.

Compositional taxonomic relations of the investigation are revealed in these examples. According to [3.27], the *preliminary study* is presented as a part of the *project.* The Classifier *preliminary* suggests that the *project* is constituted by different stages based on its extension in time. Similarly in [3.77], *future studies* is introduced as a stage of *study,* while the question of whether *future studies* are part of this *project* is unspecified.

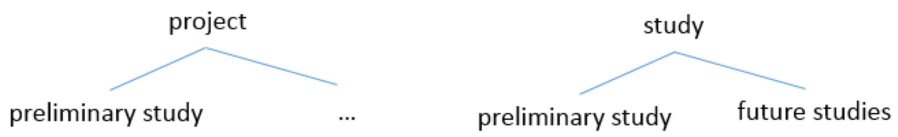


Figure 3.28 Compositions of project and study in Text 3

In terms of manner, a number of instances are identified in Text 3, including the methods used in the present study, such as *collection method* and *dissection method* in [3.27], and the methods that are proposed to be useful in the future studies, such as *biochemical tests* and *molecular sequencing methods* in [3.120-121].

> [3.27] This preliminary study aimed to determine the most practical methods to allow this project to be attempted, in particular collection and dissection methods.
> [3.120-121] Further analysis could be performed using biochemical tests or molecular sequencing methods, such as DNA sequencing.

In terms of taxonomic relations among the methods, *DNA sequencing* (in [3.120-121]) is introduced as a hyponymy of *molecular sequencing methods* through the elaborating nominal group complex. However, most of the manner activities are not taxonomically related to each other; they simply form a collection of activities undertaken.

3.4.3.3 Source

Similar to Text 1 and 2, source entities [people] who conduct the experiment are mainly implied in clauses with receptive voice: e.g. *Samples were taken from the coelomic cavity and* *digestive tract of the sea urchins (by us)*. A significant difference in regard to source entities in Text 3 has to do with referencing to publications, as exemplified in [3.23] and [3.57] below.

> [3.23] Thorsen (1999) **reported** the presence of Chytridiomycota in the digestive system of the irregular urchin, *Echinocardium cordatum*.
>
> [3.57] The presence of microbial activity in both regular and irregular sea urchins **has been demonstrated** … (da Silver et. al. (2006), Sawabe et. al. (1995), Temara, De Ridder & Kaisin (1991), Thorsen (1998), Thorsen (1999)).

These sources reinforce the shift of investigation activity from an *experiment* to a *study*. The knowledge that is established at this stage of apprenticeship is not only the recontextualised knowledge in the pedagogic texts; but also involves engaging with knowledge that is produced in published research articles.

3.4.3.4 Semiotic

The use of semiotic entities is another distinctive feature of Text 3. Apart from the semiotic entities that were identified in Text 1 and Text 2 – case (e.g. *fact*), result (e.g. *result*), idea (e.g. *knowledge*), two other types, consequence [proof] and locution appear in Text 3. The instances of consequence [proof] include *reason* and *evidence* in the examples below.

> [3.128] The identification of microorganisms within sea urchins, and attempts to understand their role in such a relationship is significant for a number of reasons.
>
> [3.29] This study also aimed to provide some evidence for the presence of chytrids within sea urchins...

In contrast to the result entities in the previous texts, which named the perceived consequential relations within the experiment (e.g. *results*), these proof entities name interpretations of cause/effect generated in the student text. Thus *reason* in [3.128] names the chunks in subsequent paragraphs which are causally related to the clause *the identification of microorganisms…is significant*. Similarly, *evidence* in [3.29] names the pieces of text in the subsequent Result and Discussion, which are related causally to *the presence of chytrids within sea urchins.* This suggests that interpreting cause and effect relationships is a significant feature of Text 3.

Secondly, locution entities are exemplified by *report* and *information* in the examples below.

[3.118] There were a number of aspects which were unaddressed in this report...

[3.130] Such research would provide information...

Report in [3.118] names the research report (Text 3) produced by the student; *information* in [3.130] names the contributions offered by a published research article. In contrast to the semiotic entities such as fact (e.g. *fact*) or ideas (*e.g. knowledge*) that position established scientific knowledge as facts in the previous texts, these locution entities in Text 3 relativise the findings of the research as knowledge which has not yet been accepted as scientific fact.

3.4.3.5 Place

Place entities, were not found in Text 1 and Text 2, but do appear in Text 3. Both ostensively and linguistically defined places are found. The ostensively defined places are realised through Circumstances in the procedure part of the text. They specify the places where the samples of organisms were collected for the purposes of the study, as shown in [3.30-31].

[3.30-31] Three species of regular sea urchin were collected from the rocky-intertidal region at Chowder Bay. Specimens of the irregular urchin, Echinocardium cordatum (heart urchin), were also collected from within the oceanic sediment at Watsons Bay.

These places refer to the regions in the Sydney metropolitan region in Australia. They can be identified by being pointed out on the map. The occurrence of these entities indicates that the activity of doing biology at the end of second undergraduate year is no longer restricted in the setting of laboratory, the application of knowledge in natural settings is also important.

Instances of linguistically defined places are also found in Text 3. They are mostly realised through Classifier=Thing structures, such as *aquatic habitats, temperate zones* and *rocky-intertidal region* in the examples below:

[3.14] Chytridiomycota are found in both aquatic and terrestrial habitats and in a diverse range of temperate zones

[3.30] Three species of regular sea urchin were collected from the rocky-intertidal region at Chowder Bay.

The Classifiers in these examples reflect the linguistically defined status of the places. For example, the uncommonsense meaning of the Classifiers such as *temperate* and *intertidal* is suggested by their Latinate origin. *Temperate* refers to moderate temperature, and *intertidal* refers to the region in between high and low water marks. Similarly, the Classifiers in *aquatic* *habitat* and *terrestrial* *habitat* are derived respectively from Latin words *aqua* 'water' and *terra* 'land'. Construing the linguistically defined status of a place entity through a Latinate Classifier is a characteristic of linguistically defined places.

Linguistically defined places are often used to construe taxonomies in fields such as geography, ecology and geology. As far as knowledge building in undergraduate biology is concerned, the place entities in Text 3 indicate that some knowledge of geography is involved in doing biology at the end of second year.

3.4.3.6 Overview of entities and dimensionalities in Text 3

Text 3 has demonstrated a greater variety of entity types in comparison to Text 1 and Text 2. The entity types are summarised in Table 3.17 below. A number of potential developmental features can be noted.

Firstly, the observational trained gaze things, which were not identified in the previous texts, are significant in Text 3. This provides some evidence that the readily observable phenomena in the commonsense world are being re-construed taxonomically in the field of biology at the end of second year.

Secondly, the tech-enhanced gaze entities, both things and activities, occur in Text 3, along with the presence of the particular instrumental entity *microscope*. These entities suggest that the biological observation is more concerned with phenomena at the micro-level.

Thirdly, the investigation activities, such as *study* and *project*, as well as the source entities (e.g. *Thorsen (1999)*), indicate that Text 3 is positioned in relation to other studies in the field. Importantly, the building of knowledge at this stage requires more than the recontextualised knowledge in the pedagogic texts: engaging with the texts for the purpose of knowledge production, e.g. published research articles, has also become critical.

Fourthly, place entities are found in Text 3. The ostensively defined places indicate that the activities of doing biology are no longer localised in the laboratory; the application of the knowledge in the natural setting is also important. The linguistically defined places indicate that some knowledge associated with geography is also required in doing biology.

Finally, the use of proof entities indicates that interpreting cause/effect relationships is significant in Text 3.

Table 3.17 Entity types in Text 1, Text 2 and Text 3

types of entity				Text 1	Text 2	Text 3
thing	ostensively defined / instrumental			*container, pipette, vial, automatic dispenser, gloves, fume-cupboard, cuvette, balance, equipment, spectrophotometer, water, dye, solution,*	*control flask, repressor, spectrophotometer,*	*water, microscope, scanning electron microscope*
	ling. def.	trained gaze	instru.	*radioactive glucose*	*mercaptoethanol, chloroform, glycerol medium, sodium carbonate,*	*salt agar media*
			obser.			*sea urchin, Echinocardium cordatum, digestive tract, caecum, algae, gut, invertebrate,*
		tech enhanced gaze				*chytridiomycota, zoospore, protist, eukaryotic cells, sporangium, flagella,*
		inferable			*protein, cytosol, enzyme, lactose, glucose, B-galactosidase,*	*enzyme, fatty acid, amino acid, nitrogen,*
activity	enacted/ osten. def.	investigation		*experiment,*	*experiment,*	*study, project, experiment,*
		manner		*method, weight-of-water, spectrophotometry, radioactivity*	*treatment*	*method, dissection method, culturing methods, sampling method, molecular sequencing method*
	obser. /ling. def.	tech enhanced gaze				*physical process, host-microbial relationship, parasitism, commensalism and symbiosis*
		inferable			*gene expression, transcription, translation, induction, bacterial growth*	*chemical process, celluloses activity,*
place	osten. def.					*Chowder Bay, Watsons Bay,*

	ling.def				*aquatic habitat, terrestrial habitat, temperate zone, rocky-intertidal region,*
semiotic	fact	case	*limitations*	*fact, mechanism*	*problem, mechanism,*
		needs	*needs*	*purpose,*	
		consq. result	*result*	*result*	*findings, results*
		consq. proof			*reasons, evidence*
	idea			*knowledge, hypothesis*	*knowledge*
	locution				*information, report*
source	people		*student (implied)*	*student (implied)*	*students, biologists (implied)*
	publication				*Sawabe et. al. (1995), Thorsen (1998)*

In terms of the ways in which entities are elaborated through dimensionalities, we have seen that the taxonomic relations among observational things are significant, as summarised in Table 3.18 below. The perceptive dimensionality and the composition of tech-enhanced gaze things name the criteria by which the tech-enhanced gaze things may be classified. This emphasizes that the taxonomising of biological phenomena has become a more significant part of the apprenticeship.

Table 3.18 Dimensionality of entity in Text 3

entity types					dimensionality			
					taxonomic relation		attribution	
					classf.	comp.	measure ment	percepti on
thing	instrumental / ostensively defined			*water, microscope, scanning electron microscope*				
	ling. defined	traine d gaze	instru	*salt agar media*			*sample size*	
			obser	*sea urchin, Echinocardium cordatum, digestive tract, caecum, algae, gut, invertebrate,*	*species,*	*part of the normal flora, an section of the gut,*		
		tech enhanced gaze		*chytridiomycota, zoospore, protist, eukaryotic cells, sporangium,*	*Other members of the geofungi,*	*structure of zoospore, gut wall*	*a number of round cells;*	*shape of flagella;*

			flagella,	*species of sea urchin, organism, phylum, species,*	*structure; composition of the microflora; structures of the fungi*		
		inferable	*enzyme, fatty acid, amino acid, nitrogen,*		*chemical composition,*		
activity	enacted	investigation	*study, project, experiment,*				
		manner	*method, dissection method, culturing methods, sampling method, molecular sequencing method*				
	obser/ ling. def.	tech enhanced gaze	*physical process, host-microbial relationship, parasitism, commensalism and symbiosis*				
		inferable	*chemical process, cellulases activity,*				
place	osten. def.		*Chowder Bay, Watsons Bay,*				
	ling.def		*aquatic habitat, terrestrial habitat, temperate zone, rocky-intertidal region,*			*a diverse range of temperate zones*	
semiotic	fact	case	*problem, mechanism, aspects*				
		consq. result	*findings, results*				
		consq. proof	*reasons, evidence*			*a number of reasons*	
	idea		*knowledge*				
	locution		*information, report*				

The deeper biological phenomena taxonomies in Text 3 suggest that an exploration field is being established. In contrast, the taxonomies of experimental procedure and utilitarian tools demonstrated only limited development from the previous texts, which indicates that the specialised field continues in the service of the exploration field.

In addition, the field construed in Text 3 resembles the field construed by published research articles (Hood, 2010). Participation in doing biology has expanded from working in a localized laboratory experiment to engaging with a wider academic community, which resembles the field of research in published research articles.

3.4.4 Entities and dimensionalities in Text 4 - third year research report

Text 4 is a research report produced in the third undergraduate year. It reports on an investigation of the interaction between insects and fungal spores. Similar features to the research report in the second year (Text 3) can be identified, such as the observation of biological phenomena through technology, research activity beyond the laboratory experiment, engagement with academic sources, and the construal of internal cause/effect relations. Most of the entity types in Text 4 have been identified in the previous texts. What is different in text 4 is the way in which entities are elaborated through dimensionalities.

3.4.4.1 Thing

Both observational and instrumental things are identified in Text 4. With respect to instrumental things there is little difference to those in Text 3. The discussion of thing entities in Text 4 is thus focused on observational things. Among these, the subtypes of trained gaze, tech-enhanced gaze and inferable are identified.

3.4.4.1.1 Observational thing

3.4.4.1.1.1 Trained gaze things

The trained gaze things in Text 4 are mostly associated with the *locust* entity. As in the previous texts, the explicit lexicogrammatical realization of classification reveals the relationship among the trained gaze things. For example, through the Classifier^Thing structure *Australian plague locust*, the entity *Australian plague locust* is identified as a hyponyms of *locust*; and through a possessive identifying process, [4.158] below, the relationship between *invertebrate hosts* and its hyponyms is identified.

> [4.158] A number of invertebrate hosts have been shown to aid fungal spore dispersal, including aphids (Meyling *et. al.* 2006), grasshoppers (Devarajan & Suryanarayanan, 2006) and snails (Dromph 2001, 2003).

While some classification can be identified through lexicogrammatical resources, as in [4.158], many taxonomic relations are not explicitly construed grammatically in the text, but rather assumed. In the examples below, no classification relations among *insect, herbivore* and *locust* are realised. These trained gaze entities are all associated with the same tech-enhanced gaze thing *fungal spore,* which implies taxonomic relations among the three.

> [4.15] <u>Insects</u> may also aid the dispersal of <u>fungal spores</u> either externally or internally
> [4.43] the ability of <u>fungal spore</u> to pass unharmed through the chemical environment found in the digestive tract of <u>herbivores</u>
> [4.134] <u>(fungal) spores</u> could be isolated from the <u>locust</u>

The assumed classification in Text 4 relies on shared knowledge between the writer and readers in the field. The classification of trained gaze things instantiated in Text 4 can be roughly mapped in Figure 3.29 below.

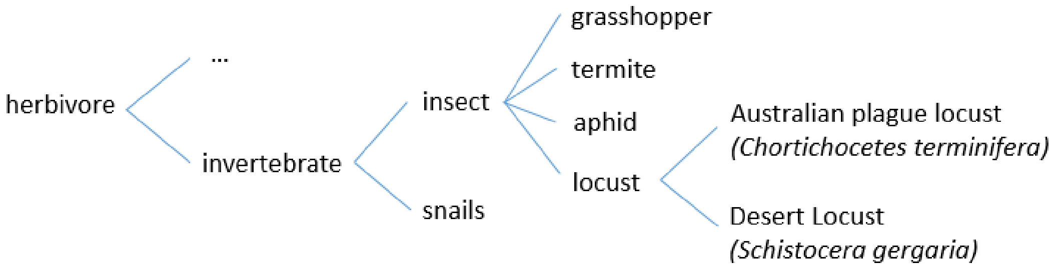


Figure 3.29 Classification in relation to locust in Text 4

The compositional relations among the trained gaze things are also realised either explicitly or implicitly. Explicit realizations include a Thing^possessive Qualifier structure (*the gastrointestinal tract of each locust*), a Classifier=Thing structure (*locust exoskeleton*), as well as a possessive attributive clause (*different developmental stages of <u>C.terminifera</u> have <u>mandibles</u> of different sizes*). Implicit compositional relationships also rely on shared knowledge between the writer and readers, e.g. the relations between *spine* and *locust,* and between *teeth* and *locust,* as well as that between *gut* and *gastrointestinal tract.* A mapping of compositional taxonomies associated with the *locust* entity can be displayed in Figure 3.30 below.

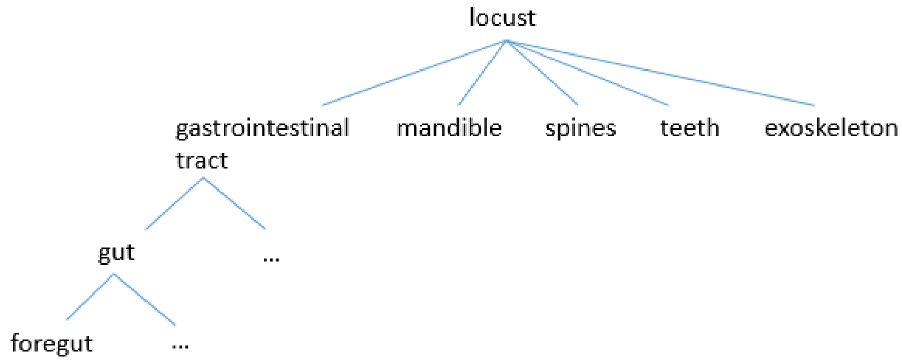


Figure 3.30 Composition of Locust in Text 4

As we can see, the trained gaze things in Text 4 demonstrate a similar depth of taxonomic relations to those in Text 3. However, the taxonomic relations are built less explicitly in Text 4; more is assumed in the discourse.

3.4.4.1.1.2 Technologically enhanced gaze thing

Tech-enhanced gaze things in Text 4 are mostly associated with the entity *fungal spore*. The explicit realizations of the classification among entities include the Classifier=Thing structure in *dung fungal spore*, the nominal group containing Focus (*<u>species of</u> Penicillium, Podopspora, Absidia, Isaria and Phycomyces*), as well as the circumstantial attributive process (*phycomyces belongs to a different fungal taxa (Zygomyces) to the other isolates*). As with the trained gaze things discussed above, many relationships among the tech-enhanced gaze things are not explicitly construed grammatically. Among these entities identified in the above examples, the relationship between *Zygomyces* and *dung fungal spore*, and the relationships among *Penicillium, Podopspora, Absidia, Isaria, Phycomyces* and *dung fungal spore* are not made explicit.

A rough mapping of the classification among the tech-enhanced gaze things is displayed in Figure 3.31 below. It seems that the depth of the taxonomic relations is comparable to the tech-enhanced gaze things in Text 3.

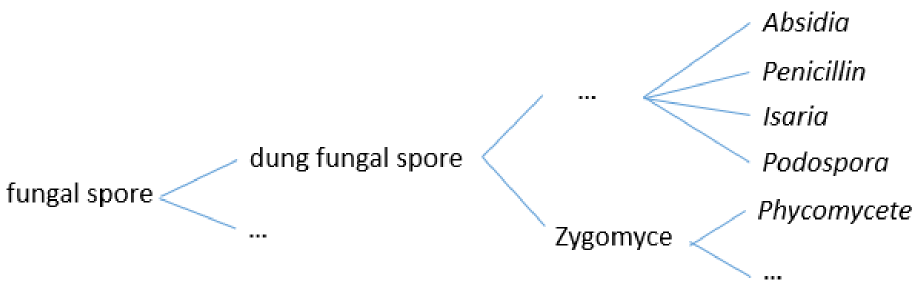


Figure 3.31 Classification of fungal spore in Text 4

A significant feature of the tech-enhanced gaze thing *fungal spore* is its elaboration through measurement. A great variety of measurements of the *fungal spore* entities are found, including both field-neutral measurements (e.g. *size, quantity*), and those which are field-specific (e.g. *concentration*, *susceptibility*, *pathogenicity*, *integrity*). These measurable dimensionalities are summarised in Figure 3.32 below.

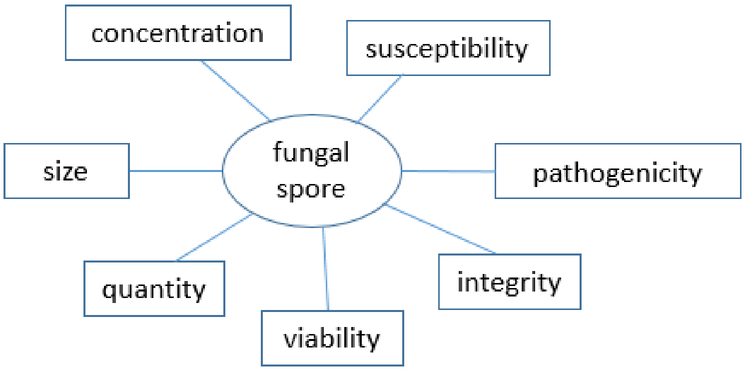


Figure 3.32 Measurement of fungal spore in Text 4

This elaboration through measurements indicates a deep exploration of *fungal spores*. As has been pointed out earlier, attribution dimensionalities such as measurement and perception name the criteria by which entities can be differentiated from one another. The great variety of the attribution in the discourse indicates that a deeper understanding of the biological phenomenon has been developed.

3.4.4.1.1.3 Inferable thing

A few instances of inferable things can be identified in Text 4, as exemplified in [4.97] and [4.113] below.

[4.97] The resident microbiota and digestive enzymes are also thought to have little involvement in the digestive process

[4.113] it is possible that intrinsic structural differences such as the constituents of the spore wall could increase susceptibility of the spores to antifungals and digestive enzymes of the locust gut.

These inferable things are associated with the inferable entity *enzyme*, which also occurred in Text 2; and a few taxonomic relations among inferable things are realised (e.g. *digestive enzymes* is a hyponym of *enzyme*). This indicates that knowledge of chemistry is also being developed in this apprenticeship.

3.4.4.2 Activity

3.4.4.2.1 Observational activity

It has been found in the previous texts that observational activities are used to name the activities involving observational things, including inferable activities such as *gene expression* in Text 2, and tech-enhanced gaze activities such as *parasitism* in Text 3. In Text 4, both the number and the variety of observational activities are significantly increased. Three types of observational activities are identified in the text. They are initiated in relation to three types of observational things: trained gaze things such as *locust*, observational things such as *fungal spore*, and inferable things such as *enzyme*. The 'agency' of an activity can be realised in grammar through a Thing^Qualifier structure in which the 'agent' is realised by the Qualifier, or through a Classifier=Thing structure in which it is realised by the Classifier.

observational activity entity realized in nominal group Thing^Qualifier

[4.30] smaller spores to more easily avoid maceration by insect mouthpieces

[4.150] The alternative explanation for the absence of colonization by *Isaria*…

observational activity entity realized by Classifier=Thing

[4.58] …by spraying a fresh PDA plate with spore solution and monitoring spore germination

[4.158] A number of invertebrate hosts have been shown to aid fungal spore dispersal

Apart from realising the grammatical configuration of a thing and its activity at group rank, their relationship can also be realised at the clause rank. In this case, lexical verbs such as *initiate, instigate, commence* play the role of Process. For example, in [4.150], the trained gaze thing *locust* is the agent of the trained gaze activity *physiological response*.

[4.150] …that the locust initiated some physiological response that prevented colonization

The correspondence between the various observational things and their activities in Text 4 is summarised in Table 3.19 below.

Table 3.19 Observational things and activities in Text 4

trained gaze		tech enhanced gaze		inferable	
thing	**activity**	**thing**	**activity**	**thing**	**activity**
locust Australian plague locust (Chortichocetes terminifera), Desert Locust (Schistocera gergaria)	*mandibular maceration, physiological response*	*fungal spore, dung fungal spore, Penicillium, Podopspora, Absidia, Isaria, Phycomyces*	*dispersal, ingestion, digestive sequence, peristalsis, lifecycle, spore germination, fungal growth, colonization, dissemination, adaptation, spore destruction*	*antifungal enzyme, digestive enzyme*	*enzymic digestion, antifungal compounds*

Some compositional relationships among observational activities are identified. In the examples below, the relationship between *adaption* and its angle is named by the Focus group *on the basis of*, and the relationship between *lifecycle* and its parts is named by the Focus groups and *the stage of*.

[4.42] The fungal taxa – *Absidia*, *Penicillin*, *Isaria*, *Podospora* and *Phycomycetes* – were chosen on the basis of the adaptations associated with their ecological niche

[4.141] …by selecting individuals (of fungal spores) at exactly the same stage of their lifecycle

In addition, it is found that different observational activities may be combined and realised through one nominal group, such as *insect-fungi interactions* in [4.17].

[4.17] insect-fungi interactions may also be detrimental to both groups

Insect-fungi interactions package the meanings of trained gaze activities involving *insects* and tech-enhanced gaze activities involving *fungi* into one nominal group through the experiential metaphor *interaction*. While *insect-fungi interaction* does not seem to be linguistically defined in textbooks, and so has not yet been distilled as a technical term in the field across texts, logogenetically, the use of experiential metaphor serves the purpose of realising more than one activity entity at once.

3.4.4.2.2 Enacted activity

Enacted activities in Text 4 are similar to those seen in Text 3. Both investigation and manner activities are found. The investigation activity *study* is positioned in relation to other studies in the field.

One new feature of enacted activities in Text 4 that needs to be commented on has to do with manner activity. In contrast to the previous texts, where the manner refers to the methods of observing biological phenomena in the laboratory, some expressions of manner in Text 4 are not associated with laboratory activities: e.g. *biocontrol* and *ecology and environmental management* in the examples below.

> [4.155] Understanding spore viability in an entomopathogen/host context is a crucial aspect of autodissemination, a biocontrol strategy that employs insects to introduce a fungal pathogen into a population
> [4.127] this would inform the design of fungal biocontrols.
> [4.169] an understanding of the relationship between fungal spore viability would be beneficial in applications of biocontrol, ecology and environmental management.

The activities *biocontrol* and *environmental management* are not implemented for the purpose of observing phenomena in order to understand what is unknown in the biological world; rather they are enacted for the purpose of intervening and managing available resources for the ultimate benefit of humanity. Such applications of scientific knowledge can be associated with activities in the fields of industry and administration. This means that at the third undergraduate year, the meaningful application of biological knowledge is becoming relevant.

3.4.4.3 Overview of entities and dimensionalities in Text 4

To consolidate the discussion of the entities identified in Text 4, it can be seen that some potential developmental features can be inferred from Text 4 in comparison to the previous texts. A summary of the entities across four texts is shown in Table 3.20 below.

One salient feature of the entity types in Text 4 has to do with the considerable number of observational activities. The trained gaze, tech-enhanced gaze and inferable activities correlate with subtypes of observational things. Another salient feature is that manner activities are not solely concerned with experimental methods, as identified in previous texts, but rather are concerned with controlling the environment.

Table 3.20 Entity types identified in Text 1, Text 2, Text 3 and Text 4

types of entity				Text 1	Text 2	Text 3	Text 4
thing	ostensively defined / instrumental			*container, pipette, vial, automatic dispenser, gloves, fume-cupboard, cuvette, balance, equipment, spectrophotometer, water, dye, solution,*	*control flask, repressor, spectrophotometer,*	*water, microscope, scanning electron microscope*	*tap water, plate, container,*
	ling. def	traine d gaze	instr.	*radioactive glucose*	*mercaptoethanol, chloroform, glycerol medium, sodium carbonate,*	*salt agar media*	*Potato Dextrose Agar, Triton-X solution,*
			obser.			*sea urchin, Echinocardium cordatum, digestive tract, caecum, algae, gut, invertebrate,*	*insects, gut, gastrointestinal tract, mouthpiece, Australian plague locust, Chortichocetes terminifera, mandible, herbivore*
		tech enhanced gaze				*chytridiomycota, zoospore, protist, eukaryotic cells, sporangium, flagella,*	*fungal spore, dung fungal spores,*
		inferable			*protein, cytosol, enzyme, lactose, glucose, B-galactosidase,*	*enzyme, fatty acid, amino acid, nitrogen,*	*pathogen, fungal entomopathogen, enzyme, cytoplasm,*
activity	enact-ed	investigation		*experiment,*	*experiment,*	*study, project, experiment,*	*study, experimental procedure*
		manner		*method, weight-of-water, spectrophotometry, radioactivity*	*treatment*	*method, dissection method, culturing methods, sampling method, molecular sequencing method*	*treatment, biocontrol, autodissemination, environmental management*
	obser. /ling. def.	trained gaze					*physiological response, maceration, peristaltic movement,*
		tech enhanced gaze				*physical process, host-microbial relationship, parasitism, commensalism and symbiosis*	*fungal suspension, germination, growth, fungal spore dispersal*

		inferable		*gene expression, transcription, translation, induction, bacterial growth*	*chemical process,*	*enzymic digestion,*
place	osten. def.				*Chowder Bay, Watsons Bay,*	
	ling.def				*aquatic habitat, terrestrial habitat, temperate zone, rocky-intertidal region,*	
semiotic	fact	case	*limitations*	*fact, mechanism*	*problem, mechanism, aspects*	
		needs	*needs*	*purpose*		
		result	*result*	*result*	*findings, results*	*result, findings, consequence,*
		proof			*reasons, evidence*	*evidence, implication, ways*
	idea			*knowledge hypothesis*	*knowledge*	*concern*
	locution				*information, report*	*literature,*
source	people		*student (implied)*	*student (implied)*	*students, biologists (implied)*	*we (students), biologists (implied)*
	publication				*Sawabe et. al. (1995), Thorsen (1998)*	*Slater (1992), Ouedraogo (2002)*

In terms of the elaboration of entities through dimensionalities, we have found many taxonomic relations are not explicitly construed in the discourse, but rely on field knowledge assumed between the writers and readers in the field. In addition, in contrast to the perceptive dimensionality which was salient in Text 3, few perceptive dimensionality was found in Text 4. That is to say, tangible attributes of biological phenomena are not emphasised on in Text 4. What is significant is the measurement of entities, in particular the field-specific measurements of tech-enhanced gaze entities.

Table 3.21 Elaboration of entity through dimensionalities in Text 4

types of entity					dimensionality of entities			
					taxonomic relations		attribution	
					classf.	comp.	measurement	perception
thing	instrumental / ostensively defined			*tap water, plate, container,*			*the <u>number</u> of samples*	
	ling. def.	trained gaze	instru.	*Potato Dextrose Agar, Triton-X solution,*				
			obser.	*insects, gut, gastrointestinal tract,*		*<u>the structure of</u> higher plant*	*the <u>size</u> of the insect mouthpiece; <u>a</u>*	

				mouthpiece, Australian plague locust, Chortichocetes terminifera, mandible, herbivore		*and animal communities*	*number of invertebrate hosts*	
		tech-enhanced gaze		*fungal spore, dung fungal spores,*	*members of the Acrididae, species of Penicillium*	*constituents of the spore wall, cell wall composition*	*the numbers of spore; the size of fungal spores, spore concentration, integrity of spores, viability of spores, spore pathogenicity,*	
		inferable		*pathogen, fungal entomopathogen, enzyme, cytoplasm,*				
activity	enacted	'study'		*study, experimental procedure*				
		manner		*treatment, biocontrol, autodissemination, environmental management*		*a crucial aspect of autodissemination*		
	obser. /ling. def.	trained gaze		*physiological response, maceration, peristaltic movement,*				
		tech-enhanced gaze		*fungal suspension, germination, growth, fungal spore dispersal*		*the same stage of their lifecycle, the basis of the adaptations*		
		inferable		*enzymic digestion,*				
semiotic	fact	case						
		needs						
		result		*result, findings, consequence,*				
		proof		*evidence, implication, ways*				
	idea			*concern*				
	locution			*literature,*			*a growing body of literature*	

At this stage of the apprenticeship, an exploration field has been further developed. In comparison to the exploration field construed in Text 3 which was associated with knowing ‘what something is’, the exploration field in Text 4 emphasizes an understanding of ‘how something happens’. Like Text 3, the specialized field, i.e. the physical steps in the experiment, assists in the building of an exploration field. A further interaction between different fields is indicated by the taxonomies concerned with the application of scientific knowledge, knowledge which can be applied in a specialised field such as industry, where its implementation may also involve an administration field. Such interaction between fields has also been identified in Rose (1997, 1998) for the specialized field of industry. He found that at the high level of the industrial hierarchy, the technical notes produced by applied scientists were concerned with applying scientific knowledge and making recommendations for technological change (1998, p. 243).

3.5 Concluding remarks

In this chapter, I have explored the construal of field in four undergraduate biology texts with respect to taxonomy building. This was achieved firstly by setting up the ideational discourse semantic system ENTITY and then exploring its elaboration through DIMENSIONALITY. The motivation for these systems has taken into account field (reasoning from above), and experiential grammar (reasoning from below), as well as other discourse semantic systems (reasoning from around).

Construal of these discourse semantic systems helps clarify the inter-stratal ideational relations among field, discourse semantics and lexicogrammar. It has been clarified that field taxonomies are realized by entities and their elaborations through dimensionality at the level of discourse semantics, which are in turn realised by nominal group systems and TRANSITIVITY at the level of lexicogrammar.

The entity and dimensionality framework has been applied to the analysis of four data texts taken from three undergraduate year levels. Based on the analysis of four snapshots of the apprenticeship into biology across the three undergraduate years, it was found that in the text at the beginning of the first year (Text 1), there was an emphasis on a specialised field, as shown by the taxonomies of utilitarian tools and methods. In the text from the beginning of the second year (Text 2), the construal of field has shifted its focus towards the exploration field. This is suggested by taxonomies concerned with the knowledge at the border of biology and chemistry. In the text from the end of second year (Text 3), the exploration field has continued to be developed, with the building of taxonomies concerned with biological phenomena, particularly in terms of the classification of biological phenomena – 'what it is'. In the third year (Text 4), the exploration field has shifted its focus from 'what it is' to 'how it happens and why'. It was also found that the meaningful application of scientific knowledge to a relevant specialised field (e.g. industry) was considered at the end of third year.

At the beginning of this chapter I asked: "What do we mean by 'concrete', 'technical' and 'abstract' entities?" The answer is that there is no single criterion for distinguishing these terms. Many factors are at stake in determining the nature of an entity. Taking the observational thing entity, for example, there are questions as to whether the entity can be ostensively defined through gestures and exophoric references, or linguistically defined through verbal language; if linguistically defined, whether it is observed based on its tangibility, or has to be inferred through scientific knowledge; if it is tangible, whether it is observed through naked eyes, or through technology (see Figure 3.33 below). Each of these questions determines a choice of entity type; and each of the choices is sensitive to the field construed by the entity. 'Concrete', 'technical' and 'abstract' are reductive terms which do not have the capacity to reveal the nature of entities nor the nature of a field.

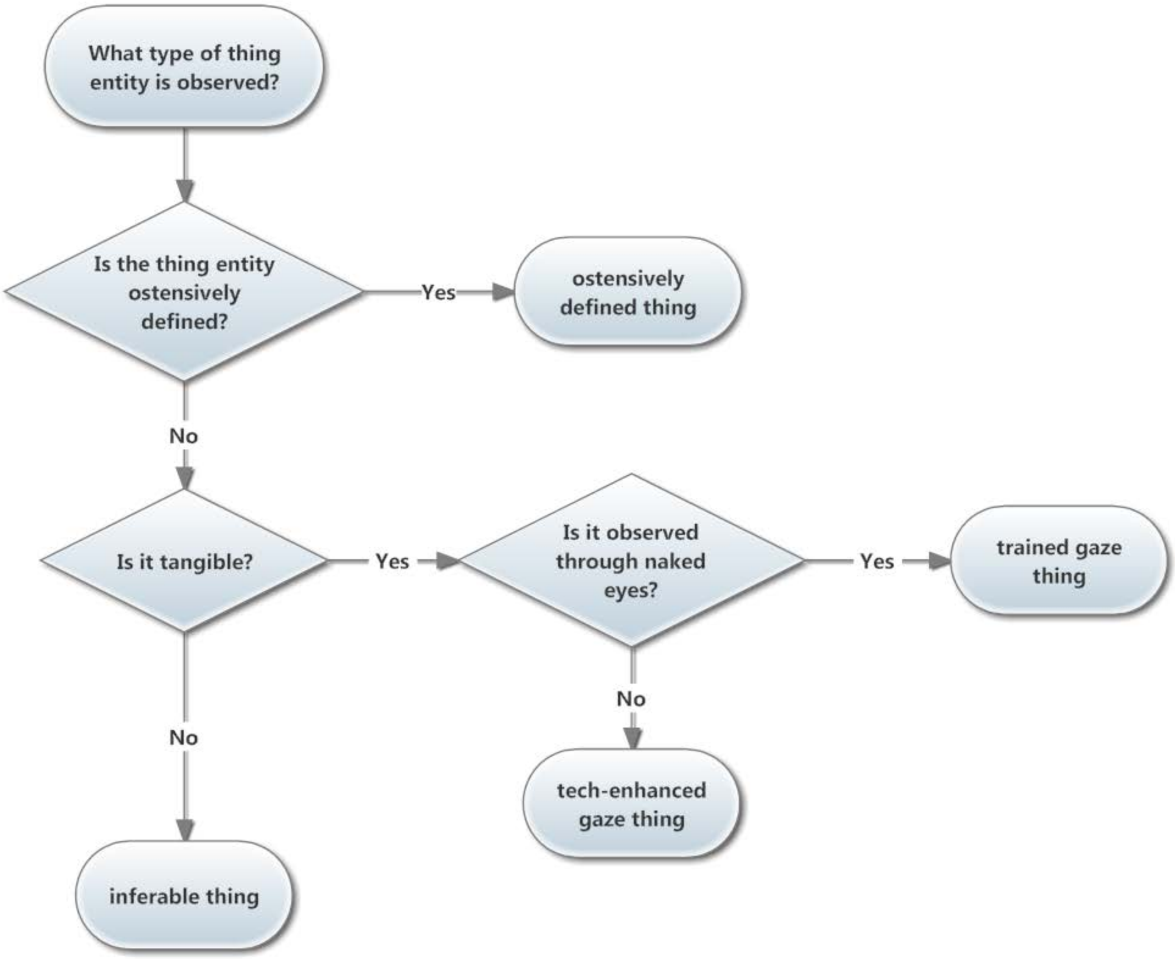


Figure 3.33 Choices of observational thing entities

In this chapter, the investigation of how field is construed through entities has contributed to the understanding of one dimensionality of field – taxonomy. In the next chapter, the other aspect of field, the sequencing of activities, will be explored.

Chapter 4 Construing activity sequence

4.1 Introduction

In Chapter 3, I explored entities and dimensionality in the field of biology. The analysis of patterning of entities in the discourse has revealed some features of taxonomy building in the field. In this chapter, I will explore the other main dimension of field – activity sequences. The exploration is approached from the level of discourse semantics, and is concerned primarily with what Halliday & Matthiessen (1999) call sequences.

As has been reviewed in Chapter 2, Martin (1992) makes a distinction between activity sequences and implication sequences in field according to whether one activity is ‘probably followed by another’, or one activity is ‘absolutely determined by another’ (Martin, 1992, p. 324). He suggests that these two ways of connecting activities in field tend to be realised by different logical relationships in the discourse. The ‘probably followed by another’ expectancy relation is likely to be realised temporally (*and then*), whereas the ‘absolutely determined by another’ relation favours causal realisations (*if/then*).

This distinction between activity and implication sequences has been useful for describing different types of field, particularly between scientific fields in opposition to other fields. However, since implication sequences were initially proposed to account for the causal relationship between scientific phenomena (Wignell et al., 1993; Martin, 1992), the distinction between the two is motivated largely at the level of field rather than through generalised patterns in discourse semantics – although they are certainly reflected in discourse semantics. It is therefore important to explore the construal of activity sequences in field, not through simply assuming the dichotomy of activity sequences and implication sequences in field, but through generalising the patterns of sequence in the discourse semantics. In this chapter, I will use ‘activity sequence’ as a superordinate term to refer to all temporally unfolding of field activities, and adopt Halliday & Matthiessen’s (1999) terms ‘sequence’ and ‘figure’ to refer to discourse semantic units. The distinct terminologies at different strata are summarised in Table 4.1.

Table 4.1 Distinctive terminology at different stratum

strata:	field	discourse semantics	lexicogrammar
terminology:	activity sequence taxonomy	sequence figure entity	clause complex clause Participant, Process, Circumstance

As reviewed in Chapter 2, a sequence is defined in Halliday & Matthiessen (1999) as 'a series of related figures' (p. 50); it is realised congruently through a clause complex. According to Halliday & Matthiessen, when grammatical metaphor is involved, a sequence may then be realised through a clause, becoming a 'figure' through a 'rankshift' in the semantics (p. 252). The clause then realises a 'junction' of a sequence and a figure. As has been argued in Chapter 3, the way of identifying semantic units is essentially an identification of grammatical units. The interstratal relationship between sequence and clause complexing, and between figure and clause remains unclear. It is therefore important to note that while I adopt the terms 'sequence' and 'figure' to name discourse semantic units, the precise nature of these units will be further explored in this thesis.

In this chapter, in order to identify how activity sequences in field are construed, we need then consider three levels along the stratification hierarchy – lexicogrammar, discourse semantics and field; as well as three levels along the rank scale in the discourse semantics – entity, figure and sequence. Intrastratally, in order to identify sequences in the discourse, the following questions need to be asked:

1) What is a discourse semantic figure?
2) How is a figure related to entities at the lower rank?
3) How are figures related in a sequence at the higher rank?

The identification of figures and sequences necessarily involves tackling the interstratal relationship between figure/sequence and clause/clause complexing. Once discourse semantic figures and sequences are identified, it is then possible for us to generalise the patterning of sequences in the data, which may then reveal the activity sequences in field. The questions pertaining to the interstratal relationships at play here are the following:

1) How are figures and sequences realised through clauses and clause complexing?
2) How does the patterning of sequences construe activity sequences in field?

To explore these issues step by step, this chapter is divided into four sections. In section 4.2, types of figures are explored. The distinction of figure types is based on the configuration of elemental discourse semantic units (entity, event and quality), as well as lexicogrammartical realisations of figures. In section 4.3, I investigate the ways in which figures are related in a sequence through discourse semantic connexions. Investigating figures and sequences involves unpacking any grammatical metaphor which creates stratal tension between discourse semantics and lexicogrammar. In section 4.4, I explore how the patterning of sequences in discourse construes activity sequences in field. Delicate types of activity sequences are identified, which further indicates delicate field distinctions in the disciplinary field of biology. Finally in section 4.5, I compare the field instantiated in the data texts, and how they are realised in the discourse – a comparison which reveals significant features of knowledge building in biology at undergraduate year levels.

4.2 Figure

A figure is a going-on in discourse semantics. Looking from above, a single figure can potentially construe a step in an activity/implication sequence in field – i.e. an activity; for example the figure *a set amount of water was pipetted* construes an activity which is a step in the activity sequence *a set amount of water was pipetted, and the weight of water was measured and recorded*. Looking from below, a figure can be realised congruently through a clause in lexicogrammar: the figure *a set amount of water was pipetted* is realised through a material process. Looking from around, a figure is a configuration of elemental discourse semantic units. One of the elemental units, entity, has been discussed in detail in Chapter 3. In this section, I will firstly note other relevant elemental units before identifying types of figures.

4.2.1 Discourse semantic elements other than entity

Entities are a key elemental unit in configuring a figure. The system of entities investigated in the data texts has been outlined in Chapter 3. Apart from entity, two other elemental units are also critical in constituting a figure. In the following examples, entities are underlined, and the other elemental units are highlighted in bold.

> [1.9] <u>the weight of water</u> [entity] + **was measured** (by <u>us</u> [entity]).
>
> [1.24] the <u>pipette</u> [entity] + **was fairly inaccurate.**

In [1.9], the figure is realized grammatically through a material process. The Participants (*the weight of water; us*) construe entities. The Process, which is realized by the verbal group (i.e. *was measured*), construes a discourse semantic **event** that has taken place. An event can be anchored to a particular point in time, as reflected here in the past tense realisation through the Finite *were* in the verbal group in [1.9]. Events can be realized by a Process in various process types, including material (e.g. *were measured* in [1.9]) mental (e.g. *we consider…*), verbal (e.g. *he told us…*) and behavioural ones (e.g. *She laughed.*).

Note that apart from Process, events can also be realised by other lexicogrammar forms, such as a Process=Range:process[15] configuration in a ranged middle clause; for example, in *Mary did a dance*, *a dance* elaborates the event as part of the event itself. That is to say, *do a dance* and *dancing* are both events. This construal of event is common in spoken discourse, for example *run a race* (cf. *race*), *sing a song* (cf. *sing*), *take bath* (cf. *bathe*), *playing tennis*.

In addition, events can be sometimes realised in the form of a phrasal verb (Martin 1992, p. 312-313), for example *look=at* (/*examine*), *look=over* (/*check*), *look=up=to* (/*admire*)). As exemplified in [3.51], *examined* and *looked at* are construing the same event.

> [3.51] We examined the digestive tracts of all species of regular sea urchin.
> [3.51i] We looked at the digestive tract of all species of regular sea urchin.

Apart from event, a discourse semantic **quality** can also be identified. The figure [1.24] above is realized by a relational attributive clause. It consists of an entity *pipette* and a quality (i.e. *fairly inaccurate*) that describes the entity. The quality is realized by an adjectival group[16]. Apart from being realized at the clause rank through an Attribute in relational attributive process, qualities can also be realized at the group rank through an Epithet in nominal group structure (e.g. *an accurate pipette*, *a very small cell*).

The presence of an event suggests that a dynamic activity is taking place; the quality provides a description of the entity. An exploration of the systems of event and quality is outside the scope of this thesis. For the discussion of event and quality, see Halliday & Matthiessen

[15] This type of Range Participant is labelled in Halliday (1994) and Martin (1992) as Range:process; it is at the same time labelled by Halliday & Matthiessen (2004, p. 193) as process Scope from the transitive perspective.
[16] An adjectival group is treated here as a subtype of nominal group, in which Epithet functions as Head (M. A. K. Halliday & Matthiessen, 1999, p. 331).

(1999, p. 62 ff.)[17]. For attitudinal dimensions of qualities, see the discussion of ATTITUDE in Martin and White (2005) and Hood (2004, 2010) and Hao & Humphrey (2012), who explore attitude in academic discourse.

4.2.2 Orbital representation of figure

As has been reviewed in Chapter 2 (section 2.2.2), experiential structures are characterised as particulate structure. While constituency and nuclearity have both been used in the literature as representations of particulate structure (e.g. Halliday & Matthiessen, 2014; Halliday, 1979/2002; Matthiessen, 1995; Martin, 1992), nuclearity (orbital and serial structures) provides a revealing representation across strata. At the level of lexicogrammar, Matthiessen (1995, p. 196) interprets clause structure along a cline of nuclearity/peripherality (see Figure 4.1 below) by drawing on the grammatical functions in the ERGATIVITY system. This cline ranges across three layers of units, reflecting the degree to which Participants and Circumstances are involved in the process.

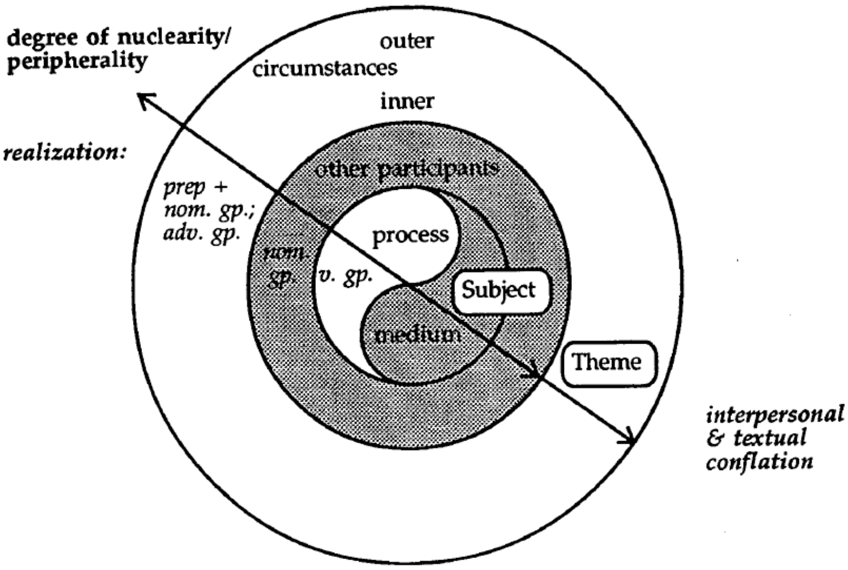


Figure 4.1 Cline of nuclearity/peripherality of involvement (from Matthiessen, 1995, p. 197)

Similarly, as reviewed in Chapter 2, Martin (1992) proposes a nuclear perspective for describing experiential structure, working at the more abstract stratum of discourse semantics. For Martin, the Classifier=Thing configuration (e.g. *paper bag*) construes one discourse semantic entity. He also illustrates that the nuclearity of discourse semantic meanings (though

[17] Note that Halliday & Matthiessen (1999) use process as an alternative term for event.

without naming them) can be construed through grammatical functions across different ranks (see Table 4.2 below).

Table 4.2 A model of nuclearity (adapted from Martin, 1992, p. 319)

structure / rank	CENTRE	NUCLEUS	MARGIN	PERIPHERY
clause	Process = Range:process	+ Medium + Range: entity	+x Agent +x Beneficiary	x Circumstance
nominal group	Classifier = Thing	+ Epithet	(+x Numerative)	x Qualifier
verbal group	Event = Particle	+ Event (event complex)	(+x causative)	x Manner adverb

As has been illustrated in Chapter 2, Martin's model of nuclearity sheds light on modelling orbital structure at the level of experiential discourse semantics; however, the naming of discourse semantic units still relies on grammatical functions. The division between the two strata is still unclear.

Building on Martin's (1992) nuclear interpretation of discourse semantics, I will use discourse semantic labels in modelling the configuration of figures. The exploration of the system and structure of figures is approached both 'from around' and 'from below'. At the level of discourse semantics, I investigate the configurations through the elemental units – entity, event and quality. At the level of lexicogrammar, I draw on ERGATIVITY, which Halliday & Matthiessen (2014) use to generalise across process types, as well as the associated voice system in exploring grammatical realisations of figures. Various complementary VOICE systems have been proposed in previous studies, for example Halliday (1967a), Davidse (1991) and Halliday & Matthiessen (2004, 2014). I will follow here the VOICE system in Halliday & Matthiessen (2004, 2014), in which a primary distinction is made between middle and effective clauses, as well as the simultaneous agentive system adapted from Martin (2013b), as shown in Figure 4.2 below.

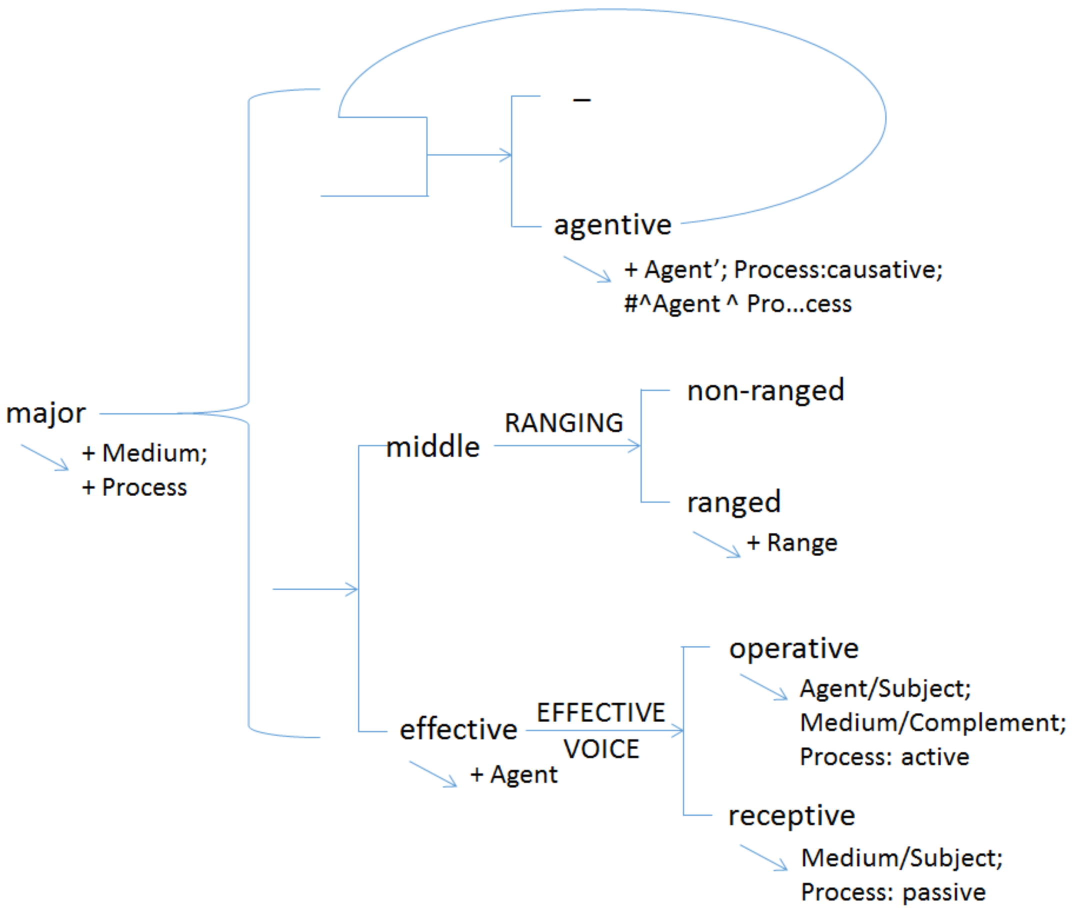


Figure 4.2 VOICE system (c.f. Halliday & Matthiessen, 2004, p. 350; Martin 2013b, p. 71)

4.2.3 Primary figure types

4.2.3.1 A departure

Drawing on the elemental discourse semantic units, entity, event and quality, we now begin the exploration of figures by looking at their particulate structure. Various configurations of event, entity and quality are possible (entities are underlined; event is in bold; and quality is in bold italics):

> [1.24] The <u>pipette</u> [entity] + was ***inaccurate*** [quality].
>
> [2.6] <u>B-galactosidase activity</u> [entity] + **increases** [event].
>
> [3.48] There were <u>a number of asymmetrically shaped organisms</u> [entity].
>
> [3.110] <u>The microbes</u> [entity] = were either <u>commensal</u> or <u>symbiotic organisms</u> [entity].

These examples suggest that a figure can be construed as entity + quality as in [1.24], as entity + event as in [2.6] and solely as entity (/entities) as in [3.48] and [3.110]. Following Martin (1992) we suggest that the relationship between entity and quality in [1.24] and between entity and event in [2.6] is that of extension; and the relationship between entities in

[3.110] is that of elaboration (see discussion of the elaboration of entities in Chapter 3, section 3.3.1).

Looking from below, the figure in [2.6] is realised through a material process, and the other figure types are realised through various relational processes: the figure [1.24] is realised through an attributive process; the figure [3.48] is realised through an existential process; and the figure [3.110] is realised through an identifying process. As has been discussed in Chapter 3, relational processes are agnate to nominal group structures; they both construe entities and the relationships among entities. For instance, the configuration of elemental units in the examples above can also be realised congruently through nominal groups, as exemplified in Table 4.3 below.

Table 4.3 Realising the configurations of elemental discourse semantics units at both clause rank and group rank

lexicogrammar / discourse semantics	**clause rank: relational process**	**group rank: nominal group**
entity + quality	[1.24] The pipette [entity] + was ***inaccurate*** [quality].	the ***inaccurate*** [quality] + pipette [entity]
entity = entity	[3.110] The microbes [entity] = were either commensal or symbiotic organisms [entity].	microbes, = either the commensal or symbiotic organisms, [entity] (were observed).
entity	[3.48] There were a number of asymmetrically shaped organisms [entity].	a number of asymmetrically shaped organisms [entity] (were seen).

As shown in Table 4.3, the same discourse semantic meaning can be realised congruently through TRANSITIVITY and nominal group structure. Davidse (1991) has also pointed out the 'hybrid thing/process' nature of relational processes (p. 176). I will return to this issue in Chapter 5. In this thesis, the figures realised through relational processes are generalised as **state figures**, and identify the figures that involve an event as **event figures**. Event figures tend to be realised congruently through process types other than relational ones, including material, mental, verbal and behavioural processes. The primary figure types are shown in Figure 4.3 below.

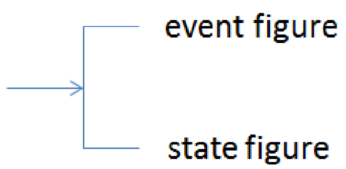


Figure 4.3 Primary choices of figure type

We now look more closely at each of the figure types.

4.2.3.2 Event figure

Event figures can be realised through clauses with various voices. In the following examples, events in the figures are highlighted in bold and the entities are underlined.

event figure realised by meteorological clause[18]:
[a] It'**s raining**.

event figure realised by ranged middle clause (examples adapted from Halliday 1994: 147):
[b] Mary [entity] + **did a dance** [event].
[c] Mary [entity] + **climbed** [event] + the mountain [entity].

event figure realised by non-ranged middle clause:
[2.6] B-galactosidase activity [entity] + **increases** [event]

event figure realised by effective clause:
[1.9] the weight of the water [entity] + **was measured** [event] (+x by us [entity]).

We can see that among these examples, figure [a] is realised by a meteorological clause consisting of only event, whereas within all the other figures, events are expanded by one or two entities. A distinction can thus be made between an event figure that is 'self-engendered' and an event figure that is engendered by an entity, as shown in Figure 4.4 below. Following the convention of system networks (Martin, 2013b), the single-directed arrow is used to symbolise the interstratal realisation statement.

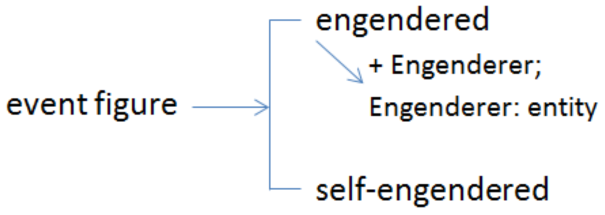


Figure 4.4 Engendered and non-engendered event figures

Given that the self-engendered figure involves only an event, the orbital structure of the figure will be treated as including only a centre, as modelled below.

[18] Meteorological process is identified by Halliday & Matthiessen (2014, p. 309) as a process type at borderline of existential and material processes.

	centre
discourse semantics	event
[a]	*(it) is raining*
lexicogrammar	Process: material
	v.gr

The structure of engendered figures involves an expansion of centre. For the engendered event figures exemplified above, the centres are expanded in various ways. Figures [2.6] and [b] involve only one entity.

	nucleus	
	centre	
discourse semantics	event	+ entity
[2.6]	*increases*	*B-galactosidase activity*
[b]	*did = a dance*	*Mary*

Notice that while sharing similar orbital structure, figures [2.6] and [b] are realised in different grammatical structures. The figure [2.6] is realised through Process (*increase*) ^ Medium (*B-galactosidase activity*) in a non-ranged middle clause.

	nucleus	
	centre	
discourse semantics	event	+ entity
[2.6]	*increases*	*B-galactosidase activity*
lexicogrammar	Process: material	Medium/Actor
	v.gr	n.gr

The figure [b], however, is realised through a ranged middle clause, with a Range Participant. We can term this Range Participant as an Inner Range to emphasise its construal of event in the centre, as displayed below.

	nucleus		
	centre		
discourse semantics	event		+ entity
[b]	*did*	*= a dance*	*Mary*
lexicogrammar	Process: mat	process Scope/ Inner Range	Medium/Actor
	v.gr	n.gr	n.gr

Similar to figure [b], figure [c] is also realised through a ranged middle clause. However, the Range Participant *the mountain* construes the domain of the event rather than the event itself.

Such Range Participants are named in Halliday (1994) as entity Range[19]. As Halliday points out, the *mountain* Participant exists with or without the act of climbing it. The entities construed by entity Range are thus annotated as =+, and positioned outside the centre – in the nucleus. We label this type of Range an Outer Range, in opposition to the Inner Range inside the centre. The orbital structure of this Outer Range figure is displayed below.

	nucleus		
	centre		
discourse semantics	event	=+ entity	+ entity
[c]	*climbed*	*the mountain*	*Mary*
lexicogrammar	Process: material	Outer Range/Scope	Medium/Actor
	v.gr	n.gr	n.gr

In my data, event figures are usually realised through effective clauses[20], such as figure [1.9] above. In this type of figure, an additional participant is involved, annotated as +x, and realised by an Agent. In contrast to the ranged middle clause, an effective clause allows for receptive voice. The occurrence of an explicit 'perpetrator' entity is thus optional (cf. the optionally elliptical *by us* in [1.9]). Given its optional role, we position the perpetrator entity realised by Agent further away from the centre – i.e. in an inner orbit (in opposition to an 'outer orbit' which will be introduced in the next section). The orbitality of 1.9 is shown below.

	inner orbit		
	nucleus		
	centre		
discourse semantics	event	+ entity	+x entity
[1.9]	*was measured*	*the weight of the water*	(*by us*)
lexicogrammar	Process: material	Medium/Goal	Agent/Actor
	v.gr	n.gr	n.gr

Engendered figures thus involve three different orbital structures. The event can be either assigned a domain or not. If it has a domain, an entity designates the event; if it does not have a domain, an additional entity may perpetrate the event. The system of event figures in Figure 4.5 below accounts for these oppositions.

[19] Note that in Halliday & Matthiessen (2004), entity Range is labelled as Scope from the transitive perspective.
[20] Note that Davidse (1991) distinguishes directed action (e.g. *They hunted the* rabbit) and non-directed action (e.g. *The cat broke the glass*) in effective clauses. In the directed clause, the nuclear participant Medium is the participant that is being 'done to' and has no control of the process. In the non-directed clause, the Medium is the participant that is being 'done to' and at the same time is involved in 'doing'. This fine-tuned distinction is not made in this thesis since it does not affect the general structure of orbitality at stake here.

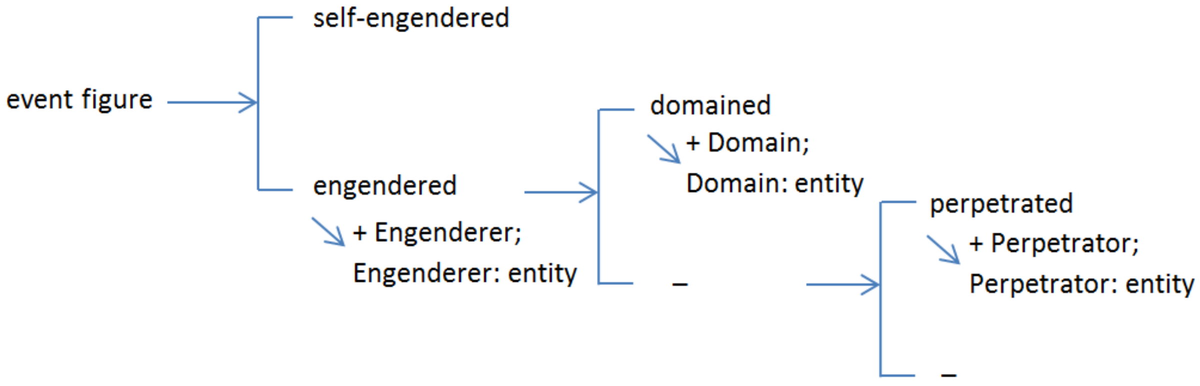


Figure 4.5 Types of event figure (1)

We can take one further step in relation to event figures in my data, based on the entity type (as established in Chapter 3) that functions as an Engenderer. As shown in the following examples, the figure in [1.9] is engendered by a people entity, and the figures in [4.146] and [2.6] are engendered by the observational thing entities.

event figure engendered by <u>entity [people]</u>

[1.9] the weight of the water + was measured (+x by <u>us</u>).

event figure engendered by <u>entity [observational thing]</u>

[4.146] Resident microbiota +x have produced + an <u>antifungal compound</u>

[2.6] <u>B-galactosidase activity</u> + increases

Looking from above, the distinction in these examples between the Engenderers as people entities and as thing entities is associated with the distinction between different activities in field – that is, whether the figure realises an activity that is enacted by biologists, or realises biological activity that is observed by biologists. We can refer to these subtypes of event figures as enacted figures and observed figures. The event figure types can now be expanded in Figure 4.6 below.

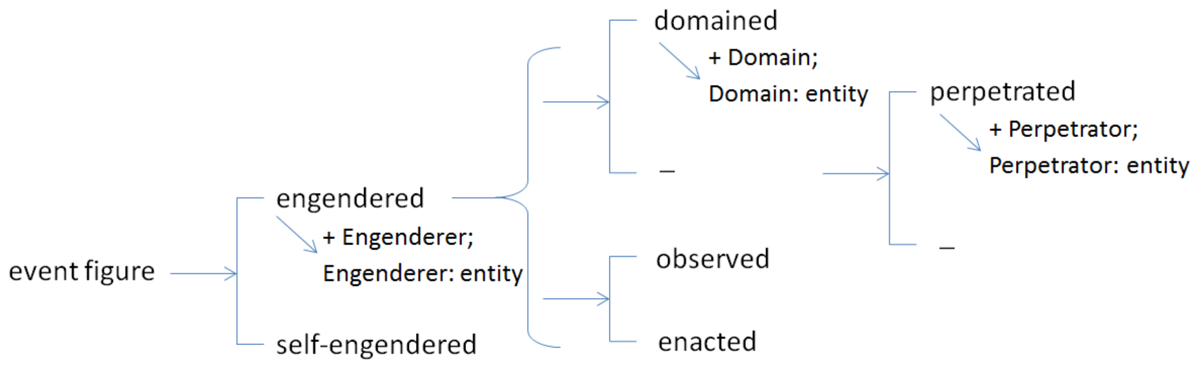


Figure 4.6 Types of event figure (2)

Additionally, event figures may involve some optional elements. Firstly, an event can be intensified. The intensification can be realised by the Circumstance of Manner. For example:

[1.9a] the weight of the water + was measured (+x by us) x **successfully**.

The intensification of event such as *successfully* in [1.9a] can be seen as an instance of **force** in the GRADUATION system (Hood, 2004, p. 83) from an interpersonal perspective. Hood suggests that such choices for force enhance the event. As far as the orbital structure in ideational discourse semantics is concerned, we can treat this intensification as an enhancement within the centre, realised through a Manner adverb[21]. That is to say, the discourse semantic element event has its own orbital structure at a lower rank. This aligns with Martin's (1992, p. 319) suggestion for treating Manner as the periphery in the orbital structure of verbal group, instead of an elemental unit at the clause rank (see Table 4.2 above). Similarly, Halliday & Matthiessen (2014, p. 318) also points out that grammatically the Manner circumstances that are realised through adverbial groups, including Quality e.g. *die <u>wretchedly, slowly, bitterly</u>* and Degree e.g. *love <u>deeply</u>, understand <u>completely</u>*, are in fact features of the Process itself. The orbital structure of event figure in which event is intensified can thus be displayed as below.

[21] Note that the enhancement of an event can also be realised through the lexical verb of the Process itself. For example, Processes such as *investigate, tested out, explore, experimented, examined* can be unpacked as 'find out/look at + effort/rigour' (Hood, 2004, p. 83).

	inner orbit		
	nucleus		
	centre		
discourse semantics	intensified event	+ entity	+x entity
[1.9a]	*were measured* x ***successfully***	*the weight of the water*	(*by us*)
lexicogrammar	Process: material	Medium/Goal	Agent/Actor
	v.gr	n.gr	n.gr

An event figure can also involve an additional entity realised in a Circumstance, such as the entity *balance* realised in the Circumstance of Manner [Means] in [1.9b].

> [1.9b] the weight of the water + were measured +x by us x **with a balance**.

As pointed out by Halliday & Matthiessen (2014, p. 318), the subtypes of Manner Circumstance, Means (*with a balance* in [1.9b]) and Comparison (e.g. *like the devil*), are more participant-like than adverbial Manner Circumstances. Unlike the Quality and Degree Circumstances that construe part of event, the entities realised in Means and Comparison are clearly dissociated from the event in the centre. Apart from Manner, other Circumstances such as Place (*in the laboratory*), Time (*in September*), and Cause (*because of you*) can also construe an entity. Given their optional roles in the figure, we situate entities realised in these Circumstances outside nucleus, in the inner orbit. Like Perpetrator entity realised by Agents, the entities realised in Circumstances are optional, and they are realised in the form of a prepositional phrase. Unlike Perpetrator entities, however, these entities are less likely to be realised as Subjects or unmarked Themes, they are therefore situated further away from the centre[22]. A distinction between delicate structural units in the inner orbit can thus be made – as margin and periphery, as exemplified below. Following Martin (1992), I annotate the relationship between the entity realised in the Circumstance and the rest of the figure they are involved in as enhancement.

[22] Note that Beneficiary (i.e. Client, Recipient, Receiver) is also likely to be positioned in inner orbit. However, since few Beneficiary Participants are found in my data texts, they are outside the scope of the discussion in this thesis.

	inner orbit			
	nucleus			
	centre		margin	periphery
discourse semantics	event	+ entity	+x entity	x entity
[1.9b]	*were measured*	*the weight of the water*	*(by us)*	*(with a balance)*
lexicogrammar	Process: material	Medium/Goal	Agent/Actor	Cir. Manner
	v.gr	n.gr	n.gr	prep.ph

It is important to point out that an event figure is not always realised congruently in the data; sometimes it can be realised at the clause rank in a metaphorical way. For example in [1.7] below, the event *compare* and the entity *these methods* are realised by a nominal group *a comparison of these methods.* A general verb such as *make* or *do* is used to enable the figure to be realised by a clause.

> [1.7] a **comparison** of these methods was made.
>
> [1.7C] we compared these methods

I illustrate the stratal tension between discourse semantics and lexicogrammar in Table 4.4 below. The discourse semantic meaning is directly reflected in the congruent grammatical realisation. The mismatch between the congruent and metaphorical realisations illustrates the stratal tension created by the grammatical metaphor.

Table 4.4 Stratal tension between event figure and material process (1)

	inner orbit		
	nucleus		
	centre		
discourse semantics	event	+ entity	+x entity
[1.7C]	*compared*	*these methods*	*we*
lexicogrammar (cong.)	Process: material	Medium/Goal	Agent/Actor
	v.gr	n.gr	n.gr
lexicogrammar (metaph.)	n.gr	v.gr	n.gr
	Medium/Goal	Process	Agent/Actor
[1.7]	*a comparison of these methods*	*was made*	*(by us)*

The data reveals that it is also possible to realise event figures metaphorically at clause rank when the event is intensified. The event can be realised nominally; and its intensification can be realised through a Process. For example in [1.64], the quality of event, which can be realised congruently by the Circumstance of Manner *several more times*, is realised metaphorically through the Process *increase.*

[1.64] **Increasing** the number of **repeats** (of the experiment)…

[1.64C] (we) repeat the experiment several more times…

Table 4.5 Stratal tension between event figure and material process (2)

<table>
<tr><td></td><td colspan="4">(inner) orbit</td></tr>
<tr><td></td><td colspan="3">nucleus</td><td></td></tr>
<tr><td></td><td colspan="2">centre</td><td></td><td></td></tr>
<tr><td>discourse semantics</td><td colspan="2">event x quality of event</td><td>+ entity</td><td>+x entity</td></tr>
<tr><td>[1.64C]</td><td>repeat</td><td>several more times</td><td>the experiment</td><td>we</td></tr>
<tr><td rowspan="2">lexicogrammar (cong.)</td><td>Process: mat</td><td>Cir: Manner</td><td>Medium/Goal</td><td>Agent/Actor</td></tr>
<tr><td>v.gr</td><td>n.gr</td><td>n.gr</td><td>n.gr</td></tr>
<tr><td rowspan="2">lexicogrammar (metaph.)</td><td>n.gr</td><td colspan="2">v.gr</td><td>n.gr</td></tr>
<tr><td>Medium/Goal</td><td colspan="2">Process</td><td>Agent/Actor</td></tr>
<tr><td>[1.64]</td><td>increasing</td><td colspan="2">the number of repeats (of the experiment)</td><td>(we)</td></tr>
</table>

4.2.3.3 State figures

State figures are distinguished from event figures since their discourse semantic configuration can be realised congruently at both the clause rank through relational processes and at group rank through a nominal group structure. When they are realised through relational processes, various subtypes are found, including existential, attributive (both the classifying and descriptive types), and identifying processes, as exemplified below.

state figure realised by existential process

[3.48] there were a number of asymmetrically shaped organisms.

state figure realised by relational attributive process

[3.110] the microbes = were either commensal or symbiotic organisms.

[1.24] the pipette [entity] + was **fairly inaccurate** [quality].

state figure realised by relational identifying process

[3.16] Members of this phylum = include plant and animal parasites, as well as the ruminant symbionts

Among these examples, the existential process in [3.48] construes a figure that involves one entity (*a number of asymmetrically shaped organisms*). Grammatically, the word *there* in such clauses does not construe a Participant (Halliday, 1994, p. 142). The figure introduces an entity in the discourse, realised through an Existent/Medium. In contrast to [3.48], the other examples involve a logico-semantic relation between elemental units. We can thus make a primary distinction between the figures that present an entity, and the figures that relate an entity to another elemental unit. These two types of state figure are named in the system below as presented and related.

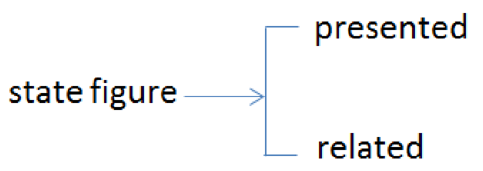


Figure 4.7 Types of state figure

The presented state figure presents an entity in the centre, as modelled below.

	centre	
discourse semantics	entity	
[3.48]	*there were*	*a number of small asymmetrically shaped organisms*
lexicogrammar	Process: existential	Medium/Existent
	v.gr	n.gr

Note that the ‘presentation’ of an entity may be lexicogrammaticalised through a Process such as *exist, appear, occur* in a material process, or through an Attribute such as *is present* in an attributive process. These realisations may be also treated as congruently presenting an entity in the discourse. Their orbital structures are displayed below.

	centre
discourse semantics	entity
[3.48]	*there were a number of asymmetrically shaped organisms*
[3.48i]	*a number of asymmetrically shaped organisms exists*
[3.48ii]	*a number of asymmetrically shaped organisms are present*

In terms of the related state figures exemplified above, an entity is either elaborated through another entity as in [3.110] and [3.16], or extended through a quality as in [1.24].

Elaborations of entity have been discussed in Chapter 3 (section 3.3); it was showed there that various types of elaboration can be realised through nominal groups and relational processes, as summarised in Table 4.6 below.

Table 4.6 Realising elaboration of an entity at group rank and clause rank

elaboration type		realisation		
		at group rank: hypotactic: nominal group	paratactic: nominal group complex	at clause rank
exposition *that is* [i.e.]	naming *is called*		*Chytridiomycota were present in the digestive system of 1 the irregular urchin, = 2 Echinocardium cordatum.*	**intensive identifying process [encoding]:** *The irregular urchin* [Vl/Id] = *is called Echinocardium cordatum* [Tk/Ir].
	unpacking *is defined as*		1 *B-galactosidase, = 2 an enzyme which breaks down lactose, was studied.*	**intensive identifying process [decoding]:** *B-galactosidase* [Tk/Id] = *is an enzyme which breaks down lactose* [Vl/Ir].
	categorising *is categorised as*	β *regular* = α *sea urchin* β *a kind of* = α *sea urchin*	*The flask containing lactose and 1 glucose, = 2 a preferred simpler food source demonstrated a lower level of B-galactosidase activity.*	**intensive attributive process (classifying type):** *Glucose* [Ca] = *is a preferred simpler food source* [Att].
	including *including*	β *rainforest's* = α *canopy*	*In this experiment a Finnpipette and a Bio-Rad P200 pipette were calibrated, using 1 three methods 2 = – weight-of-water, spectrophotometry and radioactivity.*	**possessive identifying process:** *The three methods* [Tk/Id] = *include weight-of-water, spectrophotometry and radioactivity* [Vl/Ir].
exemplification *such as, for example* [e.g.]			*Further analysis could be performed using 1 molecular sequencing methods, 2 = such as DNA sequencing.*	**intensive identifying process [encoding]:** *Molecular sequence* [Vl/Id] *is exemplified by DNA sequencing* [Tk/Ir].
clarification *in fact, indeed* [viz.]			1 *Most players, 2 = in fact everyone on the team, played well.*	

As shown in Table 4.6, various relational processes, both attributive and identifying types, can construe elaborating taxonomic relations between entities. As far as the orbital structure of figures is concerned, the elaborating relationship between the entities suggests that both entities, the Elaborated and the Elaborator, can be situated in the centre irrespective of their realisations in different process types, as modelled below.

	centre		
discourse semantics	entity	=	entity
[3.110]	*the microbes*	*were*	*either commensal or symbiotic organisms*
lexicogrammar	Med/Car	Pro: int.attr	Attr/Rg
	n.gr	v.gr	n.gr

	centre		
discourse semantics	entity	=	entities
[3.16]	*Members of this phylum*	*include*	*plant and animal parasites, as well as the ruminant symbionts*
lexicogrammar	Med/Tk/Id	Pro: poss.iden [decoding]	Rg/Vl/Ir
	n.gr	v.gr	n.gr

	centre		
discourse semantics	entity	=	entity
[3.12]	*The Chytridiomycota*	*are characterised*	*by motile, usually uni-flagellate, zoospores*
lexicogrammar	Med/Vl/Id	Proc: int.iden [encoding]	Ag/Tk/Ir
	n.gr	v.gr	n.gr

In terms of the extension of entity through a quality, as exemplified in [1.24] above, the extending relationship is realised through a descriptive attributive process (for the distinction of delicate types of attributive process, see Davidse, 1991, p. 163 ff.; Martin, 1992, p. 319). The descriptive attributive processes and Epithet+Thing structures in a nominal group illustrate enate semantic configurations – entity + quality. The following examples demonstrate the agnation between Medium +Attribute and Epithet + Thing.

semantic configuration – entity + **quality**

grammatical configuration – Medium + **Attribute**: **Epithet** + Thing::

[1.24] the pipette + was **fairly inaccurate**: the **fairly inaccurate** + pipette::

[1.47] This method + was **time consuming**: a **time consuming** + method::

[3.15] Members of this phylum + are **ecologically important**: **ecologically important** + members of this phylum

The agnation of descriptive attributive process and Epithet + Thing sheds light on the orbital structure of the figure. The entity, which can be realised either through Medium or Thing, can be situated in the centre; and the quality, which extends the entity, can be placed in the nucleus, as outlined below[23].

	nucleus		
	centre		
discourse semantics	entity	+ quality	
[1.24]	*the pipette*	*was fairly inaccurate*	
[1.47]	*this method*	*was time consuming*	
[3.15]	*members of this phylum*	*are ecologically important*	
[3.65]	*these cells*	*were motile*	
lexicogrammar	Med/Car	Pro: int.attr	Attr/Rg
	n.gr	v.gr	adj.gr

The Attributes that construe a quality are inherent in the process. As pointed out by Davidse, 'the process itself is one of attribution rather than action' (Davidse, 1991, p. 183). The bonding of Process and Attribute in construing quality is reflected in the fact that the quality in *it is smelly* can also be realised congruently through a Process as in *it smells*. This way of realising a quality is also found in other languages – for example Japanese, where it is the norm (e.g. *Kanozyo-wa* [Carrier] *yasasii* [Attribute/Process] (*She is kind*) (Teruya, 2004, p. 189)). In some other languages, the realisation of entity + quality need not involve a Process – for example Tagalog (e.g. *Matalino* [Attribute] *ang babae* [Medium] (*The woman is clever*) (Martin, 2004, p. 272)), and Mandarin Chinese (Halliday & McDonald, 2004, p. 358 ff.).

The two distinct ways of expanding an entity, either elaborating or extending, allow us to make a further distinction for the related state figure, as elaborated or extended, as shown in Figure 4.8 below.

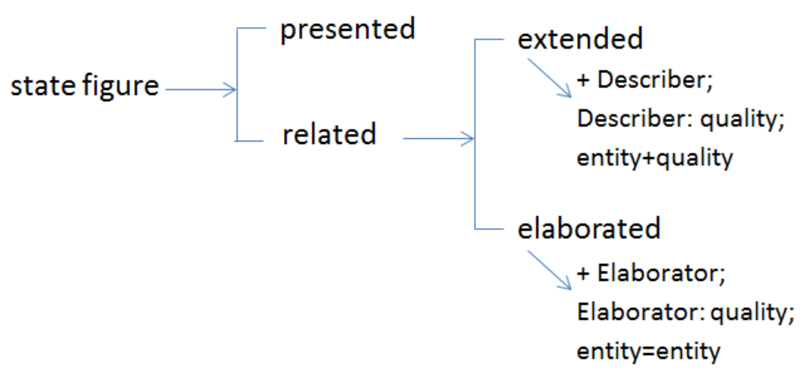


Figure 4.8 Types of state figure

[23] Note that similar to the intensification of event, the quality of entity can also be intensified, such as *fairly inaccurate* in [1.25]. Interpersonally, it is also an instance of Force in the GRADUATION system (Hood, 2004, p. 78 ff.).

We can take one further step from an interpersonal perspective. The quality of an entity may involve attitudinal meaning, including affect, judgement and appreciation (Martin & White, 2005). As has been discussed in Chapter 3, the entities in my data tend to be coupled with instances of appreciation, as in [1.24] and [3.15]. However, some qualities of entities do not carry any attitudinal meaning, but rather provide an epistemological description of the entity – e.g. *motile* in [3.65] and *anaerobic* in [3.96].

> qualities of entity that are attitudinal:
> [1.24] the pipette [entity] + was **fairly inaccurate** [quality/app: valuation].
> [3.15] Members of this phylum [entity] + are **ecologically important** [quality/app: valuation].
>
> qualities of entity that are epistemological:
> [3.65] it is likely these cells [entity] were **motile** [quality]
> [3.96] Any chytrids [entity] + would be **anaerobic** [quality]

Based on the orientation to either interpersonal or experiential meanings, we can further identify two subtypes of extended state figure, attitudinal and epistemological, as shown in Figure 4.9.

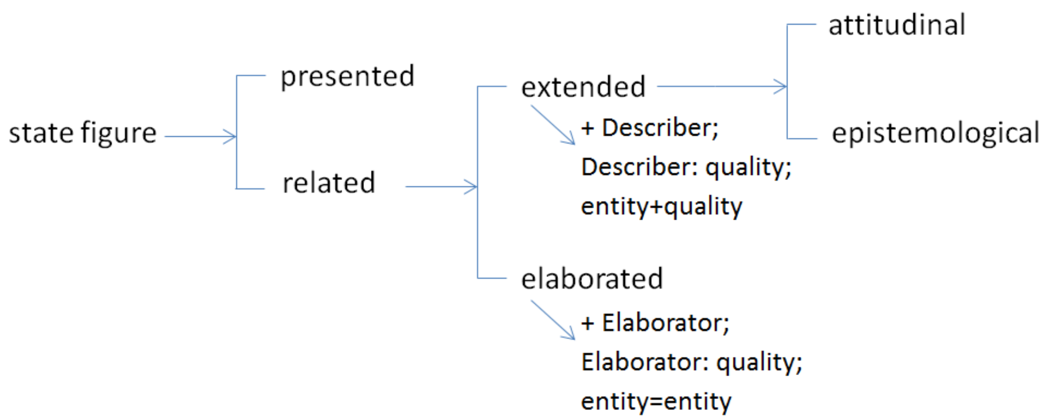


Figure 4.9 Types of state figure

Note that epistemological state figures are closely associated with dimensionality of entity systems, particularly in relation to measurable and perceptive dimensionalities (see section 3.3 in Chapter 3). As exemplified by the pairs below, dimensionality (i.e. *colour, weight, susceptibility*) can be seen as the 'name' of the type of epistemological quality involved.

> [a1] The bird [entity] is **black** [quality].
> [a2] The colour of the bird [dimensionality of entity] is **black** [entity]

[b1] The material [entity] is not **heavy** [quality].

[b2] The weight of the material [dimensionality of entity] can be measured.

[c1] The spores [entity] are **susceptible** [quality].

[c2] The susceptibility of the spores [dimensionality of entity] is lost

The move from construing the quality of an entity to construing the dimensionality of an entity can be related to all logogenetic, ontogenetic and phylogenetic time scales. As has been demonstrated in Chapter 3, dimensionality has more frequent occurrence in the texts produced in the third undergraduate year than the texts in early years. Painter (1999) also reports that the occurrence of descriptive dimensionalities comes later than the use of quality elements realised by adjectives during a child's language development.

In my data, state figures may be realised metaphorically through a nominal group, such as *care* in [1.73]. There a general lexical verb *implement* is used to enable the figure to be realised by a clause. The state figure is then realised metaphorically through a material process.

[1.73] …by implementing greater care.

[1.73C] …by being more careful.

Table 4.7 Stratal tension between state figure and material process

	nucleus		
	centre		
discourse semantics	entity	+ quality	
[1.73C]	*(we)*	*are more careful*	
lexicogrammar (cong)	Med/Car	Pro: int.attr	Attr/In.Rg
	n.gr	v.gr	adj.gr
lexicogrammar (metaph)	n.gr	v.gr	n.gr
	Med/Act	Pro: mat	In.Rg /Scope
[1.73]	*(we)*	*implementing*	*greater care*

To summarise, we have identified two primary types of figure – event and state figures. The orbital structure of event figures is motivated by the experiential grammar at clause rank, and the orbital structure of state figures is additionally motivated by the nominal group grammar, taking into account the agnation between relational processes and nominal group structure. The system of figures is shown in Figure 4.10 below.

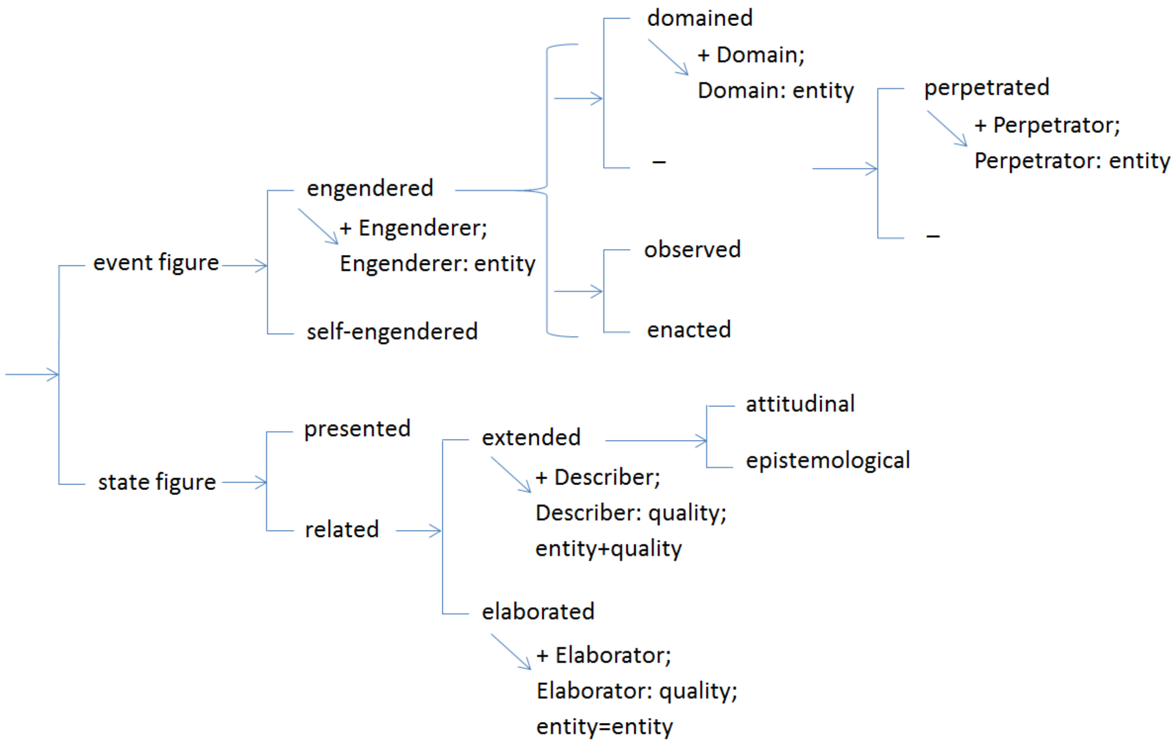


Figure 4.10 Figure types

4.2.4 Instigation of figure

Apart from the structures of event and state figures we have identified above, an additional entity can also be involved to instigate the figure. For example:

event figure with an additional entity

[4.125C] some other features of the spore, such as cell wall composition did not **make** Podospora **lose** its viability

state figure with an additional entity

[4.152C] fever **makes** the fungal infection by Metarhizium anisopliae less severe

In these examples, an additional entity is involved - *some other features of the spore, such as cell wall composition* in the event figure [4.125C]; and *fever* in the state figure [4.152C]. These entities instigate the figures; the instigation is realised through the Process in the form of verbal group complex (e.g. *make…lose; make…become*). From the transitive perspective in the grammar, such Instigator entity is realised through an additional Participant, which can be identified across process types (Halliday, 1985), as Initiator[24] in material process, (e.g.

[24] Note that Initiator is not an additional Agent in descriptive (non-directed action) material process (Halliday, 1967a). In the descriptive operative voice, Initiator can play the role of first Agent, such as *He* [Initiator/Agent]

fever in [4.152C]), Inducer in mental process, Attributor in relational attributive process (e.g. *some other features…*in [4.125C]) and Assigner in relational identifying process. From the ergative perspective, this Participant is seen as an additional Agent, in contrast to the Agent that is involved in the voice (Halliday, 1968; Davidse, 1991), as illustrated by the simultaneous system with the recursive feature [agentive] in the system network below.

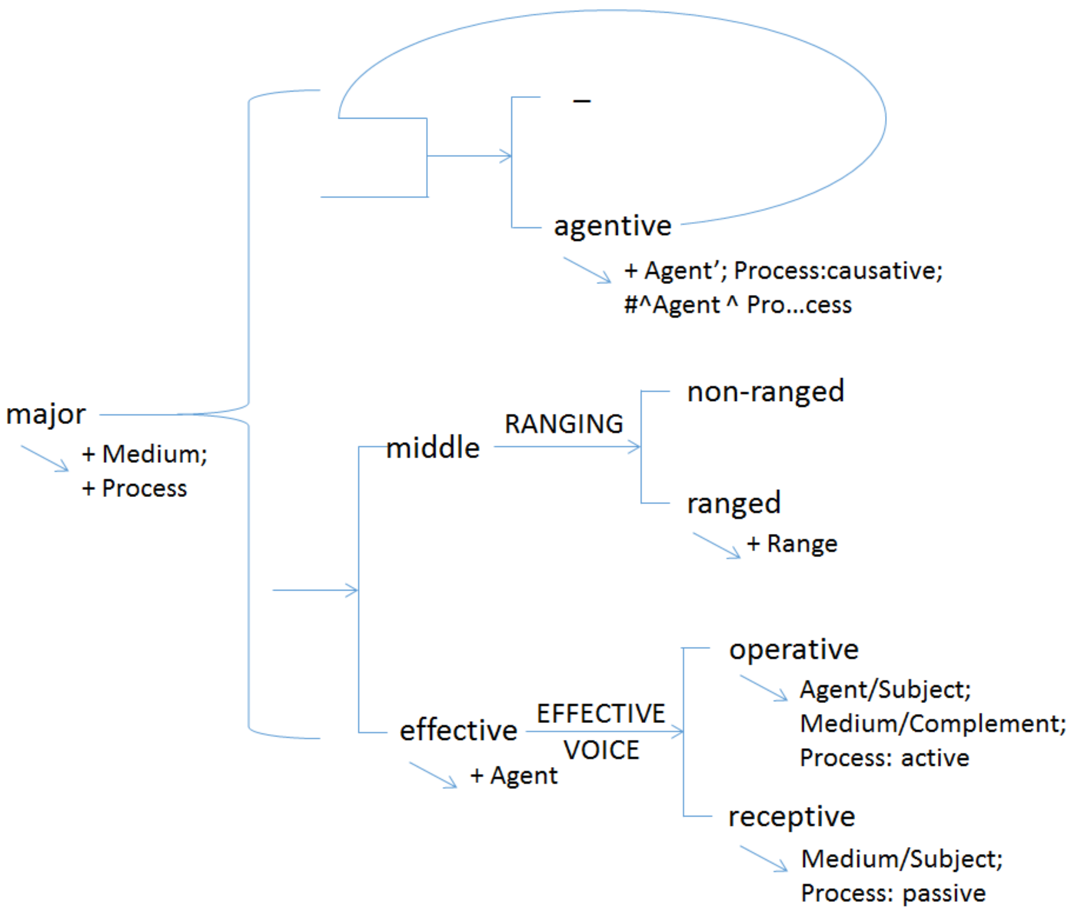


Figure 4.11 VOICE system (c.f. Halliday & Matthiessen, 2004, p. 297; Martin, 2013b, p. 71)

In this thesis, we gloss this additional Agent as 2nd order Agent. As far as the orbital structure is concerned, the Instigator entity realised by the 2nd order Agent is situated further away from the primary structure of the figure. We can name the unit with the instigator entity as an 'outer orbit'[25]. The relationship between the instigator entity and the figure is that of enhancement, annotated as 'xx'. The structure of the figures with outer orbits can be displayed as below.

---

marched the prisoners [Actor/Medium]. In the descriptive middle voice, the initiator is at the same time the Actor, playing the ergative Participant role Medium, such as *the prisoner* [Initiator/Actor/Medium] *marched.*

[25] Note that Martin (1992, p. 319) suggests that 'causative' is the margin in the orbital structure of verbal group, which can be associated with the instigation suggested here.

	outer orbit			
	inner orbit			
	nucleus			
	centre			
discourse semantics	instigated event	+ entity	+x entity	xx entity
[4.125C]	*did not make… lose*	*its viability*	*Podospora*	*some other feature of the spore, such as cell wall composition*
lexicogrammar	Pro: mat	Med/Go	1^{st} Ag/Act	2^{nd} Ag/ Ini-or
	v.gr cplx	n.gr	n.gr	n.gr

	outer orbit				
	inner orbit				
	nucleus				
	centre				
discourse semantics	entity	+ quality			xx entity
[4.152C]	*the fungal infection by Metarhizium anisopliae*	*makes…become less severe*			*fever*
lexicogrammar	Med/Car	Pro: int.attr	In.Rg/Attr		2^{nd} Ag/ Att-or
	n.gr	v.gr cplx	adj.gr		n.gr

The Instigator entity is structurally close to the entity involved in the periphery in inner orbit, since it can be alternatively realised as a Circumstance [Cause]. This observation is exemplified by Davidse (1991, p. 75) (see also Halliday, 1968, pp. 198 ff.) as following:

a1. Peter made the ball roll.

a2. The slope made the ball roll. (i.e. The ball roll because of the slope)

b1. The general made the soldiers march.

b2. Hunger made the soldiers march. (i.e. The soldiers march because of the hunger.)

Nonetheless, the entity realised through 2^{nd} order Agent is still differentiated from the entity realised in Circumstance, since the 2^{nd} order Agent can be iterative:

> The ball rolled: Fred rolled the ball: Mary made Fred roll the ball: John got Mary to make Fred roll the ball. (Halliday, 1994, p. 172)

In my data, it is common that the instigated figures are realised metaphorically. Two primary metaphorical realisations are found. The first way is to realise the Instigator entity through a 1^{st} order Agent, for example in [3.18].

[3.18] Ruminant fungi, and other microbial members of this community **aid the degradation** of fibrous plant materials within the rumen.

[3.18C] Ruminant fungi, and other microbial members of this community **make** the fibrous plant materials **degrade** within the rumen.

In this metaphorical realisation, the event *degrade* and the entity *fibrous plant material* which enacts the event is realised metaphorically by the Medium, leaving the instigation realised by the Process and the Instigator entity realised by the 1st order Agent. This stratal tension can be demonstrated in Table 4.8 below.

Table 4.8 Stratal tension between instigated figure and material process

	outer orbit			
	inner orbit			
	nucleus			
	centre			
discourse semantics	instigated event	+ entity	x entity	xx entity
[3.18C]	*make… degrade*	*fibrous plant materials*	*within the rumen.*	*Ruminant fungi, and other microbial members of this community*
lexico-grammar (cong.)	Pro: mat	Med/Go	Cir. Loc	2^{nd} Ag/ Ini-or
	v.gr cplx	n.gr	prep.ph.	n.gr
lexico-grammar (metaph)	v.gr	n.gr		n.gr
	Pro: mat	Med/Go		1^{st} Ag/Act
[3.18]	*aid*	*the degradation of fibrous plant materials within the rumen.*		*Ruminant fungi, and other microbial members of this community*

A second metaphorical realisation of instigated figure is through an attributive clause. For example,

> [4.125] The **loss** of viability in Podospora **was not due to** some other feature of the spore, such as cell wall composition.
>
> [4.125C] some <u>other feature of the spore, such as cell wall composition</u> did not **make** <u>Podospora</u> **lose** <u>its viability</u>

Being realised in this way, the event and entity are realised nominally through the Medium (*the loss of viability*), and the Instigator entity is realised through the Attribute (*due to some other features…*). The stratal tension is modelled in Table 4.9 below.

Table 4.9 Stratal tension between instigated figure and intensive attributive process

	outer orbit			
	inner orbit			
	nucleus			
	centre			
discourse semantics	instigated event	+ entity	+x entity	xx entity
[4.125C]	*did not make… lose*	*its viability*	*Podospora*	*some other feature of the spore, such as cell wall composition*
lexicogrammar (cong)	Pro: mat	Med/Go	1st Ag/Act	2nd Ag/ Ini-or
	v.gr cplx	n.gr	n.gr	n.gr
lexicogrammar (metaph)	n.gr		v.gr	prep.ph.
	Med/Car		Pro: int.att	In.Rg/Attr
[4.125]	*The loss of viability in Podospora*		*was not*	*due to some other feature of the spore, such as cell wall composition*

To take into account the figure type with an Instigator entity, we can expand the system of figure in Figure 4.12 below.

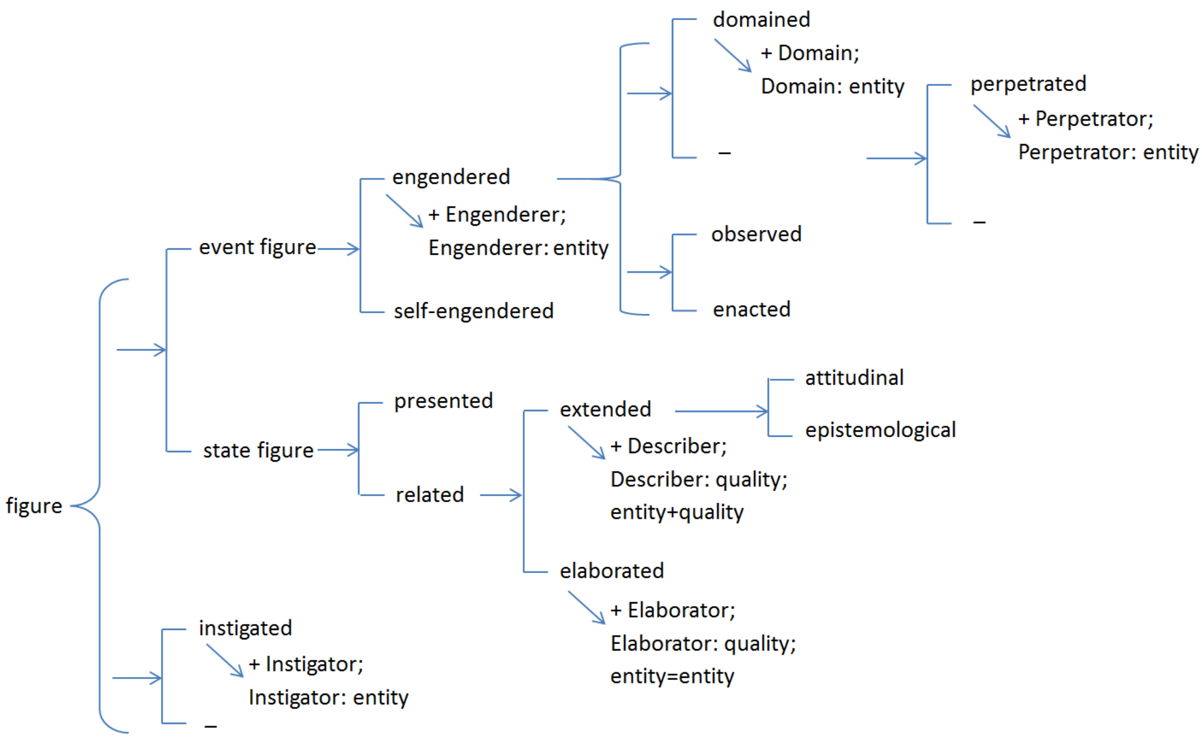


Figure 4.12 Expanded figure types with instigation

4.2.5 Augmentation of figure

Apart from the expansion through an Instigator entity, figure can also be further augmented. For example:

[3.144C] It is beneficial [[that we identify components of the normal microbial community in sea urchin]].

[4.105-106] We propose || that size also becomes a determining factor

In [3.144C], a figure (*(we) identify components of the normal microbial community in sea urchin*) is realized by an embedded clause; this figure is evaluated as being *beneficial.* The Subject *it* is an anticipatory Subject (Halliday & Matthiessen, 2014, p. 198), which refers forward to the figure realized by the embedded clause. In [4.105-106], an event figure (*size becomes a determining factor*) is realized by a projected clause, which is grammatically projected by the clause *we propose.* While clause complexes can be identified in these examples, semantically, an augmentation of figure is not to relate two figures into a sequence, but rather to provide a **dimension** (e.g. *it is beneficial…*) or a **position** (e.g. *we propose…*) of a figure. Each of these figure types will be discussed in detail.

4.2.5.1 Dimensioned figure

According to Halliday & Matthiessen (2014, p. 540, footnote 33), an attributive process with an anticipatory Subject *it* (e.g. *it is beneficial…* in [3.144C]) can be treated as a subtype of fact projection. They suggest that the embedded 'fact' clause functions as the Head of the nominal group, which in turn is an element in the ranking clause. The clause serving as a Head is always agnate to the clause serving as Postmodifier in a nominal group with a fact noun as Head. This can be exemplified below by the agnate pair [3.144C] and [3.144Ci].

[3.144C] It is beneficial [[that we identify components of the normal microbial community in sea urchin]]:

[3.144Ci] The fact [[that we identify components of the normal microbial community in sea urchin]] is beneficial.

What is then clear in these examples is that the figure realised by the embedded clause *[[that we identify…]]* can be named by a semiotic entity *fact;* the fact figure is subsumed by the ranking clause, which enacts an evaluation of the fact figure. We can conceptualize such a figure in a way that the fact figure is assigned an attitudinal dimension.

From an interpersonal perspective, the attitudinal dimension corresponds to the ATTITUDE system. As far as scientific discourse is concerned, appreciation in ATTITUDE (Martin & White, 2005, p. 56) is particularly at stake. As shown in the examples below, the subtypes of appreciation, valuation (e.g. [3.144C]) and composition (e.g. [3.131]), are evident.

dimension of figure corresponds to ATTITUDE:

[3.144C] It is beneficial [app: valuation] [[that we identify components of the normal microbial community in sea urchin]]

[3.131] It is unclear [app: composition] [[whether these possible Chytrid are related to those [[found in the rumen of terrestrial herbivores]]

Apart from assigning an attitude to figure, a dimension of figure can also modify the figure with respect to modality (Halliday & Matthiessen, 2014, p. 687 ff.), such as the explicit objective modality *it is possible* in [3.102], and the implicit objective one *possibly* in [3.102i]

[3.102] It is possible [[that they are transient, not symbiotic, members]].

[3.102i] Possibly, they are transient, not symbiotic, members.

The modification dimension can be associated with the interpersonal systems ENGAGEMENT and GRADUATION. In particular the choice of entertain in ENGAGEMENT (Martin & White, 2005, p. 135 ff.) and intensification in GRADUATION (Hood, 2004; Hood & Martin, 2007) are relevant. By means of entertain, a proposition is presented to be dialogic and contingent. By means of GRADUATION, the intensity of a proposition can be scaled. In my data, the down scaling intensity is particularly evident. The dimension of figure in relation to ENGAGEMENT and GRADUATION is exemplified below:

dimension of figure corresponds to ENGAGEMENT and GRADUATION

[3.65] It is likely [entertain & low intensification] that these cells were motile.

[3.102] It is possible [entertain & low intensification] that they may be transient, not symbiotic, members.

We have now identified two types of dimension of figure given their distinct interpersonal values - attitude and modification.

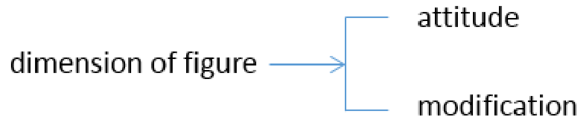


Figure 4.13 Types of dimension of figure

As far as the orbital structure of figure is concerned, a dimensioned figure has an intermediate structure between a mono-nuclear figure and a multi-nuclear sequence (which is ordered in a serial structure). We can model it as a structure of nucleus^satellite - the figure is a nucleus and its dimension is a satellite, as modelled below. Given the prominent interpersonal meaning of dimension, we can represent its prosodic structure through an arrow ranged across the orbital structure of the figure.

discourse semantics	dimension						
				inner orbit			
				nucleus			
				centre			
				figure			
				event	+ entity	+x entity	x entity
[3.144C]	*it*	*is*	*beneficial*	*identify*	*microorganisms*	*we*	*within sea urchins*
lexico-grammar	Med/Car	Pro	In.Rg/Attr	Pro: mat	Med/Act	Ag/Act	Cir: Place
	n.gr	v.gr	adj.gr	v.gr	n.gr	n.gr	pre.phr

The data reveals that a dimensioned figure can be realised metaphorically through a single clause, such as in [4.2].

> [4.14] These **interactions** may be <u>beneficial</u> to both insects and fungi
>
> [4.14C] <u>It is beneficial</u> that insects and fungi interact with each other

In this example, the event figure (*insects and fungi interact with each other*) is realised metaphorically through the Medium in the form of a nominal group *these interactions*. The tension between the discourse semantic meaning and its grammatical realisation is modelled below.

Table 4.10 Stratal tension between dimensioned figure and intensive attributive process

discourse semantics	dimension				
				nucleus	
				centre	
				figure	
				event	+ entity
[4.14C]	*it*	*is*	*beneficial*	*interact*	*insects and fungi*
lexicogr. (cong)	Med/Car	Pro	In.Rg/Attr	Pro: mat	Med/Act
	n.gr	v.gr	adj.gr	v.gr	n.gr
lexicogr. (metaph)	v.gr		adj.gr	n.gr	
	Pro: int.attr.		In.Rg/Attr	Med/Car	
[4.14]	*may be*		*beneficial*	*these interactions (between insects and fungi)*	

Note that such metaphorical realisation of a dimensioned figure may have a similar structure to the metaphorical realisation of an event figure in which the event is intensified, in that they both can be realised through an intensive attributive process, as exemplified below.

event figure (event is intensified):

[3.40] **Dissection** of both the regular and irregular sea urchin species was successful.

[3.40C] We successfully dissect both the regular and irregular sea urchin species.

dimensioned figure:

[4.14] These **interactions** may be beneficial to both insects and fungi

[4.14C] It is beneficial that insects and fungi interact with each other

In [3.40], the Attribute *successful* realises the intensification of the event - *successfully dissect*. In [4.14] however, *beneficial* realises a dimension that evaluates the event figure as a whole. If we unpack the grammatical metaphors, a dimensioned figure can always be unpacked into a clause complex with an anticipatory *it* (i.e. *it is…that…*); an intensification of event in an event figure can always be realised through a Circumstance of Manner.

Taking the dimension of figure into account, we can further expand the system of figure as in Figure 4.14 below.

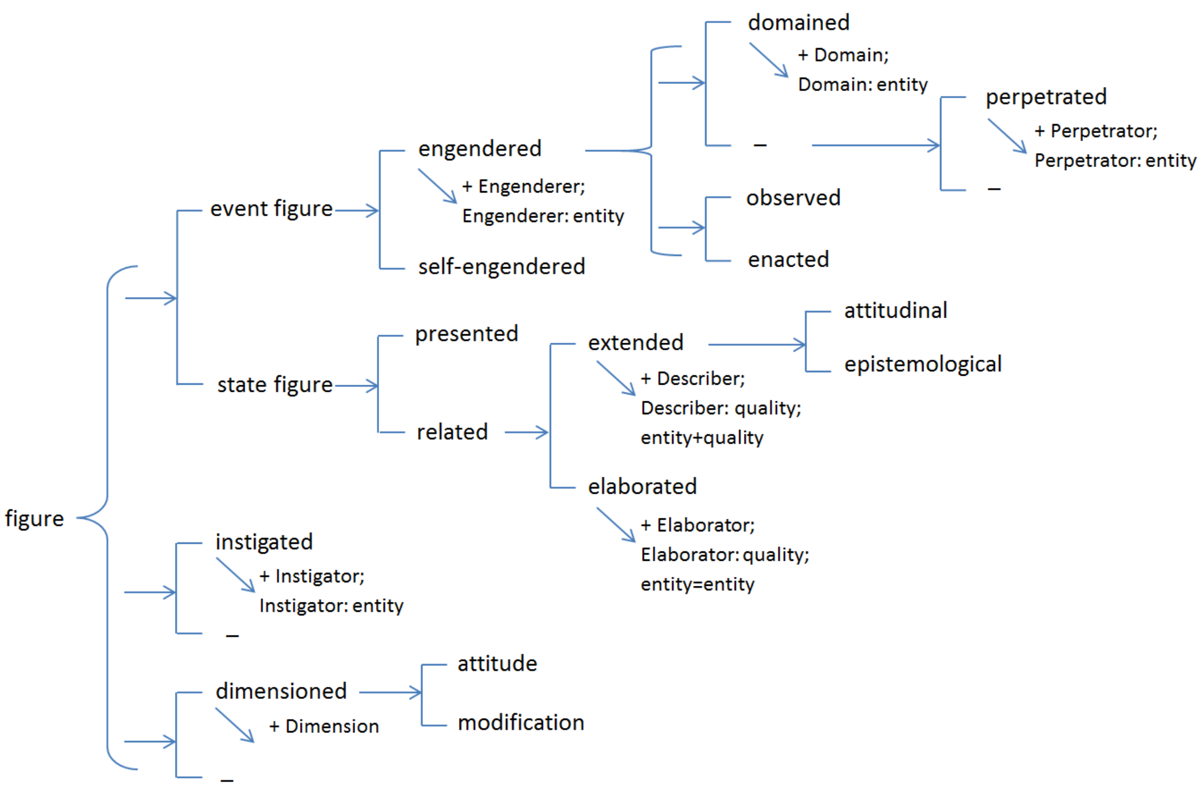


Figure 4.14 Expanded figure types

4.2.5.2 Positioned figure

A second augmentation of figure as a nucleus^satellite structure is by assigning figure a position. A positioned figure is typically realised through a clause complex of a verbal or mental projection; in my data, its realisation through hypotactic reporting is particularly common[26], as exemplified below.

> [4.105-106] <u>We propose</u> || that size also becomes a determining factor in fracture initiation
> [1.28-29C] <u>Radioactivity method suggested</u> || that the pipette was highly accurate.
> [4.109C] <u>The results for Phycomyces indicated</u> || that the viability was lost between the crop and the faeces in the second instar individuals.

In these examples, the projecting clauses construe positions. A position can rely on various types of entities, such as the people entity *we* in [4.105-106], activity entity *radioactivity method* in [1.28-29C] and semiotic entity *result* in [4.109C].

In the data, a position is not always 'meaningful', such as *<u>it is known</u> that B-galactosidase activity increases.* Other typical examples include *it is said, it is believed, it is thought* and *it seems.* As pointed out by Halliday & Matthiessen (2014), such 'impersonal' projection in the grammar is 'simply a way of turning a fact into a clause' (549). The impersonal position may be also bonded with the event of the figure, realised through a verbal group complex, such as *are thought to have* in [4.97], which can be paraphrased as *it is thought that…* in [4.97i].

> [4.97] The resident microbiota and digestive enzymes <u>are also thought</u> to have little involvement in the digestive process.
> [4.97i] <u>It is thought</u> || that the resident microbiota and digestive enzymes have little involvement in the digestive process.

Similar to the dimensioned figure, position relates to figure structurally as a satellite. We can model such nucleus^satellite structure as below. Following linguistic convention, we use " "

[26] Note that clauses such as *the method/result shows…* are at the boarder of verbal and relational processes (Halliday & Matthiessen, 2004, p. 172). On one hand they cannot have a quoted version (e.g. **the method shows, "the pipette is accurate"*), which argues for their status as a relational process; on the other hand, they can include a Receiver (e.g. *the method showed <u>us</u> the pipette is accurate*), which argues for their status as a verbal process. In this thesis, we are treating such borderline cases as **verbal processes**. An alternative interpretation is to treat the relational process as an agentive one, with the configuration of Assigner^Token (e.g. *the method* [Assigner] *showed* [Process] *<u>(the fact) [[that</u> the pipette is accurate]]* [Token] *to be a fact* [Value]) (See Halliday, 1985, p. 153-154 and Martin, 1992, p. 228).

to represent a figure that is positioned as a locution, and use ‘ ’ to represent a figure that is positioned as an idea.

			nucleus		
			centre		
			figure		
			entity	+ entity	
discourse semantics	position “ ”				
[4.105-106]	*We*	*propose*	*size*	*becomes a determining factor…*	
lexicogrammar	Med/Sayer	Pro: verbal	Med/Car	Pro: int.attr	Attr/In.Rg
	n.gr	v.gr	n.gr	v.gr	n.gr

			nucleus	
			centre	
			figure	
			entity	+ entity
discourse semantics	position ‘ ’			
[2.5-6]	*it*	*is known*	*increases*	*B-galactosidase activity*
lexicogrammar	Med/Ph	Pro: men	Pro: mat	Med/Act
	n.gr	v.gr	v.gr	n.gr

Note that a position can also be realised through a Circumstance of Angle. The agnate pairs of verbal projection and Circumstance of Angle are exemplified below.

[4.105-106] We propose || that size also becomes a determining factor:
[4.105-106i] In our opinion, size also becomes a determining factor::

[1.28-29C] Radioactivity method suggested || that the pipette was highly accurate:
[1.28-29Ci] According to radioactivity method, the pipette was highly accurate::

[4.109C] The results for Phycomyces indicated || that the viability was lost:
[4.109Ci] According to/based on the results for Phycomyces, the viability was lost

Realising position through a Circumstance reinforces the fact that position is structurally bonded to a figure as a satellite. It is more appropriate to treat the figure with a position as a subtype of figure instead of a sequence as in Halliday & Matthiessen (1999).

A positioned figure is often realised metaphorically in the data, in particular through a decoding type of intensive identifying process[27]. The construal of discourse semantic

[27] Grammatically, such an example is again situated at the border of verbal process and relational process (see footnote 26). The grammatical interpretation of [4.109] could be either a verbal process (e.g. *The results*

meanings through verbal and relational process is a complex issue, which will be discussed at several relevant places in our sequent discussion below. As far as the position of figure is concerned here, its congruent realisation through a verbal process and metaphorical realisation through an intensive identifying process can be compared in examples [4.109C] and [4.109] below. As we can see, through the intensive identifying process, the event figure (*the viability is lost…*) is realised metaphorically through a Participant (*a loss of viability…*).

realise a positioned figure metaphorically through a relational process:
[4.109] The results for Phycomyces [Token] indicated [Process] a **loss** of viability between the crop and the faeces in the second instar individuals [Value] .

realise a positioned figure congruently through a verbal process:
[4.109C] The results [Sayer] for Phycomyces indicated [Process] || that the viability was lost between the crop and the faeces in the second instar individuals [Locution]

We can display the stratal tension in [4.109] as below. The discourse semantic meaning which is reflected in its congruent realisation through the verbal process does not match its metaphorical realisation through the relational process.

Table 4.11 Stratal tension between positioned figure and intensive identifying process

			inner orbit		
			nucleus		
			centre		
			figure		
			event	+ entity	x entity
discourse semantics	position “ ”				
[4.109C]	*The results for Phycomyces*	*indicate*	*are lost*	*viability between the crop and the faeces*	*in the second instar individuals*
lexico-grammar (cong)	Med/Sayer	Pro	Pro: mat	Med/Act	Cir: Place
	n.gr	v.gr	v.gr	n.gr	prep.ph
lexico-grammar (metaph)	n.gr	v.gr	n.gr		
	Med/Tk/Id	Pro: int.iden	Outer Range/Value/Ir		
[4.109]	*The results for Phycomyces*	*indicate*	*a loss of viability between the crop and the faeces in the second instar individuals*		

[Sayer] *indicate* [Process] *a loss of viability* [Verbiage]), or a relational process (e.g. *The results* [Token] *indicate* [Process] *a loss of viability* [Value]). In this thesis, we are treating such metaphorical realisation as relational process.

Looking from an interpersonal perspective, position is sometimes agnate to dimension. Firstly, position can be agnate to a modification dimension since they can be both realised by modality. Modification of figure is associated with objective modality, and position of figure orients to subjective modality, as exemplified by the pairs below.

> modification dimension associated with objective modality:
> [3.65] <u>It is likely</u> [[that these cells were motile]].
>
> position associated with subjective modality:
> [3.65i] <u>we suppose</u> that these cells were motile.

Drawing upon the modality types in Halliday & Matthiessen (2004, p. 620), the association of position and modification dimension to modality can be summarised in Table 4.12 below.

Table 4.12 Positioned figure, dimensioned figure and modality

figure type	modality	modalization; probability	modalization: usuality	modulation: obligation	modulation: inclination
positioned figure	subjective explicit	**I think/I'm certain** that Mary knows		**I want** John to go	I'**d love** to help you.
	subjective implicit	Mary **will** know	Fred**'ll** sit quite quiet	John **should** go.	Jane **will** help
dimensioned figure [modification]	objective explicit	**it's likely/it's certain** that Mary knows	**it's usual** [[for Fred to sit quiet]]	**It's expected** [[that John goes]]	**It's my wish** to help you.
	objective implicit	Mary **probably** knows.	Fred **usually** sits quite quiet.	John **is supposed to** go.	Jane'**s keen to** help.

Modification and position can be also associated with the interpersonal discourse semantic system ENGAGEMENT, which is concerned with expanding or contracting heterroglossic voices in the discourse. Table 4.13 below summarises the ways in which dimension and position may enact the engagement of voices.

Table 4.13 Positioned figure, dimensioned figure and engagement

interpersonal: engagement	ideational: dimension of figure	Position of figure
contract	*It is clear that…*	*It is shown/demonstrated that…* *We know that…*
expand	*It is possible/likely that…*	*We suppose that…* *It could be assumed that…* *It is said/thought that…* *The method suggests/indicates that…*

Apart from the association with modification dimension, the position of figure can also be agnate to attitudinal dimension, particularly when the position is realised by the emotive type of mental process (Halliday & Matthiessen, 2014, p. 541), such as

> It is surprising (to me) that…:
> It surprises me that…

The attitudinal dimension such as *it is surprising* belongs to the reaction type of appreciation, which is topologically close to affect (Martin & White, 2005, p. 57). Neither such an example of attitudinal dimension, nor the realisation of position through emotive mental process is found in the data texts, since emotive resources are not compatible to the objectivity in scientific discourse. Nonetheless, from the interpersonal perspective, dimension and position are topologically close.

Taking into account of the positioned figure, we can then further expand the figure types in Figure 4.15 below.

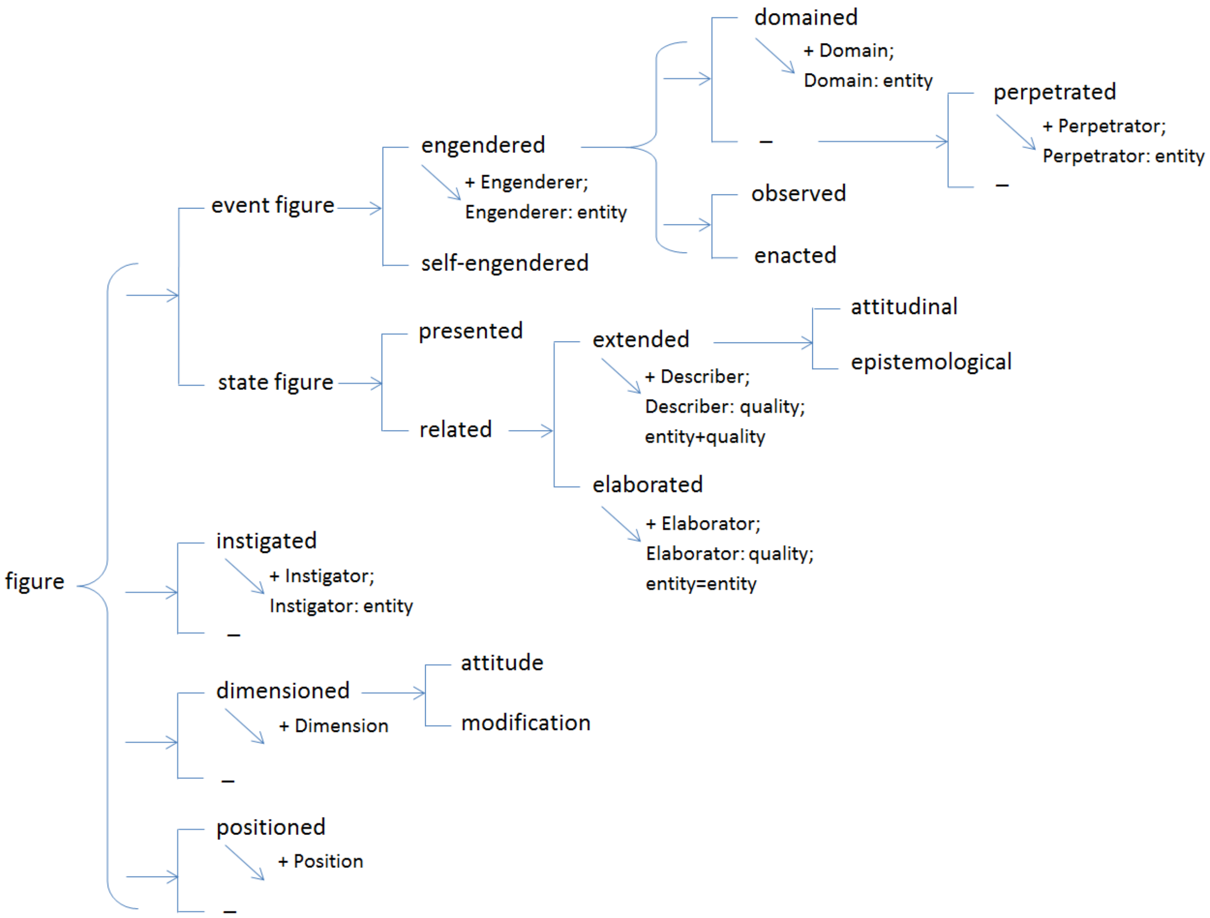


Figure 4.15 Figure types

As shown in the figure system, event and state figures can be simultaneously instigated, dimensioned and positioned. We can present the orbital structure of figure visually in Figure 4.16.

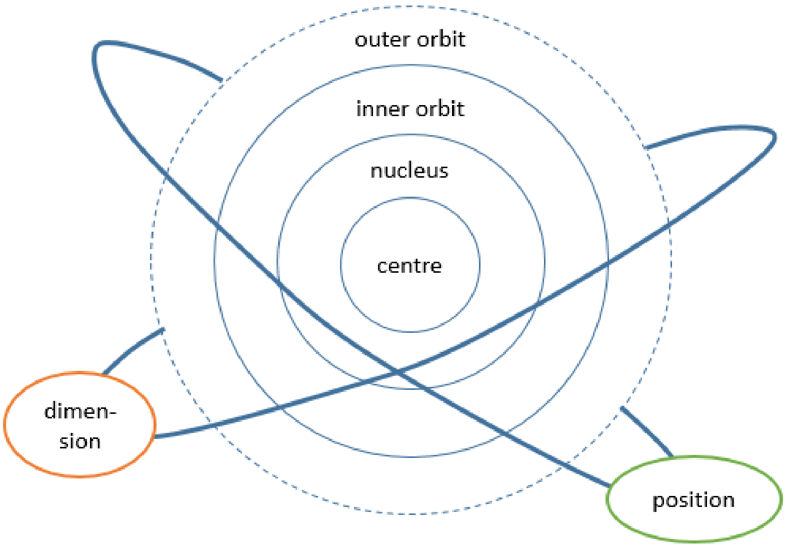


Figure 4.16 Orbital structure of figure with satellites

In the next section, our investigation will move on to sequence, which is constituted by figures. The ways in which figures are related to one another through discourse semantic connexion are particularly the focus of this investigation.

4.3 Sequence and connexion

Martin (1992) stratifies logical relations between goings-on at the level of discourse semantics (his CONJUNCTION system[28]) with respect to the logico-semantics of clause complexing. This discourse semantic system CONNEXION is proposed here as a system of logical relationships that contribute to the manifestation of activity sequence and implication sequence in discourse. In contrast to the elemental units (entity, event and quality) that contribute to the configurations of figures, connexion is a relationship between figures[29]. Two figures or series of figures can be connected into sequence.

Drawing on the figure types established in section 4.2, this section explores the ways in which figures are connected into sequence. Because the data demonstrate considerable metaphorical realisations of sequence, it is necessary to firstly unpack the stratal tension between lexicogrammar and discourse semantics before identifying their construal of activity

[28] In order to avoid the terminology confusion between CONJUNCTION as discourse semantic system and CONJUNCTION as lexicogrammatical dimension of cohesion (Halliday & Matthiessen, 2014, p. 611 ff.), in this thesis, the discourse semantic system CONJUNCTION developed in Martin (1992) is glossed as discourse semantic CONNEXION.

[29] This contrasts to Halliday & Matthiessen (1999, p. 59 & p. 177), where relator is conceptualised as one of the elements.

and implication sequence in field in section 4.4. Unpacking grammatical metaphor in the data also reveals a number of ways in which sequence may be mapped onto grammar in scientific discourse.

4.3.1 Divergent grammaticalisation of connexion

For the purpose of scientific explanation, discourse semantic connexion plays a critical role. As reviewed in Chapter 2, in scientific discourse logical connexion is often mapped onto grammar in a metaphorical way (e.g. Halliday & Martin, 1993; Halliday, 1998). Looking from below, the metaphorical realisation of connexion can be manifested in various grammatical forms. Connexion, which is comparable to Halliday & Matthiessen's (1999) 'relator', is in fact suggested to be the 'most unstable in terms of their susceptibility to metaphoric transformation' (Halliday & Matthiessen, 1999, p. 267) in comparison to other discourse semantic units of meaning such as event and quality. Halliday & Matthiessen provide an explanation for its rich metaphorical potential – that is, the logico-semantic relations of expansion (including elaboration, extension and enhancement) are 'transphenomenal' and 'fractal' in the sense that they 're-appear across the spectrum of different types of phenomena construed by the ideational systems' and they 'serve as general principles of the construal of experience' (1999, p. 268). An expansion of figure through connexion can thus be realised through various lexicogrammatical resources, such as through conjunction, Circumstance, Process in various relational processes at the clause rank, and through Qualifier at the group rank. Martin (1992) provides a summary of the divergent patterns of realising connexions, reproduced in Figure 4.17 below. The realisation of logical relations 'between processes' is relatively congruent, whereas that 'within a process[30]' depends on grammatical metaphor; one or both figures involved must be " 'thing-ized' to some extent - via embedding or nominalisation" (Martin, 1992, pp. 169-170).

[30] Note that the 'process' used by Martin in the figure here is in a grammatical sense, referring to a clause.

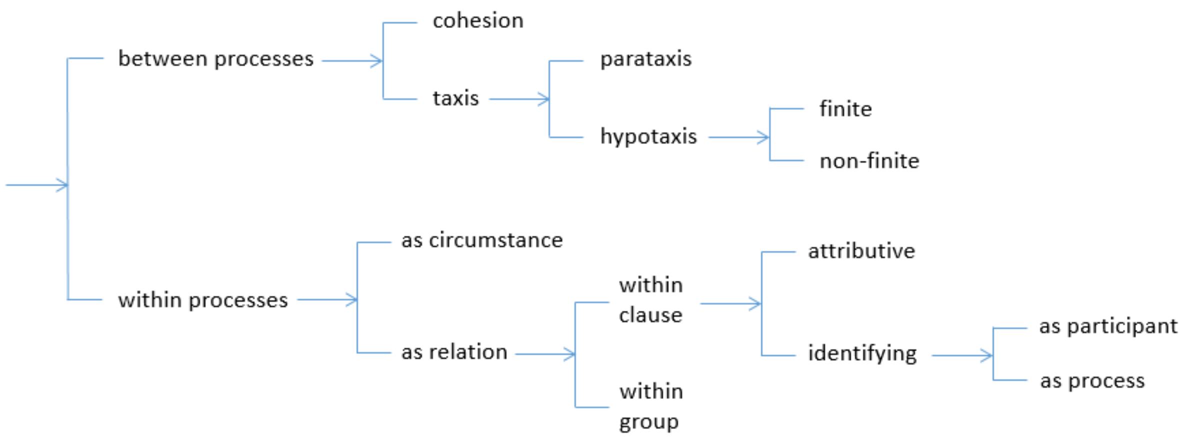


Figure 4.17 Divergent grammaticalisation of CONNEXION *(adapted from Martin, 1992, p. 170)*

The identification of connexion type draws upon the system of logical relation developed in Martin (1992, Chapter 4), in which three simultaneous systems are involved – they are types of logico-semantic relations, the opposition between internal and external, and between explicit and implicit, shown in Figure 4.18 below.

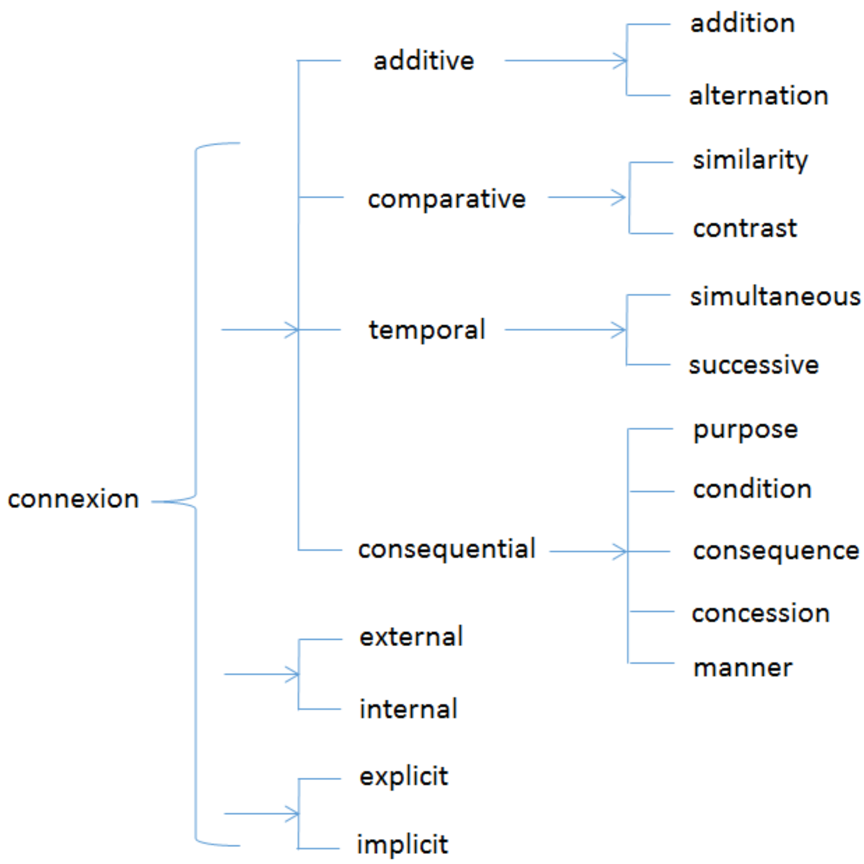


Figure 4.18 System of CONNEXION *(cf. Martin, 1992)*

As far as activity sequences and implication sequences in field is concerned, of particular relevance is the temporal and consequential connexions in the discourse. In the next section, we will explore the interstratal relationship between connexion and its diverse grammatical realisations.

4.3.2 Realisation of sequence

It is evident in the data that sequence can be realised in various ways, through clause complexing or through a clause. The diverse realisations are primarily determined by two factors:

- How many figures in the sequence are realised metaphorically?
- Is the figure realised metaphorically at the clause rank, group rank, or within a group?

Based on these two questions, I explore the realisation of a sequence through clause complexing before exploring its realisation through a clause; at the same time we consider one of the figures in the sequence realised metaphorically before considering more than one figure realised metaphorically.

4.3.2.1 Sequence realised through clause complex

4.3.2.1.1 Connexion realised through conjunction

To begin with the most congruent realisation of sequence in the grammar, sequence can be realised through a clause complex, with both figures being realised through a clause. The relationship between figures is then realised through conjunction, including cohesive conjunction (e.g. *and then*), paratactic conjunction (e.g. *so*) and hypotactic conjunction (e.g. *after…; subsequent to…*) (Martin, 1992, p. 168). Both temporal and causal connexions are used to construe a sequence, such as the temporal connexion (*and then*) between the figures in [1.8-9b] and the causal connexion (*so*) between the figures in [4.15-16b] below (the annotation of connexions follows the convention set up in Martin, 1992, Chapter 4).

[1.8-9b]

[1.8] A set amount of water was pipetted into a container

succ

[1.9a] and the weight of the water was measured

succ

[1.9b] and (the weight of the water was) recorded.

[4.15-16b]

[4.15] Insects may also aid the dispersal of fungal spores either externally or internally,

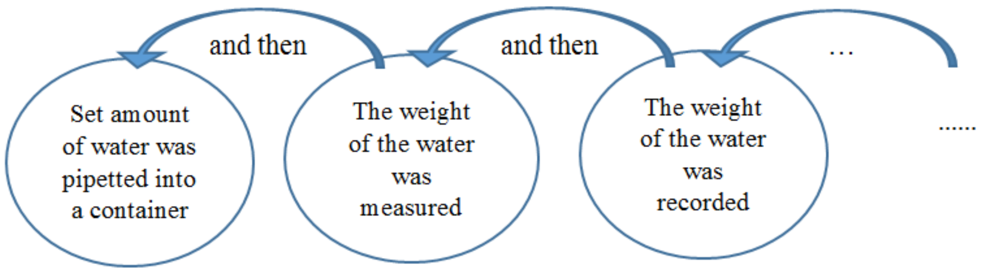
consq

[4.16a] so they increase the ecological niche in which fungal species may inhabit,

consq

[4.16b] so potentially affect higher plant and animal diversity

As we can see, the connexion between the figures involves a serial structure. This structure can be in principle expanded indefinitely in so far as the activity and implication sequence continues.



In the examples above, the figures are related to each other externally (field time). It is also possible to establish relationship between figures internally. For instance, in the sequence in [4.112-114] below, the figures [4.113b] and [4.114] are related to the preceding sequence internally through the connexions *so that* and *therefore*. Following Martin (1992, p. 226 ff.), one criteria that can be used to distinguish the internal relationship from the external is that if we switch taxis from non-hypotactic to hypotactic or vice versa, the internal relationship requires a verbal or mental process in the paraphrase. For instance, *so that* and *therefore* in the example below can be paraphrased paratactically as *so we conclude that…*

[4.112-114]

[4.112] Since *Phycomyces* belongs to a different fungal taxa (*Zygomyces*) to the other isolates,

consq

[4.113a] it is possible that their structures such as constituents of the spore wall are intrinsically different,

consq

[4.113b] so that the spore becomes more susceptible to antifungals and digestive enzymes of the locust gut.

consq

[4.114] Spore viability may therefore be dependent not only on spore size, but also other intrinsic characteristics of the fungal spore.

4.3.2.1.2 Connexion realised through verbal Process

In the data, sequence is also realised through a clause complex in a metaphorical way. In contrast to the congruent realisation through an expanding clause complex, the metaphorical realisation is typically in the form of a hypotactic projection. As exemplified below, the sequences in this case are realised by the verbal processes[31]:

[1.21-23i] [[That the result also displayed a strong linear relationship]] [Sayer] **suggested** [Process] || the pipette was both accurate and precise throughout its range [Locution].

[1.26-27] The minimal **variability** that existed between the readings [Sayer] **demonstrated** [Process] || the pipette was fairly precise [Locution].

[2.34-36] The flasks demonstrated a lower level of B-galactosidase activity. **This** [Sayer] **demonstrated** [Process] || that gene expression controls B-galactosidase activity [Locution].

In these examples, one figure is realised metaphorically through the Participant Sayer. Their metaphorical realisations are in various grammatical forms. In [1.21-23i], the figure is realised in the form of an embedded clause[32]; in [1.26-27] it is realised through a

---

[31] As noted in footnote 26, clauses as these are at the boarder of verbal and relational processes. In this thesis they are treated as verbal processes.

[32] Note that figure can also be realised by α clause in the non-finite hypotactic projection, as in the following examples: [a] *The result also displayed a strong linear relationship* [figure], ***suggesting*** [connexion] || *the pipette is both accurate and precise throughout its range* [figure]; [b] *The result also displayed a strong linear relationship,* ***which*** [figure] ***suggests*** [connexion] || *the pipette is both accurate and precise throughout its range* [figure].

nominalisation; and in [2.34-36] the figure is tracked through a discourse referent *this*, which is also treated as a metaphorical realisation (Halliday & Matthiessen, 2014, p. 717). The second figure in these examples is realised congruently through a projected clause. The consequential connexions between the figures are realised through the Processes *suggest* and *demonstrate.* We can unpack the stratal tension in these examples, and realise the sequences congruently through an expanding clause complex. This reveals that the consequential connexions are internal ones.

[1.21-23iC] It (the result) also displayed a strong linear relationship

consq

so the pipette was both accurate and precise throughout its range.

From an interpersonal perspective, the Processes *suggest* and *demonstrate* enact heteroglossic engagement (Martin & White, 2005). That is, *suggest* expands the potential voices, and *demonstrate* contracts the potential voices. The way of unpacking the logical metaphor above does not reveal these interpersonal meanings. Ideationally, we might argue that the verbal process realises a logical relationship and positioning a figure at the same time. *Suggest* and *demonstrate* can be unpacked respectively into *so we know/conlude* and *so we suppose.* By unpacking the logical metaphor in this way, the connexion as well as the heteroglossic engagement via position is thus revealed. Note that by realising the position explicitly, the internal connexion is externalised.

[1.21-23Ci] It (the result) also displayed a strong linear relationship

consq.

so we suppose the pipette was both accurate and precise throughout its range.

[1.26-27C] The readings were minimally variable between each other.

consq.

so we know/conclude the pipette was fairly precise.

[2.34-36C] The flasks demonstrated a lower level of B-galactosidase activity.

consq.

so we know/conclude gene expression controls B-galactosidase activity.

The stratal tension between the sequence and the verbal/mental process is outlined in Table 4.14 below.

Table 4.14 Stratal tension between sequence and verbal process

						nucleus		
						centre		
	nucleus					state figure		
	centre					entity	+ quality	
discourse semantics	state figure			conx	position ‘ ’			
	entity	+ quality						
[1.26-27C]	*the readings*	*were minimally variable*		*so*	*we conclude*	*the pipette*	*was*	*fairly precise*
lexicogr. (cong)	Med/Car	Pro: int.att	In.Rg/ Att			Pro	In.Rg/Att	Med/ Car
	n.gr	v.gr	adj.gr	conj	verbal pro	v.gr	adj.gr	n.gr
lexicogr. (metaph)	n.gr				v.gr	n.gr	v.gr	adj.gr
	Sayer				Pro	Med/Car	Pro	In.Rg/ Att
[1.26-27]	*the minimal variability [[that existed between the readings]]*				*demonstrated*	*the pipette*	*was*	*fairly precise*

As discussed earlier in section 4.2.3.3.2, a positioned figure is realised congruently through projection (involving a verbal or mental process). Grammatically, the congruent realisation of a positioned figure shares the same structure with the metaphorical realisation of a sequence. Compare the two examples below:

verbal process realises sequence:
[2.34-36i] [[That the flasks demonstrated a lower level of B-galactosidase activity]] [Sayer] **demonstrated** [Process] || that gene expression controls B-galactosidase activity [Locution].

verbal process realises a positioned figure:
[2.34-36ii] The result [Sayer] demonstrated [Process] || that gene expression controls B-galactosidase activity [Locution].

While both examples are realised through verbal processes, they do not have the same discourse semantic configuration. [2.34-36i] construes two figures that are related to each other causally; [2.34-36ii] on the other hand presents a proposition as a positioned fact; the semiotic entity *result* is the source of the position. This pair therefore demonstrates different grammatical metaphors.

In between such examples, there are borderline cases such as [2.34-36iii] below.

[2.34-36iii] The result [[that the flasks demonstrated a lower level of B-galactosidase activity]] demonstrated || that gene expression controls B-galactosidase activity.

In [2.34-36iii], the figure realised through the Qualifier (i.e. *[[that the flasks demonstrated…]]*) elaborates the semiotic entity *result.* The clause complexing as a whole can be read as construing a sequence, or as positioning a figure as a fact. In this thesis, such borderline cases are treated as construing a sequence given that the semiotic entity *result* is elaborated. The figure (i.e. *the flasks demonstrated a lower level of B-galactosidase activity*) realised through the Qualifier is related causally to the other figure (i.e. *gene expression controls B-galactosidase activity*).

To consolidate, the distinction between a sequence and a positioned figure has to do with whether there are two causally related propositions in the discourse semantics, or only one proposition that is presented as a fact. This is determined for this thesis by the nature of Sayer – i.e. whether the Sayer is construing a figure or an entity. As summarised in Table 4.15, below, if the Sayer construes an entity, the clause complex is taken as construing a positioned figure; if the Sayer construes a figure, the clause complex is taken as construing a sequence.

Table 4.15 Realising sequence and positioned figure through verbal process

positioned figure [entity + figure]	*The results*	*indicated*	*|| that the viability was lost between the crop and the faeces in the second instar individuals*
sequence [figure + figure]	*The result [[that the flasks demonstrated a lower level of B-galactosidase activity]]*	***<u>demonstrated</u>***	*|| that gene expression controls B-galactosidase activity.*
sequence [figure + figure]	*[[That the result also displayed a strong linear relationship]]*	***<u>suggested</u>***	*|| the pipette was both accurate and precise throughout its range.*
semantics / grammar	Sayer	Process: verbal	Locution

(key: the metaphorical realisations of connexions are in bold and underlined)

4.3.2.2 Sequence realised through a clause

When sequence is realised through a clause, at least one of the figures is realised at group rank. I explore the manifestation of one figure being realised at the group rank, and then look at clauses where both figures are realised at the group rank.

4.3.2.2.1 One figure realised at clause rank, the other realised at group rank.

4.3.2.2.1.1 CONNEXION REALISED IN CIRCUMSTANCE

When one figure is realised congruently at clause rank, a second figure can be realised metaphorically as a Circumstance, as in [2.5] below.

> [2.5] **IN** the **presence** of lactose, B-galactosidase activity increases.

In this example, the Circumstance of Time *in the presence of lactose* realises a figure *lactose is present.* The temporal connexion between the figures *when* is realised by the Minor Process *in.* The figures are related to each other externally.

> [2.5Ca] when lactose is present,
>
> simul
>
> [2.5Cb] B-galactosidase activity increases.

Since more than one Circumstance can occur in a clause, several figures can be constituted into the sequence, as in example in [4.30].

> [4.30] smaller fungal spores are more likely to retain integrity and viability, **AFTER ingestion** and **passage** through the insect gut, than larger spores, **DUE TO** the **ability** [for smaller spores to more easily avoid maceration by insect mouthpieces]

In [4.30] two figures are realised metaphorically in the Circumstances (i.e. *ingestion and passage through the insect gut; the ability [for…]*). The external connexions between the figures are realised through the Minor Processes *after* and *due to.*

> [4.30Ca] smaller fungal spores are more likely to retain integrity and viability than larger spores,
>
> succ
>
> [4.30Cb] **AFTER** they are ingested and pass through the insect gut
>
> consq
>
> [4.30Cc] **BECAUSE** the smaller spores are more able to easily avoid maceration by insect mouthpieces

We can model the stratal tension between the sequence and its metaphorical realisation as in Table 4.16 below.

Table 4.16 Stratal tension between sequence and clause, connexion and Minor Process

	nucleus					
	centre			centre		
discourse semantics	event figure		conx	state figure		
	event	+ entity		entity		
[2.5C]	*increases*	*B-galactosidase activity*	*when*	*lactose is present*		
lexicogr. (cong)	Pro: mat	Med/Act		Med/Car	Pro: int.attr	In.Rg/Attr
	v.gr	n.gr	conj	n.gr	v.gr	adj.
lexicogr. (metaph)	v.gr	n.gr	prep.ph			
			prep	n.gr		
	Pro: mat	Med/Act	Cir: Time			
[2.5]	*increases*	*B-galactosidase activity*	***in***	*the **presence** of lactose*		

4.3.2.2.1.2 CONNEXION REALISED THROUGH AN AGENTIVE PROCESS

A second way of realising sequence in a clause is by realising one of the figures through a 2nd order Agent, as exemplified below (the figures realised by 2nd order Agents are in bold; the connexions are both in bold and underlined):

> [1.1] **Calibration of a pipette <u>allows</u>** the relationship between theoretical volumes and those actually obtained to be determined.
>
> [3.59-60] **[[That some bacteria may also help fix nitrogen]] <u>allows</u>** their hosts to successfully thrive on diets with a high carbon-to-nitrogen ratio
>
> [3.111-112] (Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates, including cellulose, keratin and chitin.) **This <u>allows</u>** materials to be more readily degraded by fungi and bacteria

As shown in these examples, one of the figures is realised at the clause rank (e.g. *relationship between theoretical volumes and those actually obtained can be determined* in [1.1]), and the other is realised metaphorically at the group rank through the 2nd order Agent – the nominalisation (i.e. *the **calibration** of a pipette*) in [1.1], the embedded clause *[[that some bacteria may also help fix nitrogen]]* in [3.59-60], and the tracking via textual reference *this* in [3.111-112]). The logical relationship between the two figures is manifested in the verbal group complexes, and lexicalised by the verb *allow*. By unpacking these grammatical metaphors (e.g. [3.111-112C] below), it can be revealed that these figures are related to each other externally and consequentially.

[3.111-112C] Members of the Chytridiomycota produce enzymes

that have the ability to degrade a wide variety of substrates…

consq.

so materials can be more readily degraded by fungi and bacteria

The stratal tension between a sequence and an agentive clause is modelled in Table 4.17.

Table 4.17 Stratal tension between sequence and agentive clause

	inner orbit				**inner orbit**			
	nucleus				**nucleus**			
	centre				**centre**			
discourse semantics	event figure			conx	event figure			
	event	+ entity	+x entity		event x quality of event		+ entity	+x entity
[3.111-112C]	*produce*	*enzymes*	*Members of the Chytrid*	*so*	*can be degraded*	*more readily*	*materials*	*by fungi…*
lexicogr. (cong.)	Pro: mat	Med/Go	1^{st} Ag/ Act		Pro: mat	Man	Med/Go	1^{st} Ag/Act
	v.gr	n.gr	n.gr	conj	v.gr	adv.	n.gr	prep.ph
lexicogr. (metaphr.)	n.gr / [[embedded clause]]			v.gr cplex			n.gr	prep.ph
	2^{nd} Ag/Ini-or			Pro			Med/Go	1^{st} Ag/Act
[3.111-112]	*This / [[That members of the Chythids can produce enzymes]]*			*allows…to be more readily degraded*			*materials*	*by fungi…*

Note that the grammatical realisation of sequence through an agentive clause can be enate to the realisation of a figure involving an Instigator entity (see Section 4.2.3.2 above). Compare the examples below (2^{nd} order Agents are underlined):

realisation of an instigated figure through an agentive clause

[3.18C] <u>Ruminant fungi</u> [2^{nd} order Agent] makes the fibrous plant materials degrade within the rumen.

realisation of a sequence through an agentive clause

[1.1] <u>Calibration of a pipette</u> [2^{nd} order Agent] allows the relationship between theoretical volumes and those actually obtained to be determined.

While grammatically enate, they have different discourse semantic configurations. Based on the nature of the 2^{nd} order Agent, the construal of figure in [3.18C] and sequence in [1.1] can be differentiated. The 2^{nd} order Agent in [3.18C] realises entities (e.g. *ruminant fungi, and other microbial members of this community*), and the clause realises an instigated figure; by contrast the 2^{nd} order Agent in [1.1] realises a figure (e.g. *we calibrated a pipette*), and the clause realises a sequence.

Note that in my data, 2nd order Agents sometimes realise an activity entity in the form of a nominalisation, as in [4.20] below.

> [4.20] Physical processes such as maceration by mouthpieces [2nd order Agent] could cause spores to fracture.

In this example, *maceration* is a linguistically defined activity entity that instigates the figure at the level of discourse; the agentive clause thus realises an instigated figure rather than a sequence. Such instances may be seen as positioned on the borderline of sequence and instigated figure. In this thesis, the distinction between the two is determined by whether the nominalisation construes a linguistically defined entity (a 'dead' grammatical metaphor) or a figure (for the discussion of linguistically defined entity realised through a nominalisation, see section 3.2.2 in Chapter 3). An overview of the construal of discourse semantic meanings through an agentive clause is shown in Table 4.18.

Table 4.18 The realisations of sequence and instigated figure through agentive clause

discourse semantics	example	lexicogrammar: agentive clause
sequence	**Calibration** of a pipette allows the relationship between theoretical volumes and those actually obtained to be determined	2nd order Agent realises a figure
instigated figure	Physical processes such as maceration by mouthpieces could cause spores to fracture.	2nd order Agent realises a linguistically defined activity entity
	Ruminant fungi make the fibrous plant materials degrade within the rumen.	2nd order Agent realises a thing entity

4.3.2.2.2 Both figures realised at group rank

When sequence is realised through a clause, both figures can be realised at the group rank through the Participants, and the relationship between the figures is realised by the Process. This way of mapping discourse semantics to lexicogrammar typically involves material process or various types of relational process.

4.3.2.2.2.1 Material process

The data reveal that sequence can be mapped onto an 'abstract' material process (Halliday & Matthiessen, 2004, p. 196). For example:

[3.132] **Understanding** these relationships [Actor] would also **<u>assist</u>** [Process] **understanding** of ecological and evolutionary relationships between animals and microorganisms [Goal].

[4.108] The **survival** of small but not large spores in this study [Actor] **<u>supports</u>** [Process] the **importance** of size in fracture initiation dynamics [Goal].

In these examples, one figure in the sequence is realised through the Actor, the other is realised through the Goal. The connexion between the figures is realised by the Process (*assist; support*). If we unpack the grammatical metaphors, the connexion in [3.132] is an external one (i.e. *if…then…*); and the connexion in [4.108] is an internal one (i.e. *so we know*).

[3.132C] <u>If</u> we understand these relationship

<u>then</u> we can understand the ecological and evolutionary relationship… cond

[4.108C] Small but not large spores survived in this study.

<u>so we know</u> the size in fracture initiation dynamics is important. consq

The stratal tension between sequence and material process is outlined in Table 4.19 below.

Table 4.19 Stratal tension between sequence and material process

	nucleus				**nucleus**		
	centre				**centre**		
discourse semantics	event figure			conx	event figure		
	event	+ entity	+ entity		event	+ entity	+ entity
[3.132C]	*understand*	*these relationship*	*we*	*(if…) then*	*would understand*	*ecological and evolutionary relationships*	*we*
lexicogr. (cong)	Pro: men	Out.Rg//Ph	Med/Sen		Pro: men	Out.Rg/Ph	Med/Sen
	v.gr	n.gr	n.gr	conj	v.gr	prep.ph	n.gr
lexicogr. (metaph)	[[embedded clause]]			v.gr	n.gr		
	1st Ag/Act			Pro	Med/Go		
[3.132]	*[[understanding these relationship]]*			*would assist*	*understanding of ecological and evolutionary relationships…*		

4.3.2.2.2.2 Circumstantial identifying process

In my data a large number of sequences are mapped onto circumstantial identifying processes. For example in [2.30], both figures are realised through Participants – one is tracked by *this*, and the other is construed via an elaborated semiotic entity (*knowledge [[that…]]*). The relationship between the figures is realised through the Process *confirm*.

> [2.30] The flask containing lactose demonstrated a higher level of B-galactosidase activity in comparison to the control flask with nothing added. **This** [Token] **confirmed** [Process] previous **knowledge [[that lactose induces B-galactosidase activity]]** [Value].

Similar to the mapping of logical connexion to verbal Process in section 4.3.2.1.2, the meaning construed by the Process *confirm* can be either interpreted as an internal connexion *so/therefore*, or a combination of an external connexion and a position of figure - *so we know (for sure)*. To reveal the heteroglossic engagement, we interpret it ideationally as a combination of external connexion and position.

> [2.30C] The flask demonstrated a higher level of B-galactosidase activity...
>
> consq.
>
> so we know that lactose induces B-galactosidase activity
> (/so we know the knowledge [[that…]] is true).

We can model such stratal tension between sequences in the discourse and circumstantial identifying processes in Table 4.20 below. Grammatically, since the Process construes a consequential relationship between two figures, the identifying process can be treated as a circumstantial one.

Table 4.20 Stratal tension between sequence and circumstantial identifying process

						inner orbit		
						nucleus		
						centre		
						event figure		
	centre					event	+ entity	x entity
discourse semantics	state figure			conx	post ‘’			
	entity = entity							
[2.30C]	*The flask*	*demons trated*	*a higher level of B-galactosidase activity*	*so*	*we know*	*induces*	*B-galactosidase activity*	*lactose*
lexicogr (cong.)	Med /Tk/Id	Pro: int.iden	Rg/Vl/Ir		mental pro	Pro: mat	Med/Go	Ag/Act
	n.gr	v.gr	n.gr	conj		v.gr	n.gr	prep.ph
lexicogr (metaph)	n.gr			v.gr		n.gr		
	Med/Tk/Id			Pro: cir.iden		Out.Rg/Vl/Ir		
[2.30]	*This*			*confirmed*		*previous knowledge [[that lactose induces B-galactosidase activity]]*		

As we have identified earlier, a positioned figure can also be realised metaphorically through an identifying process (specifically an intensive one). The metaphorical realisation of a positioned figure can therefore be enate to that of a sequence. Compare the examples below:

> circumstantial identifying process realises a sequence
>
> [1.26i] The minimal **variability** [[that existed between the readings]] [Token] **demonstrated** [Process] the **precision** of the pipette [Value].
>
> intensive identifying process realises a positioned figure
>
> [4.109] The results [Token] indicated [Process] a **loss** of viability between the crop and the faeces in the second instar individuals [Value].

While both examples are realised by identifying processes, [1.26i] construes a sequence, and [4.109] construes a figure. Their semantic distinction for this thesis is determined by the nature of the Token. If the Token construes a figure, the clause construes a discourse semantic configuration of figure + figure, thus a sequence; if the Token construes an entity (in this case a semiotic entity, *results*), the clause construes a discourse semantic configuration entity + figure, thus a positioned figure.

We have also found that sequence can be realised through both circumstantial identifying processes and verbal processes. This brings us once again to the border of verbal and relational processes. Compare the realisations of a sequence in [1.26i] and [1.26] below:

> sequence realised by circumstantial identifying process
> [1.26i] The minimal **variability** [[that existed between the readings]] [Token] **<u>demonstrated</u>** [Process] the **precision** of the pipette [Value].
>
> sequence realised by verbal process
> [1.26] The minimal **variability** [[that existed between the readings]] [Sayer] **<u>demonstrated</u>** [Process] || that the pipette was precise [Locution].

For analytical purposes in this thesis, the grammatical distinction between the two is based on whether the realisation of the second figure is congruent or metaphorical. If it is realised congruently through a clause (*the pipette was precise* in [1.26]), the sequence is realised by a clause complex with verbal process projection. If it is realised metaphorically through a Participant (*the precision of pipette* in [1.26i]), the sequence is realised metaphorically through a circumstantial identifying process. In both cases, the relationship between the figures is realised through the Process, particularly by a 'showing' verb (i.e. *demonstrate*).

I have now discussed at various points the ways in which discourse semantic configurations (figure, positioned figure, and sequence) are mapped onto verbal and relational processes in grammar. Congruently, figures, particularly state figures, can be mapped onto relational process (as discussed in section 4.2.3.3 above); positioned figures are mapped onto projecting verbal processes; and sequences are mapped onto expanding clause complexes. The congruent mapping is represented in Table 4.21 below by the solid arrows. Metaphorically, both positioned figures and sequences can be mapped onto relational processes and sequences can also be mapped onto verbal processes. The metaphorical mapping is represented by the dashed arrows in Table 4.21.

Table 4.21 Interstratal relationships between discourse semantic meanings and clauses in grammar

discourse semantics	(state) figure	positioned figure	sequence
lexicogrammar	clause [relational process]	clause complex [verbal projection]	clause complex [expansion]

The agnation at both discourse semantics and lexicogrammar can therefore be categorised into four paradigms, shown in Table 4.22 below. Critically, we need to simultaneously take into consideration two discourse semantic units of meaning. As shown in Table 4.22, the first unit of meaning can be either an entity or a figure; the second unit is always a figure. The distinction between the construal of a sequence and that of a positioned figure is determined by the discourse semantic meaning of the first unit. That is, if the first unit is an entity, the whole configuration is a positioned figure, which presents the figure as a fact ([a] and [b]); whereas if the first unit is a figure, it is related causally to the second figure in a sequence ([c] and [d]). The relationship between the figures is realised through a Process. With respect to their grammatical forms, the distinction between verbal and relational processes is determined by the mapping of the second unit (i.e. a figure) on grammar. If the second unit is mapped congruently onto a clause, the process type is identified as a verbal one with a hypotactic projection ([a] and [c]); if the figure is mapped metaphorically onto a Participant, the clause is a relational one ([b] and [d]). In both verbal and relational processes, the Processes are typically realised by a 'showing' verb (e.g. *demonstrate, indicate*, *show*, *confirm, suggest, illustrate*, *explain*). A further distinction has also been made with respect to relational identifying process. If the Process construes a relationship between figures, the process is a circumstantial one ([d]); if the Process construes a position of figure, the process is an intensive one ([b]).

Table 4.22 Agnation between verbal and relational processes, and between figure and sequence

2nd unit / **1st unit**		discourse semantics: figure		
		lexicogramnmar (congruent): clause	lexicogramnmar (metaphorical): Participant	
discourse semantics	lexico-grammar			
entity	Participant	[a] *The results* [Sayer] *indicates* || *that the viability between the crop and the faeces in the second instar individuals is lost*	[intensive identifying] [b] *The results* [Token] *indicate a loss of viability between the crop and the faeces in the second instar individuals* [Value].	positioned figure
figure	Participant	[c] *Minimal variability existed between readings* [Sayer] *demonstrates* || *the pipette was fairly precise*	[circumstantial identifying] [d] *Minimal variability existed between readings* [Token] *demonstrates the precision of the pipette* [Value]	sequence
		verbal process	relational process	

It needs to be pointed out that the realisation of sequence through circumstantial identifying process in the student texts belongs specifically to the decoding type (configured with Token/Identified ˙ Value/Identifier). In scientific discourse it is also possible to realise sequence through an encoding type of circumstantial identifying process. An example is given in Halliday (1998, p. 194):

> This **acidification** [Vl/Id] was **<u>caused</u>** [Process] mainly by the **burning of coal** [[containing high levels of sulphur]] [Tk/Ir].

In this example the logical relationship between the two figures is an external consequential one, realised by the Process (i.e. *cause*).The fact that such realisation of cause/effect relationships are rare in the student texts suggests that cause/effect relationship managed there are more likely to be 'interpreted', rather than explained. This point will be elaborated further in Chapter 5 when the pedagogic implications are concerned.

4.3.2.2.2.3 Circumstantial attributive process

Sequence can also be mapped onto a circumstantial attributive process, with both figures realised through the Participants (as Carrier and Attribute. The connexion between the figures can be either realised through the Process, or through a Minor Process in the Attribute (as exemplified in [3.105] and [3.91-93] respectively):

> [3.103] **The possible presence of chytrids within the coelomic fluid of P. Phyllacanthus and E. heliopneustes** [Carrier] **<u>could have resulted from</u>** [Process] **ingestion of algae** [Attribute]

> [3.91-93] Although it was possible that chytrids were present within the samples used, none were present in culture. **This** [Carrier] may have been [Process] **<u>due to</u>** the **prolonged storage of these samples** [Attribute].

In [3.103] the connexion between the figures is realised through the Process *result from;* and in [3.91-93] it is realised through the Minor Process *due to.* By means of unpacking the grammatical metaphor, both connexions can be realised conjunctively as *because*.

[3.103C] [a] It is possible that Chytrids is present within the coelomic fluid of *P. Phyllacanthus* and *E. heliopneustes.*

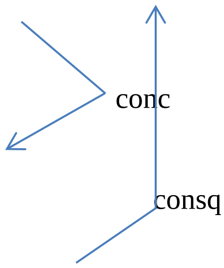
consq

[b] perhaps <u>because</u> algae is ingested.

[3.91-93C] [a] <u>Although</u> it was possible that chytrids were present within the samples used,

[b] none were present in culture.

[c] Perhaps <u>because</u> we stored these samples for a long time.



Note that in these examples, most of the figures involve a dimension which subjectifies their probability (as indicated by *it is possible/possibly*, *perhaps*, etc.). The modification is radiated across the sequence. It provides an attitudinal 'scope' through which the volume of the certainty of propositions is turned down (see also 'scoping clause' and 'scoping adverbials' in McGregor, 1997). We can represent the prosody of dimension with the arrow ranging throughout the sequence in Table 4.23 below. The stratal tension between the sequence and the circumstantial attributive process is also displayed in Table 4.23.

Table 4.23 Stratal tension between sequence and circumstantial attributive process

discourse semantics	dimension	→							
		inner orbit						**nucleus**	
		nucleus						**centre**	
		centre							
		state figure					conx	event figure	
		entity				x entity		event	+ entity
[3.103C]	*it is possible / possibly,*	*Chytrids*	*was*	*present*		*within the coelomic fluid*	*perhaps because*	*was ingested*	*algae*
lexicogr. (cong)	clause / modal Adj	Med/Car	Pro: int.attr	In.Rg/ Attr		Cir		Pro: mat	Med/Go
		n.gr	v.gr	adj		n.gr	conj	v.gr	n.gr
lexicogr. (metaph)	n.gr						v.gr	n.gr	
	Med/Car						Pro: cir.iden	In.Rg/Attr	
[3.103]	*The possible **presence** of chytrids within the coelomic fluid*						*could have resulted from*	*ingestion of algae*	

4.3.2.2.3 Figure realised within group

I have illustrated above the various ways in which a sequence can be mapped onto a clause, with both figures being mapped onto Participants at the clause rank. A figure in a sequence can be also mapped onto the functions at the group rank, typically a Qualifier. The connexion between figures can be realised nominally through the Head noun of the Participant. The process type for nominal groups featuring this kind of realisation is typically an intensive identifying process (specifically an encoding type), as exemplified below.

> [4.87] The absence of *Podospora* from the crop [Token/Identifier] is [Process] **evidence** [for **mandibular damage to the spores**] [Value/Identified]

> [4.150] The alternative **explanation** [for **the absence of colonization by Isaria**] [Value/Identified] is [Process] [[that the locust initiated some physiological response]] [Token/Identifier].

> [4.134] The **consequence** [of **the inadvertent transmission**] [Value/Identified] is [Process] [[that spores could be isolated from the locust]] [Token/Identifier].

In these examples, a figure is mapped onto the Token in the form of nominalisation (i.e. *the absence of Podospora…*in [4.87]) or embedded clause (i.e. *[[that the locust initiated…]]* in [4.150]); and the other figure in the sequence is mapped onto the Qualifier (e.g. *[for mandibular damage to the spore]* in [4.87]) of the nominal group which functions as the Value at the clause rank. The connexion between the figures is mapped onto the Head of the nominal group in the form of a nominalisation (i.e. *evidence, explanation, consequence*). By unpacking the grammatical metaphor, it can be revealed that the connexion between the figures is a causal one - specifically, it is an internal consequential one in [4.87] (*so we know*) and [4.150] (*because we know),* and external conditional one in [4.134] (*if…then…*). In order to show the heteroglossic engagement construed by *evidence* and *explanation* (i.e. contracting an alternative voice), the examples are unpacked into a configuration of an external connexion and a position of a figure, as illustrated below:

[4.87C] *Podospora* from the crop is absent,

consq

so we know mandibular damaged the spores.

[4.150C] The colonization by Isaria is absent,

<u>because we know</u> the locust initiated some physiological response. — consq

[4.134C] <u>If</u> we transmit it inadvertently,

<u>then</u> the spores could be isolated from the locust — cond

The stratal tension between sequence and intensive identifying process is displayed in Table 4.24 below, using [4.84] as an example.

Table 4.24 Stratal tension between sequence and intensive identifying process

						inner orbit		
						nucleus		
						centre		
						event figure		
	centre					event	+ entity	x entity
discourse semantics	state figure			conx.	post. ‘’			
	entity							
[4.87C]	*Podospora from the crop*	*is*	*absent*	*so*	*we know*	*damaged*	*the spores*	*mandibular*
lexicogrm. (cong.)	Med/Car	Pro	In.Rg/Att		mental pro	Pro: mat	Med/Go	Ag/Act
	v.gr	n.gr	n.gr	conj.		v.gr	n.gr	prep.ph
lexicogrm. (metaph.)	n.gr			v.gr		n.gr		
	Med/Tk/Id			Pro: int.iden		Out.Rg/Vl/Ir		
[4.87]	*The absence of Podospora from the crop*			*is*		*evidence for mandibular damage to the spores*		

Note nominalisations such as *evidence, explanation* and *consequence* may function as a realisation of a semiotic entity. When construing a semiotic entity, the nominalisation is a name for a figure (or a sequence) that functions as a cause or effect in the discourse; the semiotic entity can be elaborated through a fact projection as Qualifier (e.g. *the result = [[that the flasks demonstrated a lower level of B-galactosidase activity]]*). However, when the nominalisation realises a logical connexion between two figures, it is usually modified by a Qualifier in the form of a prepositional phrase, as in examples above ([4.87], [4.150] and [4.134]). The logico-semantic relation between the Thing and the Qualifier is that of an enhancement (*evidence* x *[for mandibular damage to the spores]*), instead of an elaboration.

For a fuller account of the distinction between semiotic entity and logical metaphor, see section 3.2.2.2.3 in Chapter 3.

4.3.2.3 Overview of interstratal tension between sequence and clause

To this point we have illustrated the various ways in which sequence can be realised lexicogrammatically. Several findings of grammatical metaphors are consolidated below.

Firstly, I have shown that figures can be realised in the form of a down-ranked clause, a nominalisation or tracked through a textual reference, as summarised in Table 4.25 below.

Table 4.25 Metaphorical realisation of figure

Metaphorical realisation of figure	Examples
down-ranked clause	**[[*That chytrids were present within the sample*]]** *may have been* ***<u>due to</u>*** *the* ***prolonged storage****.* *The result =* **[[*that the flasks demonstrated a lower level of B-galactosidase activity*]]** ***<u>demonstrated</u>*** *that gene expression controls B-galactosidase activity.*
nominalisation	*The* ***survival*** *of small but not large spores* ***<u>supports</u>*** *the* ***importance*** *of size in fracture initiation dynamics.* *The* ***absence*** *of Podospora from the crop is* ***<u>evidence</u>*** *x [for mandibular* ***damage*** *to the spores].*
textual reference	(*Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates.*) ***This*** ***<u>allows</u>*** *materials to be more readily degraded by fungi and bacteria.*

(key: the instances of experiential metaphors are in bold; and logical metaphors are in bold and underlined)

Secondly, I have shown that when sequence is realised metaphorically, one or two figures are realised at group rank or even within a group. An overview of the diverse grammatical realisations of sequence is shown in Table 4.26 below. These realisations are arranged in Table 4.26 in a way that moving from the top row to the bottom, there is a general shift from mapping figures to clauses, and then mapping (one or both) figures to groups (Participants), and finally to mapping a figure further down-ranked to an embedded group (Qualifier). It is suggested that the more down-ranked the realisations of the figures, the stronger stratal tension between sequence and its grammatical realisation may become[33].

Table 4.26 An overview of the realisation of sequence

	sequence	figure(s)	connexion	example
congruent	clause complex	figure a – clause, figure b – clause	conjunction	*A set amount of water was pipetted into a container, and the weight of the water was measured.*
		figure a – clause, figure b – clause (metaphorical)	conjunction	*Since these fungi vary in spore size, the **use** of dung fungi is ideal.*
		figure a – clause, figure b – group	verbal Process	*The minimal **variability** [[that existed between the readings]] **demonstrated** the pipette was fairly precise.*
	clause	figure a – clause, figure b – group	Minor Process in Cir.	*Smaller fungal spores are more likely to retain integrity and viability, **due to** the **ability** to more easily avoid maceration.*
		figure a – clause, figure b – group	within Process	***Calibration** of a pipette **allows** the relationship between theoretical volumes and those actually obtained to be determined.*
		figure a – group, figure b – group	Process	*The **survival** of small but not large spores **supports** the **importance** of size in fracture initiation dynamics.*
			Minor Process in Participant	***[[That chytrids were present within the samples used]]** may have been **due to** the **prolonged storage**.*
metaphorical		figure a – group, figure b – within group [Qualifier]	Participant	*The alternative **explanation** [for the **absence** of colonization by Isaria] is **[[that the locust initiated some physiological response]]**.*

Third, the data reveal that internal and external connexions favour different metaphorical realisations, summarised in Table 4.27 below. Internal connexions tend to be realised through a 'showing' Process (e.g. *show*, *suggest*, *demonstrate*, *imply*, *indicate*, *prove*, *confirm*, etc.), either in a verbal process or a circumstantial identifying one (specifically the decoding type); and it can also be realised nominally through a Participant in an intensive identifying process. Note that in this thesis, in order to reveal the heteroglossic engagement construed by the 'showing' Process, the metaphorical realisations of internal connexions are unpacked into a

[33] The scale of grammatical metaphor has also been pointed out by Halliday (e.g. 1998, p. 221) as a 'general drift' from realising 'relator' in a clause complex to realising it in a nominal group. Chapter 2 has also reviewed the scale of realising internal and external logical relations in Halliday (1988/2004, p. 155).

combination of an external connexion and a position (e.g. *so we know/suppose*). In contrast to the internal connexions, external connexions are realised in my data in more diverse ways, including through a Minor Process, an instigation, the Processes in material, circumstantial identifying (specifically the encoding type) and attributive clauses, as well as through a nominalisation in intensive identifying process.

Table 4.27 Diverse metaphorical realisations of internal and external logical connexions[34]

	internal connexion	external connexion
Minor Process		▪ Circumstance: *Smaller fungal spores are more likely to retain integrity and viability, **due to** the ability to be more easily avoid maceration.*
Process	▪ verbal process: *The minimal variability that existed between the readings **demonstrated** that the pipette was fairly precise.* ▪ circumstantial identifying (decoding): *The minimal variability that existed between the readings **demonstrated** the precision of pipette.*	▪ instigation: *Calibration of a pipette **allows** the relationship between theoretical volumes and those actually obtained to be determined.* ▪ material process: *The survival of small but not large spores **supports** the importance of size in fracture initiation dynamics.* ▪ circumstantial identifying (encoding): *This acidification was **caused** mainly by the burning of coal containing high levels of sulphur.* ▪ circumstantial attributive: *The possible presence of chytrids within the coelomic fluid of P.Phyllacanthus and E.heliopneustes **could have resulted from** ingestion of algae.*
Participant	▪ intensive identifying process: *The alternative **explanation** [for the absence of colonization by Isaria] is [[that the locust initiated some physiological response]].*	▪ Minor Process within Participant in circumstantial attributive: *[[That chytrids were present within the samples used]] may have been **due to** the prolonged storage.* ▪ intensive identifying process: *The **consequence** [of the inadvertent*

[34] Note that logical connexions may be also realised through Epithet (e.g. *causal, subsequent*) (Halliday 1998/2004, p. 41-42). However, such realisation is not found in my data, therefore is not accounted for.

		transmission] is [[that spores could be isolated from the locust]]

(key: the metaphorical realisations of connexions are in bold and underlined)

4.3.3 Metaphorical realisation of sequence across the data texts

In this section, I comment on how sequences are realised metaphorically in the four student texts ranged across different undergraduate year levels. Drawing on the types of metaphorical realisations summarised in Table 4.26 and Table 4.27 above, the instances of grammatical metaphors in these texts are calculated. This data set is relatively small; more quantitative observation in larger data set is necessary to reveal the use of grammatical metaphor. However, a trend of increasing control of grammatical metaphor can be noticed across these student texts. The discussion below firstly compares the ways in which sequences with internal connexions are realised in the texts; it then compares the realisations of sequences with external connexions.

Based on the overviews in Table 4.27 above, among the metaphorical realisations of the sequences with internal connexions (including verbal process, circumstantial identifying process and intensive identifying process), a degree of metaphorical mapping from less metaphorical to more metaphorical is suggested. This is shown on a cline in Figure 4.19 below. The least metaphorical mapping, sequence mapped onto verbal process, occurs frequently in Text 1 (e.g. *the* ***minimal variability*** *that existed between the readings demonstrated || that the pipette was fairly precise*). This realisation becomes less frequent in the texts produced in the later years. The second way of mapping sequence, onto circumstantial identifying processes (e.g. *This motion seemed to suggest the* ***presence*** *of flagella*), starts to emerge in Text 2 and is increasingly used in Text 3 and Text 4. Significantly, the third way of mapping sequence, onto intensive identifying process (which involves a nominal realisation of the internal connexion (e.g. *the absence of Podospora from the crop is* ***evidence*** *[for mandibular damage to the spores]*)) is found only in Text 4. The instances found across the four texts indicate that there is a tendency to increase stratal tension between sequences with internal connexion and lexicogrammar across the texts.

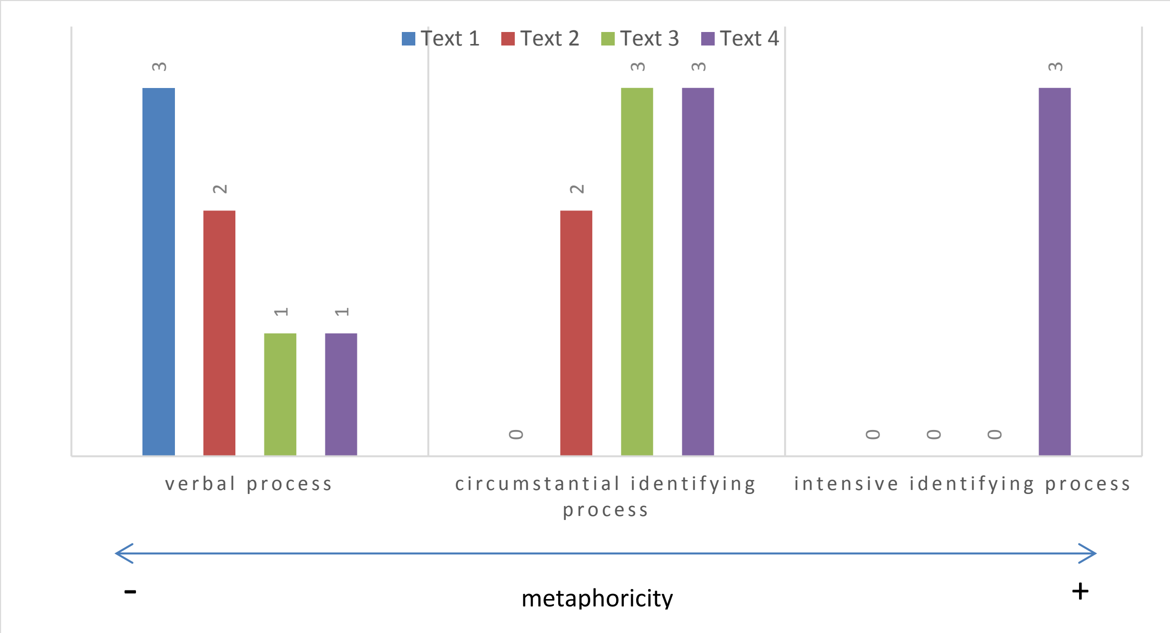


Figure 4.19 The metaphorical realisations of sequences with internal connexions across texts

In terms of the ways in which the sequences with external connexions are realised in the texts, several salient developmental features are also indicated. The degree of metaphorical mapping of sequences with external connexion onto grammar is shown on a cline in Figure 4.20 below. From left to right, the first metaphorical mapping, of sequence to a clause with Circumstance, is frequent in all texts except in Text 2. Instances of the second metaphorical mapping, mapping a sequence to an agentive clause, are only found in Text 1. Further, the instances of mapping sequence to non-agentive clause, including material processes and circumstantial attributive processes, show a tendency to increase across the texts. Lastly, the mapping of sequence to intensive identifying process, which involves a nominal realisation of the external connexion (e.g. *the* ***consequence*** *[of the inadvertent transmission] is [[that spores could be isolated from the locust]]*), is only found in Text 4. Note that while the mapping of figures in sequence to Circumstances seems to be frequently used in the texts at different year levels, it is found that realisations via Minor Processes in Circumstances are more diverse in Text 4 (e.g. *on account of, in relation to, in the process of*) in comparison to the texts in earlier years (*e.g. with, in, due to*). These features suggest that the realisation of sequences with external connexions in clauses also tends to be more metaphorical in the texts produced in later years.

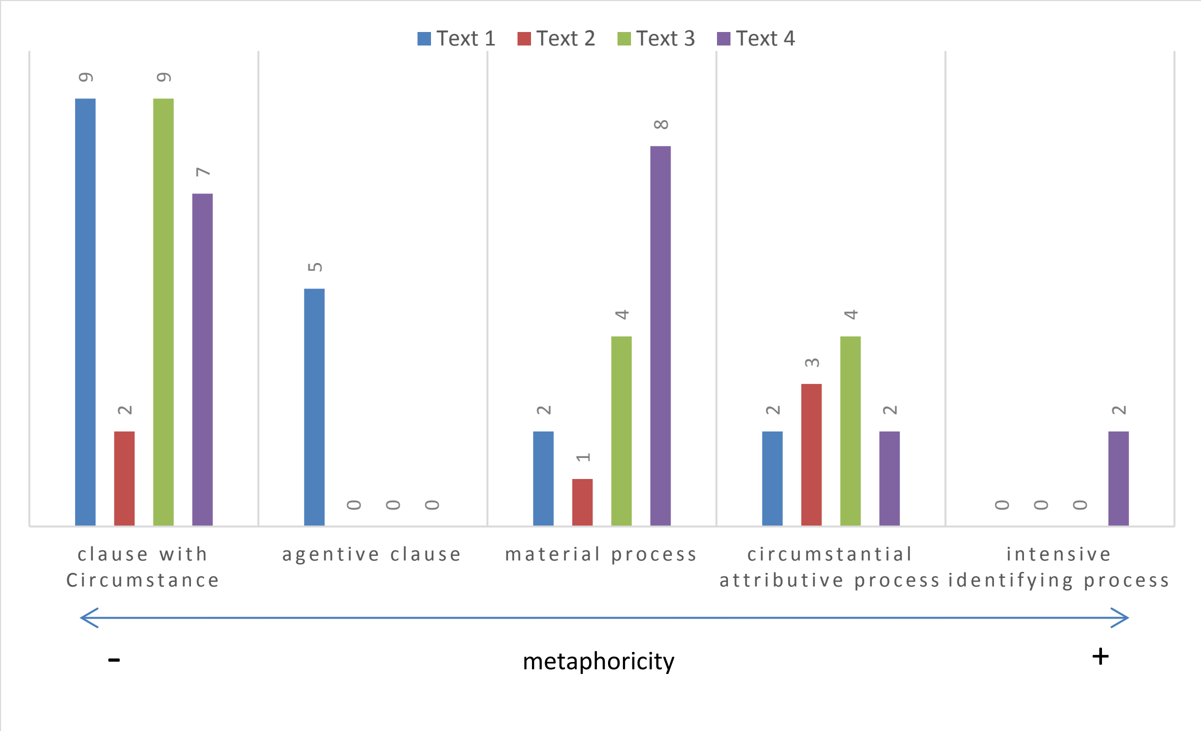


Figure 4.20 The metaphorical realisations of sequences with external connexions across texts

In this section, the investigation of sequence has been approached by looking from below, at the level of lexicogrammar. Where grammatical metaphors are involved, the unpacking of stratal tension allows sequences to be identified in the discourse. In the next section, I will make a further step towards identifying activity sequences in field based on the patterning of discourse semantic sequences.

4.4 Construing activity sequences through discourse semantic sequences

In the previous section, I explored the divergent realisations of sequence in the data. When sequences are realised metaphorically, unpacking grammatical metaphors can help identify sequences in the discourse. In this section, the patterns of sequences are investigated, which allows the construal of activity sequences in the field to be identified.

We begin the investigation from the sequencing of event figures, since it is the event figures that construe field activities. In the data, event figures are sequenced through both temporal and causal connexions; and the connexions can be either external or internal ones. Given that external connexions are by definition oriented to the unfolding of field and internal connexions organise text (Martin, 1992, p. 180), sequences with external connexions are thus another promising place to start the exploration. While event figures and external connexions are most relevant to the construal of activity sequences, I will show below that some internal connexions may be also involved in constructing activity sequences but these are of a different kind. Apart from the choice of connexion, we will see that the patterning of sequences may be associated with other discourse semantic features, such as different types of event figures involved in a sequence, and whether a sequence is generalised or specific. In addition to discourse semantic patterns, I will also adopt a perspective from above field at the level of genre. The divergent types of activity sequence revealed by the patterns of sequences will further indicate different types of field.

4.4.1 Sequencing event figures through external connexions

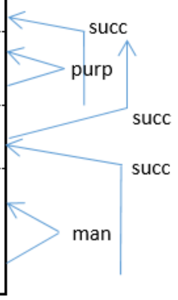
Among external sequences, temporal sequences are by and large concerned with enacted event figures; and causal sequences can be associated with both enacted and observed event figures.

4.4.1.1 Temporal sequencing

Across the four texts, a series of event figures may be organised as a sequence through temporal connexions. An excerpt [1.10-15] from Text 1 below exemplifies this pattern. The external connexions are annotated on the right hand side of the table; the implicit connexions which are not lexicalised in the texts are placed in parentheses.

[1.10-15]

		inner orbit			
		nucleus			
		centre		margin	periphery
no.	conx.	event	+ entity [instrumental thing]	+x entity [people]	x entity [instrumental thing]
1.10		*were pipetted*	*set amounts of dye*	*(by us)*	*into 1mL cuvettes*
1.11	*and*	*was added*	*water*	*(by us)*	
1.12	*to*	*give*	*a total volume of 1mL*	*(we)*	
1.13	*(and then)*	*was mixed*	*Each solution*	*(by us)*	
1.14	*and*	*were read*	*absorbances (of solution)*	*(by us)*	
1.15	*(by)*	*using*	*a spectrophotometer*	*(we)*	

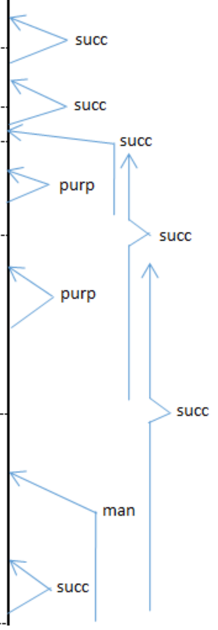


In this excerpt, several event figures are constituted into the sequence primarily through temporal [successive] connexions (i.e. *and then*). Apart from temporal connexions, figure [1.15] and figure [1.12] are related to the sequence through manner (*by means of*) and purpose (*in order to*) connexions. The external relationships between the figures construe the unfolding of the activity sequence in the field. The orbital configurations of these event figures involve doing events in the centre (e.g. *were pipetted, was added, give*), instrumental entities in the nucleus (i.e. *dye, water, solution, spectrophotometer*) and people entities who enact the events in the inner orbit (i.e. elliptical *we/the students* in margin). The events are realised in past tense, which indicates that the activities are being recounted. Following the criteria in Martin (1992), such a patterning of figures in a temporal sequence suggests that an **activity sequence** in field is being construed -- specifically an activity sequence conducted in a laboratory experiment. Note that the use of purpose and manner connexions suggests the activity sequences are planned in a way that one activity **facilitates** another; in Martin's (1992) terms, the Effect in the discourse is 'modulated' by the connexion. The facilitated activity sequence is a characteristic of specialised fields such as sports, trades and crafts; it differs from the activity sequences in everyday fields where one activity **expects** another but does not facilitate another.

At the level of genre, this type of activity sequence in the data is found by and large in the Method stage of a procedural recount. The Method stage functions to report the procedure undertaken step by step in an experiment. The temporal scaffolding and the configurations of having events in the centre and people entities (mainly elliptical) in the inner orbit are consistent patterns in construing activity sequences of this kind. However the entities involved in the nucleus are not necessarily all instrumental things; observational things are also possible, as exemplified in the excerpt [4.50-59] of Method from Text 4 below.

[4.50-59]

		inner orbit			
		nucleus			
		centre		margin	periphery
no.	conx.	event	+ entity	+x entity	x entity
4.50		*were isolated*	*Species of Penicillium, Podopspora, Absidia, Isaria and Phycomyces*	*(by us)*	*from possum faeces*
4.51	*(and then)*	*were cultured*	*The fungi*	*(by us)*	*on 3.5% Potato Dextrose Agar (PDA)*
4.52	*(and then)*	*were flooded*	*Plates of each fungus*	*(we)*	*with 0.02% Triton-X*
4.53	*and*	*agitated*	*the mycelium*	*(by us)*	
4.54	*to (in order to)*	*remove*	*the spores*	*(by us)*	
4.55	*(And then)*	*were inoculated*	*Individual spore suspensions*	*(by us)*	
4.56	*(in order) to*	*surface*	*sterilized wheat*	*(we)*	*with five replicates of each fungus and a control (0.02% Triton-X solution)*
4.57	*(And then)*	*checked*	*[[whether spore suspension is effectively inoculated]]*	*(we)*	
4.58	*by*	*spraying*	*a fresh PDA plate with spore solution*	*(we)*	
4.59	*and*	*monitoring*	*spore germination*	*(we)*	



These activity sequences revealed in Methods are usually re-instantiated from the sequences which are earlier construed in a procedural genre -- either through the mode of physical demonstration in classroom or via a written text in laboratory manuals. The procedures function to instruct rather than to recount. The excerpt in Table 4.28 below from a laboratory manual - *Guide to Pipetting* - exemplifies the same activity sequence, calibrating pipette, which was recounted in Text 1 above. The connexions in the excerpt below are underlined; the implicit connexions are in parentheses.

Table 4.28 An excerpt of laboratory manual - calibrating pipette

1. Press the operating button to the first stop.
2. (<u>And then</u>) Dip the tip into the solution to a depth of 1cm,
   <u>and</u> slowly release the operating button.
   (<u>And then</u>) Wait 1-2 seconds

and withdraw the tip from the liquid,
(by) touching it against the edge of the reservoir
(in order) to remove excess liquid.

3. (And then) Dispense the liquid into the receiving vessel
   by gently pressing the operating button to the first stop
   and then press the operating button to the second stop.
   This action will empty the tip.
   (And then) Remove the tip from the vessel,
   (by) sliding it up the wall of the vessel.
4. (And then) Release the operating button to the ready position.

Similar to the sequence in Text 1 above, this sequence in the lab manual is also scaffolded successively, either explicitly via numbers and conjunctions, or implicitly via juxtaposition of clauses; and some figures are related to the sequence through purpose (*in order to*) and manner (*by*) connexions. This indicates that the field activities instantiated in the lab manual are facilitated. In contrast to the discourse semantic sequence in Text 1 involving statements realised through declarative clauses, the sequence in the lab manual consists of commands realised through imperative clauses. This shift of interpersonal meanings indicates that the activity sequence in the lab manual has an instructional rather than a recording function. This underpins the higher level distinction between genres – procedural recounts in student texts versus procedures in the lab manuals.

While the recording of activity sequences in the laboratory experiment is typically realised through temporal sequencing, it is also possible to construe such activity sequences through figures and entities. In the excerpt of lab manual above, the activity sequence concerned with *pipetting* is realised through a series of figures. In the student text (excerpt [1.10-1.15]) however, the same activity sequence (i.e. *pipetting*) is realised through one summative figure [1.10] (i.e. *set amount of dye were pipetted*).

Activity entities can also be used to realise this type of activity sequence. For example, the activity sequence realised in excerpt [1.10-1.15] above is named in Text 1 as *spectrophotometry* (one of three *methods*) in [1.5].

> [1.5] In this experiment a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated, using three methods – weight-of-water, spectrophotometry and radioactivity

Table 4.29 below summarises the various discourse semantic resources (sequence, figure and entity) that realise an activity sequence in the field.

Table 4.29 Realisation of activity sequence in discourse

field: activity sequence		‘calibrating a pipette through a spectrophotometer’
Discourse semantics	**sequence**	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and water was added to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*
	figure	*We used the spectrophotometry method.*
	entity	*method, spectrophotometry*

4.4.1.2 Causal sequencing

External causal connexions also relate event figures in a sequence, involving both enacted event figures and observed event figures.

4.4.1.2.1 Sequencing enacted event figures

Different types of causal connexions (condition, purpose and consequence) relate enacted event figures in a sequence externally, as exemplified below:

[3.120-122]

			inner orbit			
			nucleus			
			centre			
Function	no.	conx.	event	entity	entity	
Cause	3.120		*could analyse further*	*it (zoospore like structure)*	*we*	man
	3.121	*by*	*using*	*biochemical tests or molecular sequencing methods, such as DNA sequencing*	*(we)*	purp
Effect	3.122	*in order to*	*identify*	*these organisms*	*(we)*	

[4.126-127]

				inner orbit		
				nucleus		
				centre		
				figure		
				event	entity	entity
Function	no.	conx.	position "			
Effect	4.126		*we would know*	*design*	*fungal biocontrols*	*(we)*
Cause	4.127	*as*		*would resolve*	*a more defined point at which spores cease to become viable*	*(we)*

consq

In these examples, the orbital configurations of these figures are similar to the figures construing activity sequences we have identified above in that they are enacted by people entities. However in contrast to temporal connexions, which do not modulate, the causal connexions in these examples modulate the Effect figures, proposing ‘what we should do’ in the future.

It is also possible to review causally ‘what we did/have done’ and ‘what we should have done’ in the past, as exemplified in [2.28a-b] and [4.129-130] below.

[2.28a-b]

			inner orbit		
			nucleus		
			centre		
Function	no.	conx.	event	+ entity	+x entity
Effect	2.28a		*obtained*	*the result*	*we*
Cause	2.28b	*because*	*used*	*the treatment*	*we*

consq

[4.129-130]

			inner orbit		
			nucleus		
			centre		
Function	no.	conx.	event	+ entity	+x entity
Effect	4.129		*could have been resolved*	*The effect of developmental stage on spore size and viability*	*(by us)*
Cause	4.130	*if*	*have used*	*spore sizes [[which are more comprehensively spread, especially in the 6-14 micron range]].*	*we*

cond

The causal sequencing of enacted event figures construes a distinct type of activity sequence from the activity sequences that were realised temporally. Unlike the temporal ones that are found in procedure and in Method of a procedural recount, the causal type is often found in exposition and in Discussion of a procedural recount. The different discourse semantic patterns and their occurrence in different genres suggest two distinct types of activity sequence in field - one is concerned with **operation of** activities, step by step, the other is concerned with **reviewing** (or **previewing**) activities. The realisations of these types of activity sequence are summarised in Table 4.30 below.

Table 4.30 Types of activity sequence (1)

types of activity sequence	**discourse semantic realisations**	**example**
operation	**sequence** [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*
	figure	*We used the spectrophotometry method.*
	entity [enacted activity]	*method, spectrophotometry*
re/previewing	**sequence** [causal sequencing of enacted event figures]	*We obtained results because we used the treatment.*

4.4.1.2.2 Sequencing observed event figures

Observed event figures can also be sequenced externally through causal connexions. In my data, the purpose and consequence connexions are commonly used, as exemplified below.

[2.51a-b]

			inner orbit		
			nucleus		
			centre		
Function	no.	conx.	event	+ entity	+x entity
Effect	2.51a		*is induced*	*B-galactosidase*	
Cause	2.51b	*because*	*is controlled*	*B-galactosidase*	*by gene expression*

consq

[4.103a-c]

			inner orbit			
			nucleus			
			centre			
Function	no.	conx.	event	+ entity	+x entity	
Effect	4.103a		*needs to be initiated*	*a fracture*	*(by the material)*	succ
	4.103b	*(and)*	*propagated*	*(a fracture)*	*(by the material)*	
Cause	4.103c	*so that*	*can be fragmented*	*the materials*	*(by mandibles)*	purp

[4.93a-b]

			inner orbit			
			nucleus			
			centre			
Function	no.	conx.	event	+ entity	+x entity	
Cause	4.93a		*manipulated*	*the ingested material*	*the mandibular*	consq
Effect	4.93b	*so*	*sustained to be damaged*	*the ingested material*		

[4.143-144]

			inner orbit				
			nucleus				
			centre		margin	periphery	
Function	no.	conx.	event	+ entity	+x entity	x entity	
Effect	4.143		*lost*	*their viability*	*the spores*		consq
Cause	4.144	*since*	*were recovered*	*spores*		*from both the crop and faeces in all treated individuals*	

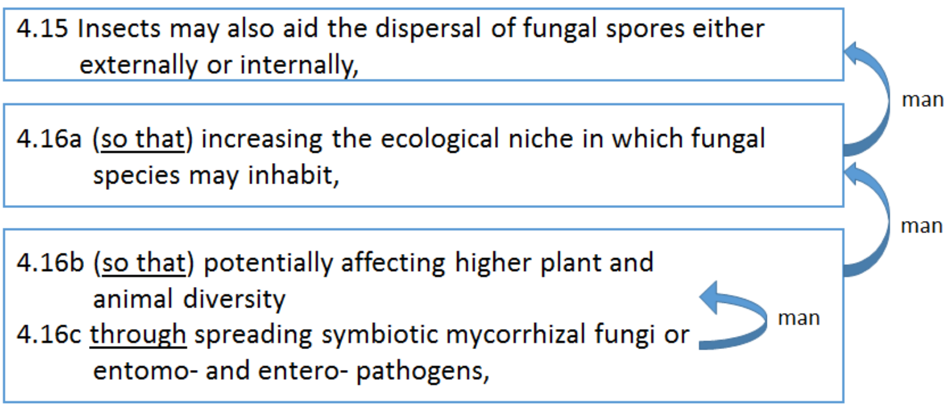
In these examples, the sequences have similar features in that they all involve observed event figures and causal connexions; they construe activities of biological phenomena. Looking from a textual perspective, a distinction among these examples can be revealed with respect to how generalised the sequences are. The generalisation is associated with the ways in which the entities in the sequences are identified via the IDENTIFICATION system as either generic or specific (Martin, 1992, Chapter 3). The entities involved in sequences [2.51a-b] and [4.103a-c] are generic entities (e.g. *B-galactosidase, a fracture, mandibles)*; whereas those involved in the sequences [4.93a-b] and [4.143-144] are specific ones (e.g. *the mandibular, the spores*).

This distinction between generic and specific entities goes hand in hand with the different realisations of events. Events engendered by the generic entities are timeless, realised through simple present tense (e.g. *B-galactosidase <u>is induced</u>* in [2.51a]); whereas the events engendered by the specific entities are anchored in the past, realised through past tense (e.g. *the mandibular* *__manipulated__* *the ingested materials* in [4.93a]). These differences suggest that discourse semantic sequences can either construe activities of biological phenomena as a generalised phenomenon across time and space or as a specific phenomenon in a particular time and space, such as what is observed in a particular experiment. Once the activities of biological phenomena are generalised, they become a scientific principle in the field and the way in which one activity is followed by another is determined by a scientific principle. This way of ordering activity sequences (i.e. as one **determining** another) has been referred to in Martin (1992) as an **implication sequence.** Note that instead of being in an opposition to activity sequences as in Martin (1992), implication sequences are identified here as a type of activity sequence. At the level of genre, implication sequences typically occur in an explanation genre (Unsworth, 1995; Veel, 1997; Martin & Rose, 2008). By contrast to implication sequences, specific activities of biological phenomena observed in a particular experiment occur in a recount genre. The specific activity sequences in field that involve observing specific biological phenomena can be named as **observation**.

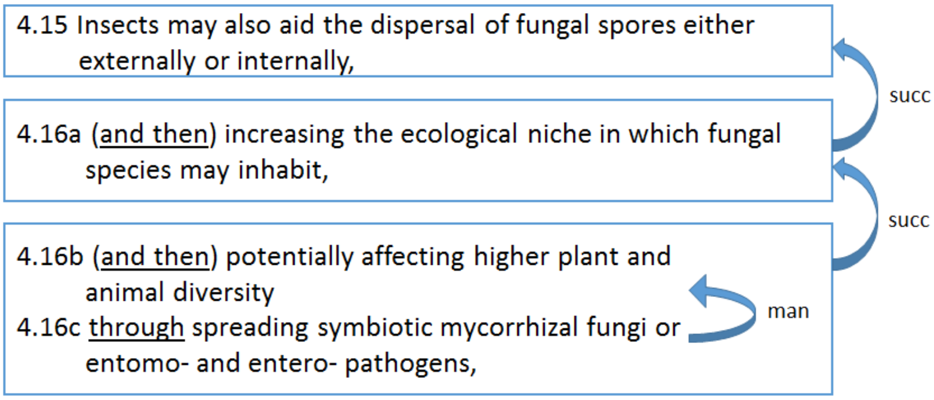
Note that it can be ambiguous sometimes to determine whether an implication sequence is realised temporally or consequentially, particularly when the logical connexions are implicit ones – as exemplified in excerpt [4.15-4.16c] below.

> [4.15] Insects may also aide the dispersal of fungal spores either externally or internally,
> [4.16a] (so then) increasing the ecological niche in which fungal species may inhabit,
> [4.16b] (so then) potentially affecting higher plant and animal diversity
> [4.16c] <u>through</u> spreading symbiotic mycorrhizal fungi or entomo- and entero- pathogens.

The implicit logical connexions between [4.15] and [4.16a], and between [4.16a] and [4.16b] can be interpreted as involving manner, as modelled below.



Alternatively, their logical connexions can also be interpreted as temporal successive ones:



What seems to be at issue here is that in such implication sequences, temporality and causality do not need to be distinguished. Using Barthes' (1975) term, the implication sequences are 'chronological' and 'logical' at the same time.

In my data, the instantiation of implication sequences in the student texts is usually supported with references, as exemplified in [4.15-16] (references are underlined). This suggests that these implication sequences are construed in the first instance in published research articles and then re-instantiated in the student texts.

> [4.15-16] Insects may also aid the dispersal of fungal spores either externally or internally, increasing the ecological niche in which fungal species may inhabit and potentially affecting higher plant and animal diversity through the spread of symbiotic mycorrhizal fungi or entomo- and entero-pathogens (Collier & Bidatnodo, 2008; Dromph, 2000; Devarajan & Suryanarayanan, 2006; Nakamori & Suzuki, 2009; Vernes & Dunn, 2009).

Similar to the recording type of activity sequences, implication sequences can also be realised through figures or named through entities. When they are realised through figures, delicate steps in the implication sequence may be subsumed. For instance, *lactose induces B-galactosidase activity* in a student text is one discourse semantic figure. However, the induction of *enzymes*, of which *B-galactosidase* is a particular kind, is explained in the textbook step by step through a discourse semantic sequence -- as in excerpt below (Table 4.31) (the boundaries between activities are marked by letters; connexions are underlined).

Table 4.31 Explanation of how enzyme is activated

a. In an enzymatic reaction, the substrate binds to the active site.
b. In most cases, the substrate is held in the active site by weak interactions, such as hydrogen bonds and ionic bonds.
c. (And then/so then) side chains (R group) of a few of the amino acids make up the active site,
d. (And then/so then) the side chains catalyse the conversion of substrate to product,
e. and (/so then) the product departs from the active site.
f. The enzyme is then free to take another substrate molecule into its active site. (Campbell & Reece, 2005, p. 152-153)

Apart from being realised through sequence and figure, implication sequences can also be named through activity entities, such as the underlined activity entities in [3.97-98] below.

> [3.107-108] Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea. Host-microbial relationships may include parasitism, commensalism and symbiosis.

These named implication sequences in [3.107-108] are typically unpacked through a series of figures in the textbook. As shown in the excerpt below, *parasitism* is unpacked through a sequence which is constructed causally.

Table 4.32 Explanation of parasitism

a. Some parasites change the behaviour of their hosts
b. by increasing the probability of the parasite being transferred from one host to another.
c. For instance, if parasitic acanthocephalan (spiny-headed) worms is present,
d. then their crustacean hosts engage in a variety of atypical behaviours,
e. including leaving the protection of cover
f. and (/so that) moving into the open.
g. As a result of their modified behaviour, the crustaceans have a greater chance of being eaten by the birds that are the second host in the parasitic worm's life cycle. (Campbell & Reece, 2005, p. 1163)

Parasitism condenses the meaning of an implication sequence into a single entity – i.e. an activity entity. Naming implication sequences through activity entities is a resource for taxonomising them. As has been illustrated in Chapter 3, these entities are usually linguistically defined in pedagogic texts through a Token^Value identifying clause (e.g.

Parasitism [Token] *is a +/- symbiotic interaction in which one organism, the parasite, derives its nourishment from another organism, its host, which is harmed in the process* [Value] (Campbell & Reece, 2005, p. 1163)) (see also the discussion on linguistically defined entity in section 3.2.3.2, Chapter 3). The taxonomy established around the implication sequence *parasitism* shown in Figure 4.21 below.

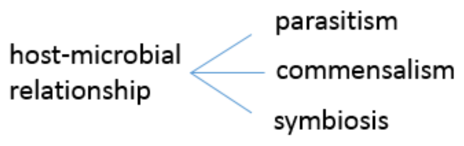


Figure 4.21 Classification of host-microbial relationship

Apart from the implication sequences that are re-instantiated from textbooks and published research articles, in the student texts it is also possible to construe implication sequences which are produced in a student's own research. Such implication sequences can be realised either through positioned figures/sequence, or through naming a semiotic entity. For example, in [4.92-94] below, the implication sequence (i.e. *mandibular manipulate the ingested material so it controls…*) is firstly realised through a positioned sequence (i.e. *the result suggest that…*), and then the same implication sequence is named as a semiotic entity *findings.*

> [4.92-94] <u>The results suggest || that mandibular manipulate the ingested material, so it controls how much the materials are damaged</u>. Such **findings** are consistent with current understanding of food processing by members of the Acrididae.

We can now extend the types of activity sequence in Table 4.33.

Table 4.33 Types of activity sequence (2)

types of activity sequence	discourse semantic realisations	example
operation	**sequence**: [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*
	figure	*We used the spectrophotometry method.*
	entity [enacted activity]	*method, spectrophotometry*
re/preview	**sequence** [causal sequencing of enacted event figures]	*We obtained results because we used the treatment.*
observation	**sequence** [causal sequencing of observed event figure involving specific entities]	*The ingested materials were manipulated by the mandibles so they sustained to be damaged.*
implication sequence	**sequence** [causal sequencing of observed event figure involving generic entities]	*- Some parasites change the behaviour of their hosts* *- by increasing the probability of the parasite being transferred from one host to another.* *- For instance, if parasitic acanthocephalan (spiny-headed) worms is present,* *- then their crustacean hosts engage in a variety of atypical behaviors, …* *- As a result of their modified behaviour, the crustacean have a greater chance of being eaten…*
	figure	*Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea*
	entity [observational activity; semiotic]	*parasitism, symbiosis,* *findings*

4.4.3 Identifying fields through activity sequences

So far we have identified various types of activity sequences that are construed in the data – recording, reviewing/previewing, observation and implication sequence. These distinct types of activity sequences suggest further differentiations of field.

Firstly, a field that is characterised by implication sequences has been named by Martin (1992) an **exploration** field. Its implication sequences are generalised. The other subtypes of activity sequences (operation, review/preview and observation) tend to be concerned with specific activities, either enacted or observed activities. A field that is concerned with specific activities can be termed a **specialised** field (c.f. Martin, 1992). Delicate distinctions can be made within the specialised fields based on different types of activity sequence. A field that is concerned with the activity sequences of observation is termed here **depiction**; examples of depiction might involve observation of a football game that is being played in the stadium, or the motion of cells that is being observed under a microscope. A field concerned with operating activity sequences step by step is termed here **practice**, for example conducting an experiment in a laboratory, or a procedure related to cooking or craft. A field that is concerned with reviewing/previewing activity sequences is termed **reflection**, such as reflecting on the reasons for what was done in the past, either it was in an experiment, a cooking, or a football game, or previewing what should be done in the further. An outline of these systems in relation to type of activity sequence is presented in Figure 4.22 below.

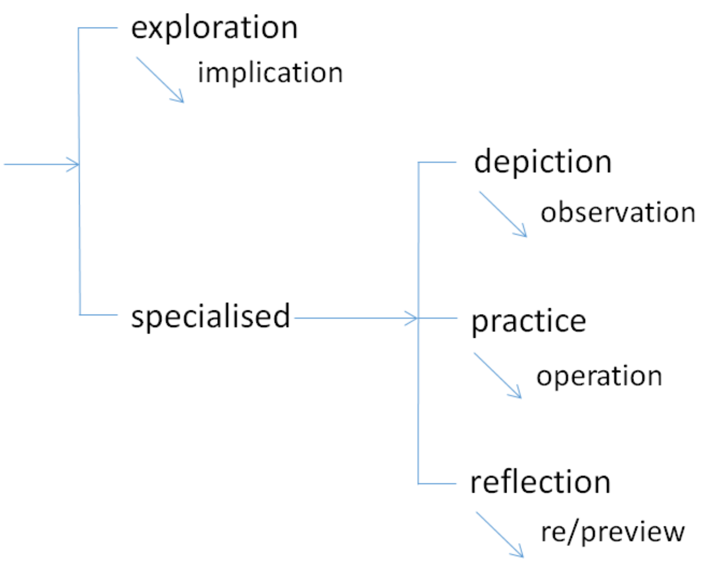


Figure 4.22 Field types (1)

4.4.4 Construing taxonomy in field through sequences

The patterns of sequences illustrated above are constituted with event figures. The data reveal that apart from event figures, state figures can also be related in a sequence, particularly through causal connexions, as exemplified below.

[3.55-56]

			nucleus	
			centre	
Function	no.	conx.	entity	+ quality
Cause	3.55		*the compositions of urchins*	*are different*
Effect	3.56	*as*	*the diet and habitat of regular and irregular urchins*	*are different significantly.*

consq

[3.124a-c]

			nucleus		
			centre		
Function	no.	conx.	entity (= entity)	+ quality	
Effect	3.124a		*the components of the digestive tract and coelom of sea urchins*	*are greatly different*	consq
Cause	3.124b	*because*	*each section has different roles and environmental conditions – including variation in pH, chemical composition and oxygen concentration and toxicity*		
Effect	3.124c	*so that*	*the microbial composition and activity*	*are different accordingly*	consq

As we can see, in these examples, no field activity is construed given the lack of event figures; but the figures are constituted with entities and their dimensionalities, such as *the components of digestive tract, the compositions of urchins*. These sequences of state figures are concerned with another dimension of field – taxonomy building. Our exploration of taxonomy building in field has so far focused on the discourse semantic entities and their dimensionality (see Chapter 3). The sequencing of state figures indicates that it is possible to construe field taxonomies through various kinds of discourse semantic resources– naming through entities, establishing relationships between entities through a state figure, or describing a relationship between entities through a sequence.

The above examples suggest that when entities are described through a sequence, what is described may be a causal relationship between different dimensionalities of an entity. As exemplified in [3.55-56], a causal relationship is established between the compositional dimensionality and attributive dimensionality of a trained gaze entity (i.e. *composition of sea urchin* and *diet and habitat of sea urchin*). Example [3.124a-c] on the other hand shows that the description is the relationships among entities of different types; the entities in [3.124a-c] are linguistically defined ones which have different means of observation, as summarised below.

inferable entities	**trained gaze entities**	**tech-enhanced gaze**
chemical composition; oxygen concentration; oxygen toxicity;	*the components of the digestive tract and coelom of sea urchins; each section (of the digestive tract)*	*microbial composition; microbial activity*

From a textual perspective, the linguistically defined entities in [3.55-56] and [3.124-a] are identified as generic ones. This suggests that the taxonomy building in these examples is associated with an exploration field. We can annotate this way of building exploration field through a realisation statement in the system, as shown in Figure 4.23.

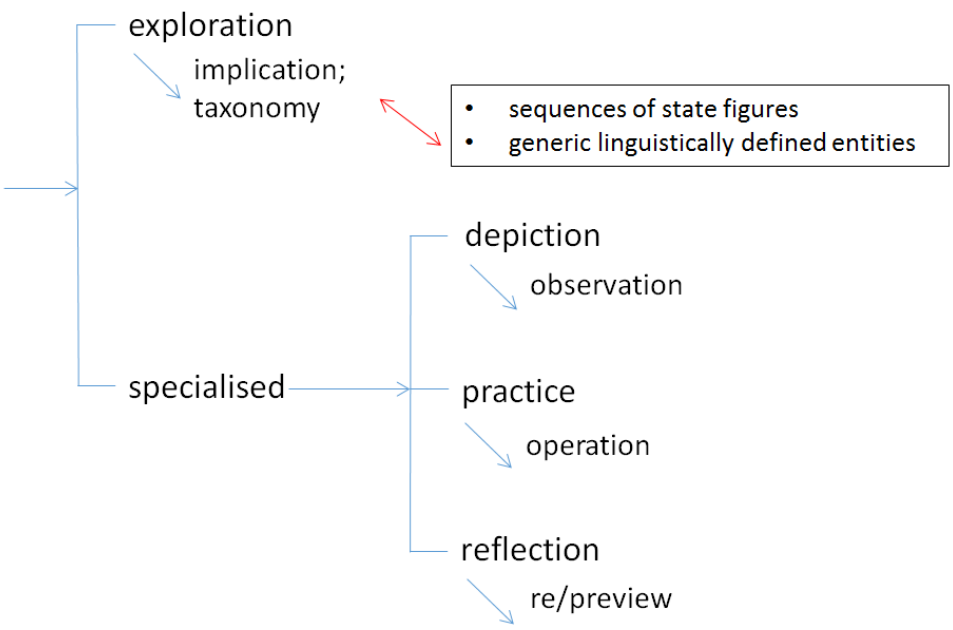


Figure 4.23 Field types (2)

4.4.5 Sequencing through internal connexions

Apart from sequencing figures through external connexions, internal connexions are also used in the data. As exemplified in example [4.37-39b], a sequence [4.37-38] is related internally to the other sequence [4.39a-b] through *therefore*.

[4.37-39b]

				inner orbit		
				nucleus		
				centre		
no.	int.conx.	pos. & dim.	ext.conx.	event / entity(=entity)	+ entity / + quality	+x entity
4.37				*different developmental stages of C. terminifera have mandibles of different size*		
4.38			*yet*	*consume*	*the same food*	*(different developmental stages of C. terminifera)*
4.39a	*therefore*	*it is ideal*		*to use*	*this insect*	*(we)*
4.39b			*in order to*	*test*	*our model*	

consq (4.37–4.38 → 4.39a–b); conc (4.37 – 4.38); purp (4.39a – 4.39b)

In previous studies, it has been found that internal logical connexions can be used to relate implication sequences to one another in pedagogic texts (e.g. Unsworth, 1995). According to

Unsworth's (1995) observation, internal connexion establishes relationships between implication sequences in different 'domains'. As he explains,

> "explanations of the tides, seasons, phases of the moon etc. may well involve deductive reasoning which relates implication sequences in one 'domain' to implication sequences in another. In the case of explaining the tides, one has to deal with the inter-relationship among at least three such domains: the earth's orbit around the sun, the moon as a satellite of the earth and the consequent variation in the relative positioning of the sun and the moon with respect to the earth; the concept of gravitational force; and the movement of the tides…" (Unsworth, 1995, p. 71)

In my data, internally related sequences also construe different 'domains'. However, in contrast to pedagogic texts in which implication sequences in different 'domains' involve established knowledge (i.e. exploration fields), in the student texts these 'domains' can be any of the field types we have so far identified. As exemplified in [4.37-39b], there is a shift from an implication sequence in the exploration field ([4.37-38]) to previewing activities in the field of reflection ([4.39a-b]).

						inner orbit			
						nucleus			
						centre			
	field	no.	int.conx.	pos. & dim.	ext.conx.	event / entity(=entity)	+ entity / + quality	+x entity	
	exploration	4.37				*different developmental stages of C. terminifera have mandibles of different size*			conc
consq		4.38			*yet*	*consume*	*the same food*	*(different developmental stages of C. terminifera)*	
	reflection	4.39a	*therefore*	*it is ideal*		*to use*	*this insect*	*(we)*	purp
		4.39b			*in order to*	*test*	*our model*		

Earlier in section 4.3.2.1.2 we illustrated that internal connexion can be paraphrased as a combination of an external connexion and a position or a dimension. Compare the pair of examples below.

[4.82-84i] sequencing through internal connexion:

				inner orbit			
				nucleus			
				centre		margin	periphery
field	no.	int. conx	ext. conx.	event	+ entity	+x entity	x entity
depiction	4.82			*did not retain*	*their viability*	*the larger spores of Podospora*	
	4.83		*and*	*fractured*	*material*	*Smaller mandibles*	*into smaller fragments*
exploration	4.84i	*so*		*would be more easily damaged*	*larger fragments*	*by mandibular action*	

consq

add

[4.82-84ii] sequencing through externalised internal connexion::

					inner orbit			
					nucleus			
					centre		margin	periphery
field	no.	int. conx	ext. conx. + pos.& dim.	ext. conx.	event	+ entity	+x entity	x entity
depiction	4.82				*did not retain*	*their viability*	*the larger spores of Podospora*	
	4.83			*and*	*fractured*	*material*	*Smaller mandibles*	*into smaller fragments*
exploration	4.84ii		*so we know*		*would be more easily damaged*	*larger fragments*	*by mandibular action*	

add

consq

In the pair above, the internal connexion is agnate to a combination of external connexion and position: *so we know*. In another pair below, the internal connexion is agnate to a combination of external connexion and a dimension: *if… (then) it is possible.*

[3.101-102i] sequencing through internal connexion:

			centre
field	no.	int. conx	entity (= entity)
depiction	3.101	*if*	*chytrids were present within the Echinoidea*
exploration	3.102i		*they may be transient, not symbiotic, members.*

cond

[3.101-102] sequencing through externalised internal connexion

					centre
field	no.	int. conx	ext. conx. + pos.& dim.	ext. conx.	entity (= entity)
depiction	3.101			*if*	*chytrids were present within the Echinoidea*
exploration	3.102		*it is possible*		*they may be transient, not symbiotic, members.*

cond

As illustrated by the annotation of connexions, the internal connexions in these examples (*so* and *if…then…*) are externalised when the Effect figures are augmented, either through a position as in [4.84i] (i.e. *so we know*) or through a dimension as in [3.102] (i.e. *it is possible*). Dimensioning and positioning of figures allow the sources of 'who positions the proposition' and 'who evaluates/modifies the proposition' to be made explicit in the discourse. The source of a position is typically a people entity (*we/biologists propose/suppose/know/think…*) or a semiotic entity (*the result shows…; the data demonstrate…*); and the evaluator of a dimension is typically the student writer. That is to say, internal connexion not only functions to navigate the shifts among different fields; but importantly, it also construes an additional activity sequence in the field – it in effect 'externalises' the logical reasoning of the student writer. Activity sequences of this kind are generalised in Figure 4.24 below.

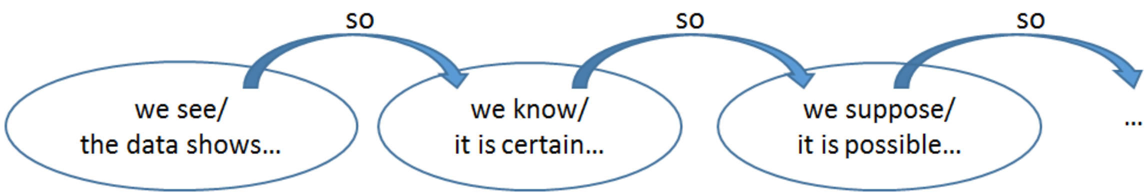


Figure 4.24 Externalised reasoning

This kind of reasoning activity sequence is explicitly concerned with the production of knowledge. Phylogenetically, it marks the transition from knowledge reproduction to knowledge production in a discipline. Ontogenetically, it indicates the growth of a student's knowledge. Logogenetically, it reveals a shift towards the accumulation of new information in the text (i.e. New, hyper-New, and Macro-New). As far as apprenticeship into biology is concerned, when the reasoning is realised through the combination of external connexion and position/dimension, the field time of the student's knowledge expansion matches the text time. From an interpersonal point of view, dimension and position can introduce potential heteroglossing voices in the discourse, which allow the student writer to enact the objectivity of scientific reasoning. We can expand the types of activity sequence as in Table 4.34.

Table 4.34 Types of activity sequence (3)

types of activity sequence	discourse semantic realisations	example
operation	**sequence**: [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, <u>and then</u> water was added <u>(in order) to</u> give a total volume of 1mL. <u>(And then)</u> each solution was mixed, and absorbances were read, <u>(by)</u> using a spectrophotometer.*
	figure	*We used the spectrophotometry method.*
	entity [enacted activity]	*method, spectrophotometry*
re/preview	**sequence** [causal sequencing of enacted event figures]	*We obtained results <u>because</u> we used the treatment.*
observation	**sequence** [causal sequencing of observed event figure involving specific entities]	*The ingested materials were manipulated by the mandibles so they sustained to be damaged.*
implication	**sequence** [causal sequencing of observed event figure involving generic entities]	*- Some parasites change the behaviour of their hosts* *- by increasing the probability of the parasite being transferred from one host to another.* *- For instance, if parasitic acanthocephalan (spiny-headed) worms is present,* *- then their crustacean hosts engage in a variety of atypical behaviors, …* *- As a result of their modified behaviour, the crustacean have a greater chance of being eaten…*
	figure	*Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea*
	entity [observational activity; semiotic]	*parasitism, symbiosis,* *findings*
reasoning	**sequence** [internal causal connexion; external causal connexion ^ dimension/position]	*<u>We saw</u> (chytrids were present within the Echinoidea), <u>so we suppose/it is possible</u> (they may be transient, not symbolic, members).*

The activity sequences of reasoning allow us to identify an additional type of field, which we term here **inquiry**, as shown in Figure 4.25.

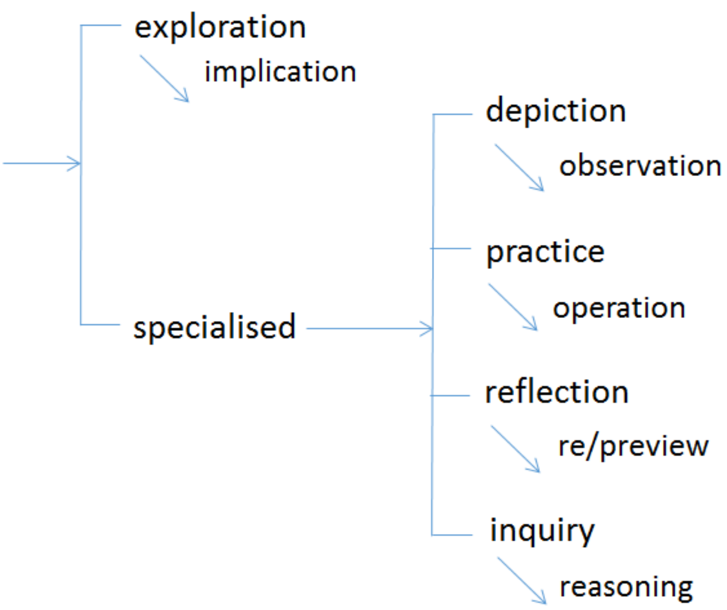


Figure 4.25 Field types (3)

Grammatically speaking, activity sequences of reasoning tend to be realised through the projecting mental, verbal clauses and fact projections. The other activity sequences are typically realised through projected clauses. In other words, the field of inquiry can 'project'[35] other fields. The division of two fields realised through grammatical projection has been found in Hood (2004, 2010), where introductions to research articles are considered. Hood identifies two fields – one field refers to the field of object of study; the other field, the field of research, has to do with 'construction of the process of research itself' and 'the process of enquiry and knowledge building' (2010, p. 121). The field of object of study is seen as being 'projected' by the field of research. As she explains,

> "The notion of relocating, recontextualising, or re-presenting one field of human experience into another is highly applicable to the context of academic research. The field of research projects a representation of experience from another 'world' (field of the object of study) as 'metaphenomenon' (Halliday, 1994, p. 252). The field of research relocates the field of the object of study as intimately related although retaining separate field status. The phenomena of the field of the object of study are brought into being and construed in certain ways by the processes of enquiry (mental)

[35] Note that 'projection' is used in a metaphorical sense to describe the level of field, although it can be realised through mental, vernal and fact projection in lexicogrammar. For the discussion of one field projects the other, see also Christie's work on curriculum genre (e.g. Christie, 1997, 2002) which in turn draws on Bernstein's work on pedagogic discourse (e.g. 1990).

and processes of reporting (verbal) that construe the field of research." (Hood, 2010, p. 135)

Based on the grammatical realisation through projection, the field of inquiry identified above resonate with the field of research identified in Hood (2010). The opposition between field of research and field of object of study in academic discourse therefore provides a complementary perspective to the opposition between exploration and specialised fields. The simultaneous systems can then be established in the disciplinary field of biology, as shown in Figure 4.26 below.

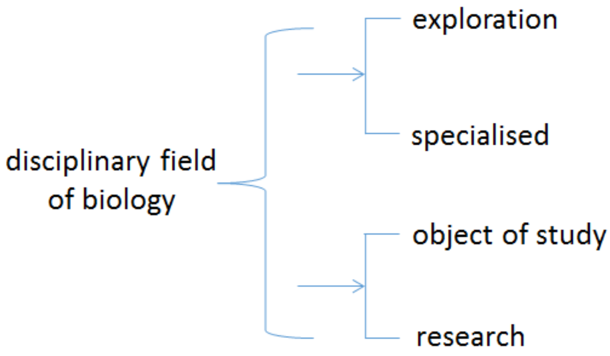


Figure 4.26 Field types in the disciplinary field of biology

In my data, the two systems cross-classify; in particular, the delicate types of specialised field are found to combine with either the field of object of study or research. The general interaction between the two systems is that exploration and specialised [depiction] are oriented to the field of object of study; specialised [reflection] and specialised [inquiry] are orientated to the field of research; specialised [practice] is associated with both the field of research (e.g. where an operation of laboratory experiment is conducted for the purpose of a biological observation) and the field of object of study (e.g. where an operation of an experiment aims to test the effectiveness of the method). An overview of the cross-classification of field types in relation to their discourse semantic realisations is provided in Table 4.35. In addition to the parameter of activity sequences in field, we also draw on the other aspect of field (i.e. taxonomy building) in Table 4.35 by including the entity types established in Chapter 3. Taxonomy in different fields tends to be realised through different entity types. The arrows in Table 4.35 annotate the syntagmatic realisations of field through activity sequences and taxonomy, and the double arrows annotate the interstratal realisation of activity sequences and taxonomy through discourse semantic resources.

Table 4.35 Field types and their realisations

field types		object of study	research
exploration		• **activity sequence [implication]** o sequence: temporal/causal sequencing of observed event figures [generic] o entity: linguistically defined observational activity [generic]; semiotic entity • **taxonomy**: o sequence: sequencing of state figures o figure: state figures o entity: linguistically defined things [generic]	
special-ised	depiction	• **activity sequence [observation]** o sequence: temporal/causal sequencing of observed event figures [specific] o entity: linguistically defined observational activity [specific] • **taxonomy** o sequence: temporal/causal sequencing of observed event figures [specific] o figure: state figures o entity: linguistically defined things [specific]	
	practice	• **activity sequence [operation]** o sequence: temporal sequencing of enacted event figures o entity: enacted activity entity • **taxonomy** o entity: instrumental things [ling. def. & osten. def.] o figure: state figures	• **activity sequence [operation]** o sequence: temporal sequencing of enacted event figures o entity: enacted activity entity • **taxonomy** o entity: instrumental things [ling. def. & osten. def.] o figure: state figures
	reflection		• **activity sequence [pre/review]** o sequence: causal sequencing of enacted event figures

			o <u>entity</u>: enacted activity entity • **taxonomy** o <u>entity</u>: instrumental things [ling. def. & osten. def.]
	inquiry		• **activity sequence [reasoning]** o <u>sequence</u>: 1) internal connexions; 2) external causal sequencing of position/connexions • **taxonomy** o <u>entity</u>: source entity [people/publication]; semiotic entity; enacted activity entity

In the next section, we will apply this framework to analyse fields that are instantiated in the four student texts at different undergraduate year levels.

4.5 Construal of field in undergraduate biology texts

In this section, I interpret the four student texts by drawing on the framework established above. The following questions are considered in the analysis across the four texts:

- What types of field are instantiated in the text?
- How are the fields differentiated through the types of activity sequences or taxonomy?
- How are the activity sequences and taxonomy realised through discourse semantic resources?
- In what ways do the features of fields and discourse semantic resources in a text differ as the student's apprenticeship unfolds?

As in Chapter 3, the discussion is organised according to the order in which the texts appeared in the undergraduate program.

4.5.1 The construal of field in Text 1 – first year laboratory report

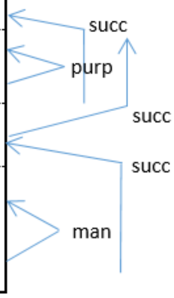
Several types of field were found to be instantiated in Text 1. The identification of field types is divided below into the field of research and field of object of study.

4.5.1.1 Field of research

In Text 1, the field of research consists of two types of specialised field, practice and inquiry. Firstly, the field of **practice** is indicated by the activity sequence [operation], which is realised through temporal sequencing of event figures in the Method stage; this is exemplified in the excerpt [1.10-15] below.

[1.10-15]

		inner orbit			
		nucleus			
		centre		margin	periphery
no.	conx.	event	+ entity [instrumental thing]	+x entity [people]	x entity [instrumental thing]
1.10		*were pipetted*	*set amounts of dye*	*(by us)*	*into 1mL cuvettes*
1.11	*and*	*was added*	*water*	*(by us)*	
1.12	*to*	*give*	*a total volume of 1mL*	*(we)*	
1.13	*(and then)*	*was mixed*	*Each solution*	*(by us)*	
1.14	*and*	*were read*	*absorbances (of solution)*	*(by us)*	
1.15	*(by)*	*using*	*a spectrophotometer*	*(we)*	



The practice field in Text 1 concerns laboratory experimentation. This field involves the activity sequences of the experiment, and the taxonomies of methods and utilitarian tools.

The second field of research in Text 1 is the field of **inquiry**, which is identified according to the activity sequence [reasoning]. Reasoning is realised in discourse through the positioning of figures, for example *according to spectrophotometry method… so we know…* in example [1.24-27]; and *radioactivity method suggests…so we know* in [1.28-30b] below. The sources of the positions are either activity entities (i.e. *spectrophotometry method*; *radioactivity method*) or the people entity *we*.

[1.24-27]

			inner orbit			
			nucleus			
			centre			
	no.	dim./post. (externalised internal)	entity	+ quality	x entity	
	1.24	*According to spectrophotometry method*	*the pipette*	*was fairly inaccurate,*		
succ	1.25		*the pipette*	*became less accurate*	*towards the larger end of the pipette's range*	
add	1.26		*the readings*	*were minimally variable*		
	1.27	***so we know***	*the pipette*	*was fairly precise*		consq

[1.28-30b]

			inner orbit			
			nucleus			
			centre			
	no.	dim./post. (externalised internal)	entity	+ quality	x entity	
	1.28-29a	*Radioactivity method suggested*	*the pipette*	*was highly accurate*	*throughout its range*	consq
	1.29b		*the set and measured volumes for volumes of 150ul and 200ul*	*are different (3%)*		
conc	1.30a		*the readings*	*were significantly variable*		
	1.30b	***so we know***	*the pipette*	*was highly imprecise*		consq

At the level of lexicogrammar, positioning is realised through either Circumstances of Angle (e.g. *according to spectrophotometry method* in [1.24]) or verbal processes (e.g. *we know* in [1.30b]*; radioactivity method suggests* in [1.28-29a]).

As discussed above, the field of inquiry as a field of research can project other fields. What is 'projected' leads us to the field of the object of study in Text 1.

4.5.1.2 Field of object of study

The field of object of study in Text 1 can be identified through its 'projection' by the field of inquiry. It is found that the 'projected' field is not established by its activity sequence, but by taxonomies of utilitarian tools (e.g. *pipette*) and methods (e.g. *method; radioactivity method*) that are realised through instrumental entities and activity entities. In this discourse, these taxonomies are realised by and large through state figures that describe the qualities of entities, as shown in the examples below (the entities are underlined, and the qualities are in bold).

[1.29a] the pipette **was highly accurate throughout its range**.

[1.47] the method **was time consuming**.

[1.50] the equipment **was inexpensive**.

While no activity sequences are construed through state figures, the taxonomies indicate that it is the practice field (i.e. the experimentation) that is the object of the study. The field of practice is therefore both the field of research and field of object of study in Text 1. This is because the aim of the laboratory experiment reported in Text 1 is to evaluate and compare the effectiveness of the different methods and the efficiency of the tools that are utilised.

4.5.1.3 Overview

In summary, several types of specialised field are instantiated in Text 1. Specifically, practice and inquiry are identified as two types of research field; practice is at the same time identified as the field of object of study. As a field of research, the practice field is indicated by its activity sequences [operation] and the taxonomies involved; as the field of object of study, practice is identified through the taxonomies of utilitarian tools and methods that are evaluated. The field types and their realisations in Text 1 are summarised in Table 4.36 below.

Table 4.36 Field types and their realisations in Text 1

field types		**field aspects**	**discourse semantic realisations**	**examples**
object of study/ practice		taxonomy	**figure** [state figure]	*The pipette was highly accurate throughout its range.* *The method was time consuming* *The equipment was inexpensive*
research	**practice**	activity sequence [operation]	**sequence** [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*
		taxonomy	**entity** [enacted activity entities; instrumental things]	*method, spectrophotometry, dye, pipette, cuvette, solution, spectrophotometer.*
	inquiry	activity sequence [reasoning]	**sequence** [external connexions + positions]	*Radioactivity method suggests… so we know…*

The analysis reveals that the field of biology construed in Text 1 is a specialised field that consists of delicate subfields. The identification of the specialised field in Text 1 aligns with my findings in Chapter 3, where the specialised field was identified by means of exploring taxonomy building through discourse semantic entities. By taking into account the dimension of activity sequences, more delicate subtypes of specialised fields in Text 1 and their relationships are identified.

4.5.2 The construal of field in Text 2 – second year laboratory report

In comparison to Text 1, in Text 2 a greater variety of fields are instantiated. Below the fields that emerge in Text 2 will be discussed.

4.5.2.1 Field of object of study

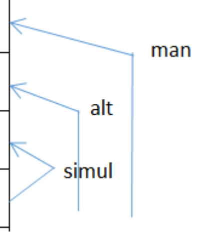
The object of study in Text 1 is a specialised field [practice]. Text 2, however, concerns a different object of study, specifically the field of exploration and the specialised field of [depiction].

4.5.2.1.1 exploration

The instantiation of the exploration field in Text 2 is identified by its implication sequence. These implication sequences are realised through causally related event figures involving generic and linguistically defined entities [observational things], as exemplified in [2.1-3b] and [2.32-33] below.

[2.1-3b]

		inner orbit			
		nucleus			
		centre		margin	periphery
no.	**ext. conx.**	**event**	**+ entity**	**+x entity**	**x entity**
2.1		*can be controlled*	*The activity of proteins*		
2.2	*through*	*influencing*	*levels of gene expression*		
2.3a	*or through*	*activating/deactivating*	*proteins*		
2.3b	*when*	*they (proteins) are already present*			*in the cytosol*



[2.32-33]

		nucleus		
		centre		
no.	ext. conx.	event	+ entity	
2.32		*does not run out*	*the IPTG, unlike the lactose,*	consq
2.33	*as*	*is never metabolized*	*it (the IPTG)*	

This identification of exploration field resonates with the interpretation of field construed through entities in Text 2 (Chapter 3, section 3.4.2). In Chapter 3, the taxonomies in the exploration field were found to be construed through various entity types – including trained gaze entities (e.g. *mercaptoethanol*, *chloroform*), inferable entities (e.g. *protein, cytosol*, *enzyme*) and observational activity entities (e.g. *gene expression*, *transcription*, *induction*). Both aspects of exploration field, implication sequence and taxonomy, construe the exploration field.

4.5.2.1.2 Depiction

The other field of object of study in Text 2 is the specialised field [depiction], which is identified by its activity sequence [observation]. As discussed earlier, the difference between exploration and depiction in the disciplinary field of biology is that exploration field refers to the activity sequences and taxonomies of generalised scientific phenomena, but depiction refers to the activity sequences and taxonomies of specific phenomena that are observed in a particular laboratory experiment. For example, [2.41-42] and [2.43-45] below demonstrate the activity sequences (i.e. [observation]) involving *B-galactosiade activity* that are observed in the laboratory experiment.

[2.41-42]

		nucleus		
		centre		
no.	ext. conx.	event / entity=entity	+ entity	
2.41	*at first*	*The flask demonstrated a lower level of B-galactosidase activity*		succ
2.42	*after a period of time*	*sharply rose*	*the level of B-galactosidase activity*	

[2.43-45]

		nucleus		
		centre		
no.	ext. conx.	event	+ entity	
2.43-44		*was only activated*	*the B-galactosidase*	simul
2.45	*when*	*was depleted*	*the alternative food source*	

The identification of exploration and depiction as two delicate fields of object of study suggests that in Text 2 the student writer was not only dealing with the observation of the 'here and now' in the lab, but also needed to associate the specific phenomena in the experiment to the generalised knowledge of biology construed in pedagogic texts.

4.5.2.2 Field of research

The specialised fields [practice] and [inquiry] as field of research which were found in Text 1 are also found in Text 2. Apart from these, an additional type of the field of research – reflection, is also found in Text 2. Reflection is indicated by the review of 'what we have done', realised in the discourse through causally related event figures, as exemplified in [2.23a-b].

[2.28a-b]

		inner orbit			
		nucleus			
		centre			
no.	conx.	event	entity	entity	
2.28a		*obtained*	*the result*	*we*	consq
2.28b	*because*	*used*	*the treatment*	*we*	

Apart from the greater variety of fields that are instantiated in Text 2 in comparison to those found in Text 1, Text 2 also demonstrates another salient feature, namely managing the shift of fields through the activity sequence of reasoning.

4.5.2.3 Reasoning

As indicated above, since both depiction and exploration are identified as the object of study, associating the specific depiction in the experiment to the generalised exploration is a critical task in Text 2. The relationship between these two fields is built in Text 2 through the activity sequence of reasoning by the student writer. In [2.29-30] and [2.34-36] below; the activity sequence [reasoning] (*we saw… so we know…*) allows the field of depiction to be generalised towards the field of exploration.

[2.29-30]

		inner orbit				
		nucleus				
		centre		**margin**	**periphery**	
no.	**exter. conx. + dim./pos.**	**event / entity=entity**	**+ entity**	**+x entity**	**x entity**	
2.29	*(we saw)*	*The flask demonstrated a higher level of B-galactosidase activity*				
2.3	***so we know***	*induces*	*B-galactosidase activity*	*lactose*		consq

[2.34-36]

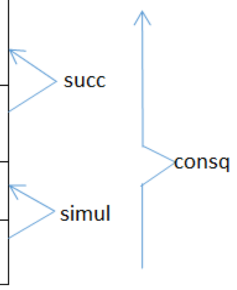
		inner orbit				
		nucleus				
		centre		**margin**	**periphery**	
no.	**exter. conx. + dim./pos.**	**event / entity=entity**	**+ entity**	**+x entity**	**x entity**	
2.34	*(we saw)*	*The flasks demonstrated a lower level of B-galactosidase activity*				
2.35-36	***so we know***	*controls*	*B-galactosidase activity*	*gene expression*		consq

From an interpersonal perspective, the generalisation towards the exploration field is enacted through a choice of 'contraction' in ENGAGEMENT (Martin & White, 2005, Chapter 3). Contraction functions to close down the heteroglossic space for other voices (e.g. *we know…* in example [2.3] and [2.35-26] above). We can say that Text 2 features contraction because the implication sequences in the exploration field present established knowledge which has been recontextualised in pedagogic texts. The student's laboratory experiment only 'confirms' what has been known. These instances of contraction are realised metaphorically in grammar through *demonstrate/confirm*.

Apart from the generalisation from depiction to exploration, reasoning also plays the role of explaining the phenomena in the field of depiction, as shown in [2.41-45].

[2.41-45]

			inner orbit	
			nucleus	
			centre	
no.	exter. conx. + dim./pos.	ext. conx.	event / entity=entity	+ entity
2.41	*(we saw)*	*at first*	*The flask demonstrated a lower level of B-galactosidase activity*	
2.42		*after a period of time*	*sharply rose*	*the level of B-galactosidase activity*
2.43-44	***so we suppose***		*was only activated*	*the B-galactosidase*
2.45		*when*	*was depleted*	*the alternative food source*



Notice that the reasoning of the student's own depiction of the experiment is achieved interpersonally through expansion (e.g. *so we suppose*) instead of contraction. Since what is deduced here is the student's own observation instead of an established knowledge, expanding the space for potential voices enacts the student's objectivity of the reasoning,

It is through the activity sequence of reasoning that student writer manages to establish the relationships among phenomena in the field of object of study, including both relating the specific phenomena in the depiction to the generalised knowledge of biology (i.e. exploration), and explaining the activity sequence in the field of depiction.

4.5.2.3 Overview

In summary, Text 2 demonstrates several distinctive features in comparison to the fields construed in Text 1. Firstly, a greater variety of fields are instantiated in Text 2, including the exploration field, and the specialised fields [depiction] and [reflection]. Of particular salience is the construal of an exploration field, which indicates that the field building at this stage of the apprenticeship has developed from a specialised field to an uncommonsense field. In Bernstein's term, this is a move from horizontal discourse to vertical discourse. This finding aligns with our findings in Chapter 3, where the exploration field in Text 2 was revealed by the taxonomies of biology phenomena realised through entities.

A second salient feature in Text 2 has to do with establishing relationships of phenomena in the field of object of study, both relating instance of depiction to exploration, and relating instances within the field of depiction. This is achieved through the activity sequences of reasoning.

Table 4.37 below provides an overview of the field types instantiated in Text 2 and their discourse semantic realisations, in comparison to those found in Text 1.

Table 4.37 Field types and their realisations in Text 1 and Text 2

field types		field aspects	discourse semantic realisations	Text 1	Text 2
object of study	**exploration**	activity sequence [implication]	**sequence** [temporal/causal sequencing of observed event figures (generic)]		*The activity of protein can be controlled through influencing levels of gene expression, or through activating/deactivating proteins when they are already present in the cytosol.*
		taxonomy	**entity** [trained gaze entity; inferable entity; observational activity entity]		*mercaptoethanol, chloroform, protein, cytosol, enzyme, gene expression, transcription, induction*
	depiction	activity sequence [operation]	**sequence** [temporal sequencing of observed event figures (specific)]		*at first the flask demonstrated a lower level of B-galactosidase activity, after a period of time the level of B-galactosidase activity sharply rose.*
	practice	taxonomy	**figure** [state figure]	*- The pipette was highly accurate throughout its range.* *- The method was time consuming*	
research	**practice**	activity sequence [operation]	**sequence** [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*	*E.coli bacteria were cultured in a glycerol medium, and then one of the six treatment was added to the bacterial culture, and bacteria growth was monitored by measuring absorbance…*
		taxonomy	**entity** [enacted activity entities; instrumental things]	*method; spectrophotometry,*	*treatment; ONPG assay*
	reflection	activity sequence [re/preview]	**sequence** [causal sequencing of enacted event figures]		*we obtained the results because we used the treatment*
	inquiry	activity sequence [reasoning]	**sequence** [external connexions + positions]	*Radioactivity method suggests….so we know the pipette was highly imprecise.*	*(We saw) the flasks demonstrated a lower level of B-galactosidase activity, so we know gene expression controls B-gal. activity*

4.5.3 The construal of field in Text 3 – second year research report

In comparison to the field types that were instantiated in Text 1 and Text 2, no additional field type is found in Text 3. However, Text 3 demonstrates distinct features of field building in two other ways. Firstly, building the field of object of study is achieved through taxonomy building, realised through various discourse semantic resources. Secondly, Text 3 demonstrates a greater complexity in terms of establishing relationships between instances of different fields through reasoning.

4.5.3.1 Construing taxonomy in the field of object of study

Similar to the field of object of study instantiated in Text 2, both fields of exploration and depiction as object of study are instantiated in Text 3. However in contrast to Text 2, exploration and depiction in Text 3 are not established with respect to activity sequences (i.e. exploration and observation respectively), but through building taxonomies. The realisations of taxonomies are identified in discourse semantics in various ways. Firstly, taxonomy is realised through state figures concerned with qualities and entities, for example the realisation of taxonomy in the field of depiction in [3.64-66] (e.g. *these cells were motile*) and the realisation of taxonomy in exploration field example [3.55-56] (e.g. *the compositions of urchins are different*).

[3.64-66]

			nucleus		
			centre		
no.	ext. conx. + dim./pos.	ext. conx.	entity/event	+ entity	
3.64		*as*	*moved against the Brownian current*	*the small circular cells*	consq
3.65			*these cells were motile*		
3.66	*so we suppose*		*flagella were present*		consq

[3.55-56]

		nucleus		
		centre		
no.	conx.	entity	+ quality	
3.55		*the compositions of urchins*	*are different*	consq
3.56	*as*	*the diet and habitat of regular and irregular urchins*	*are different significantly.*	

Secondly, taxonomy is realised through state figures which establish relationships between entities. In example [3.101-102] below, a classificatory relationship among *chytrids*, *transient members* and *symbiotic members* is established.

[3.101-102]

			centre
no.	ext. conx. + dim./pos.	ext. conx.	entity
3.101		*if*	*chytrids were present within the Echinoidea*
3.102	*it is possible*		*they were transient, not symbiotic, members.*

cond

A third way of construing taxonomies is through entities in event figures, as in [3.41a-b] below. These event figures construe a step within the activity sequence of reasoning (i.e. *we saw…, so we know…*), particularly the step of observation, as realised through mental processes (i.e. *we saw…*). The entities that 'were seen' (i.e. realised through Phenomena in the mental processes) construe the taxonomies in the field of depiction.

[3.41a-b]

		inner orbit		
		nucleus		
		centre		
no.	ext. conx.	event	+ entity	+x entity
3.41a		*saw*	*bacterial species, protists – such as Paramecium – sea urchin haemocytes and other eukaryotic cells*	*We*
3.41b	*also*	*were seen*	*Round, motile, zoospore-like structures and structures that were similar in morphology to sporangium*	*(by us)*

add

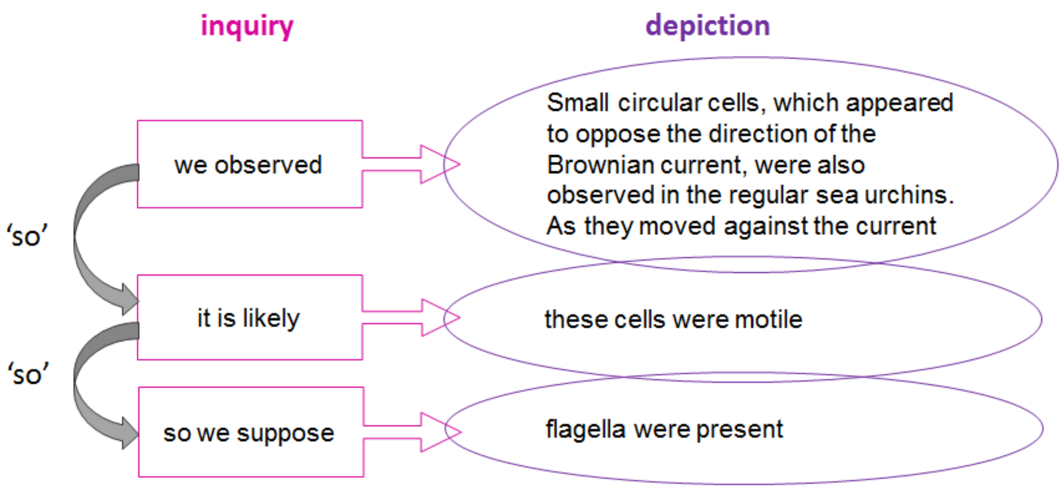
The identification of field from the perspective of taxonomy building was also noted in Text 1, where taxonomy in the field of practice realised through entities and state figures. The state figures in Text 1 were concerned mostly with the qualities of entities which are measurable (e.g. *the pipette is precise/imprecise*, *the methods is effective/ineffective*). By contrast, the state figures in Text 3 are concerned with the dimensionality of entities – the classification and composition of entities as well as their perceptive attributes such as shape and size. This suggests that taxonomy building in different fields is not only construed through different entity types but also associated with different qualities and dimensionality of entities.

4.5.3.2 Reasoning

A second distinctive feature of field building in Text 3 has to do with managing relationships between different instances of field through the activity sequence of reasoning in the field of research. Several patterns of reasoning can be identified.

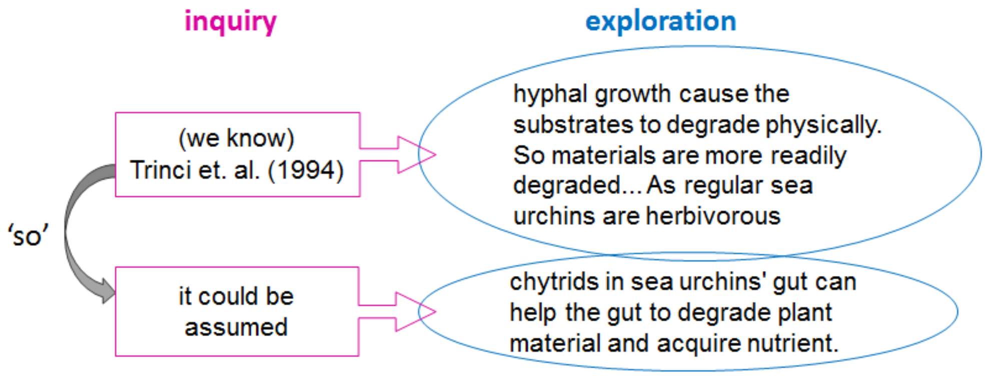
One pattern of reasoning involves interpreting the phenomenon within the field of depiction. Relating different phenomena in the field of depiction through reasoning has also been found in Text 2, where the reasoning was concerned with explaining the activity sequence in depiction. However, since the depiction in Text 3 has to do with taxonomy building, the reasoning targets on describing the specific phenomena that are observed in the experiment. For example in [3.63-66] below, the descriptions of phenomena (i.e. *these cells were motile; flagella were present*) are deduced from the observation of the phenomena. The arrows on the left represent the activity sequence of reasoning from cause to effect.

[3.63-66]



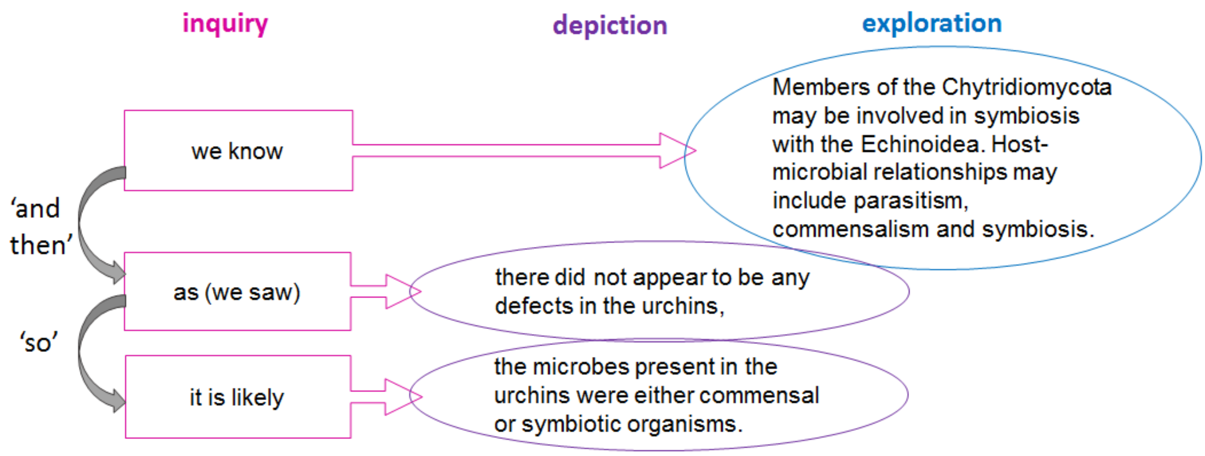
Secondly, reasoning also plays the role of making a hypothesis within the field of exploration. As exemplified in [3.112-116] below, the established knowledge in the exploration field ('what we know') is referenced to publications (e.g. *Trinci et al. 1994*), based on which the student writer 'assumes' an implication sequence in the exploration field.

[3.112-116]



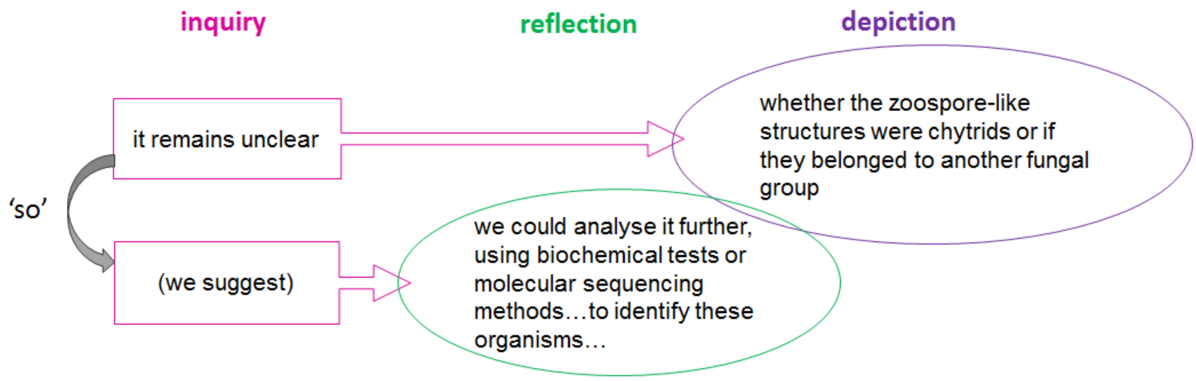
Thirdly, the activity sequence of reasoning can also shift from an instance of generalised phenomena in the exploration field to interpret a specific phenomenon in the field of depiction. In other words, 'what we know' is drawn on to interpret 'what we observed'.

[3.107-110]



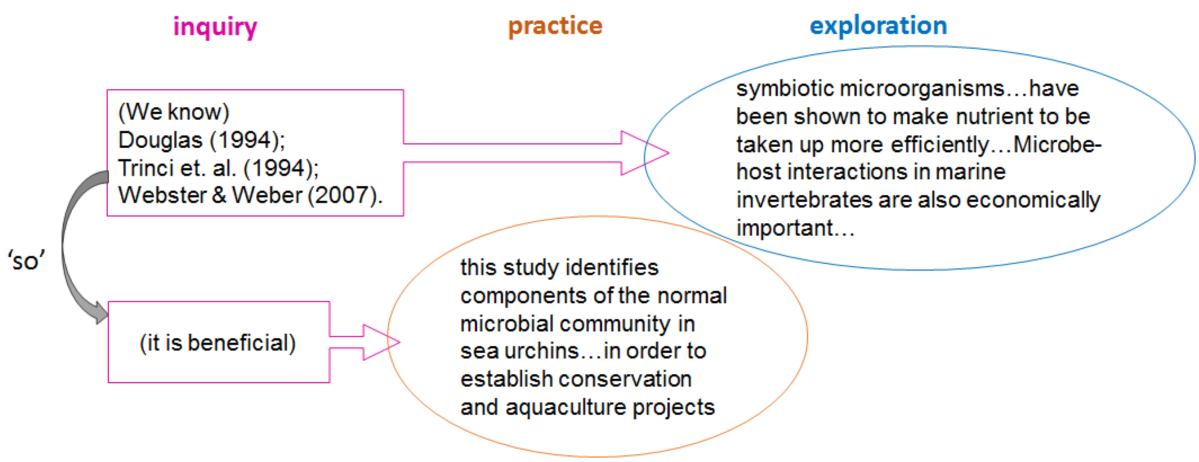
So far the phenomena related through reasoning illustrated above all belong to the field of object of study (i.e. exploration and depiction). Text 3 shows that reasoning can also relate the instances in the field of object of study to the field of research. For example, in [3.119-122], the reasoning relates an instance in the field of depiction to the field of reflection which previews the activity sequences of 'what we should do in the future'.

[3.119-122]



Another instance of relating the field of object of study to research field is exemplified in [3.140-144] below. In this example, the reasoning functions to explain the significance of the current study. This is achieved by deducing the significance of the student's study (e.g. *it is beneficial that this study identifies…*) from the significance of the object of study – i.e. the generalised knowledge in the exploration field (e.g. *microbe-host interactions are economically important*). This shows that an evaluation of the research field from an interpersonal perspective is achieved in combination with a logical reasoning. In other words, the subjective value is enacted by means of an objective reasoning.

[3.140-144]



These patterns of reasoning in the field of research (i.e. inquiry) suggest that reasoning plays a critical role in managing relationships between various types of field. It describes the phenomena in the field of depiction; it applies knowledge in the field of exploration to interpret the instance in the field of depiction; it provides a rationale for the future research; and it highlights the significance of the current research through in an objective way.

4.5.3.3 Overview

To summarise, Text 3 demonstrates several distinctive features in comparison to the findings in Text 1 and Text 2. While the typology of field instantiated in Text 3 is comparable to that in Text 2, it has been found that the construal of object of study in Text 3 – including both field of exploration and depiction – emphasises taxonomy building rather than activity sequencing (see the overview in Table 4.38 below). Several ways in which taxonomies are realised through discourse semantic resources have been identified. A second significant characteristic of the fields construed in Text 3 is the various patterns of reasoning in the field of research. Through reasoning, the student writer manages the relationship between instances from different types of field.

In Chapter 3, the investigation of entities construing taxonomies in Text 3 revealed that the exploration field involves elaborated taxonomies. In this section, through the analysis of field with respect to activity sequence, it is suggested that apart from developing the depth of knowledge in relation to taxonomies, knowledge building at this stage of apprenticeship is also concerned with dealing with the complexity of the relationships among various subfields in the disciplinary field of biology.

Table 4.38 Field types and their realisations in Text 1, Text 2 and Text 3

field types		**field aspects**	**discourse semantic realisations**	**Text 1**	**Text 2**	**Text 3**
object of study	**exploration**	activity sequence [implication sequence]	**sequence** [temporal/causal sequencing of observed event figures (generic)]		*The activity of protein can be controlled through influencing levels of gene expression, or through activating/deactivating proteins when they are already present in the cytosol.*	*Ruminant fungi, …help fibrous plant materials to degrade within the rumen and providing a source of readily digestible short chain fatty-acids and amino-acids (Douglas (1994)).*
		taxonomy	**figure** [state figure]			*The Chytridiomycota are considered the most primitive phylum of the fungi. They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation.*
	depiction	activity sequence [observation]	**sequence** [temporal sequencing of observed event figures (specific)]		*at first the flask demonstrated a lower level of B-galactosidase activity, after a period of time the level of B-galactosidase activity sharply rose.*	*Small circular cells, which appeared to oppose the direction of the Brownian current, were also observed in the regular sea urchins*
		taxonomy	**figure** [state figure]			*The organisms had apparent motility and shape;* *The structures were morphologically similar to sporangium*
	practice	taxonomy	**figure** [state figure]	*- The pipette was highly accurate throughout its range.* *- The method was time consuming*		
research	**practice**	activity sequence [operation]	**sequence** [temporal sequencing of enacted event figures]	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*	*E.coli bacteria were cultured in a glycerol medium, and then one of the six treatment was added to the bacterial culture, and bacteria growth was monitored by measuring absorbance…*	*The samples were then dissected… and were viewed at 10 and 40 times magnification, using a light microscope…*
		taxonomy	**entity** [enacted activity entities; instrumental things]	*method; spectrophotometry, pipette; cuvette*	*treatment; ONPG assay; glycerol medium; solution*	*dissection; microscope; 3.5% salt agar media*
	reflection	activity	**sequence** [causal		*we obtained the results because we*	*we could analyse it further, using*

		sequence [re/ preview]	sequencing of enacted event figures]		*used the treatment*	*biochemical tests or molecular sequencing methods…to identify these organisms…*
	inquiry	activity sequence [reasoning]	**sequence** [external connexions + positions]	*Radioactivity method suggests….so we know the pipette was highly imprecise.*	*(We saw) …, so we know gene expression controls B-galactosidase activity*	*we saw… so we know…;* *it remains unclear… so we suggest…*

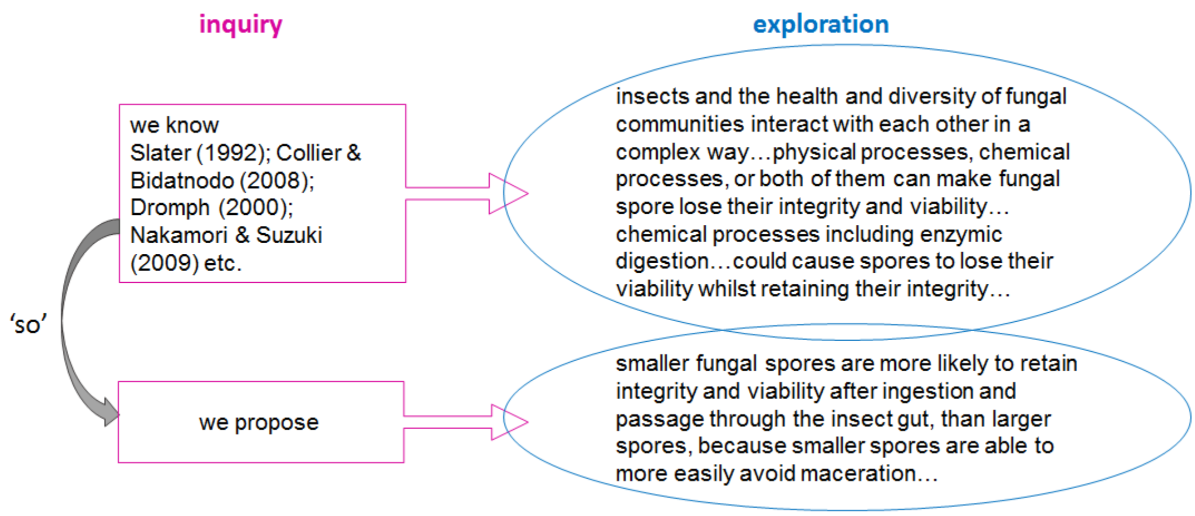
4.5.4 The construal of field in Text 4 – third year research report

The instantiation of field in Text 4 is comparable to the fields that have been identified in the previous texts, not only in terms of the types of field that are instantiated but also the ways in which the fields are construed. The typology of fields and their identification with respect to activity sequences and taxonomies are therefore not repeated here. However, one feature revealed in Text 4 that needs to be highlighted is a distinctive pattern of activity sequence of reasoning in the field of research.

4.5.4.1 Reasoning

As has been found in Text 3, various patterns of reasoning are significant in establishing relationships between instances in different fields, among which building the relationship between the generalised phenomena in the field of exploration to the specific observation in the field of depiction is a salient feature. In Text 3, the reasoning draws on established knowledge to interpret the phenomena in depiction; in other words, the activity sequence of reasoning tends to orient towards the specific findings in the field of depiction. By contrast, in Text 4, reasoning tends to orient towards the field of exploration. Logogenetically, in the beginning stage of Text 4 (i.e. Introduction), the student writer makes a hypothesis of implication sequence by deducing from the phenomena in the exploration field, as shown in [4.13-30] below.

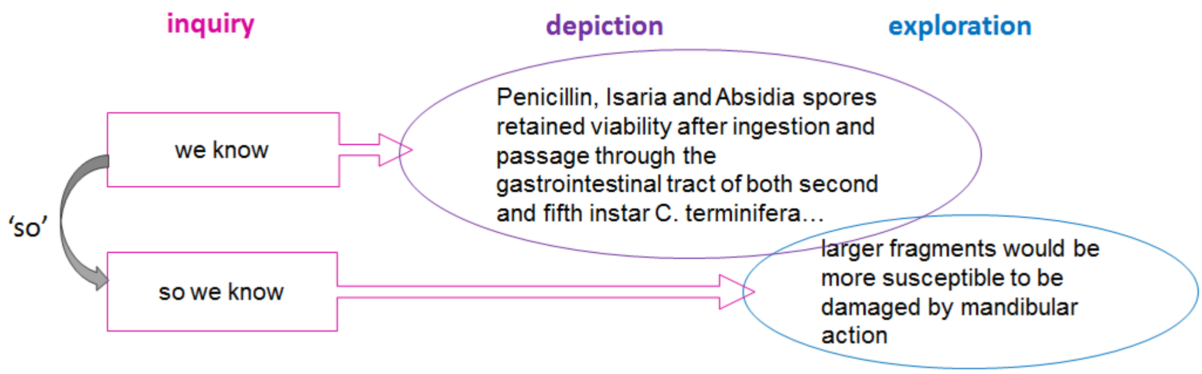
[4.13-30]



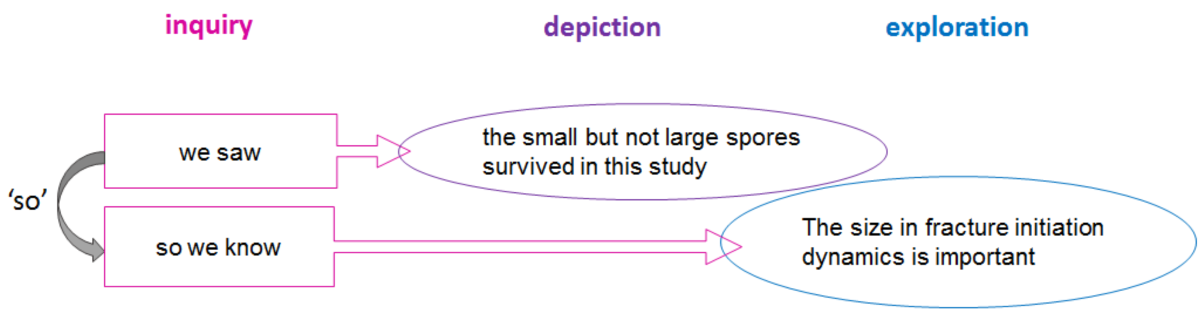
This reasoning of a hypothesis is enacted interpersonally through expanding heteroglossic space (i.e. *we propose…*). This hypothesis is a potential expansion of student's knowledge in the exploration field.

As the text unfolds to the Discussion stage, the activity sequence of reasoning associates the phenomena in the field of depiction with the hypothesised phenomena in the field of exploration, as exemplified in [4.81-85] and [4.108] below.

[4.81-85]



[4.108]

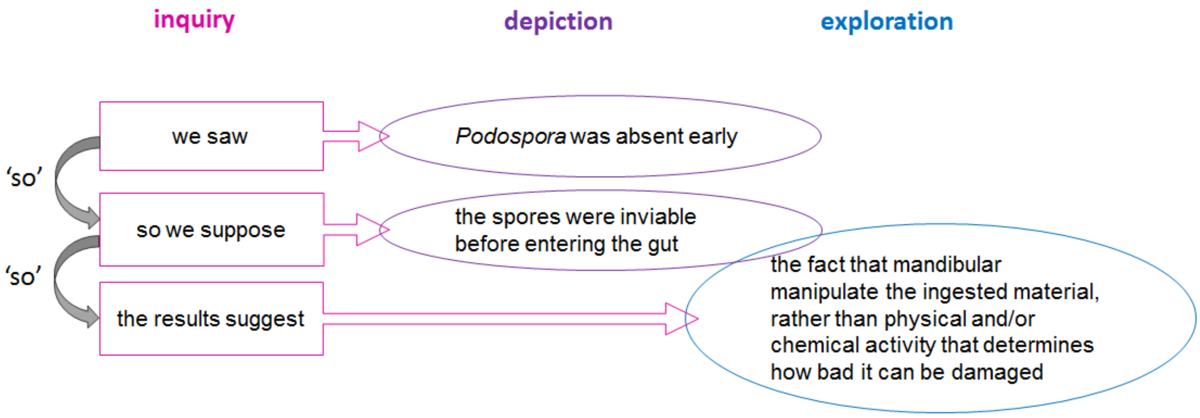


In these examples, the reasoning towards the field of exploration is enacted by contracting other voices (i.e. *so we know*); the logical relationships are realised metaphorically through Processes (i.e. *stands to reason; supports*). Based on the legitimate observation in the field of depiction, the contraction allows the student writer to confirm the initial hypothesis with greater certainty.

As discussed earlier, the reasoning to exploration relation has also been found in Text 2, where the reasoning also contracted potential voices; recall that the reasoning there was to confirm a recontextualised knowledge. In Text 4, there is a greater complexity of expanding and contracting heteroglossic space to legitimise an expansion of student's knowledge.

Apart from legitimising a hypothesis through contraction, the expansion of knowledge in the field of exploration is also deduced through expanding voices, as exemplified in [4.89-93].

[4.89-93]



These examples demonstrate that in Text 4, instead of drawing on an exploration field for the purpose of interpreting the phenomena in the field of depiction, the concern is to expand the understanding of the generalised knowledge in the field of exploration. This shift is a significant one, since it provides evidence that at the end of the third undergraduate year knowledge building is concerned with exploring what is 'unknown' based on what has been known. This is also a necessary transition towards doing research in a disciplinary field – a move from knowledge reproduction to knowledge production.

4.5.4.2 Overview

Table 4.39 below summarises the types of field instantiated in all four texts analysed above. In comparison to the previous texts, Text 4 demonstrates recurrent instantiation of field types as well as the ways in which they are construed in the discourse; distinctively however the pattern of the activity sequence of reasoning revealed in Text 4 has marked a significant transition from knowledge application to knowledge expansion.

Table 4.39 Field types and their realisations in Text 1, Text 2, Text 3 and Text 4

field types		field aspects	discourse semantic realisations	Text 1	Text 2	Text 3	Text 4
object of study	**exploration**	activity sequence	**sequence** [temporal/causal sequencing of observed event figures (generic)]		*The activity of protein can be controlled through influencing levels of gene expression, or through activating/deactivating proteins when they are already present in the cytosol.*	*Ruminant fungi, …help fibrous plant materials to degrade within the rumen and providing a source of readily digestible short chain fatty-acids and amino-acids (Douglas (1994)).*	*physical processes, chemical processes, or both of them can make fungal spore lose their integrity and viability after ingestion and passage through the insect gastrointestinal tract*
		taxonomy	**figure** [state figure]; **entity** [observational activity]			*The Chytridiomycota are considered the most primitive phylum of the fungi. They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation.*	*fungal dispersal; chemical processes;*
	depiction	activity sequence	**sequence** [temporal sequencing of observed event figures (specific)]		*at first the flask demonstrated a lower level of B-galactosidase activity, after a period of time the level of B-galactosidase activity sharply rose.*	*Small circular cells, which appeared to oppose the direction of the Brownian current, were also observed in the regular sea urchins*	*Podospora spores were not re-isolated from any of the extracts of any individual.*
		taxonomy	**figure** [state figure] **entity** [observational activity]			*The organisms had apparent motility and shape;* *the structures were morphologically similar to sporangium.*	*Phycomyces; fungal spores; C. terminifera*
	practice	taxonomy	**figure** [state figure]	*- The pipette was highly accurate throughout its range.* *- The method was time consuming*			
research	**practice**	activity sequence [operation]	**sequence** [temporal sequencing of enacted event	*Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, <u>and then</u> water*	*E.coli bacteria were cultured in a glycerol medium, and then one of the six treatment was*	*The samples were then dissected…and were viewed at 10 and 40 times magnification, using a light microscope…*	*Species of Penicillium, Podopspora, Absidia, Isaria and Phycomyces were isolated from possum*

			figures]	*was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.*	*added to the bacterial culture, and bacteria growth was monitored by measuring absorbance…*		*faeces; the fungi were cultured on 3.5% Potato Dextrose Agar. And then plates of each fungus were flooded with 0.02% Triton-X*
		taxonomy	**entity** [enacted activity entities; instrumental things]	*method; spectrophotometry, pipette; cuvette*	*treatment; ONPG assay; glycerol medium; solution*	*dissection; microscope; 3.5% salt agar media*	*3.5% Potato Dextrose Agar; 0.02% Triton-X; spore solution*
	reflection	activity sequence [re/ preview]	**sequence** [causal sequencing of enacted event figures]		*we obtained the results because we used the treatment*	*we could analyse it further, using biochemical tests or molecular sequencing methods…to identify these organisms…*	*If we investigate further, it would be beneficial to use a larger sample size to allow for the unexpected death…*
	inquiry	activity sequence [reasoning]	**sequence** [external connexions + positions]	*Radioactivity method suggests….so we know the pipette was highly imprecise.*	*(We saw) …, so we know gene expression controls B-galactosidase activity*	*we saw… so we know…; it remains unclear… so we suggest…*	*we know… so we suppose…;*

4.6 Concluding remarks

In this chapter, I have explored the construal of field with respect to activity sequences. In order to do so, I built on the system of ENTITY established in Chapter 3 to explore the system of FIGURE at a higher rank in discourse semantics; this further allows the sequences constituted by figures to be explored. The system of figure consists of the primary figure types (event and state figures) as well as several types of augmented figures – including instigated figures, dimensioned figures and positioned figures. I have then explored the temporal and causal sequencing of these figure types. The structure of figures and sequences is modelled in terms of orbitality (Martin, 1996). In this model figures are orbital structures with potentially augmented satellites (mono-nuclear structures), and sequences are serial structures (multi-nuclear).

Given that grammatical metaphor is a significant characteristic of the discourse of biology, investigation of figure types and sequences depends on unpacking the stratal tension between figure/sequence in the discourse semantics and their grammatical realisations. Using the discourse semantic categories established in this thesis, I have modelled stratal tension by explicitly identifying meanings at both the levels of discourse semantics and lexicogrammar. By unpacking stratal tension, various types of metaphorical mapping of sequence to grammar have been revealed. These various mappings have been summarised along a scale in Figure 4.26 above.

Based on discourse semantic figures and sequences, I then identified various patterns of sequences in the data according to the constitution of figure types and connexion types, as well as specific or generic identification of entities involved in the sequences. The various patterns of discourse semantic sequences further allow us to identify the construal of types of activity sequences in field. Different types of activity sequences further indicate delicate types of field, including an exploration field and several sub-types of specialised field. I have drawn on both Martin's (1992) field typology (i.e. exploration and specialised fields) and Hood's (2010) identification of field in academic discourse (i.e. object of study and research) in identifying types of field, and their interactions.

Drawing on the framework of identifying the construal of field and activity sequences, the four student texts ranged at different undergraduate years were analysed. Text 1 revealed several subtypes of specialised field, among which the field of specialised [practice] was identified as involving the field of object of study and the field of research. In Text 2, several other field types have been identified, including exploration, depiction and reflection. Significantly, the field of exploration as the object of study indicates that an uncommonsense field has been established. In Text 3, while no additional fields were identified, it was revealed that building the object of study (exploration and depiction) emphasised taxonomy building rather than activity sequencing. Also significant was the activity sequence of reasoning in the field of research, which manages the interaction between instances in various field types. In Text 4, an additional salient feature has to do with the activity sequence of reasoning. This activity sequence establishes the relationship between the specific observations in the field of depiction to the generalised phenomena in the field of exploration, and indicates a significant transition from knowledge application construed in the previous texts to knowledge expansion construed in Text 4. These findings resonate with the findings related to taxonomy building as construed by entities in these texts analysed in Chapter 3. In short, the analysis of taxonomy construed by entities has revealed the width and depth of knowledge in the data; the analysis of field and activity sequences has revealed the complexity of establishing various types of subfields and their interactions.

Chapter 5 Conclusion

5.1 Introduction

The aim of this study was to provide a linguistic framework for exploring knowledge building. Underpinned by SFL theory, the specific focus in this study was developing an ideational discourse semantic framework for exploring the construal of field.

This chapter firstly reviews the major findings and contributions in this study (section 5.2), These contributions include the development of ideational discourse semantics; the development of further understanding of how ideational discourse semantics is related to field and to lexicogrammar; and the understanding of some characteristics of field building in undergraduate biology. In section 5.3, some potential pedagogic implications are considered. Section 5.4 addresses several issues raised from this study, which point to directions for future research.

5.2 Summary of findings and contributions

5.2.1 The development of ideational discourse semantics

The primary contribution of this thesis is to the development of ideational discourse semantics in SFL. The conceptualisation of ideational discourse semantics has been approached from a trinocular perspective: by reasoning from above, in terms of taxonomy and activity sequences in field; reasoning from below, in terms of TRANSITIVITY and nominal groups in lexicogrammar; and reasoning from around, at the level of discourse semantics where the ways in which ideational meanings interact with interpersonal and textual discourse semantic meanings are explored.

Three significant contributions in relation to the development of ideational discourse semantics are summarised below. Firstly, the ideational discourse semantic meanings identified in this thesis: entity, figure, and sequence are reviewed. Secondly, some significant clarifications of the interstratal relationships between discourse semantic meanings and lexicogrammatical meanings are consolidated. And finally the construals of taxonomy and activity sequences in field through the patterning of discourse semantic meanings are reviewed.

5.2.1.1 Ideational discourse semantic meanings

Chapter 3 began the development of ideational discourse semantics with discourse semantic entities. Figure 5.1 presents an overview of the ENTITY TYPE system.

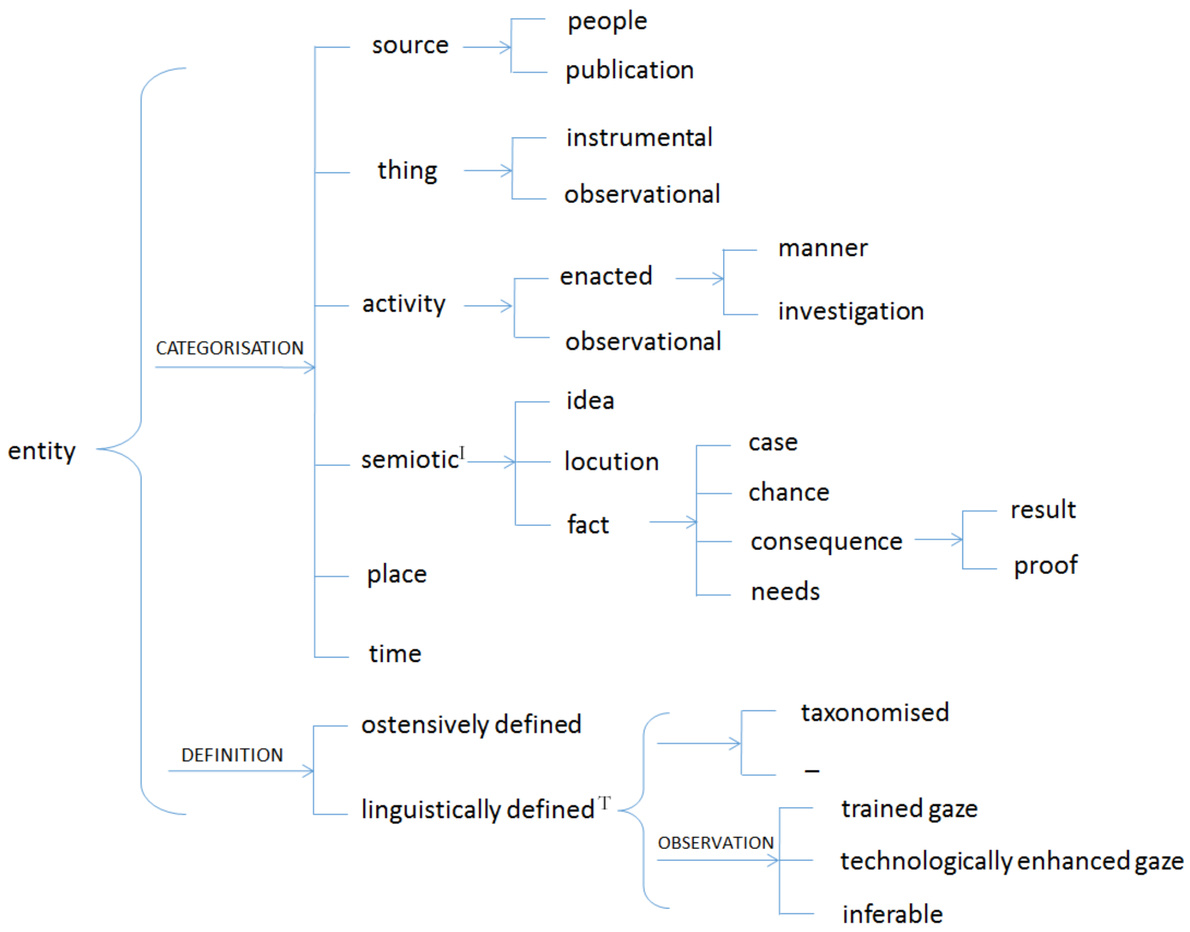


Figure 5.1 ENTITY TYPES in undergraduate biology texts

When looking from below at the level of lexicogrammar, the features in the CATEGORISATION system (i.e. source, thing, activity, semiotic, place, and time) are firstly distinguished based on their various grammatical realisations, including different Participant roles and Circumstances. When looking from around, these distinctions are reinforced by their interactions with discourse semantic systems in the other metafunctions, including ATTITUDE in APPRAISAL in the interpersonal metafunction, PERIODICITY in the textual metafunction, and CONNEXION in the logical metafunction.

A discourse semantic interaction between entities and IDENTIFICATION in the textual metafunction motivates the simultaneous system DEFINITION. According to the observation of entities that are defined in both spoken and written texts, a primary distinction is made between the specific entities that are defined through exophoric reference (i.e. ostensively defined entities) and the generic entities that are referenced to in texts (i.e. linguistically defined entities). It has been emphasised that while the ostensively defined and linguistically defined entities are sensitive to spoken and written modes respectively, it is possible to define an entity linguistically in the spoken mode (e.g. *An order is something that you tell someone and they have to do*). It has been found that the critical characteristic of linguistically defined entities in the discourse of biology is that their linguistic definitions are concerned primarily with establishing taxonomic relations. For example, in a definition of *lysosome* (i.e. *A lysosome is a membranous sac of hydrolytic enzymes…*), a classificatory taxonomic relation between *lysosome* and *membranous sac of hydrolytic enzymes* is established.

A further system, OBSERVATION, is concerned specifically with the linguistically defined entities found in biology texts, which include entities of things and activities. This system is sensitive to the concurrence of science and technology in a field. It has been stressed that the distinction between tech-enhanced gaze and inferable entities in a field is determined by the different technologies employed in the field for observing phenomena.

While entity types are useful for revealing the construal of different taxonomies in a field, the similarities and differences among entities (of the same or different types) are explored through the system of DIMENSIONALITY of entity. Types of dimensionality identified in the data texts include classification, composition, measurement and perception (Figure 5.2 below).

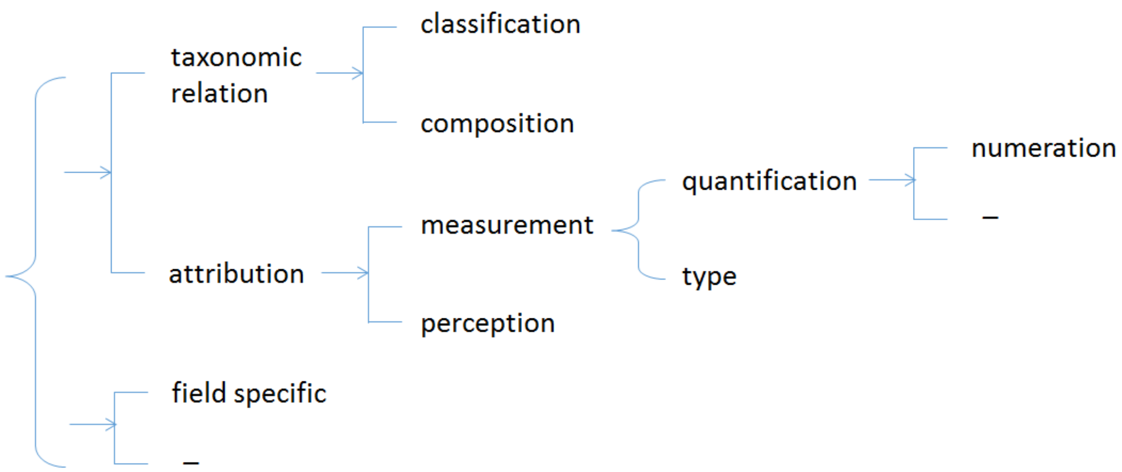


Figure 5.2 DIMENSIONALITY of entity

In the discourse semantics, dimensionality is conceptualised as an elaboration of entities. Two characteristics of the ways in which dimensionality is realised through lexicogrammar need to be stressed. Firstly, the dimensionality of an entity can be either lexicogrammaticalised through a Focus^Thing in which the dimensionality is named by the Focus (e.g. *a* ***kind*** *of sea urchin*); or it can be realised through a grammatical structure without being named, such as the classificatory dimensionality realised in a Classifier=Thing structure at the group rank: *paper bag* (i.e. *paper bag is a* ***kind*** *of bag*), or in a relational process at the clause rank: *B-galactosidase is an enzyme which breaks down lactose* (i.e. *B-galactosidase is a* ***kind*** *of enzyme*). Secondly, while the elaborating nominal groups and their agnate relational processes are the key grammatical resources for realising dimensionality, various other realisations found in the data are also outlined, such as Thing^Qualifier (e.g. *coelomic cavity and digestive tract of the sea urchins*), possessive Deictic^Thing (e.g. *their colours and shapes*) and comparative references (e.g. *alternative food sources*).

Chapter 4 extended the systems of ENTITY and DIMENSIONALITY to the higher ranks at which discourse semantic figures and sequences were explored. An overview of the FIGURE system is provided in Figure 5.3.

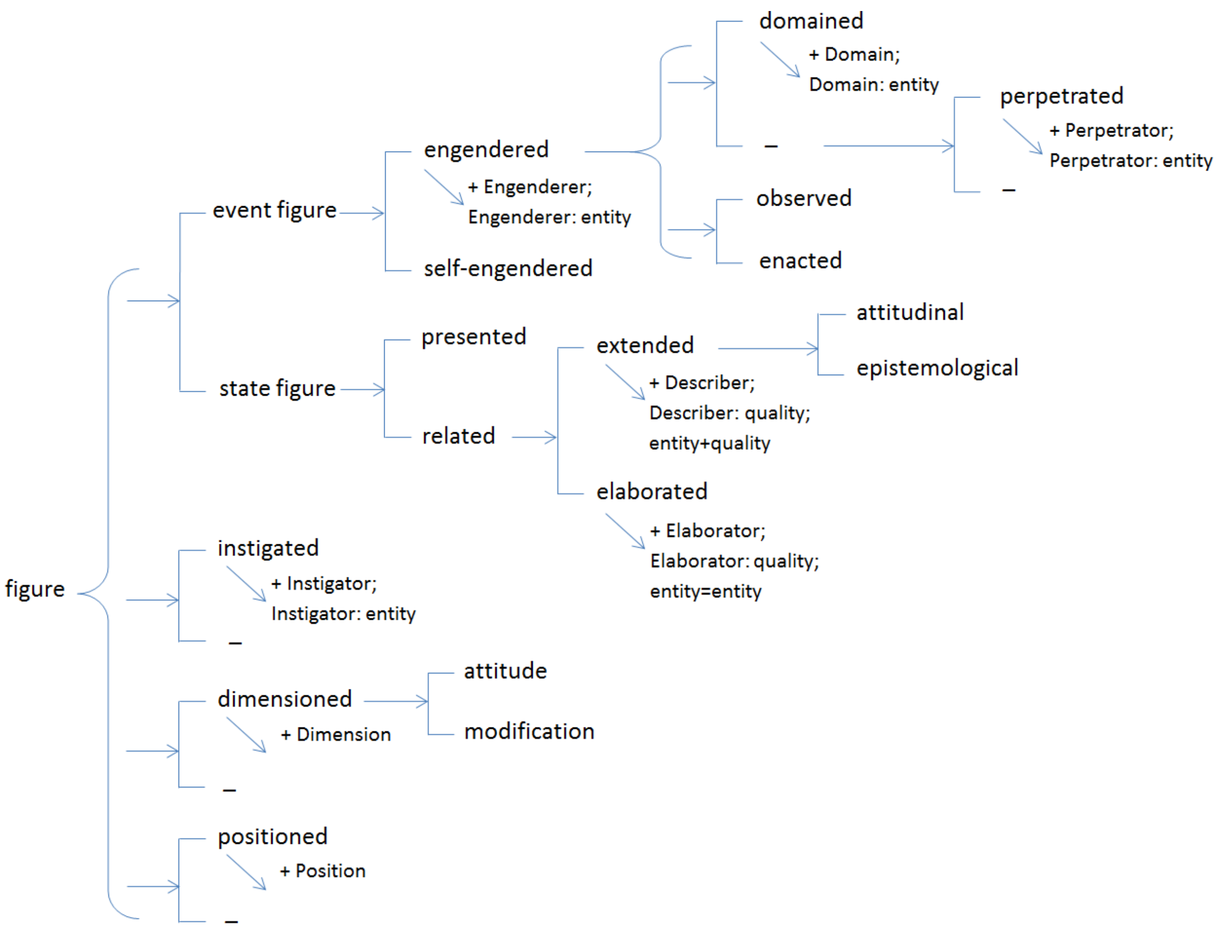


Figure 5.3 FIGURE TYPE

The system of FIGURE TYPE is motivated by the ERGATIVITY and VOICE systems in lexicogrammar when reasoning from below. When reasoning from around, it is motivated by the discourse configurations of entity, event and quality as well as their interactions with the interpersonal discourse semantic system APPRAISAL (including ATTITUDE, ENGAGEMENT and GRADUATION). It was these interactions in particular that provided the reasoning for identifying the features of dimensioned figures and positioned figures. It has been argued that verbal, mental and fact projections construe the dimensions and positions of figures since they function in the discourse to enact heteroglossic engagement of a proposition (e.g. *Radioactivity method demonstrates* [contract] || *that the pipette was highly accurate*) or provide an evaluation of a proposition (e.g. *It is likely* [entertain & low intensification] *that these cells were motile*). This identification of figure types from a metafunctional perspective contrasts significantly with the classification in Halliday & Matthiessen (1999). For these theorists, the boundary between two figures is determined by the clause boundaries. The identification of figure types in this study has an advantage of differentiating discourse semantic figures from clauses, and sequences from clause complexes. This leads to a further advantage, namely that of clarifying the modelling of grammatical metaphor as stratal tension between discourse semantic meanings and their lexicogrammatical realisations (as elaborated in section 5.2.1.2 below).

To represent the syntagmatic structures of figure types, this study adopted an orbital representation. Various figure types can be positioned around an orbital structure potentially consisting of: centre (+ nucleus (=x inner orbit (xx outer orbit))). This orbital structure can be further augmented through satellites (i.e. position and dimension). Table 5.1 below exemplifies an orbital structure of figure; and Table 5.2 exemplifies its further augmentation involving a dimension as a satellite.

Table 5.1 An example of orbital structure of figure

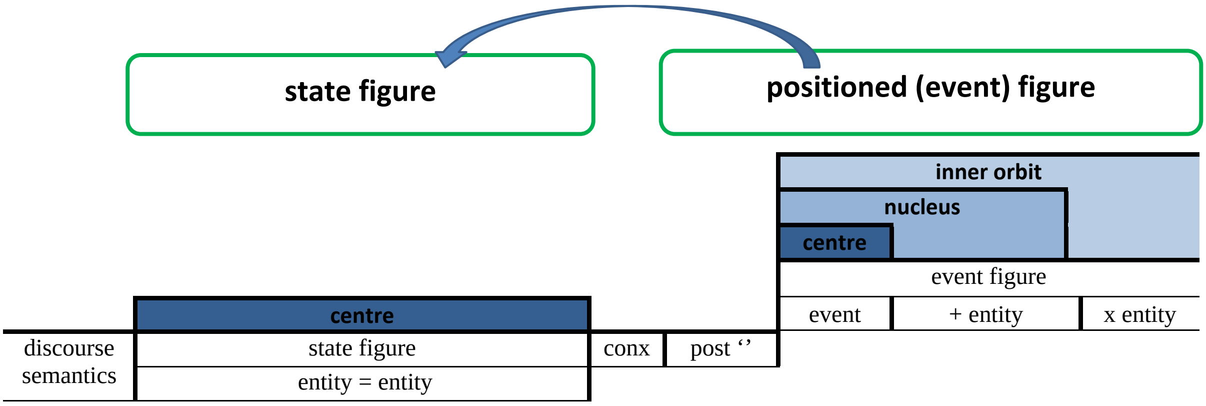
	outer orbit			
	inner orbit			
	nucleus			
	centre			
discourse semantics	instigated event	+ entity	+x entity	xx entity
[4.114C]	*did not make… lose*	*its viability*	*Podospora*	*some other feature of the spore, such as cell wall composition*
lexicogrammar	Pro: mat	Med/Go	1^{st} Ag/Act	2^{nd} Ag/ Ini-or
	v.gr cplx	n.gr	n.gr	n.gr

Table 5.2 An example of figure with the structure of orbital + satellite

discourse semantics	dimension			→			
				outer orbit			
				inner orbit			
				nucleus			
				centre			
				figure			
				instigated event	+ entity	+x entity	xx entity
[4.114Ci]	*it*	*is*	*possible*	*did not make… lose*	*its viability*	*Podospora*	*some other feature of the spore, such as cell wall composition*
lexico-grammar	Med/Car	Pro	In.Rg/Attr	Pro: mat	Med/Go	1^{st} Ag/Act	2^{nd} Ag/Ini-or
	n.gr	v.gr	adj.gr	v.gr cplx	n.gr	n.gr	n.gr

Based on the identification of figure types, it has been made clear that discourse semantic sequences involve the expansion of figures into a serial structure. The figures are related to each other through discourse semantic connexions (c.f. Martin 1992). Table 5.3 exemplifies a sequence and its serial structure.

Table 5.3 An example of serial structure of a sequence



[2.30C]	*The flask*	*demonstrated*	*a higher level of B-galactosidase activity*	*so*	*we know*	*induces*	*B-galactosidase activity*	*lactose*
lexico-grammar	Med /Tk/Id	Pro: int.iden	Rg/Vl/Ir		verbal process	Pro: mat	Med/Go	Ag/Act
	n.gr	v.gr	n.gr	conj		v.gr	n.gr	prep.ph

The identification of discourse semantic units allows the distinctive meanings at both the levels of discourse semantics and lexicogrammar to be described and represented. The independent representations of strata help clarify the modelling of the stratal tension between the two levels.

5.2.1.2 Notes on ideational metaphor

The identification of discourse semantic units of meaning in this study has been associated with differentiating the instances of discourse semantic meanings from those involving ideational metaphors. Below I highlight some significant distinctions that have been made in this thesis.

5.2.1.2.1 Entity [semiotic], entity [activity] and ideational metaphor

As discussed in Chapter 2, distinguishing between the nominalisations of ‘live’ and ‘dead’ grammatical metaphors has been a challenging issue in previous studies (e.g. Halliday & Martin, 1993). In this thesis, the identification of semiotic and activity entities has helped to clarify this distinction.

One criterion developed for distinguishing semiotic entities from ideational metaphors is their interaction with PERIODICITY – that is, semiotic entities are regularly positioned in higher level Theme or higher level New and function there to preview or review pieces of text (e.g. *The identification of the microorganism is significant for a number of reasons. Firstly… Secondly… Furthermore…*). Secondly, when semiotic entities are not positioned to preview or review text, they may name a figure (or a sequence) that functions as a cause or effect in the discourse. Grammatically, the semiotic entity is realised through a Thing, and the figure/sequence it refers to is realised through a Qualifier (i.e. *result* in *the result=[[that the flasks demonstrated a lower level of B-galactosidase activity]] suggested that gene expression controls B-galactosidase activity…*). The relationship between the semiotic entity and the figure/sequence is an elaboration. By contrast, when a nominalisation is a metaphorical realisation of a logical connexion between two figures, it is usually modified by a Qualifier in the form of a prepositional phrase, in which case the logico-semantic relation between the Thing and Qualifier is that of enhancement instead of elaboration (e.g. *explanation* in *the alternative* ***explanation*** x *[for the absence of colonization by Isaria] is [[that the locust initiated some physiological response]]*).

The distinction between activity entities and ideational metaphors in this thesis has been determined by the linguistic definitions of activity entities. That is, if the nominalisation is linguistically defined as a Token in a Token/Value structure (Martin, 1993a, 1993b; Halliday, 1998), such as the definition of *dispersal* exemplified below, it is then an activity entity that construes taxonomy in the field of biology, instead of an ideational metaphor.

The movement of individuals away from centre of high population density or from their area of origin	*is called*	*dispersal*
Value	Process	Token

Nominalisations in a vertical discourse, such as those found in biology texts, are often identified as activity entities. However, it needs to be stressed that not all activity entities are lexicalised through nominalisations. For example, the enacted activity entities *methods* and the specific types of methods (e.g. *weight-of-water method; spectrophotometry*), as well as the observed activity entities which have Latinised names (e.g. *parasitism, osmosis*) are not instances of nominalisations.

Distinguishing semiotic and activity entities from ideational metaphors provides the basis for further distinctions of figures and sequences from ideational metaphors.

5.2.1.2.2 Sequence, (positioned) figure vs. relational and verbal processes

At the level of lexicogrammar, the distinction between verbal and relational processes is often unclear (Halliday & Matthiessen, 2004, p. 172). As exemplified below, the congruent realisation of the positioned figure, *the result shows the pipette was fairly precise*, can be read as either a verbal process or a relational process.

> verbal process:
> The result [Sayer] showed [Process] || the pipette was precise [Locution].
>
> relational process:
> The result [Token] showed [Process] (the fact) [[(that) the pipette was precise]] [Value].

This ambiguity in lexicogrammar brings further challenges for identifying the grammatical structures when a positioned figure and even a sequence are realised metaphorically, such as the examples below.

> metaphorical realisation of positioned figure:
> The result showed the **precision** of the pipette.
>
> metaphorical realisation of sequence:
> The minimal **variability** that existed in the readings demonstrated that the pipette was precise.
> The minimal **variability** that existed in the readings demonstrated the **precision** of the pipette.

In this thesis, in order to tease out the meanings at two levels, a practical decision has been made – that is, treating the proposition in the congruent realisation of the positioned figure (i.e. *the pipette was fairly precise*) as a projected Locution in a verbal process rather than as a Value realised as an embedded clause in a relational process. In doing so, different figure types and sequences are mapped congruently onto different clause types: that is, relation figures are mapped onto relational processes, positioned figures are mapped onto clause complexes of projection (in addition to the realisation of position through Circumstances of Angle – e.g. *According to the result/the method…*), and sequences are mapped onto clause complexes of expansion. These congruent mappings are shown in Table 5.4 below.

Table 5.4 Congruent mappings between figure/sequence and lexicogrammar

discourse semantics	(state) figure	figure (with position)	sequence
lexicogrammar	clause [relational process]	clause or clause complex [verbal process]	clause complex [expansion]

Based on these congruent mappings, it is then possible to model the metaphorical mappings of positioned figures and sequences onto the grammar – that is, positioned figures can be realised metaphorically through relational process, while sequences can be realised metaphorically through both verbal and relational processes. Table 5.5 summarises the possible realisations of figures and sequences.

Table 5.5 The mappings of state figure, positioned figure and sequence onto relational process, projecting verbal process and expanding clause complex

discourse semantics / lexico-grammar	state figure	positioned figure	sequence
relational process	*The crop and the faeces in the second instar individuals* [entity] *have little viability* [entity].	*The results* [semiotic entity/Token] *indicated* [Process] *the* ***loss*** *of the viability between the crop and the faeces in the second instar individuals* [figure/Value].	*The minimal* ***variability*** *that existed between the readings* [figure/Token] ***demonstrated*** [connexion/Process] *the* ***precision*** *of the pipette* [figure/Value].
projecting clause complex (e.g. verbal process)		*The results* [semiotic entity/Sayer] *indicated* [Process]|| *that the viability between the crop and the faeces in the second instar individuals was lost* [figure/Locution].	*The minimal* ***variability*** *that existed between the readings* [figure/Sayer] ***demonstrated*** [connexion/Process] || *that the pipette was fairly precise* [figure/Locution].
expanding clause complex			The readings were minimally variable [figure/clause], so we know that the pipette was fairly precise [positioned figure/projecting verbal process]

5.2.1.2.3 Sequence, (instigated) figure vs. relational and agentive clause

Another important parameter for distinguishing sequence/figures from grammatical metaphors involves instances with lexical verbs such as *make* and *cause* in verbal group complexes. At stake here is the identification of instigated figure types, which is realised congruently through an agentive clause (e.g. *Ruminant fungi* [Instigator entity/2nd order Agent] *make the fibrous plant materials* [entity/1st order Agent] *degrade* [instigated event/Process] *within the rumen* [entity/Circumstance]). The congruent mapping between an Instigated figure and an agentive clause allows us to clarify the stratal tension between an instigated figure and its realisation through a relational process, and between a sequence and its realisations through an agentive clause. Table 5.6 below demonstrates the congruent mapping between these clause types and their construal of discourse semantics meanings.

Table 5.6 Congruent mapping of state figure, instigated figure, sequence on to relational process, agentive clause and expanding clause complex

discourse semantics	(state) figure	instigated figure	sequence
lexicogrammar	clause [relational process]	agentive clause	clause complex [expansion]

Based on these congruent mappings, it is then possible to model the stratal tension between the meanings at two levels, as summarised in Table 5.7 below.

Table 5.7 The mappings of state figure, instigated figure and sequence onto relational process, agentive clause and expanding clause complex

discourse semantics / lexico-grammar	**state figure**	**instigated figure**	**sequence**
relational process	*The crop and the faeces in the second instar individuals* [entity] *have little viability* [entity].	*Physical processes such as maceration by mouthpieces* [Instigator entity/Token] *could cause the **fracture** of the spore* [figure/Value].	***Calibration** of a pipette* [figure/Token] ***<u>allows for</u>*** [connexion/Process] *the **determination** of the relationship between theoretical volumes and those actually obtained* [figure/Value].
agentive clause		*Physical processes such as maceration by mouthpieces* [Instigator entity/2nd order Agent] *could cause spores to fracture* [figure].	***Calibration** of a pipette* [figure/2nd order Agent] *allows* [connexion/Process] *the relationship between theoretical volumes and those actually obtained to be determined* [figure/clause]
expanding clause complex			*We calibrated a pipette* [figure/clause], so [connexion] *we determined the relationship between theoretical volumes and those actually obtained* [figure/clause].

The patterns of stratal tension revealed in the data suggest that internal sequences are typically mapped metaphorically onto verbal processes; external sequences are mapped metaphorically onto agentive clauses. Both internal and external sequences can be realised through relational processes. However, internal sequences tend to be realised through the decoding type of circumstantial identifying processes, whereas external sequences tend to be realised through the encoding type of circumstantial identifying processes and circumstantial attributive processes.

5.2.1.2.4 Unpacking metaphorical realisations of internal connexion

When identifying the discourse semantic meanings in the data, unpacking grammatical metaphors was a critical step. In the process of unpacking, it was found that the metaphorical realisation of internal connexions can be unpacked into either an internal connexion, or a combination of external connexion with a position or a dimension. For example, the metaphorical realisation *suggests* in [1.23] *[[That the result also displayed a strong linear relationship]]* ***suggests*** *the pipette is both accurate and precise throughout its range* can be unpacked as either *so* in [1.23C] or *so we suppose* or *so it is likely* in [1.23Ci] below.

[1.23C] The result also displayed a strong linear relationship

consq

so the pipette is both accurate and precise throughout its range.

[1.23Ci] The result also displayed a strong linear relationship

consq

so we suppose/so it is likely that the pipette is both accurate and precise throughout its range.

A second way of unpacking the logical metaphor – i.e. to unpack it into the combination of external connexion and a position or dimension – has been employed in this thesis. This strategy has proven to be advantageous in two significant ways. Firstly, the position and dimension of a figure allow the heteroglossic engagement in the discourse to be enacted when considered from an interpersonal perspective. Secondly, at the level of field, externalising the internal connexion can indicate an activity sequence of reasoning that is developed temporally in the field.

5.2.1.2.5 The modelling of ideational metaphor

A further contribution made by this study to the understanding of ideational metaphor is to provide a way of modelling ideational metaphor as stratal tension, with both levels of meaning (lexicogrammatical and discourse semantic) explicitly identified. Table 5.8 below exemplifies the modelling of stratal tension between a sequence and its realisation through a relational process. The congruent grammatical realisation [3.93C] is used to reflect the discourse semantic meanings and their structure of nuclearity (i.e. orbital structures of figures and serial structure of sequence); the fact that the congruent realisation does not match the metaphorical realisation reveals the stratal tension between the discourse semantic sequence and the relational process.

Table 5.8 An example of modelling stratal tension between sequence and clause

discourse semantics	dimension								
		inner orbit							
		nucleus						nucleus	
		centre						centre	
		state figure					conx	event figure	
		entity				x entity		event	+ entity
[3.93C]	*it is possible/ possibly*	*Chytrids*	*is*	*present*		*within the coelomic fluid*	*perhaps because*	*is ingested*	*algae*
lexicogr. (cong)	clause / modal Adj.	Med/Car	Pro: int.attr	In.Rg/ Attr		Cir		Pro: mat	Med/Go
		n.gr	v.gr	adj.		n.gr	conj	v.gr	n.gr
lexicogr. (metaph)	n.gr						v.gr	n.gr	
	Med/Car						Pro: cir.iden	In.Rg/Attr	
[3.93]	*The possible **presence** of chytrids within the coelomic fluid*						*could have resulted from*	***ingestion** of algae*	

5.2.1.3 The construal of field through ideational discourse semantics

The identification of discourse semantic entities, figures and sequences, and the unpacking of stratal tension between discourse semantics and lexicogrammar, together provide a foundation for generalising patterns of discourse semantic meanings construing field. It has been illustrated that both aspects of field – taxonomy and activity sequence – can be realised through various ideational discourse semantic units of meaning.

While the primary investigation of the construal of taxonomy in this study has been on the discourse semantic entities and their dimensionality (Chapter 3), it was found in Chapter 4 that state figures can provide a description of taxonomy in a field – for example describing their qualities and taxonomic relations. Two kinds of field taxonomies, for biological phenomena and utilitarian tools, were found in the data to be described in discourse through state figures apart from being identified through entities, as exemplified in Table 5.9.

Table 5.9 Construing field taxonomies of biological phenomena and utilitarian tools through state figures and entities

taxonomy \ discourse semantics	state figure	entity
biological phenomena	The Chytridiomycota are considered the most primitive phylum of the fungi. They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation.	**[observational things & activity: trained gaze; tech-enhanced gaze; inferable]** mercaptoethanol, chloroform, protein, cytosol, enzyme, gene expression, transcription, induction
utilitarian tools	The pipette was highly accurate throughout its range. The method was time consuming	**[instrumental things: ostensively defined; trained gaze]** pipette, balance, spectrophotometer, microscope, 3.5% salt agar media, solution

The other dimension of field, activity sequence, can also be realised through various discourse semantic resources in the data. In particular, it was found that the activity sequence [operation] and [implication sequence] can be realised through sequences and figures, as well as being named through entities. Table 5.10 provides an overview of the typical ways of realising different types of activity sequences in the discourse revealed in the data.

Table 5.10 Realisations of different types of activity sequence

discourse semantics / activity sequence	sequence	figure	entity
operation	**[temporal sequencing of enacted event figures]** Set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and then water was added (in order) to give a total volume of 1mL. (And then) each solution was mixed, and absorbances were read, (by) using a spectrophotometer.	**[event figure]** We used the spectrophotometry method.	**[enacted activity]** method, spectrophotometry; experiment
implication sequence	**[causal sequencing of observed event figure involving generic entities]** - Some parasites change the behaviour of their hosts - by increasing the probability of the parasite being transferred from one host to another. - For instance, if parasitic acanthocephalan (spiny-headed) worms is present, - then their crustacean hosts engage in a variety of atypical behaviors, … - As a result of their modified behaviour, the crustacean have a greater chance of being eaten…	**e.g. [state figure]** Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea	**[observational activity]** parasitism, symbiosis, reproduction **[semiotic]** findings, evidence, knowledge
re/preview	**[causal sequencing of enacted event figures]** We obtained results because we used the treatment.		
observation	**[causal sequencing of observed event figure involving specific entities]** The ingested materials were manipulated by the mandibles so they sustained to be damaged.		
reasoning	**[internal causal connexion; external causal connexion ^ dimension/position]** We saw (chytrids were present within the Echinoidea), so we suppose/it is possible (they may be transient, not symbolic, members).		

These findings regarding the realisation of taxonomies and activity sequences in field through various discourse semantic resources contrast with the identification of field taxonomies and activity sequences in previous studies (e.g. Wignell et al., 1993; Martin, 1993a, 1993b, 2007). There the taxonomies were often identified through nominal group realisations, and activity sequences were typically identified through their realisations as clause complexes. It is the independent representation of ideational discourse semantics in this study that has made possible the clarification of interstratal relationship between field and ideational discourse semantic meanings.

The distinctive activity sequence types identified in the data further revealed delicate types of fields, including the primary distinction between exploration and specialised field, and within the specialised field, the distinctions among depiction, practice, reflection and inquiry were made (see Figure 5.4).

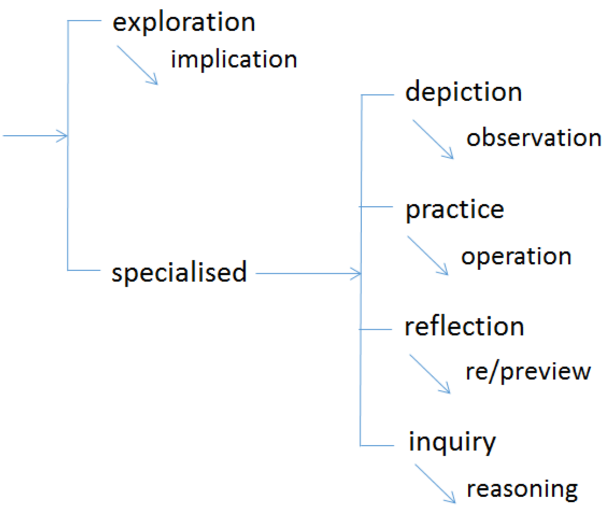


Figure 5.4 FIELD TYPES

Each field type can be characterised intrastratally by the aspects of activity sequence and taxonomy; and each aspect can be further realised interstratally through sequence, figure and entities. Table 5.11 below exemplifies the intrastratal and interstratal realisations of the exploration field.

Table 5.11 Intrastratal and interstratal realisations of exploration field

field types	**field aspects**	**discourse semantic realisations**	**examples**
exploration	activity sequence [implication sequence]	**sequence** [temporal/causal sequencing of observed event figures]	*Ruminant fungi, …help fibrous plant materials to degrade within the rumen and providing a source of readily digestible short chain fatty-acids and amino-acids (Douglas (1994).*
		figure	*Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea*
		entity [observational activity (generic)]; [semiotic]	*fungal dispersal; chemical processes; findings, evidence, knowledge*
	taxonomy	**figure** [state figure]	*The Chytridiomycota are considered the most primitive phylum of the fungi. They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation.*
		entity (generic) [observational activity]	*fungal dispersal; chemical processes;*

The intrastratal relationships in field and the interstratal relationship between field and discourse semantics are represented in Figure 5.5.

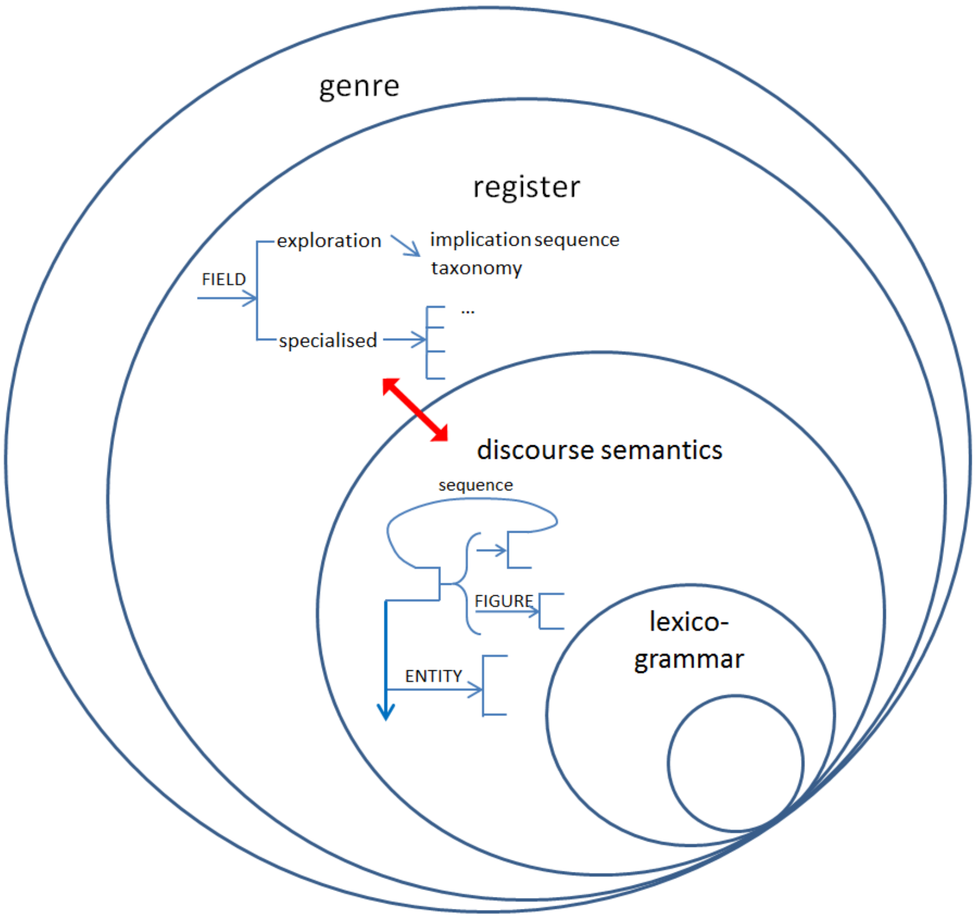


Figure 5.5 Intrastratal and interstratal realisations of field

5.2.1.4 A note on 'technicality' and 'abstraction'

As introduced in Chapter 1, 'technicality' and 'abstraction' have often been used in studies to characterise vertical discourse, particularly the discourses of science and history (Martin 1993a, 1993c; Wignell et al., 1993). While these descriptive terms have been useful in describing the different characteristics of the discourse of science and history, their precise reference to systematic features and strata has been unclear. Firstly, it is unclear whether 'technicality' and 'abstraction' were referring to field or to discourse semantic features. Secondly, it has been found that both 'technicality' and 'abstraction' are associated with grammatical metaphors; however there has been a lack of clarity in terms of how instances of 'technicality' and 'abstraction' can be distinguished from grammatical metaphors. Thirdly, the differences between the instances of technicality and abstraction themselves have been unclear. Instances of field specific terminologies (e.g. *gene, inflation*) have sometimes been referred to in terms of 'technicality' and 'abstraction/abstract entity' (Martin, 1993a; Martin & Rose, 2007; Wignell, 2007). An important reason for these ambiguities is that the distinctions among field, discourse semantics and lexicogrammar were unclear. In this study, given that independent terminology has been developed to represent meanings at different strata, the descriptive terms ‘technicality’ and ‘abstraction’ have been redundant. However, given that ‘technicality’ and ‘abstraction’ have been widely used in SFL work and potentially can be useful as metalanguage for pedagogic purposes, we can rearticulate the notion of ‘technicality’ and ‘abstraction’ in relation to the strata that have been clarified in this thesis.

The notion of ‘technicality’ may be clarified in relation to field and discourse semantics. At the level of field, ‘technicality’ particularly refers to taxonomies in the exploration field (e.g. science, social sciences and the humanities); at the level of discourse semantics, technicality is realised by linguistically defined entities which are taxonomised in their definitions, such as observational things and activities in the discourse of biology (e.g. *A <u>lysosome</u> is a membranous sac of hydrolytic enzymes…*). In terms of their realisations in lexicogrammar, it is common that ‘technicality’ is lexicalised through a nominalisation (e.g. *fungal* ***dispersal; evaporation***); although not all technicality involves nominalisations (e.g. *lysosome; gene*). In terms of its relationship to grammatical metaphor, technicality may involve a distillation of grammatical metaphor (Martin, 1993a) – a ‘dead’ grammatical metaphor as a discourse semantic entity. However, once it has the status of ‘technicality’, it is no longer a grammatical metaphor.

As outlined in Chapter 2, the notion of ‘abstraction’ has been associated in the relevant SFL literature with a range of language features. Various discourse semantics meanings discussed in this study, including semiotic entities, internal connexions, and the dimensionality of entities, as well as grammatical metaphors, have been referred to in previous studies as instances of ‘abstraction’ as it has been referred to in previous studies. At times instances associated with ‘technicality’, as noted above, have also been treated as a kind of ‘abstraction’ (c.f. Martin, 1993c, p. 233; Martin & Rose, 2007, p. 114; Wignell, 2007, p. 48). In addition, the notion of abstraction has been used theoretically in SFL to characterise levels of stratification (e.g. field is more abstract than discourse semantics, which is more abstract than lexicogrammar). ‘Abstraction’ is therefore a problematic term, which potentially conflates different discourse semantic categories, obscures discourse semantic resources involved or not in stratal tension, and fails to dissociate theoretical description of stratification from discourse analysis.

It is beyond the scope of this thesis to define 'technicality' and 'abstraction'. However, the point that needs to be emphasised here is that while one may find interpretive labels useful for describing texts, it is always important to be explicit about what resources at which stratum are being referred to. This thesis has made an important step towards making possible explicit reference to the resources across strata.

5.2.2 The understanding of field-building in undergraduate biology

Based on the identification of field types and their intrastratal and interstratal realisations, this study analysed the instantiation of field in the biology student texts ranged at different stages of undergraduate apprenticeship. The analysis has revealed some features of field-building in undergraduate biology.

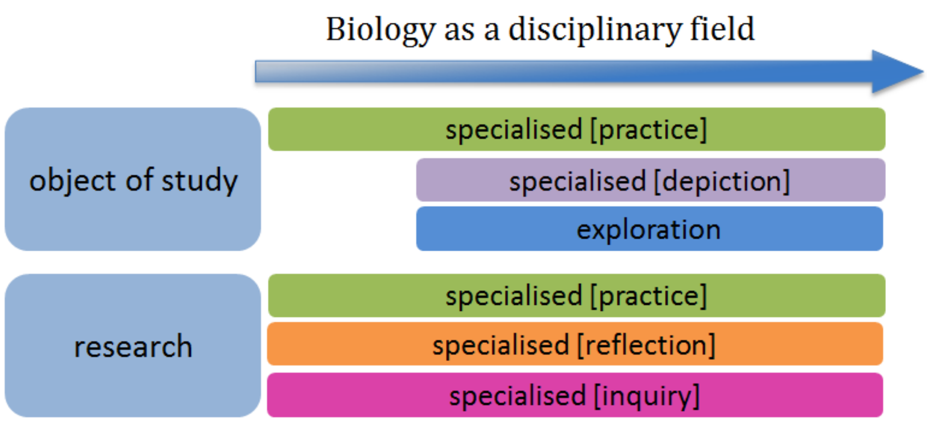
Firstly, in terms of the instantiation of field types, it was found that biology is a disciplinary field which involves different subtypes of field – exploration fields and various types of specialised fields. A complementary perspective on field – the opposition between the field of object of study and the field of research found in academic discourse (Hood, 2010) – was also drawn on in this study. Exploring the interaction between the two systems of field has been a productive way of exploring field building in undergraduate biology.

It was found that across the four student texts, the field of object of study was developed from a field of specialised [practice] at the beginning of the first year (Text 1) – where the effectiveness of laboratory methods was concerned. In the texts produced in the later stages of the apprenticeship, the object of study shifted to a combination of specialised fields [depiction] (which was concerned with laboratory observation) and exploration fields (which was concerned with knowledge in biology).

The field of research was found to be associated only with the specialised fields across the four texts; of particular relevance were the subtypes [practice], [reflection] and [inquiry]. The specialised field [practice] was concerned with the procedures of experiments that were conducted. Across the four student texts, there was a shift from emphasising the utilitarian tools, which were realised by ostensively defined instrumental things (e.g. *balance; pipette*), to emphasising the experimental materials, which were realised by trained gaze things (e.g. *glycerol medium; sodium carbonate*). The specialised field [reflection] was concerned with either reviewing the research that was conducted or with previewing activity sequences in future research. The specialised field [inquiry] functioned to establish relationships among various fields. Of particular significance was to establish a relationship between the specific field of specialised [depiction] and the generalised field of exploration. It was illustrated that the field of inquiry was critical in students' knowledge expansion in the exploration field.

It was hypothesised earlier in Chapter 3 (section 3.2.1) that specialised field is in the service of the development of exploration fields in undergraduate biology. The delicate types of specialised field identified in the data texts have made this role explicit. The development of exploration fields is assisted by the physical activities in the laboratory (i.e. specialised [practice]), by the observation of the experiment (i.e. specialised [depiction]), and critically also by generalising phenomena from the field of depiction by means of logical reasoning (i.e. specialised [inquiry]). The concurrence of subfields in the field of undergraduate biology is illustrated in Table 5.12 below.

Table 5.12 Involvement of subfields in the field of undergraduate biology



The development of exploration fields was also revealed by distinctive patterns of discourse semantic realisations across the four student texts. Firstly, the development was suggested by the increasing variety of entity types that were involved across the texts. Secondly, the building of exploration field was indicated by the growing complexity of taxonomic relations, which was realised by the increasing variety of the dimensionalities of entities in the texts.

Drawing on the ideational discourse semantic systems established in this study, analysing the instantiation of field types (with respect to both activity sequences and taxonomy) allows the complexity of establishing various types of subfields and the interactions among the fields to be revealed. Examining the taxonomy of field through entities and dimensionality suggests the width and depth of knowledge building.

5.3 Pedagogic implications

This thesis has positioned itself in the realm of appliable linguistics. While developing discourse semantics in SFL has been its major focus, the primary motivation of this linguistic study, as positioned in Chapter 1, is to understand how knowledge is built through language in order to support a pedagogy dedicated to building knowledge. As such it contributes ultimately to fostering a more democratic distribution of knowledge.

The application of SFL theory in educational practice has been developing for several decades. One of the significant impacts of SFL in education is that it develops teachers' awareness that knowledge about language (KAL) plays a significant role in teaching literacy. SFL's linguistic description of language provides rich resources which can be recontextualised into a systematic and accessible metalanguage in teaching – that is a shared language between teacher and students for talking about subject knowledge and the texts they read and write. The development of metalanguage goes along with SFL's engagement with educational work. In the 1980s, the *Writing Project* and *Language and Social Power* project aimed to identify the genres that students were required to write in Australian primary schools. The system of genres (e.g. narrative, explanation, descriptive report, etc.) and their stages (e.g. Orientation, Complication, Evaluation and Resolution in a narrative genre) developed in those projects became an effective metalanguage for teacher and students to talk about texts and to talk about the ways of constructing a text. In the 1990s, the *Write it Right* project particularly focused on extending the understandings of subject specific knowledge (e.g. science and history) and knowledge in work places (e.g. media, administration and industry). The concern with different discourses in different fields at the time extended the metalanguage of discourse semantic resources (e.g. 'technicality', 'abstraction', 'classification', 'cause-and-effect' relationships and 'evaluation'). At the same time, many terms for discourse semantics were 'borrowed' from grammatical functions (e.g. participants, processes, and circumstances). This recontextualisation of linguistic terminology for pedagogic purposes is potentially the result of the ongoing development of stratification; and is at the same time a reason for the continuing theoretical ambiguity among field, ideational discourse semantics and lexicogrammar in SFL. In order to engage with knowledge building in the classroom, an effective metalanguage for talking about discourse semantic resources and field is critical. This is particularly important for building uncommonsense knowledge, as has been illustrated in this study.

Developing an independent metalanguage for discourse semantics for pedagogic purposes has been a continuing concern in educational applications of SFL. For example, the *Reading to Learn* program underpinned by SFL (Rose & Martin, 2012, p. 2) extends the metalanguage to account for both discourse semantic resources, such as the use of 'event', 'entity', and 'quality' (e.g. Rose & Martin, 2012, p. 260). Significantly also, Humphrey (e.g. 2013a) develops a 4x4 toolkit which contributes to recontextualising a metalanguage that refers to meanings at different levels which are associated with ranks and strata. This thesis contributes to the further development of such a metalanguage. The description of meanings at the level of discourse semantics and field in this study provides systematic and fine-grained resources, which can be potentially employed and recontextualised as a metalanguage in the classroom. Below I use two features that are identified in this study to exemplify the ways in which they may be used as knowledge about language in teaching reading and writing.

5.3.1 Explicit knowledge building of 'causality' in implication sequence

As illustrated in this study, implication sequence is a critical dimension of an exploration field (i.e. an uncommonsense field). Field activities in an implication sequence are related to each other 'causally' in a sense that one determines another. While the causal relationships in the implication sequence can be 'overt' in the discourse, by being realised through connexions in the discourse, a great deal of causality in implication sequences is 'covert', since it is in a sense subsumed in discourse semantic activity entities (e.g. *fungal disposal; parasitism; evaporation*). As exemplified in Figure 5.6 below, an implication sequence of biological activities is condensed and realised through the activity entity *parasitism.* When realising the implication sequence through a series of figures rather than an activity entity, the causality is revealed by a number of discourse semantic connexions.

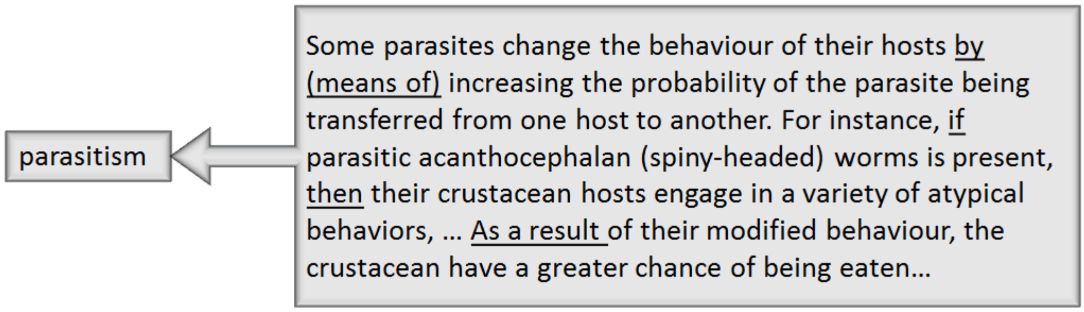


Figure 5.6 Implication sequence construed by 'parasitism'

In addition to the distinction between covert and overt causality, the 'overt' causality established by connexions may be realised either congruently (e.g. *so, because, and then, consequently, therefore*, etc.) or metaphorically (e.g. *as a result; cause; an effect of…; reasons*, etc.) in the grammar. These different kinds of causal relationships are summarised in Figure 5.7 below.

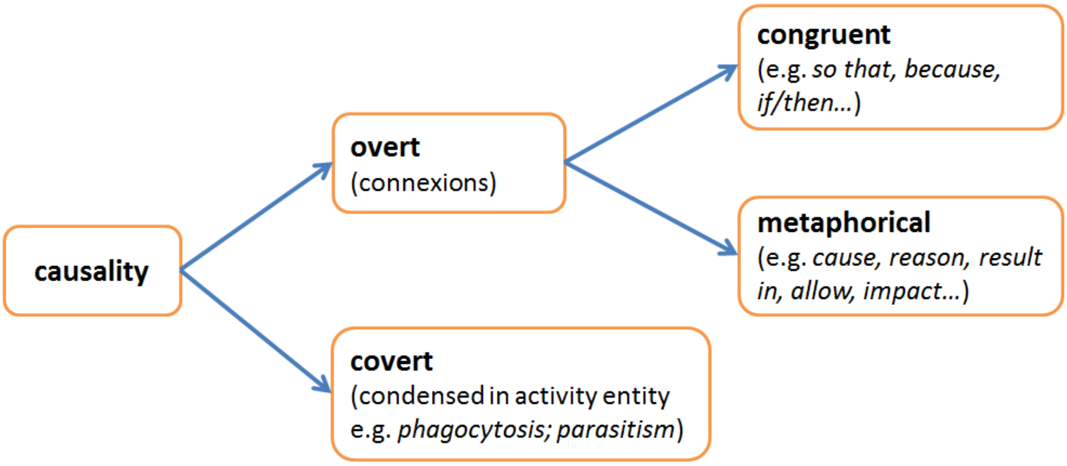


Figure 5.7 Kinds of causal relations in texts

In teaching practice, a pedagogic text may involve both 'covert' causality condensed in the activity entities, and 'overt' causality established through discourse semantic connexions which may be realised metaphorically, such as the example [5a] below (activity entities are underlined; metaphorical realisations of figures are in bold; and an 'overt' causality is both in bold and underlined).

> [5a] The <u>parasitism</u> by C. plutellae <u>**resulted in**</u> a significant **reduction in immunocompetent cells of P. xylostella**. (Ibrahim & Kim, 2006, p. 946)

It is important to deconstruct the complexity of the causal relationships to students. The deconstruction in this instance may involve unpacking the causality in two steps. We can firstly unpack the metaphorical realisation of discourse semantic meanings, since the tension between discourse semantics and lexicogrammar is at the lower order of abstraction along the stratification hierarchy. This unpacking is exemplified in [5a-1].

> [5a-1] Due to the <u>parasitism</u> by C. plutellae, immunocompetent cells of P. xylostella were significantly reduced.

In the second step, we can focus on the relationship between activity entities in the discourse and implication sequences in the field. The implication sequence construed by *parasitism* in [5a] can be unpacked into a series of figures with explicit connexions being realised (such as in Figure 5.6 above). Once the implication sequence condensed in *parasitism* is revealed, it can then be related to its further effect – *so immunocompetent cells of P. xylostella were significantly reduced*, as in [5a-2].

> [5a-2] The parasites of C. plutellae change the behaviour of their host by means of… so then the hosts' behaviour were modified… so that immunocompetent cells of P. xylostella were significantly reduced.

The unveiling of implication sequences by unpacking grammatical metaphor and activity entities may be useful for reading activities in the classroom. For example, in *Reading to Learn* program (see Figure 5.8), the step of 'Detailed Reading' particularly provides the space for deconstructing knowledge (field building) (Rose, 2011; Rose & Martin, 2012). During this stage, the teacher guides students to identify wordings within each sentence in a reading text, and then the teacher elaborates their meanings in more depth and detail (Rose & Martin, 2012, p.154). The strategy of unpacking the causality in the implication sequence illustrated above can be useful in the teacher's elaboration.

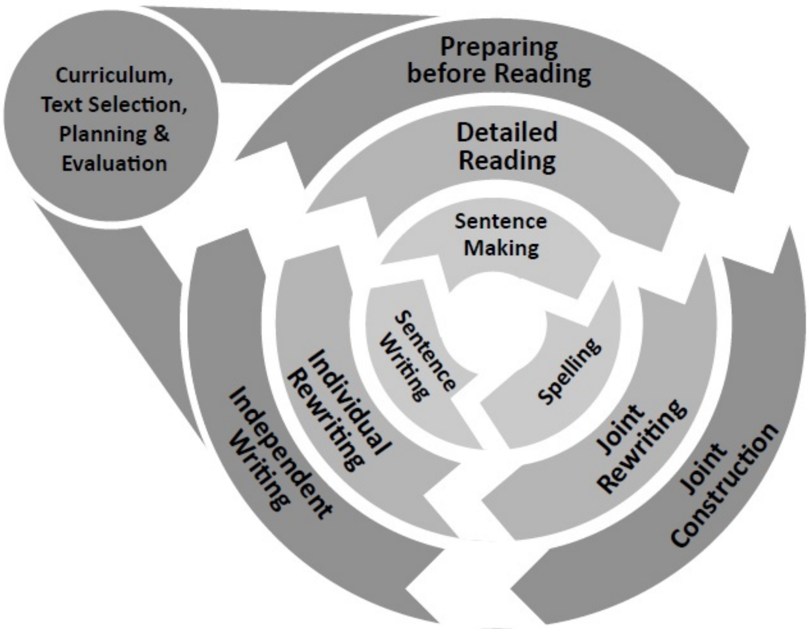


Figure 5.8 Strategies in Reading to Learn program

Once the knowledge of an implication sequence is built in the Detailed Reading, the teacher can further guide the student to re-instantiate the knowledge, such as by composing a text to explain the implication sequence (i.e. an explanation genre). This occurs at the stages of Joint Rewriting and Joint Construction in the Reading to Learn program. During this process, the teacher may encourage students to identify the knowledge of the implication sequence, and recall its naming through the activity entity *parasitism*. Once the field knowledge is instantiated in the text, the teacher may take a further step to guide the students to orchestrate the activity entity with grammatical metaphors to achieve a more coherent information flow in relation to the co-text.

The metalanguage illustrated here for unpacking causality is also relevant to inter-disciplinary dialogue. In a collaborative educational project, theorists in SFL and Legitimation Code Theory (LCT) (Maton, 2014) have explored the nature of cumulative knowledge building (Maton, 2009). Maton (2013) argues that successfully riding a 'semantic wave' is the key to cumulative knowledge building. Semantic waves are navigated in relation to the strengths of 'semantic gravity' and 'semantic density'. Semantic gravity (SG) refers to 'the degree to which meaning relates to its context' (Maton, 2013, p. 11). Semantic gravity may be 'relatively stronger or weaker along a continuum. When semantic gravity is stronger, meaning is more closely related to its social or symbolic context of acquisition or use; when it is weaker, meaning is less dependent on its context.' (Maton, 2014, p. 110) The other parameter, semantic density, refers to 'the degree of condensation of meaning within socio-cultural practices (symbols, terms, concepts, phrases, expressions, gestures, actions, clothing, etc.)' (Maton, 2014, p. 129). Similarly, semantic density may be 'relatively stronger (+) or weaker (-) along a continuum of strengths. The stronger the semantic density (SD+), the more meanings are condensed within practices; the weaker the semantic density (SD-), the less meanings are condensed' (p. 129). Effective shifting downwards and upwards on the wave is necessary in cumulative knowledge building.

In response to the notion of 'semantic wave', particularly to the notion of 'semantic density', Martin (2013) recontextualises the key linguistic features involved in building uncommonsense knowledge in terms of 'power words', 'power grammar' and 'power composition'. The language features illustrated in this section (i.e. activity entities, grammatical metaphors) for unpacking causality in implication sequences when reading, as well as constructing implication sequence in writing, provide some explicit linguistic foundations relevant to Martin's 'power trio'. From the perspective of LCT, unpacking the covert and overt causality involved in grammatical metaphor in reading activities can be interpreted as a process of weakening semantic density; and the re-instantiating the knowledge of implication sequences in the writing activities is an process of strengthening semantic density (see also Macnaught et al.'s (2013) discussion on semantic wave in Joint Construction).

5.3.2 Supporting students to develop 'scientific reasoning'

The description of field and discourse semantics can be used to support students in developing logical reasoning in academic writing. Taking the laboratory reports and research reports in science for example, the Discussion stage is found to be particularly challenging for the student writers. A writing guide advises the students that

> "(in the Discussion stage), the ideas need to be developed and related to your data and to the literature in a logical way… These developed ideas are the 'arguments'… you must argue and justify them in the face of what is already known of the subject. Each of your arguments in your Discussion will be a separate piece of logical writing…the Discussion then becomes a collection of such arguments about the relevance, usefulness or limitations of your experiment and your results, and the possibilities they open for new research" (Lindsay, 2011, p. 41).

Apart from being 'logical', students are at the same time encouraged to be persuasive: 'Readers of Discussion in scientific articles need to be satisfied with what they read'; 'you need constantly to help them feel that they are finding out something worthwhile' (Lindsay, 2011, p. 41). What these writing 'tips' describe is the dual function of academic writing as 'objective' and 'persuasive' (e.g. Bazerman, 1988; Hyland, 2005; Hood, 2010). In Hood's (2010) term, 'the writer subjectifies the objectivity'. The notions of **field,** the activity sequence of **reasoning,** as well as the **position** and **dimension** of figures described in this study can be useful in the classroom to scaffold students in the composition of an effective 'argument'.

For example, making a logical connection between a specific observation in a laboratory experiment (i.e. the field of depiction) and the theoretical understanding of biology (i.e. the field of exploration) is a significant task for students. As has been found in the student texts in this study, it indicates the student's expansion of knowledge. In order to guide the students to build an argument in relation to depiction and exploration, the following steps may be used. Firstly, by explicitly referring to the two realms of meaning, depiction and exploration, teachers can guide the students to generalise a specific depiction to their theoretical exploration. As shown in examples [5b] and [5c] below, the depictions in the experiment are identified as the Causes (in italics), and the potential theoretical explorations are identified as the Results. They are related to each other through the causal connexions (underlined).

> [5b] Because *the structures were morphologically similar to sporangium*, these organisms are chytrid zoospores

> [5c] If *the chytrids were present within the Echinoidea*, they are transient, not symbiotic, members.

It may be necessary to emphasise that by 'changing gears' (i.e. shifting field), grammatical features are involved; this may prove especially important for the students from English as second language or foreign language (ESL and EFL) backgrounds. The field of depiction involves specific events in the past (thus involving past tense – *were present*) and reference to the specific phenomena that were observed (thus involving specific reference – *the structures, the chytrids*). The field of exploration however, refers to biological activity across time and place, and therefore involves simple present tense (e.g. *are*) and generic reference (e.g. *Chytrid zoospores*).

After establishing logical reasoning, students can be then guided to provide an 'objective yet persuasive' voice. This voice can be achieved by adding a **position** or a **dimension** to the propositions concerned with their theoretical explorations, as exemplified in [5b-1] and [5c-1] below (dimension and position are in bold).

> [5b-1] Because *the structures were morphologically similar to sporangium*, **it can be suggested** that these organisms are chytrid zoospores

> [5c-1] If *chytrids were present within the Echinoidea*, **it is possible** that they are transient, not symbiotic, members.

Guiding students to develop reasoning by relating different fields may be distinguished from building the causality of implication sequence illustrated in section 5.2.1 above. As we can see, different linguistic resources were at stake: building implication sequences involves external connexions; but developing reasoning involves external connexion +

position/dimension (or internal connexion). We may refer to these strategies respectively as ‘explaining’ and ‘interpreting’.

Shifting from the field of depiction to the field of exploration can also be associated with the concept of semantic waves in LCT, in particular with the parameter of ‘semantic gravity’ (Maton, 2014, p. 110). The shifting from the specific field of depiction to the generalised field of exploration may be interpreted as a process of shifting from the stronger semantic gravity to the weaker semantic gravity along an unfolding the semantic wave. Maton (2013) points out that the upwards shifts on the semantic wave are particularly challenging, but crucial in cumulative knowledge building in classroom discourse as well as in high-stakes writing. As illustrated in this study, the instances of shifting from the field of depiction to the field of exploration in the student’s texts indicate some of the critical steps taken towards the expansion of theoretical knowledge. Making explicit the linguistic resources at stake should prove helpful for teachers attempting to support students undertaking these important steps.

The intention in this section is to suggest some ways in which the linguistic features identified in this study may be useful in teaching academic literary. Other effective teaching activities and the recontextualisation for an economical and accessible metalanguage are certainly necessary.

5.4 Future directions

This study raises some issues, which open up opportunities for future research. Several directions are listed below.

i. Dimensionality of entity and state figures

It was found in Chapter 3 that discourse semantic dimensionality of entities can construe taxonomy in field, both in terms of taxonomic relations among entities and attributions of entities. The realisations of dimensionality of entity include nominal groups at the group rank and relational processes at the clause rank. In Chapter 4, relational processes were treated as the congruent realisations of state figures, which have configurations of either entity=entity (e.g. *Elephants are mammals*) or entity + quality (e.g. *The pipettes were imprecise*). An important reason for their status as figures was that they can be instigated by entities (e.g. *you made him a fool*), and augmented via dimension and position (e.g. *the data showed that the pipettes were imprecise; it is possible that these organisms are chytrid zoospores*). However, both dimensionality and state figures construe taxonomy in field, and they involve comparable grammatical realisations – i.e. through nominal group grammar and relational processes. This leads to uncertainty as far as making a distinction between the two in the discourse semantics. Nonetheless, some differences between the two were evident. For example, it was found that dimensionality can 'name' the qualities in state figure, as exemplified by the pairs below.

> The bird [entity] is **black** [quality].
> The colour of the bird [dimensionality=entity] is **black** [entity]
>
> The material [entity] is not **heavy** [quality].
> The weight of the material [dimensionality=entity] can be measured.
>
> The spores [entity] are **susceptible** [quality].
> The susceptibility of the spores [dimensionality=entity] is lost

It may be useful to further explore dimensionality and state figures from an ontogenetic or phylogenetic perspective. The data analysis reported in Chapter 3 points to some ontogenetic features, namely that dimensionality had more frequent occurrence in the texts produced in the third undergraduate year than the texts in early years. In Painter's (1999) case study of a child language development, she reports that it was not until when Stephen was 4 years and 6 months of age, 'after long experience of comparing things in terms of specific colour, shape and size properties, that he began to try to construe qualities as nouns' (p. 121) – i.e. as dimensionality of entities. The selected interactions from Painter (1999) below exemplify Stephen's construal of the quality *fast* and his attempt to construe its associated dimensionality *speed* at different ages.

> 3;7;17 S: …speeding. Speeding means **fast**.
>
> 4;8;30 (F says the current (hired) car can't go as fast as the usual one)
> S: I thought – I thought all cars could – all cars could go the same – all cars could go the same (pause) fast.
> M: The same speed.
> S: Yes, same speed.

This ontogenetic perspective has a potential to shed light on the difference between discourse semantic qualities in a state figure and the dimensionality of an entity.

ii. Realisations of activity sequences in specialised field through discourse semantic figures

It has been illustrated that activity sequence (particularly their operation in the field of practice) and implication sequence in the field of exploration can be realised through discourse semantic entities, figures and sequences. The way in which they are identified in this study is by analysing agnate texts – including those from the textbook, lab manuals and laboratory and research reports. When activity sequences are named through activity entities, they are usually nominalisations, or lexicalised by Greek and Latin derived terms, which serve as the indicators for their status as construing activity sequences.

However, the ways in which activity sequences are realised by figures are less easily identified. For example, in the specialised field [operation], the same activity sequence ('pipetting') can be realised by the figure *a set amount water was pipetted* or the sequence *we press the operating button to the first stope, and then dip it into a depth of 1cm, and slowly release the operating button, and then wait 1-2 seconds, and then withdraw the tip from the water (…).* Similarly, in the exploration field, the activity sequence ('induction') realised in the student text by the figure *lactose induces B-galactosidase activity* is realised in the textbook through the sequence *the substrate is held in the active site by weak interactions, such as hydrogen bonds and ionic bonds. (And then) side chains (R group) of a few of the amino acids make up the active side, and then the side chains catalyse the conversion of substrate to product (…).* While looking for agnate texts from the same field can be helpful for identifying the 'tiering' through figures, no explicit indicator for such tiering has yet been found and further research is warranted.

iii. A further step into orbitality of figure

The orbital structure of figure explored in this study involves entities that are realised grammatically by Medium, different types of Range, 1st order Agent, 2nd order Agent, and Circumstances. However, several issues remain to be explored.

Firstly, the data used in this study does not include instances of entities realised as Beneficiary (i.e. Client, Recipient, and Receiver) (e.g. *She threw the ball to <u>the dog</u>*). The orbital structure of figure involving entities realised by Beneficiaries needs to be explored, particularly its relationship to other optional entities realised through 1st order Agent, 2nd order Agent and Circumstances.

Secondly, entities realised by Participants can be sometimes realised congruently through Circumstances. For example, the entity *pipette* realised by a Goal in [5d] is realised through a Circumstance [Means] in [5e].

[5d] <u>we</u> [Agent] used [Process] <u>the pipette</u> [Goal] || to measure [Process] <u>the water</u> [Goal].
[5e] <u>we</u> [Agent] measured [Process] the water [Goal] <u>with the pipette</u> [Cir: Manner: Means].

It is unresolved whether [5d] and [5e] construe the same discourse semantic meaning. The discourse semantic meanings construed by Participants and Circumstance (particularly the subtypes of Manner, see Halliday & Matthiessen, 2014, p. 318) need to be further explored.

iv. Down-ranked clauses and grammatical metaphor

In this thesis, the metaphorical realisations of figures in grammar were realised via nominalisations and ana/cataphoric text reference as well as embedded clause (Table 5.13).

Table 5.13 Metaphorical realisations of figure

Metaphorical realisation of figure	Examples
down-ranked clause	**[[*That chytrids were present within the sample*]]** *may have been* ***<u>due to</u>*** *the* ***prolonged storage****.* *The result =* **[[*that the flasks demonstrated a lower level of B-galactosidase activity*]]** ***<u>demonstrated</u>*** *that gene expression controls B-galactosidase activity.*
nominalisation	*The* ***survival*** *of small but not large spores* ***<u>supports</u>*** *the* ***importance*** *of size in fracture initiation dynamics.* *The* ***absence*** *of Podospora from the crop is* ***<u>evidence</u>*** *x [for mandibular* ***damage*** *to the spores].*
textual reference	(*Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates.*) ***This <u>allows</u>*** *materials to be more readily degraded by fungi and bacteria.*

(key: the instances of experiential metaphors are in bold; and logical metaphors are in bold and underlined)

In previous studies, the ideational metaphors in form of nominalisations (e.g. Halliday & Martin, 1993; Halliday & Matthiessen, 1999) and text reference (Halliday & Matthiessen, 2014, p. 717) have been documented, but there is no consensus in terms of whether embedded clause is a realisation of ideational metaphor. Embedding is treated as a metaphorical realisation in Ravelli (1988); Painter (2003, p. 191) refers to the embedded clause in the child language development as a 'protometaphorical' realisation, which 'may serve as a 'gateway'' to further metaphorical realisation. Similarly, Derewianka (2003) also suggests treating embedded clauses as 'protometaphors'. In her case study, she found a significant increase in the use of embedded clauses in the child's written language development from age 9 to 10. However, during this period the instances of grammatical metaphors realised through transcategorisations also demonstrate a large increase. As far as treating grammatical metaphor as stratal tension is concerned, previous studies do not provide clarification as to whether embedded clauses contribute to stratal tension. In this study, one reason for identifying the embedded clause as exemplified in Table 5.14 as an ideational metaphor is the fact that the figure is mapped onto a Participant at the clause rank; and secondly it is part of the syndrome of mapping a sequence onto a clause. More linguistic evidence for treating embedded clause as metaphorical realisation of figure (or not) needs to be provided.

v. Field, phases and genre

Field, as one register variable, is strongly associated with the system of genre. Some features of field are more likely to be contextualised in some genres than in others. For example, implication sequences in science (i.e. exploration field) are reflected in explanation genres, and activity sequences in specialised field are likely to occur in a procedure. Based on a delicate identification of fields and the description of taxonomies and activity sequences in field, it is possible to further explore fields in relation to genres and phases.

As noted in Chapter 2, various phases can be identified in the data texts. From a perspective of axial relations, each genre in the GENRE system is identified based on its syntagmatic configuration of stages; each stage can be explored in relation to different types of phases that realise (intrastratally) a stage. In other words, a system of phases can be situated at the lower rank of the system of genres. However, the motivation for identifying phases from below requires further clarification. This involves further work on the relationship between register and genre, and the distinction between phases and embedded elemental genres. While it is not the place in this thesis to pursue these goals, an initial attempt at identifying phases in the data texts is provided in Appendix A, which is offered as a starting point for future research. The different types of phases are identified primarily on the basis of different configurations of field types and their interaction with interpersonal meanings. More rigorous exploration of phases, stages and genres is required in future studies.

5.5 Concluding remarks

This chapter has summarised the major findings and contributions in this study. This study has deepened the understanding of discourse semantics and its relationship to lexicogrammar and to field in SFL framework. This development hopefully has taken us a step forward towards a more conscious understanding of knowledge building through language. Understanding knowledge building through language is the necessary step towards its recontextualisation for achieving a democratic distribution of knowledge. I have suggested some ways in which the linguistic features described in this study may be helpful for teaching academic literacy. More effort needs to be made towards its potential recontextualisation for pedagogic purposes.

The research reported in this thesis has inevitably led to more questions, such as those listed in section 5.4, among many others. These queries will certainly lead us to an enhanced linguistic depiction of knowledge building through language and a growing understanding of ideational meaning across strata in the exploration field of SFL.

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Appendix A Genre analysis

Notes on analysis:

The analysis of stages in the data texts follows the schematic structures of procedural recounts identified in Martin & Rose (2008, p. 200).

The identification of different types of phases draws on the field types identified in this study as well as the voice roles in academic discourse identified in Hood (2004, Chapter 6). The types of phases and their distinctive configurations of meanings are summarised as below.

phases	configurations of meanings	occurrence in stages
background experience	field of practice (generalised)	Abstract/Introduction
background facts	field of exploration (either taxonomy or activity sequence)	Abstract/Introduction
purpose	field of reflection with activity sequence of previewing the present study	Abstract/Introduction
hypothesis	field of exploration; Cause/exploration ^ Effect/exploration	Introduction/Discussion
prediction	field of depiction (future tense)	Introduction
justification	a configuration of exploration and practice fields (Cause/exploration ^ Effect/practice)	Introduction
step	field of practice (specific)	Method
data analysis	Tables and/or Figures other than verbal language	Results
result	field of depiction (Cause/depiction ^ Effect/depiction)	Results
finding	a configuration of depiction and exploration fields (Cause/depiction ^ Effect/exploration)	Discussion
rationale	a configuration of depiction and exploration fields (Cause/exploration ^ Effect/depiction)	Discussion
outcome	a configuration of depiction and practice fields (Cause/practice ^ Effect/depiction)	Discussion
assessment	an investigator voice evaluating the field of object of study	Discussion
limitation	a critic voice evaluating the field of research negatively	Introduction/Discussion
contribution	a critic voice evaluating the field of research positively	Discussion
comparison	internal contrasting	Discussion/Conclusion
summary	internal adding	Conclusion
recommendation	field of reflection with activity sequence of previewing future study	Discussion

Text 1

Stages	Text 1	phases
Introduction	Calibration of a pipette allows the relationship between theoretical volumes and those actually obtained to be determined. It is necessary to ensure consistency throughout an experiment, with high levels of accuracy (closeness of measured value to the set value) and precision (closeness of measured values to each other) needed to reduce variability and increase the experiment's reproducibility.	background experience
	In this experiment a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated, using three methods – weight-of-water, spectrophotometry and radioactivity – and a comparison of these methods was made.	purpose
Method	Weight of water: set amount of water was pipetted into a container, and the weight of the water dispensed was measured and recorded.	steps 1
	Spectrophotometry: set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes, and water was added to give a total volume of 1mL. Each solution was mixed, and absorbances were read, using a spectrophotometer, l=445nm.	steps 2
	Radioactivity: set amounts (0, 20, 50, 100, 150 and 200uL) of radioactive C-14 glucose were pipetted into vials, and 5mL of scintillant were added. The radioactive content of each vial was then measured, using a specialized spectrophotometer.	steps 3
Results	Weight-of-water: this method showed close correlation between the theoretical pipette and experimental values with little variability (Figure 1). It also displayed a strong linear relationship - shown by its correlation coefficient (R2) of 0.9999, suggesting the pipette to be both accurate and precise throughout its range (0-200uL).	result 1
	Spectrophotometry: according to this method, the pipette was fairly inaccurate, with an 11% error with pipette volume of 200uL and 51% for 20uL. Furthermore, this accuracy decreased towards the larger end of the pipette's range. The minimal variability that existed between readings demonstrated the pipette was fairly precise (Figure 2).	result 2

	Radioactivity: this method suggested that the accuracy of the pipette was quite high throughout its range, with approximately a 3% difference between set and measured volumes for volumes of 150ul and 200ul (Figure 3). However, the presence of significant variability between the readings obtained showed a high degree of imprecision (Figure 3).	result 3
Discussion	The three methods used did not agree upon the pipette's calibration. The weight-of-water method suggested high levels of accuracy and precision throughout the pipette's range. Similarly, spectrophotometry suggested the pipette was precise. However it also suggested that the pipette declined in accuracy as the set volumes increased, whilst radioactivity suggested the pipette was moderately inaccurate and highly imprecise.	comparison (of results)
	While the weight-of-water method appeared to provide the best calibration of the pipette, there were a number of limitations associated with it. Firstly, the sensitivity of the balance was limited, with its only measurements larger than 1mg detected. Thus it could not be used in calibrating a P20 and to some extent a P200. Secondly, the balance used was imprecise with external interference like breathing, which is able to cause the reading to fluctuate by 1-2g. This method was time consuming and the least useful in calibration. However, it was easy to perform, and the equipment (was) inexpensive. This method could prove more efficient in calibrating tools, i.e. automatic dispensers, which dispense larger volumes.	assessment (advantages of method 1)
	The other two methods used (spectrophotometry and radioactivity) were able to measure to a higher degree of accuracy and could be used in calibrating all three pipettes - providing a significant advantage. This discrepancy between the degrees of accuracy could also explain why such different calibration results between the methods were obtained.	assessment (advantages of method 1 and 2)
	While the radioactivity method contained a fairly high degree of accuracy, it involved a long waiting period. And the readings contained high levels of variability. Such variability could be due to experimental error, such as not depressing the pipette to the first stop or sucking up air bubbles in the pipette. Increasing the number of repeats could minimize such errors. The high expense, due to the use of C-14 glucose and the specialized spectrophotometer, would not be cost effective if this method were to be used regularly. Furthermore safety hazards associated with the use of radioactive C-14 glucose must be considered and precautions, such as the use of gloves and the fume-cupboard, must be implemented.	assessment (disadvantages of method 3)

	In comparison variability between the readings in the spectrophotometer was much less; this, combined with its high sensitivity to variations in volumes, could be used in the calibration for all three pipettes. This variability observed in the readings could be due to things such as, fingerprints on the cuvette and incomplete mixing of solution, which could be reduced by implementing greater care. Although the equipment used would have been initially expensive, frequent use would ensure its cost effectiveness. Additionally, the spectrometer provided results that were easily and efficiently obtained.	assessment (advantages of method 2)
Conclusion	The different methods used in pipette calibration contained varying degrees of accuracy. Although the use of the weight-of-water method was simple and inexpensive, it did not provide an accurate representation of the accuracy and precision of the pipette. Similarly, there were disadvantages associated with the radioactivity method including high costs and elaborate preparation. Instead, spectroscopy provided results that balanced the need for high levels of precision and accuracy with safety, speed and efficiency.	comparison (of advantages and disadvantages)

Text 2

Stages	Text 2	phases
Introduction	The activity of proteins can be controlled through influencing levels of gene expression or by their activation/deactivation when already present in the cytosol.	background facts
	In this experiment the activity of B-galactosidase, an enzyme which breaks down lactose, was studied. It is known that in the presence of lactose B-galactosidase activity increases. The aim of this experiment was to determine whether the induction of B-galactosidase resulted from the production of the enzyme through gene expression (transcriptional and translational processes) or through activation of the existing enzyme.	purpose 1
	Also investigated was the effect of adding glucose, and alternative food source to lactose. This was achieved by analysing B-galactosidase induction in *E. coli* colonies exposed to six different treatments: IPTG, lactose, lactose and glucose, lactose and 5-FU, lactose and chloroamphenicol, and no treatment.	purpose 2
Method	*E. coli* bacteria were cultured in a glycerol medium (pH7). One of the following six treatments was added to the bacterial culture: IPTG (0.48mM); lactose (o.41mM); Lactose (0.41mM) and Glucose (5.4mM); Lactose (0.4mM) and 5-FU (0.02mg/ml); Lactose (0.40mM) and chloramphenicol (0.02mg/ml); no treatment (control). Bacterial growth was monitored by measuring absorbance at 600nm of samples taken at 0, 10, 20, 35 min, ensuring logarithmic growth.	steps
	Samples to measure of B-galactosidase activity were taken at 0, 2, 4, 8, 16 and 32 minutes, and cellular reactions were stopped by the addition of Z Buffer (100mN sodium phosphate buffer (pH7), 10mM KCL, 1mM $MgSO_4$, 50mM 2-mercaptoethanol), SDS and chloroform.	steps
	An ONPG assay was carried out in order to determine the amount of B-galactosidase present. O-NPG (colourless) + B-Galactosidase (colourless) -> O-NP (yellow)	steps
	The samples were incubated at 28°C and ONPG (2.2mM) added. The reaction was stopped with sodium carbonate (6.9mM) once a significant amount, of visible O-NP had been produced in one of the samples. Concentration of O-NP, and hence B-galactosidase, was measured spectroscopically taking absorbance at 420nm, and 550nm to allow for turbidity correction.	steps

Results	*Table 1: E. coli growth, as measured by protein concentration, during the course of the experiment. Protein concentration estimated using the equation c=A600x 150/1.4* *Figure 1: E. coli growth, as measured by protein concentration, during the course of…* *Table 2: …* *Figure 2: …*	data analysis
Discussion	The control flask with nothing added demonstrated a basal level of B-galatosidase activity (Figure 2). Its purpose was to demonstrate that the results obtained were due to the treatment used.	finding 1
	The flask containing lactose demonstrated a higher level of B-galactosidase activity in comparison to the control flask with nothing added (Figure 2). This confirmed previous knowledge, that lactose induces B-galactosidase activity.	finding 2
	The flask containing IPTG, a non-metabolised inducer, demonstrated a significantly higher level of B-galactosidase activity in comparison to the flask containing lactose (Figure 2). This is because the IPTG, unlike the lactose does not run out as it is never metabolized.	finding 3
	The flasks containing lactose as well as 5-FG or Chloramphenical, inhibitors of transcription and translation respectively, demonstrated a lower level of B-galactosidase activity in comparison to the flask containing just lactose (Figure 2). This demonstrated that gene expression controls B-galactosidase activity.	finding 4
	If the alternative hypothesis, that activating the already present B-galactosidase induces activity, was correct. Then the flasks containing lactose as well as 5-FU or Chloramphenicol would have demonstrated a similar level of B-galactosidase activity in comparison to the flask containing just lactose (Figure 3). This is because inhibiting transcription and translation would have no effect on B-galactosidase activity, as this isn't how it is activated.	rationale
	The flask containing lactose and glucose, a preferred simpler food source, initially demonstrated a lower level of B-galactosidase activity in comparison to the flask containing lactose (Figure 2). After a period of time the level of B-galactosidase activity sharply rose (Figure 2). This suggests that the B-galactosidase was only activated once the alternative food source was depleted.	finding 5
	There was a high variability of the data in this experiment, demonstrated by the large error bars (Figure 2). This could be due to the fact that we are dealing with living systems that are subject to variability. Also problems with equipment such as the spectrophotometer, could have contributed. Lastly, the collection of the data by many different student groups increases the variability of the data.	limitations

Conclusion	The induction of B-galactosidase has been shown to be controlled by gene expression rather than the activation/deactivation of the already present B-galactosidase. A possible mechanism to explain this is that the presence of lactose promotes transcription or translation of B-galactosidase by removing a repressor. Also demonstrated was, that in the presence of a more preferable food source, glucose, B-galactosidase activity is decreased. Possible mechanisms are that the presence of glucose represses B-galactosidase activity or the absence of glucose activates B-galactosidase activity.	summary (of findings)

Text 3

Stages	Text 3	phases
Abstract	The phylum Chytridiomycota contains many ecologically important species. In particular, some symbiotic species play an essential role in animal herbivory, aiding the digestion of fibrous plant material ingested by the animal through both mechanical and enzymatic action.	background facts
	Whilst chytrids have been observed within the microflora of the irregular sea urchin, *E. cordatum* by Thorsen (1999) and are thought to be essential for herbivory, little work has been done to identify and characterise them within the Echinoidea.	limitation
	This preliminary study aimed to investigate methods of dissection of sea urchins as well as to present some evidence for the possibility presence of chytrids within both regular and irregular sea urchins. Small, round and motile structures observed in the samples taken from the coelom and digestive tract, as well as larger structures with what appear to be rhizoids, may represent zoospores and sporangium. Such observations provide some evidence for the possibility of the presence of chytrids within the Echinoidea.	purpose
Introduction	The Chytridiomycota are considered the most primitive phylum of the fungi. They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation. Although they require water to survive, they are found in both aquatic and terrestrial habitats and in a diverse range of temperate zones (James *et. al.* 2006, Shearer *et. al.* 2007). Members of this phylum are ecologically important, and include plant and animal parasites, as well as the ruminant symbionts (Webster & Weber, 2007).	background facts
	Ruminant fungi, and other microbial members of this community, play a significant role in animal nutrition – aiding the degradation of fibrous plant materials within the rumen and providing a source of readily digestible short chain fatty-acids and amino-acids (Douglas, 1994). In particular, chytrids aid such degradation through physical and chemical processes, such as the activity of cellulases and hemi-cellulases (Douglas, 1994; Webster & Weber, 2007).	background facts

	Ruminant symbiosis has been studied significantly, yet there has been little work as to the role of chytrids in marine invertebrate hosts. Thorsen (1999) reported the presence of Chytridiomycota in the digestive system of the irregular urchin, *Echinocardium cordatum* (Spantangoida: Echinodermata), however there has been no work since which has elaborated on these findings (Thorsen, 1999).	limitation
	The aim of the project would be to confirm the presence of members of the Chytridiomycota within different species of sea urchin (Echinodermata), and to attempt to understand why such organisms were present.	purpose
	This preliminary study aimed to determine the most practical methods to allow this project to be attempted, in particular collection and dissection methods. It also aimed to provide some evidence for the presence of chytrids within sea urchins, through microscopic observation and culturing methods	purpose
Method	Three species of regular sea urchin, *Erythrogramma heliocidaris* (purple sea urchin), *Pyonotilus holopneustes* (pink sea urchin) and *Parvispirus phyllacanthus* (slate pencil urchin), were collected from the rocky-intertidal region at Chowder Bay and Long-Reef Marine Reserve. Specimens of the irregular urchin, *Echinocardium cordatum* (heart urchin), were also collected from within the oceanic sediment at Watsons Bay by SCUBA.	steps
	These were then dissected, with the dissection of *E. cordatum* following the model presented by Thorsen (1998). Samples were then taken from the coelomic cavity and digestive tract of the sea urchins and were viewed at 10 and 40 times magnification using a light microscope.	steps
	Samples taken from *E. heliocidaris* and *P. phyllacanthus* were stored at four degrees Celsius for a week, before being plated onto 3.5% salt agar media. These were then stored at four degrees Celsius for a week before incubating them aerobically at room temperature.	steps
Results	Dissection of both the regular and irregular sea urchin species was successful, with cuts made around the equator of the test (Figure 1).	result 1
	Microscopic observation of the coelomic fluid of *E. Heliocidaris* and *P. phyllacanthus* showed bacterial species, protists – such as *Paramecium* –, sea urchin haemocytes and other eukaryotic cells. Round, motile, zoospore-like structures and structures that were similar in morphology to sporangium were also seen (Figures 2 and 3).	result 2

	The coelomic fluid from the heart urchin, *E. cordatum*, contained eukaryotic organisms, including protists and a bi-flagellate organism (Figures 4a and 4b). A number of round cells were also observed, however these did not to appear to be motile (Figures 4a, 4b and 5).	result 3
	Samples taken from specimens of *E. cordatum* that had been stored at 4C for a week, as well as a frozen sample, contained lower numbers of microorganisms and cell debris in comparison to samples taken immediately after collection. No motile zoospore-like structures were observed but there were a number of small asymmetrically shaped organisms that appeared and move a little against the Brownian current.	comparison (of results)
Discussion	Both prokaryotic and eukaryotic organisms, including bacteria cells, protists - including *Paramecium* – and sea urchin haemocytes, were observed within the samples taken from the coelomic cavity and digestive tract of all species of regular sea urchin examined (Figures 2, 3, 4a, 4b & 5). Similarly, both prokaryotic and eukaryotic organisms were seen in samples taken from *E. cordatum*, however the composition of this sample appeared to be varied to those observed in the regular urchins.	comparison
	Whilst the sample sizes are much too small to provide significant evidence for variation, such variation would not be unusual as the diet and habitat of regular and irregular urchins differs significantly. The presence of microbial activity in both regular and irregular sea urchins has been demonstrated, with the microbial community thought to contribute to and aid host digestion and nutrition through both physical and chemical methods (da Silver *et. al.* 2006; Sawabe *et. al.* 1995; Temara, De Ridder & Kaisin, 1991; Thorsen, 1998; Thorsen, 1999). In particular, it is likely that bacteria present may produce fatty acids, which the host would be unable to synthesise, as well as enzymes which aid degradation of ingested material (da Silva *et. al.,* 2006; Temara, De Ridder & Kaisen, 1991). Some bacteria may also help fix nitrogen, allowing their hosts to successfully thrive on diets with a high carbon-to-nitrogen ratio (Harris, 1992). These aquatic microorganisms may play a similar role to terrestrial gut symbionts – aiding host digestion and nutrition in return for a constant supply of nutrients within a homeostatic environment (Harris, 1992; Webster & Weber, 2007).	rationale
	Small circular cells, which appeared to oppose the direction of the Brownian current, were also observed in the regular sea urchins (Figures 2 & 3). As their movement opposed the current it is likely these cells were motile. This motion seemed to suggest the presence of flagella;	result
	however the microscopic resolution obtained was not enough to allow the presence of single or multiple flagella to be observed.	limitation

	The combination of their apparent motility and their shape suggests that these organisms could be chytrid zoospores. Such suggestions were further reinforced by the presence of structures that were morphologically similar to sporangium (Figures 2 & 3).	result
	Such findings in regular sea urchins have not been reported previously.	contribution
	In contrast, no motile zoospore-like structures were seen in specimens of *E. cordatum* collected. This was not expected as previous findings by Thorsen (1999) showed them to be present in the anterior and posterior caecum of the digestive tract (Thorsen, 1999).	result
	Such discrepancy is likely to be due to problems with the sampling methods used and the individual sea urchins studied, as well as the limited knowledge in identifying possible structures of the fungi in the samples, as described in Sparrow (1960). Such taxonomic identification would be followed closely in future studies.	limitations
	Prokaryotic organisms, likely to be bacteria, were also seen in these samples (Figures 4a, 4b & 5). Whilst these were not identified, it is likely that they included the bacterial taxons *Bacteroidetes, Firmicutes* and *α-Proteobacteria*, all of which have been found in *E. cordatum* (da Silver *et. al.,* 2006).	result
	Plating samples taken from the regular urchins provided some information as to the composition of the microflora observed, with three bacterial and nine fungal colonies in total. These included filamentous fungi, possibly species of *Penicillium* or *Aspergillus* – but not chytrids. *Penicillium* and *Aspergillus* are abundant fungal taxon in terrestrical environments but have also been shown to inhabit a wide range of hosts within marine environments, as such their presence would be expected (Morrison-Gardiner, 2002). Other members of the geofungi, terrestrial fungi which are able to live in marine environments, such as *Cladosporium* and *Alternaria* may also be present within sea urchins and other marine invertebrates (Morrison-Gardiner, 2002).	rationale
	The densities of these colonies were much less than were expected from the high densities of microbes initially observed. This decline may have resulted from the prolonged storage of the samples at six degrees Celcius before plating, resulting in only the more resilient organisms remaining viable.	outcome
	Although it was possible that chytrids were present within the samples used, none were present in culture. This may have been due to the prolonged storage of these samples at low temperatures for a week, as well as the growth conditions used.	outcome

	Members of the Neocallimastigomycota, well known for inhabiting the rumen of ruminant grazers, are obligate anaerobes (Trinci *et. al.,* 1994; Webster & Weber, 2007). As the only documentation of chytrids within the Echinodermata have been within the anaerobic environment of the caecum of *E. cordatum,* it is probable that any chytrids present within members of the Echinodermata would also be obligately anaerobic, and would not be viable on cultures grown under aerobic conditions (Thorsen, 1999)).	rationale
	Furthermore, as mentioned previously, only very resilient microbes would have remained viable after the extended storage periods.	outcome
	The body of sea urchins are open systems. If chytrids were present within the Echinoidea it is possible that they may be transient, not symbiotic, members. In particular, the possible presence of chytrids within the coelomic fluid of *P. Phyllacanthus* and *E. heliopneustes* could have resulted from ingestion of algae. For example, *Chytritium polysiphoniae*, a parasite of brown algae, may have been ingested by the urchins via normal feeding mechanisms, and may not be present as part of the normal flora (James *et. al.,* 2006; Webster & Weber, 2007).	rationale
	The possibility of such transience should be investigated in future experiments.	recommendation
	Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea. Host-microbial relationships may include parasitism, commensalism and symbiosis. As there did not appear to be any defects in the urchins, it is likely that the microbes present in the urchins studied were either commensal or symbiotic organisms. Members of the Chytridiomycota produce enzymes that have the ability to degrade a wide variety of substrates, including cellulose, keratin and chitin (Douglas, 1994; Trinci *et. al.,* 1994; Webster & Weber, 2007). This, in addition to the physical degradation of substrates resulting from hyphal growth, allows materials to be more readily degraded by fungi and bacteria (Douglas, 1994).	rationale
	Anaerobic chytrids play essential roles in terrestrial herbivores (Trinci *et. al.,* 1994). As regular sea urchins are herbivorous it could be assumed that chytrids present in their gut might aid the degradation of plant material and nutrient acquisition,	hypothesis
	however further study would be needed to confirm this.	recommendation
	There were a number of aspects which were unaddressed in this report and should be accounted for in future studies. Firstly, it remains unclear whether the zoospore-like structures were chytrids or if they belonged to another fungal group.	limitation

	Further analysis could be performed using biochemical tests or molecular sequencing methods, such as DNA sequencing, to identify these organisms present to a species specific level. Higher resolution microscopy, and possibly observation of the gut wall structure using a scanning electron microscope could also aid in identification and further understanding of the host-microbe relationship.	recommendation
	Secondly, the components of the digestive tract and coelom of sea urchins vary greatly, with each section having differing roles and environmental conditions – including variation in pH, chemical composition, oxygen concentration and toxicity – with the microbial composition and activity present varying accordingly (da Silva *et. al.,* 2006; Thorsen, 1998; Thorsen, 1999). Such variation was not considered within this preliminary work, with samples taken from an unidentified section of the gut.	limitation
	Further study should also involve greater specificity in the sampling methods, taking into account this variation in microhabitats.	recommendation

	The identification of microorganisms within sea urchins, and attempts to understand their role in such a relationship is significant for a number of reasons. As there has been limited research on both the identification and role of microbes within the Echinodermata, such research would provide information on an area where there is a current lack of knowledge. Although it is unclear whether these possible chytrids are related to those found in the rumen of terrestrial herbivores, understanding these relationships would also assist understanding of ecological and evolutionary relationships between animals and microorganisms. Secondly, the Chytridiomycota are a polyphyletic taxon, which are characterised by the presence of flagellated zoospores. This characteristic is thought to have been present in the common ancestor of the fungi, and the use of this plesiomorphic character for classification means that the classification of this phylum is only weakly supported by phylogenetic analysis (James *et. al.,* 2006). Sampling a greater diversity of environments, including within the Echinoidea, may provide further understanding of phylogenetic diversity and relationships of the Chytridiomycota, aiding the classification of such organisms (James *et. al.,* 2006)). Furthermore, symbiotic microorganisms, including anaerobic fungi, have been shown to increase the efficiency of nutrient uptake, and may be necessary for herbivory (Douglas, 1994; Trinci *et. al.,* 1994; Webster & Weber, 2007). Microbe-host interactions in marine invertebrates are also of economic importance as they can affect the health of animals, including shellfish (Harris, 1992). Therefore, identifying components of the normal microbial community in sea urchins, and understanding such relationships would also be beneficial in establishing of conservation and aquaculture projects.	contribution

Text 4

Stages	Text 4	phases
Abstract	The viability of fungal spores after ingestion and passage through the gastrointestinal tract of an insect may be determined by the effect of the physical and chemical processes involved in the ingestion and digestion of food. In particular, mandibular maceration could damage fungal spore integrity and result in spores losing their viability.	background facts
	The purpose of this study was to determine whether the size of fungal spores was a factor in affecting spore viability after passage through the gastrointestinal tract of the Australian plague locust, *Chortichocetes terminifera*. The effect of spore size on viability was tested using five genera of dung fungi – *Absidia*, *Isaria, Penicillin, Phycomycetes* and *Podospora* – whose spores were fed to either second or fifth instar *C. terminifera*. *Absidia, Isaria* and *Penicillin* spores were recovered from both the faecal and gut samples from second and fifth instars, following feeding by *C. terminifera* on wheat inoculated with fungal spores.	purpose
	Phycomyces was not recovered from faecal material obtained from second instars but was present in all other samples. *Podospora* spores, 20um in diameter, were not recovered from any of the samples	result
Introduction	A complex interaction exists between insects and the health and diversity of fungal communities. These interactions may be beneficial to both insects and fungi, for example symbiotic relationships between termites and cellulase-producing gut fungi (Slater, 1992). Insects may also aid the dispersal of fungal spores either externally or internally, increasing the ecological niche in which fungal species may inhabit and potentially affecting higher plant and animal diversity through the spread of symbiotic mycorrhizal fungi or entomo- and entero-pathogens (Collier & Bidatnodo, 2008; Dromph, 2000; Devarajan & Suryanarayanan, 2006; Nakamori & Suzuki, 2009; Vernes & Dunn, 2009). However, insect-fungi interactions may also be detrimental to both groups as shown in the effectiveness of the use of fungal entomopathogens in biocontrol (Ouedraogo, 2002) and in the loss of spore viability, in some fungal taxa, after ingestion and passage through the gut of insects (Nakamori & Suzuki, 2009; Pupital *et al*, unpublished data)	background facts

	Loss of fungal spore integrity and viability after ingestion and passage through the insect gastrointestinal tract may result from either physical processes, chemical processes or a combination of both. Physical processes such as maceration by mouthpieces or peristaltic movement through the gut could cause spores to fracture and lose their integrity. Similarly, chemical processes including enzymic digestion or antifungal compounds could cause spores to lose their viability whilst retaining their integrity (Dillan, 2001; Clissold, 2008). These mechanisms may explain why fungal spore viability after passage through the insect gut is either reduced or unaffected (Dromph, 2000; Devaranjan & Suryanarayanan, 2006; Nakamori & Suzuki, 2009; Pupitel *et al*, unpublished data). The ability for fungal spores to withstand such processes may be due to intrinsic characteristics of the fungal spore, in particular spore size may explain why some fungal spores retain their viability whilst other spores lose viability (Pupitel *et al*, unpublished data).	hypothesis
	We propose a model whereby smaller fungal spores are more likely to retain integrity and viability, after ingestion and passage through the insect gut, than larger spores, due to the ability for smaller spores to more easily avoid maceration by insect mouthpieces.	hypothesis
	This model was tested using dung fungal spores and examining their passage through the gut of the Australian plague locust, *Chortichocetes terminifera*. The Australian plague locust, *Chortichocetes terminifera*, ingests large amounts of biomass and travels over a large geographical range, making such a study ecologically realistic and important (Walker *et al*, 2007). In particular, different developmental stages of *C. terminifera* have mandibles of different sizes, yet consume the same food, making this insect ideal to test our model of fungal spore size affecting viability after ingestion and passage.	justification
	Coprophilous fungal spores were used as a model for spore size to test this model, on account of their specialization to survive passage through the guts of herbivorous animals (Dix & Webster (1995)). The fungal taxa chosen – *Absidia, Penicillin, Isaria, Podospora* and *Phycomycetes* – were chosen on the basis of the adaptations associated with their ecological niche, that is, the ability to pass unharmed through the chemical environment found in the digestive tract of herbivores (Dix & Webster, (1995)). As these fungi also vary in spore size the use of dung fungi to test this model is ideal.	justification
	Applying the model above to the system of dung fungi and *C. terminifera*, it is likely that the viability of spores will be dependent on both the size of fungal spores and the size of the insect mouthpiece. It is predicted that small spores will retain viability in after ingestion by both second and fifth instar *C. terminifera* whilst larger spores will lose viability after ingestion by either fifth instar *C. terminifer* only or both developmental stages.	prediction

Method	Species of *Penicillium, Podopspora, Absidia, Isaria* and *Phycomyces* were isolated from possum faeces (Table 1). The fungi were cultured on 3.5% Potato Dextrose Agar (PDA). Plates of each fungus were flooded with 0.02% Triton-X and the mycelium agitated to remove the spores.	steps
	Individual spore suspensions were inoculated to surface sterilized wheat, with five replicates of each fungus and a control (0.02% Triton-X solution). The effectiveness of inoculation was checked by spraying a fresh PDA plate with spore solution and monitoring spore germination. Thirty second instar and thirty fifth instar larvae of gregarious phase *C. terminifera* were starved for 24 hours.	steps
	Individual locusts were placed on one of the six treatments and allowed to feed for a period of 24 hours. Individual locusts were then moved to clean containers and all faeces were collected. The gastrointestinal tract of each locust was removed following collection of the faeces.	steps
	Faceal samples were macerated in 50 or 100ul of sterile de-ionised water for fifth and second instar samples respectively because the quantity was much greater from the larger insects. A one in ten dilution of each collection was then prepared and plated onto dung extract agar with antibiotics (2% agar, 20 pellets of possum dung per litre of media, 25mgL^{-1} Penicillin G, 25mgL^{-1} Streptomycin Sulphate in tap water to provide trace elements). Samples of digesta from the GIT were diluted one in twenty and plated out on dung extract agar.	steps
	The plates were observed over a period of 4-14 days and any colonies unique to treatment plates were identified.	steps
Results	A positive result for spore viability after ingestion determined when the target fungi was isolated from three or more of the five replicates. Additional growth on treatment plates was compared to non-target fungal growth present on control plates from the spore-free controls.	result 1
	Growth of *Absidia*, *Penicillium* and *Isaria* on dung extract media, from the faecal and gastrointestinal tract samples of their respective treatments, for both second and fifth instar *C. terminifera* was positive (Table 1 and 2).	result 2
	Phycomyces was absent from the faeces of the second instar locusts, but was successfully isolated from thesecond instar crop and the fifth instar crop and faeces.	result 3
	Podospora spores were not re-isolated from any of the extracts of any individual.	result 4

Discussion	*Penicillin, Isaria* and *Absidia* spores retained viability after ingestion by and passage through the gastrointestinal tract of both second and fifth instar *C. terminifera* (Table 1 and 2). In comparison, the larger spores of *Podospora* (14-20um) did not retain their viability (Table 1 and 2). Smaller mandibles fracture material into smaller fragments, so it stands to reason that larger fragments would be more susceptible to damage by mandibular action (Clissold, 2008). The retention of viability by the small spores can be explained in relation to our model initially proposed, in that spore size affects the viability of spores. The absence of *Podospora* from the crop is evidence for mandibular damage to the spores (Table 2b). The crop is early in the digestive sequence, so the early absence of *Podospora* indicates that the spores were inviable before entering the gut. The results suggest that mandibular manipulation of ingested material determines the level of damage sustained by the ingested material, rather than physical and/or chemical activity that occurs later within the gastrointestinal tract of *C. terminifera*.	finding
	Such findings are consistent with current understanding of food processing by members of the Acrididae, with fractionation of material with teeth or mandibles the primary mechanism of food processing (Clissold, 2008). Although the foregut is lined with sclerotised spines (Hochuli, *et. al.*, 1994; Uvarov, 1966) this is thought to aid in peristalsis and separation of material from digestive enzymes, rather than in the mechanical degradation of ingested material (Clissold, 2008; Hochuli, *et. al.*, 1994). The resident microbiota and digestive enzymes are also thought to have little involvement in the digestive process, since the passage time of the ingested food is extremely short (Charnley *et. al.,* 1985; Clissold, 2008; Uvarov, 1966). The literature and our findings support for the model that the loss of fungal spore viability is mediated by mandibular maceration.	finding
	Mandibles play a crucial role in the digestive process of the locust by fragmenting ingested plant material to release the nutritious cytoplasm (Clissold, 2008). Fragmentation of materials requires a fracture to be initiated and propagated through the material. Fracture initiation is dependent upon the fracture stress and toughness of the material (Clissold, 2008; Samson, 2006; Samson *et. al.,* 2001). We propose that size also becomes a determining factor in fracture initiation where fungal spores are concerned, since the probability of a mandible encountering a spore to initiate a fracture is dependent upon the circumference of the spore. The survival of small but not large spores in this study supports the importance of size in fracture initiation dynamics.	finding

	The results for *Phycomyces* indicated a loss of viability between the crop and the faeces in the second instar individuals. The loss of viability as a result of passage through the gastrointestinal tract was unexpected, especially because all other small fungal spores remained viable after passage through the gut of *C. terminifera* (Tables 1 and 2). Since *Phycomyces* belongs to different fungal taxa (Zygomyces) to the other isolates, it is possible that intrinsic structural differences such as the constituents of the spore wall could increase susceptibility of the spores to antifungals and digestive enzymes of the locust gut. Spore viability may therefore be dependent not only on spore size, but also on other intrinsic characteristics of the fungal spore including spore-wall composition.	finding
	However, two of the five second instar *C. terminifera* replicates for *Phycomyces* treatment died during the treatment. No faecal material was recovered and the crops obtained from these individuals discarded. Thus, the loss of viability between the crop and faeces is probably not significant, since the sample number was three rather than five locusts.	finding
	As the young locusts were found to be quite delicate, further investigations would benefit from the use of a larger sample size to allow for unexpected deaths.	recommendation
	The capacity to interpret the absence of *Podospora* in the crop and faeces is somewhat limited, since there was no progression of spore sizes between 6-14 microns through which to evaluate the size at which viability was lost. Without other results to corroborate the loss of viability at 14-20 microns, it is impossible to be sure that the loss of viability in *Podospora* was size related and not due to some other feature of the spore, such as cell wall composition.	limitation
	Future studies would benefit from resolving a more defined point at which spores cease to become viable, as this would inform the design of fungal biocontrols.	recommendation
	No correlation between the developmental stage of the insects and the size at which spores lost their viability was observed.	result
	The effect of developmental stage on spore size and viability could have been resolved if a more comprehensive spread of spore sizes had been used, especially in the 6-14 micron range.	recommendation
	The potential for false positive results was considered and carefully controlled for in the experimental procedure. A key concern was to avoid the inadvertent transmission of spores on the locust cuticle between the feeding and 'spore-free' containers. The consequence of non-specific transmission is that spores could be isolated from the locust without having passed through the mandibles and gastrointestinal tract.	result

	The recovery of spores from the crop was confirmation that spores has been ingested rather than being transported between containers on the locust exoskeleton.	confirmation
	It was also noted that individuals preparing to moult ceased to eat, which had implications for the numbers of spores consumed and therefore the spore concentration in the crop and faeces. Varying spore concentrations would have affected the chances of a spore being plated from the serial dilutions.	result
	Fasting prior to moulting and the associated potential bias in data could be avoiding by selecting individuals at exactly the same stage of their lifecycle.	recommendation
	Interestingly, none of the test organisms exposed to *Isaria* - a known entomopathogen – appeared to have contracted an infection. The lack of pathogenicity cannot be attributed to a loss of spore viability, since viable spores were recovered from both the crop and faeces in all treated individuals.	result
	The absence of *Isaria* pathogenicity can be explained in two ways. Resident microbiota in the gut of the Desert Locust *(Schistocera gregaria)* has produced an antifungal compound that inhibits the germination of fungal spores invivo and invitro (Dillon & Charnley, 1985; Dillon & Charnley 1995). However given that the *Isaria* spores were viable after passage through the gut, the antifungal would need to be fungistatic in its action. The literature provides evidence that the compound is fungicidal.	rationale
	The alternative explanation for the absence of colonization by *Isaria* is that the locust initiated some physiological response that prevented colonization. Evidence from *Locusta migratoria* has indicated that some locusts have an ability to induce a fever that reduces the incidence and severity of fungal infection by *Metarhizium anisopliae* (Ouedraogo, 2002).	rationale
	If entomopathogens are to be developed towards a biocontrol, there are a number of fungal-insect interactions beyond physical spore destruction that require consideration. Understanding spore viability in an entomopathogen/host context is a crucial aspect of autodissemination, a biocontrol strategy that employs insects to introduce a fungal pathogen into a population (Ignoffo, 1977; Dromph, 2003; Meyling *et. al.* 2006). Our results indicate that the success of an autodissemination strategy involving ingestion will require that spores are sufficiently small to survive ingestion.	recommendation

	A number of invetebrate hosts have been shown to aid fungal spore dispersal, including aphids (Meyling *et. al.* 2006), grasshoppers (Devarajan & Suryanarayanan, 2006) and snails (Dromph 2001, 2003). The dissemination of spores may hold implications for the structure of higher plant and animal communities (Devarajan & Suryanarayanan, 2006; Vernes & Dunn, 2009) as many fungal taxa are implicated in the health of ecological systems. For example, grasshoppers (Acrididae) transfer the spores of fungal endophytes between plants in rainforest communities thereby contributing to the diversity of endophyte communities (Devarajan and Suryanarayanan, 2006). The extent to which Acrididae-mediated dissemination occurs is possibly limited by the size of the spores, since dissemination would be futile if the spore were rendered inviable by the mandibles in the process of macerating the leaf containing the spores.	hypothesis
	Fungal spore size appears to correlate to spore viability after ingestion and passage through the gastrointestinal tract of the Australian plague locust, *C. terminifera*. The results of this investigation contribute to a growing body of literature documenting the role of insects in transporting fungal spores. As transport of fungal spores has implications as to the health and diversity of animal and plant species, as well as the structure of higher plant and animal communities, an understanding the relationship between fungal spore viability would be beneficial in applications of biocontrol, ecology and environmental management.	contribution

Appendix B Unpacking of grammatical metaphors

Notes on analysis:

The unpacking of grammatical metaphors as stratal tension is to recover the metaphorical mappings between discourse semantic meanings and lexicogrammatical meanings into their congruent mappings. The identification of discourse semantic meanings follows the system of ENTITY TYPES established in Chapter 3 and FIGURE TYPES established in Chapter 4.

Note that many instances of nominalisations in the data are not treated as grammatical metaphors, since they construe discourse semantic entities. These nominalisations include the realisations of dimensionality of entities (e.g. *<u>activity</u> of proteins* in [2.1]), activity entities (e.g. *gene expression* in [2.2]; *reproduction* in [3.21]), as well as semiotic entities (e.g. *limitation* in [1.41], and *disadvantages* in [1.80]).

Text 1

NO.	original text – 1st year lab report (MBLG1901)	grammatical metaphor unpacked
	Introduction	
1.1	**Calibration** of a pipette **ALLOWS** the **relationship** between theoretical volumes and those actually obtained to be determined.	1.1a We **calibrate** a pipette
		1.1b **SO** we could determine how the theoretical volumes are related to the volume [[we obtained]]
1.2	It is necessary to **ensure consistency** throughout an experiment, **WITH high levels of accuracy** (**closeness** of measured value to the set value) **<u>AND</u> precision** (**closeness** of measured values to each other) [[needed]]	(IN ORDER TO DO SO) 1.2a It is necessary to **make** the experiment **consistent**
		1.2b **(BY) making** the measured value and the set value **highly and consistently accurate** (the measured value are **close** to the set value)
		1.2c **<u>AND</u> making** the measured values **highly and consistently precise** (the measured values are **close** to each other)

Key: 1) **figure [metaphorical realisation]**; 2) **EXTERNAL CONNEXION [METAPHORICAL REALISATION]**; 3) EXTERNAL METAPHOR [CONGURENT REALISATION]; 4) **<u>INTERNAL CONNEXION [METAPHORICAL REALISATION]</u>**; 5) <u>INTERNAL CONNEXION [CONGRUENT REALISATION]</u>;
6) (non-lexicalised connexions)

1.3	TO **reduce variability**	IN ORDER TO **make** the experiment **less variable**
1.4	AND **increase** the experiment's **reproducibility**.	AND **make** the experiment **more able to be produced again**,
1.5	In this experiment a Finnpipette, ranged 200 – 1000uL, and a *Bio-Rad* P200 pipette were calibrated	
1.6	(BY) using three methods – weight-of-water, spectrophotometry and radioactivity	
1.7	– AND a **comparison** of these methods **was made**.	AND (THEN) we **compared** these methods.
	Method	
1.8	Weight of water: set amount of water was pipetted into a container	
1.9	AND the weight of the water [[dispensed]] was measured and recorded.	
1.10	Spectrophotometry: set amounts of dye (0, 20, 50, 100, 150 and 200uL) were pipetted into 1mL cuvettes,	
1.11	AND water was added	
1.12	TO give a total volume of 1mL.	
1.13	(AND THEN) Each solution was mixed,	
1.14	AND absorbances were read	
1.15	(BY) using a spectrophotometer, l=445nm.	
1.16	Radioactivity: set amounts (0, 20, 50, 100, 150 and 200uL) of radioactive C-14 glucose were pipetted into vials,	
1.17	AND 5mL of scintillant were added.	
1.18	The radioactive content of each vial was then measured	
1.19	(BY) using a specialized spectrophotometer.	

Key: 1) **figure [metaphorical realisation]**; 2) **EXTERNAL CONNEXION [METAPHORICAL REALISATION]**; 3) EXTERNAL METAPHOR [CONGURENT REALISATION]; 4) **INTERNAL CONNEXION [METAPHORICAL REALISATION]**; 5) INTERNAL CONNEXION [CONGRUENT REALISATION];
6) (non-lexicalised connexions)

	Results	
1.20	Weight-of-water: this method showed close **correlation** between the theoretical pipette and experimental values **WITH** little **variability** (Figure 1).	1.20a. weight of water method showed the theoretical pipette and experimental value **are closely correlated,**
		1.20b**. BECAUSE** the values are not variable
1.21	(AND) it also displayed a strong linear **relationship**	1.21**.** The method also displayed that theoretical and experimental values are **related** to each other linearly.
1.22	- **SHOWN** by its correlation coefficient (R2) of 0.9999,	1.22. **BECAUSE WE SEE THAT** the correlation coefficient (R2) (between theoretical pipette and experimental values) is 0.9999
1.23	**SUGGESTING** the pipette to be both accurate and precise throughout its range (0-200uL).	**SO WE SUPPOSE** the pipette is both accurate and precise throughout its range (0-200uL)
1.24	Spectrophotometry: according to this method, the pipette was fairly inaccurate, with an 11% error with pipette volume of 200uL and 51% for 20uL.	
1.25	FURTHERMORE this **accuracy decreased** towards the larger end of the pipette's range.	FURTHERMORE it **became less accurate** towards the larger end of the pipette's range.
1.26-27	The minimal **variability** [[that existed between readings]] **DEMONSTRATED** the pipette was fairly precise (Figure 2).	1.26 The readings were minimally **variable**
		1.27 **SO WE KNOW** the pipette was fairly precise.
1.28-29	Radioactivity: this method suggested that the **accuracy** of the pipette was quite high throughout its range, **WITH** approximately a 3% difference between set and measured volumes for volumes of 150ul and 200ul (Figure 3).	1.28-29a. Radioactivity method suggested the pipette was highly **accurate** throughout this range
		1.29b. **BECAUSE** the set and measured volumes for volumes of 150ul and 200ul are different (3%)
1.30	HOWEVER the **presence** of significant **variability** between the readings [[obtained]] **SHOWED** a high degree of **imprecision** (Figure 3).	1.30a. HOWEVER the readings [[obtained]] were significantly **variable**,
		1.30b. **SO WE KNOW** it (the pipette) was highly imprecise.
	Discussion	

Key: 1) **figure [metaphorical realisation]**; 2) **EXTERNAL CONNEXION [METAPHORICAL REALISATION]**; 3) EXTERNAL METAPHOR [CONGURENT REALISATION]; 4) **INTERNAL CONNEXION [METAPHORICAL REALISATION]**; 5) INTERNAL CONNEXION [CONGRUENT REALISATION];
6) (non-lexicalised connexions)

1.31	The three methods [[used]] did not agree upon the pipette's calibration.	
1.32	The weight-of-water method suggested high levels of **accuracy** and **precision** throughout the pipette's range.	The weight-of-water method suggested it (the pipette) was highly **accurate** and **precise** throughout its range.
1.33-34	SIMILARLY, spectrophotometry suggested the pipette was precise	
1.35-36	HOWEVER it also suggested that the pipette **declined** in **accuracy**	HOWEVER it also suggested that the pipette **became less accurate**
1.37	AS the set volumes increased,	AS/WHEN the set volumes increased
1.38-39	WHILST radioactivity suggested the pipette was moderately inaccurate and highly imprecise.	
1.40	WHILE the weight-of-water method appeared to **provide** the best **calibration** of the pipette	WHILE the weight-of-water method **seems to make** us **calibrate** the pipette the best
1.41	there were a number of limitations associated with it.	
1.42	FIRSTLY, the **sensitivity** of the balance **was limited**, **WITH** it(s) only **measurements** larger than 1mg [[detected]].	1.42a FIRSTLY, the balance **was not sensitive enough**, 1.42b **BECAUSE** the balance only **measures** and detects things larger than 1mg
1.43	THUS it could not be used	
1.44	IN (WHEN) calibrating a P20 and to some extent a P200.	
1.45	SECONDLY the balance [[used]] was imprecise **WITH** external **interference** like breathing,	1.45a SECONDLY, the balance [[used]] was imprecise 1.45b **BECAUSE WHEN / IF** it is **interfered** externally like breathing
1.46	which is able to **CAUSE** the reading to fluctuate by 1-2g.	**THEN** the reading can fluctuate by 1-2g
1.47	(AND) This method was time consuming	
1.48	AND(THEREFORE) (was) the least useful **IN calibration**,	1.48 THEREFORE (was) the least useful 1.48 **WHEN** we **calibrate pipette**,

Key: 1) **figure [metaphorical realisation]**; 2) **EXTERNAL CONNEXION [METAPHORICAL REALISATION]**; 3) EXTERNAL METAPHOR [CONGURENT REALISATION]; 4) **INTERNAL CONNEXION [METAPHORICAL REALISATION]**; 5) INTERNAL CONNEXION [CONGRUENT REALISATION];
6) (non-lexicalised connexions)

1.49	<u>HOWEVER</u> it was easy to perform	
1.50	<u>AND</u> the equipment (was) inexpensive.	
1.51	<u>(FURTHERMORE)</u> This method could **PROVE** more efficient in calibrating tools, i.e. automatic dispensers, which dispense larger volumes.	<u>(FURTHERMORE)</u> 1.51a **IF** we use calibrating tools, i.e. automatic dispensers, which dispense larger volumes. 1.51b **THEN** this method would be more efficient.
1.52	The other two methods [[used]] (spectrophotometry and radioactivity) were able to measure to a higher degree of **accuracy**	The other two methods [[used]] (spectrophotometry and radioactivity) were able to measure things more **accurately**
1.53	<u>AND</u> could be used	
1.54	IN calibrating all three pipettes	
1.55	- <u>**PROVIDING**</u> a significant advantage	<u>**SO**</u> they are significantly **advantageous**.
1.56-57	This **discrepancy** between the degrees of **accuracy** could also <u>**EXPLAIIN**</u> why such different **calibration** results between the methods were obtained.	1.56 the methods are **accurate to different** degree, 1.57 <u>**SO WE KNOW**</u> why such different results were obtained based on the methods for **calibrating** pipette.
1.58	<u>WHILE</u> the radioactivity method **contained** a fairly high degree of **accuracy**	<u>WHILE</u> the radioactivity method was fairly **accurate**
1.59	it **involved** a long **waiting** period	we had to **wait for a long period of time**
1.60	<u>AND(/SECONDLY)</u> the readings **contained** high levels of **variability**.	<u>AND(/SECONDLY)</u> our readings were highly **variable,** due to experimental errors
1.61	Such **variability** could be due to experimental error,	
1.62	SUCH AS not depressing the pipette to the first stop	
1.63	OR sucking up air bubbles in the pipette.	
1.64	<u>(HOWEVER)</u> **Increasing the number of repeats** could **minimize** such	1.64a <u>(HOWEVER)</u> if we **repeat it more times** 1.64b we could make **minimal** errors as such.

Key: 1) **figure [metaphorical realisation]**; 2) **EXTERNAL CONNEXION [METAPHORICAL REALISATION]**; 3) EXTERNAL METAPHOR [CONGURENT REALISATION]; 4) <u>**INTERNAL CONNEXION [METAPHORICAL REALISATION]**</u>; 5) <u>INTERNAL CONNEXION [CONGRUENT REALISATION]</u>;
6) (non-lexicalised connexions)

	errors.	
1.65	(THIRDLY) The high **expense**, **DUE TO** the **use** of C-14 glucose and the specialized spectrophotometer, would not be **cost effective**	1.65a (THIRDLY) We **spend lots of money** 1.65b **BECAUSE** we **use** C-14 glucose and the specialized spectrophotometer in the experiment 1.65c (SO) The money would not be **spent effectively**
1.66	IF this method were to be used regularly.	IF we use this method regularly.
1.67	FURTHERMORE safety hazards **ASSOCIATED WITH** the **use** of radioactive C-14 glucose must be considered	1.67a FURTHERMORE We must consider the safety hazards 1.67b **BECAUSE** we use radioactive C-14 glucose,
1.68	AND **precautions**, SUCH AS the **use** of gloves and the fume-cupboard, **must be implemented**.	1.68a AND we must **consider some other things in advance**, 1.68b FOR EXAMPLE, the gloves and the fume-cupboard **are used**
1.69	IN COMPARISON **variability** between the readings in the spectrophotometer was much less;	IN COMPARISON the readings in the spectrophotometer were much less **variable**
1.70	this, combined with its high **sensitivity TO variations** in volumes, could be used **IN** the **calibration** for all three pipettes.	1.70a(ALSO) spectrophotometer is highly **sensitive** 1.70b **WHEN** volumes **vary**. 1.70c (SO) spectrophotometer can be used 1.70d **WHEN calibrate** all three pipettes.
1.71	This **variability** [[observed in the readings]] could be due to things such as, fingerprints on the cuvette and incomplete **mixing** of solution,	(IN ADDITION) readings are **variable**, due to things such as fingerprints on the cuvette, and the solution not being **mixed** completely,
1.72	which could be **reduced**	(HOWEVER) we can make it **less variable**
1.73	by implementing **greater care**.	by being **more careful**,
1.74	(FURTHERMORE) ALTHOUGH the equipment [[used]] would have been initially expensive,	
1.75	**frequent use** would **ENSURE** its **cost effectiveness.**	1.75a **IF** we **use** the equipment frequently, 1.75b **THEN** the money would be more effectively spent.

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6) (non-lexicalised connexions)

1.76	ADDITIONALLY, the spectrometer provided results [[that were easily and efficiently obtained]].	
	Conclusion	
1.77	The different methods [[used in pipette **calibration**]] **contained** varying degrees of **accuracy**.	(IN CONCLUSION) we used different methods to calibrate pipette these methods **were inaccurate** to different degrees
1.78	ALTHOUGH the **use** of the weight-of-water method was simple and inexpensive,	ALTHOUGH it was simple and inexpensive to **use** weight-of-water method
1.79	it did not **provide** an accurate **representation** of the **accuracy** and **precision** of the pipette.	this method did not **make/present** pipette (to be) **accurate** and **precise**
1.80	SIMILARLY there were disadvantages associated with the radioactivity method **INCLUDING** high **costs** AND **elaborate preparation**.	1.80a SIMILARLY there were disadvantages associated with the radioactivity 1.80b **THAT INCLUDE: it costs more money,** 1.80c AND it needs to be **prepared** more elaborately
1.81	INSTEAD spectroscopy provided results that **balanced** the need for high levels of **precision** and **accuracy** with **safety**, **speed** and **efficiency**.	1.81a INSTEAD, spectroscopy provided results that are **precise** and **accurate**, which balanced our need 1.81b and the method is **safe, quick** and **efficient**

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Text 2

NO.	**original text – 2nd year laboratory report (MBLG2971)**	**grammatical metaphor unpacked**
	Introduction	
2.1	The activity of proteins can be controlled	
2.2	THROUGH influencing levels of gene expression	
2.3	OR (THROUGH) their **activation/deactivation** [[when already present in the cytosol]].	2.3a OR (THROUGH) **activating/deactivating** proteins, 2.3b WHEN they are already present in the cytosol,
2.4	In this experiment the activity of B-galactosidase, an enzyme [[which breaks down lactose]], was studied.	
2.5-6b	It is known that **IN** the **presence** of lactose, B-galactosidase activity increases.	2.5-6a it is known that **WHEN there is** lactose, 2.6b B-galactosidase activity increases.
2.7	The **aim** of this experiment was [[to determine [[whether the **induction** of B-galactosidase **RESULTED FROM** the **production** of the enzyme through gene expression (transcriptional and translational processes) OR **THROUGH activation** of the [[existing]] enzyme]].	2.7a This experiment **aims** to determine whether the B-galactosidase **is induced** 2.7b **BECAUSE** enzyme **is produced** through gene expression (transcriptional and translational processes) 2.7c OR **BECAUSE** the [[existing]] enzyme **is activated**
2.8	(IN ADDITION) [[Also investigated]] was the effect of [[adding glucose, and alternative food source to lactose]].	
2.9	This was achieved	
2.10-11	BY analyzing B-galactosidase **induction** in *E. coli* colonies [[exposed to six different treatments: IPTG, lactose, lactose and glucose, lactose and 5-FU, lactose and chloroamphenIol, and no treatment]].	BY analyzing how B-galactosidase is **induced** in *E. coli* colonies [[which is exposed to six different treatments: IPTG, lactose, lactose and glucose, lactose and 5-FU, lactose and chloroamphenIol, and no treatment]].
	Results	
2.12	*E. coli* bacteria were cultured in a glycerol medium (pH7).	

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2.13	(AND THEN) One of the [[<u>FOLLOWING</u>]] six treatments was added to the bacterial culture: IPTG (0.48mM); lactose (0.41mM); Lactose (0.41mM) and Glucose (5.4mM); Lactose (0.4mM) and 5-FU (0.02mg/ml); Lactose (0.40mM) and chloramphenicol (0.02mg/ml); no treatment (control).	
2.14	(AND THEN) Bacterial growth was monitored	
2.15	BY measuring absorbance at 600nm of samples [[taken at 0, 10, 20, 35 min]],	BY measuring absorbance at 600nm of samples [[taken at 0, 10, 20, 35 min]],
2.16	(IN ORDER TO) ensuring logarithmic growth]]	(IN ORDER TO) make sure (it has) logarithmic growth
2.17	Samples [[to measure B-galactosidase activity]] were taken at 0, 2, 4, 8, 16 and 32 minutes,	
2.18	AND cellular reactions were stopped BY the **addition** of Z Buffer (100mN sodium phosphate buffer (pH7), 10mM KCL, 1mM $MgSO_4$, 50mM 2-mercaptoethanol), SDS and chloroform.	2.18a AND THEN cellular reactions were stopped || 2.18b BY **adding** Z Buffer (100mN sodium phosphate buffer (pH7), 10mM KCL, 1mM $MgSO_4$, 50mM 2-mercaptoethanol), SDS and chloroform.
2.19	(AND THEN) An ONPG assay was carried out	
2.20	IN ORDER TO determine the amount of B-galactosidase present.	
2.21	The samples were incubated at 28°C	
2.22	AND THEN ONPG (2.2mM) added.	
2.23	(AND THEN) The reaction was stopped with sodium carbonate (6.9mM)	
2.24	once/when a significant amount, of visible O-NP had been produced in one of the samples.	
2.25	(AND THEN) Concentration of O-NP, and hence B-galactosidase, was measured spectroscopically	

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2.26	(BY) taking absorbance at 420nm, and 550nm	
2.27	TO (IN ORDER TO) allow for turbidity correction.	
	Discussion	
2.27	The control flask with nothing [[added]] demonstrated a basal level of B-galactosidase activity (figure 2),	
2.28	its **<u>PURPOSE</u>** was [[to demonstrate that the results [[obtained]] were **DUE TO** the treatment [[used]]]].	2.28a **<u>SO WE WOULD KNOW</u>** we obtained the results 2.28b **BECAUSE** we used the treatment
2.29	The flask [[containing lactose]] demonstrated a higher level of B-galactosidase activity in comparison to the control flask with nothing [[added]] (figure 2).	
2.30	**This <u>CONFIRMED</u>** previous knowledge [[that lactose induces B-galactosidase activity]].	**<u>SO WE KNOW</u>** the previous knowledge [[that lactose induces B-galactosidase activity]] is true.
2.31	The flask [[containing IPTG, a non-metabolised inducer]], demonstrated a significantly higher level of B-galactosidase activity in comparison to the flask [[containing lactose]] (figure 2).	
2.32	<u>THIS IS BECAUSE</u> the IPTG, unlike the lactose, does not run out,	**BECAUSE** the IPTG, unlike the lactose, does not run out
2.33	AS it is never metabolized.	
2.34	The flasks [[containing lactose as well as 5-FG or Chloramphenical, inhibitors of transcription and translation respectively]], demonstrated a lower level of B-galactosidase activity in comparison to the flask [[containing just lactose]] (figure 2).	
2.35-36	This **<u>DEMONSTRATED</u>** || that gene expression controls B-galactosidase activity.	**<u>SO WE KNOW</u>** gene expression controls B-galactosidase activity
2.37	IF the alternative hypothesis [[that activating the already present B-galactosidase induces activity]] was correct.	

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2.38	THEN the flasks [[containing lactose as well as 5-FU or Chloramphenicol]] would have demonstrated a similar level of B-galactosidase activity in comparison to the flask [[containing just lactose]] (figure 3).	
2.39	<u>THIS IS BECAUSE</u> [[inhibiting transcription and translation]] would have no effect on B-galactosidase activity,	
2.40	AS this isn't [[how it is activated]].	
2.41	The flask [[containing lactose and glucose, a preferred simpler food source]], **INITIALLY** demonstrated a lower level of B-galactosidase activity in comparison to the flask [[containing lactose]] (figure 2).	**AT THE BEGINNING**, The flask [[containing lactose and glucose, a preferred simpler food source]], demonstrated a lower level of B-galactosidase activity in comparison to the flask [[containing lactose]]
2.42	After a period of time, the level of B-galactosidase activity sharply rose (figure 2).	
2.43-44	This **<u>SUGGESTS</u>** || that the B-galactosidase was only activated ||	**<u>SO WE SUPPOSE</u>** the B-galactosidase was only activated
2.45	ONCE(/WHEN) the alternative food source was depleted.||	
2.46	There was a high **variability** of the data in this experiment,	the data in this experiment was highly **variable,**
2.47	demonstrated by the large error bars (figure 2).	which is demonstrated by the large error bars
2.48	**This** could be **<u>DUE TO</u>** the fact [[that we are dealing with living systems [[that are subject to **variability**]]]].	**<u>POSSIBLY BECAUSE</u>** we are dealing with living systems [[which are subject to be variable]].
2.49	<u>ALSO</u> problems with equipment such as the spectrophotometer, could have contributed.	
2.50	<u>LASTLY</u> the **collection** of the data, by many different student groups **INCREASES** the **variability** of the data.	<u>LASTLY</u>, 2.50a many different student groups **collected** the data, 2.50b (**SO**) the data can be **more variable**
	Conclusion	
2.51	The **induction** of B-galactosidase has been shown to be	2.51a It has been shown that B-galactosidase is induced

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6) (non-lexicalised connexions)

	controlled by gene expression RATHER THAN the activation/deactivation of the already present B-galactosidase]].	2.51b **BECAUSE** it is controlled by gene expression 2.51c **NOT BECAUSE** activating/decativating the already present B-galactosidase
2.52	A possible mechanism to **EXPLAIN this** is [[that the **presence** of lactose promotes transcription or translation of B-galactosidase BY removing a repressor]].	2.52a **BECAUSE WE KNOW** when **there is** lactose 2.52b lactose promotes transcription or translation of B-galactosidase 2.52c BY removing a repressor
2.53	[[Also demonstrated]] was, [[that **IN** the **presence** of a more preferable food source, glucose, B-galactosidase activity is decreased]].	2.53a it was also demonstrated that **WHEN** a more preferable food source, glucose **is present**, 2.53b B-galactosidase activity is decreased
2.54	Possible mechanism are [[that the **presence** of glucose represses B-galactosidase activity OR the **absence** of glucose activates B-galactosidase activity]].	2.54a it is possible that IF glucose **is present**. 2.54b **THEN** it represses B-galactosidase activity 2.54c OR **IF** glucose is **absent**, 2.54d **THEN** it activates B-galactosidase activity

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6) (non-lexicalised connexions)

Text 3

NO.	original text – 2nd year research report (BIOL2912)	grammatical metaphor unpacked
	Abstract	
3.1	The phylum Chytridiomycota contains many ecologically important species.	
3.2	In particular, some symbiotic species play an essential role in animal herbivory,	
3.3	aiding the digestion of fibrous plant material ingested by the animal through both mechanical and enzymatic action.	
3.4	Whilst chytrids have been observed within the microflora of the irregular sea urchin, *E. cordatum* by Thorsen (1999)	
3.5	and are thought to be essential for herbivory,	
3.6	little work has been done to identify and characterise them within the Echinoidea.	
3.7	This preliminary study aimed to investigate methods of dissection of sea urchins	
3.8	as well as to present some evidence for the possible **presence** of chytrids within both regular and irregular sea urchins.	as well as to present some evidence [[that chytrids are possibly present within both regular and irregular sea urchins.
3.9	Small, round and motile structures observed in the samples [[taken from the coelom and digestive tract, as well as larger structures with what appear to be rhizoids]], may represent zoospores and sporangium.	
3.10	Such **observations** provide some **<u>EVIDENCE</u>** for the **possibility** of the **presence** of chytrids within the Echinoidea.	3.10a We observe these samples 3.10b **<u>SO/THEN WE KNOW IT IS POSSIBLE THAT</u>** chytrid are present within the Echinoidea.
	Introduction	

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6) (non-lexicalised connexions)

3.11	The Chytridiomycota are considered the most primitive phylum of the fungi.	
3.12	They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation.	
3.13	ALTHOUGH they require water to survive,	
3.14	they are found in both aquatic and terrestrial habitats and in a diverse range of temperate zones (James *et. al.* (2006), Shearer *et. al.* (2007)).	
3.15	Members of this phylum are ecologically important,	
3.16	<u>AND</u> include plant and animal parasites, as well as the ruminant symbionts (Webster & Weber (2007)).	
3.17	Ruminant fungi, and other microbial members of this community, play a significant role in animal nutrition	
3.18	– <u>(THAT IS,)</u> **aiding** the **degradation** of fibrous plant materials within the rumen	– <u>(THAT IS,)</u> **help** fibrous plant materials **to degrade** within the rumen
3.19	AND providing a source of readily digestible short chain fatty-acids and amino-acids (Douglas (1994)).	
3.20	<u>IN PARTICULAR</u>, chytrids **aid** such **degradation** through physical and chemical processes, such as the activity of cellulases and hemi-cellulases (Douglas (1994), Webster & Weber (2007)).	<u>IN PARTICULAR</u>, chytrids **help** fibrous plant materials **to degrade** through physical and chemical processes, such as the activity of cellulases and hemi-cellulases
3.21	Ruminant symbiosis has been studied significantly,	
3.22	YET there has been little work as to the role of chytrids in marine invertebrate hosts.	

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6) (non-lexicalised connexions)

<table>
<tr><td>3.23</td><td>Thorsen (1999) reported the presence of Chytridiomycota in the digestive system of the irregular urchin, Echinocardium cordatum (Spantangoida: Echinodermata),</td><td>Thorsen (1999) reported that Chytridiomycota is present in the digestive system of the irregular urchin, Echinocardium cordatum</td></tr>
<tr><td>3.24</td><td><u>HOWEVER</u> there has been no work</td><td></td></tr>
<tr><td>3.25</td><td>since which has elaborated on these findings (Thorsen (1999)).</td><td></td></tr>
<tr><td rowspan="2">3.26</td><td rowspan="2">The aim of the project would be to confirm the presence of members of the Chytridiomycota within different species of sea urchin (Echinodermata), <u>AND</u> to attempt to understand why such organisms were present.</td><td>3.26a the project aims to confirm that members of the Chytridiomycota are present within different species of sea urchin (Echinodermata)</td></tr>
<tr><td>3.26b <u>AND</u> this project attempts to understand why such organisms were present</td></tr>
<tr><td>3.27</td><td>This preliminary study aimed to determine the most practical methods</td><td></td></tr>
<tr><td>3.28</td><td>(IN ORDER) TO allow this project to be attempted, in particular collection and dissection methods.</td><td></td></tr>
<tr><td rowspan="3">3.29</td><td rowspan="3">It <u>ALSO</u> aimed to provide some evidence for the presence of chytrids within sea urchins, through microscopic observation and culturing methods.</td><td>3.29a It (This preliminary study) <u>ALSO</u> aimed to provide some evidence [[that chytrids are present within sea urchins]]</td></tr>
<tr><td>3.29b through/BY observing through microscopy</td></tr>
<tr><td>3.29c and using culturing methods</td></tr>
<tr><td></td><td>Methods</td><td></td></tr>
<tr><td>3.30</td><td>Three species of regular sea urchin, Erythrogramma heliocidaris (purple sea urchin), Pyonotilus holopneustes (pink sea urchin) and Parvispirus phyllacanthus (slate pencil urchin), were collected from the rocky-intertidal region at Chowder Bay and Long-Reef Marine Reserve.</td><td></td></tr>
</table>

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3.31	Specimens of the irregular urchin, *Echinocardium cordatum* (heart urchin), were ALSO collected from within the oceanic sediment at Watsons Bay by SCUBA.	
3.32	These were then dissected, **WITH** the **dissection** of *E. cordatum* following the model presented by Thorsen (1998).	3.32a These were then dissected,
		3.32b (**BY**) following/using the model presented by Thorsen (1998).
3.33	Samples were THEN taken from the coelomic cavity and digestive tract of the sea urchins	
3.34	AND were viewed at 10 and 40 times magnification	
3.35	(BY) using a light microscope.	
3.36	(AND) Samples taken from *E. heliocidaris* and *P. phyllacanthus* were stored at four degrees Celsius for a week,	
3.37	BEFORE being plated onto 3.5% salt agar media.	
3.38	These were THEN stored at four degrees Celsius for a week	
3.39	BEFORE incubating them aerobically at room temperature.	
	Results	
3.40	**Dissection** of both the regular and irregular sea urchin species was successful,	3.40a We successfully **dissected** both regular and irregular sea urchin species,
	WITH cuts made around the equator of the test (Figure 1).	3.40b **BY cutting** around the equator of the test
3.41	Microscopic **observation** of the coelomic fluid of *E. Heliocidaris* and *P. phyllacanthus* **showed** bacterial species, protists – such as *Paramecium* –, sea urchin haemocytes and other eukaryotic cells.	3.41a We **observed** the coelomic fluid of *E. Heliocidaris* and *P. phyllacanthus* with microscopy
		3.41b (THEN) **we see** bacterial species, protists – such as *Paramecium* –, sea urchin haemocytes and other eukaryotic cells
3.42	Round, motile, zoospore-like structures and structures that were similar in morphology to sporangium were ALSO seen (Figures 2 and 3).	

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3.43	(AND) The coelomic fluid from the heart urchin, *E. cordatum*, contained eukaryotic organisms, including protists and a bi-flagellate organism (Figures 4a and 4b).	
3.44	A number of round cells were ALSO observed,	
3.45	HOWEVER these did not to appear to be motile (Figures 4a, 4b and 5).	
3.46	Samples [[taken from specimens of *E. cordatum* [[that had been stored at 4C for a week]]]], as well as a frozen sample, contained lower numbers of microorganisms and cell debris in comparison to samples [[taken immediately after collection]].	
3.47	No motile zoospore-like structures were observed	
3.48	BUT there were a number of small asymmetrically shaped organisms that appeared	
3.49	and moved a little against the Brownian current.	
	Discussion	
3.50	(FIRSTLY) Both prokaryotic and eukaryotic organisms, including bacteria cells, protists - including *Paramecium* – and sea urchin haemocytes, were observed within the samples [[taken from the coelomic cavity]]	
3.51	AND digestive tract of all species of regular sea urchin examined (Figures 2, 3, 4a, 4b & 5).	
3.52	SIMILARLY, both prokaryotic and eukaryotic organisms were seen in samples [[taken from *E. cordatum*,]]	
3.53	HOWEVER the composition of this sample appeared to be varied to those [[observed in the regular urchins]].	
3.54	WHILST the sample sizes are much too small to provide significant evidence for variation,	WHILST the sample sizes are much too small to provide significant evidence [[that the compositions of urchins vary]]

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3.55	such **variation** would not be unusual	it is not unusual that they **vary**
3.56	AS the diet and habitat of regular and irregular urchins differs significantly.	
3.57	The **presence** of microbial activity in both regular and irregular sea urchins has been demonstrated, **WITH** the microbial community thought to contribute to and aid host digestion and nutrition through both physical and chemical methods (da Silver et. al. (2006), Sawabe et. al. (1995), Temara, De Ridder & Kaisin (1991), Thorsen (1998), Thorsen (1999)).	3.57a It has been demonstrated that microbial activity is **present** in both regular and irregular sea urchins. 3.57b **as** it is thought/we knew that the microbial community aid host digestion and nutrition through both physical and chemical methods.
3.58	IN PARTICULAR, it is likely that bacteria present may produce fatty acids, which the host would be unable to synthesise, as well as enzymes which **aid degradation** of ingested material (da Silva *et. al.* (2006), Temara, De Ridder & Kaisen (1991)).	3.58a IN PARTICULAR, it is likely that when bacteria is present, 3.58b it may produce fatty acids, 3.58c which the host would be unable to synthesise; 3.58d and it may produce enzyme, 3.58e which **help** the ingested material to **degrade**
3.59	Some bacteria may also help fix nitrogen,	
3.60	**ALLOWING** their hosts to successfully thrive on diets with a high carbon-to-nitrogen ratio (Harris (1992)).	**SO THAT** their hosts can successfully thrive on diets with a high carbon-to-nitrogen ratio
3.61	These aquatic microorganisms may play a similar role to terrestrial gut symbionts	
3.62	– (THAT IS,) aiding host digestion and nutrition in return **FOR** a constant **supply** of nutrients within a homeostatic environment (Harris (1992), Webster & Weber (2007)).	-(THAT IS,) 3.62a these aquatic microorganisms aid host digestion and nutrition in return 3.62b **IN ORDER TO supply** nutrients constantly within a homeostatic environment

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3.63	(SECONDLY) Small circular cells, which appeared to oppose the direction of the Brownian current, were ALSO observed in the regular sea urchins (Figures 2 & 3).	
3.64	AS their **movement** opposed the current	AS they moved against the current
3.65	It is likely these cells were motile.	
3.66	This **motion** seemed to **SUGGEST** the **presence** of flagella;	**SO WE SUPPOSE** flagella **were present**
3.67	HOWEVER the microscopic resolution [[obtained]] was not enough to allow the presence of single or multiple flagella to be observed.	HOWEVER the microscopic resolution [[obtained]] was not enough to allow us to observe the simple or multiple flagella
3.68-69	The **combination** of their apparent motility and their shape **SUGGESTS** that these organisms could be chytrid zoospores.	3.68 (NONETHELESS) they have apparent motility and shape,. 3.69 **SO WE SUPPOSE** that these organisms could be chytrid zoospores
3.70	Such **suggestions** were further **REINFORCED BY** the **presence** of structures [[that were morphologically similar to sporangium]] (Figures 2 & 3).	3.70a (FURTHERMORE) the structures were morphologically similar to sporangium 3.70b **SO WE ARE MORE CERTAIN** that these organisms were chytrid zoospores
3.71	Such findings in regular sea urchins have not been reported previously.	
3.72	IN CONTRAST, no motile zoospore-like structures were seen in specimens of *E. cordatum* collected.	
3.73	This was not expected	
3.74-75	as previous findings by Thorsen (1999) showed || them to be present in the anterior and posterior caecum of the digestive tract.	

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3.76	Such **discrepancy** is likely to be due to problems with the sampling methods [[used]] and the individual sea urchins [[studied]], as well as the limited knowledge in identifying possible structures of the fungi in the samples, as described in Sparrow (1960).	[[That it **is discrepant**]] is likely to be due to problems with the sampling methods [[used]] and the individual sea urchins [[studied]], as well as the limited knowledge in identifying possible structures of the fungi in the samples, as described in Sparrow (1960).
3.77	Such taxonomic identification would be followed closely in future studies.	
3.78	<u>(FURTHERMORE)</u> Prokaryotic organisms, likely to be bacteria, were also seen in these samples (Figures 4a, 4b & 5).	
3.79	WHILST these were not identified,	
3.80	it is likely that they included the bacterial taxons *Bacteroidetes, Firmicutes* and *α-Proteobacteria*,	
3.81	all of which have been found in E. cordatum (da Silver et. al. (2006)).	
3.82	Plating samples [[taken from the regular urchins]] provided some information as to the composition of the microflora [[observed]], with three bacterial and nine fungal colonies in total.	
3.83	These included filamentous fungi, possibly species of *Penicillium* or *Aspergillus* – BUT not chytrids.	
3.84	*Penicillium* and *Aspergillus* are abundant fungal taxon in terrestrical environments	
3.85	<u>BUT</u> have also been shown to inhabit a wide range of hosts within marine environments,	
3.86	AS SUCH their **presence** would be expected (Morrison-Gardiner (2002)).	AS SUCH (according to Morrison-Gardiner) we expected to see them **present**

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3.87	Other members of the geofungi, terrestrial fungi which are able to live in marine environments, such as Cladosporium and Alternaria may also be present within sea urchins and other marine invertebrates (Morrison-Gardiner (2002)).	
3.88	The densities of these colonies were much less than were expected from the high densities of microbes [[**INITIALLY** observed]].	The densities of these colonies were much less than were expected from the high densities of microbes [[that we observed **AT FIRST**]].
3.89	This **decline** may **HAVE RESULTED FROM** the **prolonged storage** of the samples at six degrees Celcius BEFORE plating,	3.89a The density **is less** 3.89b maybe **BECAUSE** we **stored** the sample at six degrees **for long time** 3.89c BEFORE plating
3.90	**RESULTING IN** only the more resilient organisms remaining viable.	**SO** only the more resilient organisms remain viable
3.91	ALTHOUGH it was possible that chytrids were present within the samples [[used]],	
3.92	none were present in culture	
3.93	**This** may **HAVE BEEN DUE TO** the **prolonged storage** of these samples at low temperatures for a week**, as well as** the growth conditions [[used]].	3.93a perhaps **BECAUSE** we **extend the time of storing** these samples at low temperatures for a week 3.93b **AND ALSO BECAUSE** the conditions [[we used]] may be problematic
3.94	Members of the Neocallimastigomycota, <<well known for inhabiting the rumen of ruminant grazers>>, are obligate anaerobes (Trinci *et. al.* (1994), Webster & Weber (2007)).	
3.95	AS the only **documentation** of chytrids within the Echinodermata have been within the anaerobic environment of the caecum of *E. cordatum*	AS chytrids within the Echinodermata have only **been documented** within the anaerobic environment of the caecum of *E. cordatum*

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3.96	it is probable that any chytrids [[present within members of the Echinodermata]] would also be obligately anaerobic,	
3.97	AND would not be viable on cultures [[grown under aerobic conditions]] (Thorsen 1999).	
3.98-99	FURTHERMORE, as mentioned previously, only very resilient microbes would have remained viable **AFTER** the extended **storage** periods.	3.99a only very resilient microbes would have remained viable
		3.99b **AFTER** they are **stored** for extended periods
3.100	The body of sea urchins are open systems.	
3.101	(SO) IF chytrids were present within the Echinoidea	
3.102	it is possible that they may be transient, not symbiotic, members.	
3.103	IN PARTICULAR, the possible **presence** of chytrids within the coelomic fluid of *P. Phyllacanthus* and *E. heliopneustes* could **HAVE RESULTED FROM ingestion** of algae	IN PARTICULAR, 3.103a chytrids are possibly **present** within the coelomic fluid of *P. Phyllacanthus* and *E. heliopneustes*
		3.103b perhaps **BECAUSE** algae have been **ingested**
3.104	FOR EXAMPLE, *Chytritium polysiphoniae*, a parasite of brown algae, may have been ingested by the urchins via normal feeding mechanisms,	
3.105	AND may not be present as part of the normal flora (James *et. al.* (2006), Webster & Weber (2007)).	
3.106	The possibility of such **transience** should be investigated in future experiments.	The possibility [[that it is **transient**]] should be investigated in future experiments.
3.107	Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea.	
3.108	Host-microbial relationships may include parasitism, commensalism and symbiosis.	
3.109	AS there did not appear to be any defects in the urchins,	

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3.110	it is likely that the microbes [[present in the urchins [[studied]]]] were either commensal or symbiotic organisms.	
3.111	Members of the Chytridiomycota produce enzymes that have the **ability** to degrade a wide variety of substrates, including cellulose, keratin and chitin (Douglas (1994), Trinci *et. al.* (1994), Webster & Weber (2007)).	Members of the Chytridiomycota produce enzymes [[which are able to degrade a wide variety of substrates, including cellulose, keratin and chitin]]
3.112	This, in addition to the physical **degradation** of substrates **resulting from** hyphal growth, **ALLOW** materials to be more readily degraded by fungi and bacteria.	3.112a hyphal growth **causes** the substrates to **degrade** physically. 3.112b **SO** materials are more readily degraded by fungi and bacteria
3.113	Anaerobic chytrids play essential roles in terrestrial herbivores (Trinci *et. al.* (1994)).	
3.114	AS regular sea urchins are herbivorous	
3.115-116	it could be assumed that chytrids present in their gut might **AID** the **degradation** of plant material and nutrient **acquisition**,	it could be assumed that 116a chytrids [[that are present]] in sea urchins' gut can help the gut to degrade plant material 116b and acquire nutrient.
3.117	<u>HOWEVER</u> further study would be needed to confirm this.	
3.118	There were a number of aspects [[which were unaddressed in this report <u>and</u> should be accounted for in future studies]]	
3.119	<u>FIRSTLY,</u> it remains unclear whether the zoospore-like structures were chytrids <u>OR</u> IF they belonged to another fungal group	
3.120	Further **analysis** could be **performed**	we could **analyse** it further.
3.121	(BY) using biochemical tests or molecular sequencing methods, such as DNA sequencing,	
3.122	(IN ORDER) TO identify these organisms [[present to a species specific level]].	

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3.123	Higher resolution microscopy, and possibly **observation** of the gut wall structure [[(BY) using a scanning electron microscope]] could also **aid** in **identification and** further **understanding** of the host-microbe relationship.	3.123a **IF** we observe the gut wall structure,
		3.123b by using a scanning electron microscope or higher resolution microscopy,
		3.123c **THEN** we could **identify**…
		3.123d AND THEN **understand** further the host-microbe relationship
3.124	SECONDLY, the components of the digestive tract and coelom of sea urchins vary greatly,	SECONDLY, 3.124a the components of the digestive tract and coelom of sea urchins vary greatly,
	WITH each section [[having differing roles and environmental conditions – including variation in pH, chemical composition, oxygen concentration and toxicity	3.124b **BECAUSE** each section has different roles and environmental conditions . – including variation in pH, chemical composition and oxygen concentration and toxicity
	– **WITH** the microbial composition and activity present varying accordingly]] (da Silva *et. al.* (2006), Thorsen (1998), Thorsen (1999)).	3.124c **SO THAT** the microbial composition and activity [[that are present]] vary accordingly.
3.125	Such **variation** was not considered within this preliminary work, **WITH** samples [[taken from an [[unidentified]] section of the gut]].	3.125a [[That they vary]] was not considered within this preliminary work,
		3.125b **BECAUSE** samples are taken from an [[unidentified]] section of the gut.
3.126	(THEREFORE) Further study should also **involve** greater **specificity** in the sampling methods,	(THEREFORE) sampling methods need to be **more specific in** further study
3.127	(BY) taking into account this variation in microhabitats.	
3.128	The **identification** of microorganisms within sea urchins, and **attempts** to understand their role in such a relationship is significant for a number of reasons.	3.128a It is significant to **identify** microorganisms within sea urchins,
		3.128b AND we **attempt** to understand their role in such a relationship, for a number of reasons

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3.129	AS there has been limited research on both the **identification** and role of microbes within the Echinodermata,	AS there has been limited research on [[**identifying** microbes]] and (studying) its role within the Echinodermata
3.130	such research would provide information on an area [[where there is a current **lack** of knowledge]].	such research would provide information on an area [[where the current knowledge is **not enough**]].
3.131	ALTHOUGH it is unclear whether these possible chytrids are related to those [[found in the rumen of terrestrial herbivores]],	
3.132	[[understanding these relationships]] would also **ASSIST** [[**understanding** of ecological and evolutionary relationships between animals and microorganisms]].	3.132a **BY** understanding these relationships 3.132b we could **understand** the ecological and evolutionary relationships between animals and microorganisms
3.133	SECONDLY, the Chytridiomycota are a polyphyletic taxon,	
3.134	which are characterised by the **presence** of flagellated zoospores.	Chytridiomycota are characterised by the fact [[that flagellated zoospores are **present**]]
3.135	This characteristic is thought to have been present in the common ancestor of the fungi,	
3.136-137	AND the **use** of this plesiomorphic character **FOR classification MEANS** that the **classification** of this phylum is only weakly **supported** by phylogenetic analysis (James *et. al.* (2006)).	3.136a AND we **used** this plesiomorphic character 3.136b **IN ORDER TO classify** the organism 3.137 **SO THAT** the phylogenetic analysis only weakly allows this phylum **to be classified**.
3.138	[[Sampling a greater diversity of environments, including within the Echinoidea]], may **PROVIDE** further **understanding** of phylogenetic diversity and relationships of the Chytridiomycota,	3.138a **IF** we sample a greater diversity of environments, including within the Echinoidea, 3.138b **THEN** we could **understand** further about phylogenetic diversity and how Chytridiomycota **relate** to each other.
3.139	**AIDING** the **classification** of such organisms (James *et. al.* 2006).	**SO THAT** we can **classify** such organisms

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3.140	FURTHERMORE, symbiotic microorganisms, including anaerobic fungi, have been shown **to increase** the **efficiency** of nutrient **uptake**,	FURTHERMORE it has been shown that symbiotic microorganisms, including anaerobic fungi **make** nutrient **to be taken up more efficiently**.
3.141	and may be necessary for herbivory (Douglas (1994), Trinci et. al. (1994), Webster & Weber (2007)).	
3.142	Microbe-host interactions in marine invertebrates are also of economic **importance**	Microbe-host interactions in marine invertebrates are also economically **important**
3.143	AS they can affect the **health** of animals, including shellfish (Harris (1992)).	AS they can **make** animals including shellfish **healthy**
3.144	THEREFORE, [[identifying components of the normal microbial community in sea urchins]], and [[understanding such relationships]] would also be beneficial **IN** [[**establishing** of conservation and aquaculture projects]].	THEREFORE, 3.144a it would be beneficial to identify components of the normal microbial community in sea urchins, 3.144b and understand such relationships 3.144c **WHEN/IF** we **establish** conservation and aquaculture projects.

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Text 4

NO.	original text – 3rd year research report (BIOL3917)	grammatical metaphor unpacked
	Abstract	
4.1	The viability of fungal spores after ingestion and **passage** through the gastrointestinal tract of an insect may be determined by the effect of the physical and chemical processes involved in the ingestion and digestion of food.	The viability of fungal spores after ingestion and **passing** through the gastrointestinal tract of an insect may be determined by the effect of the physical and chemical processes involved in the ingestion and digestion of food.
4.2	In particular, mandibular maceration could damage fungal spore integrity	
4.3	AND **RESULT IN** spores losing their viability.	**SO THAT** spores lose their viability
4.4	The purpose of this study was to determine whether the size of fungal spores was a factor in affecting spore viability after **passage** through the gastrointestinal tract of the Australian plague locust, *Chortichocetes terminifera*.	The purpose of this study was to determine whether the size of fungal spores was a factor in affecting spore viability after **passing** through the gastrointestinal tract of the Australian plague locust, *Chortichocetes terminifera*.
4.5	The effect of spore size on viability was tested	
4.6	(BY) using five genera of dung fungi – *Absidia*, *Isaria, Penicillin, Phycomycetes* and *Podospora*	
4.7	– whose spores were fed to either second or fifth instar *C. terminifera*.	
4.8	*Absidia, Isaria* and *Penicillin* spores were recovered from both the faecal and gut samples from second and fifth instars,	
4.9	**FOLLOWING** feeding by *C. terminifera* on wheat inoculated with fungal spores.	**AND THEN** they were fed by *C. terminifera* on wheat inoculated with fungal spores.
4.10	*Phycomyces* was not recovered from faecal material obtained from second instars	
4.11	but was present in all other samples.	
4.12	*Podospora* spores, 20um in diameter, were not recovered from	

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	any of the samples.	
	Introduction	
4.13	A complex **interaction** exists between insects and the health and diversity of fungal communities.	Insects and the health and diversity of fungal communities interact with each other in a complex way.
4.14	These **interactions** may be beneficial to both insects and fungi, for example symbiotic relationships between termites and cellulase-producing gut fungi (Slater, 1992)	it is **beneficial** that insects and fungi interact…
4.15	Insects may also aid the dispersal of fungal spores either externally or internally,	
4.16	increasing the ecological niche [[in which fungal species may inhabit]] and potentially affecting higher plant and animal diversity through the **spread** of symbiotic mycorrhizal fungi or entomo- and entero-pathogens (Collier & Bidatnodo, 2008; Dromph, 2000; Devarajan & Suryanarayanan, 2006; Nakamori & Suzuki, 2009; Vernes & Dunn, 2009).	4.16a (AND THEN/SO) increasing the ecological niche [[in which fungal species may inhabit]]
		4.16b (AND THEN/SO) potentially affecting higher plant and animal diversity
		4.16c through **spreading** symbiotic mycorrhizal fungi or entomo- and entero- pathogens,
4.17	HOWEVER, insect-fungi interactions may also be detrimental to both groups	
4.18	AS **shown** in the **effectiveness** of the **use** of fungal entomopathogens in biocontrol (Ouedraogo, 2002) AND in the **loss** of spore viability, in some fungal taxa, after ingestion and **passage** through the gut of insects	4.18a AS Quedraogo (2002) shows fungal entomopathogens is **effectively used** in biocontrol; ||
		4.18b ALSO BECAUSE spore viability **is lost** in some fungal taxa after ingestion and **passaging** through the gut of insects ||
4.19	**Loss** of fungal spore integrity and viability after ingestion and passage through the insect gastrointestinal tract may **result from** either physical processes, chemical processes or a **combination** of both.	physical processes, chemical processes, or both of them can **make** fungal spore **lose** their integrity and viability after ingestion and passage through the insect gastrointestinal tract

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4.20	Physical processes such as maceration by mouthpieces or peristaltic movement through the gut could cause spores to fracture	
4.21	AND THEN (cause spore to) lose their integrity.	
4.22	SIMILARLY, chemical processes including enzymic digestion or antifungal compounds could cause spores to lose their viability	
4.23	WHILST retaining their integrity	
4.24	These mechanisms may **EXPLAIN**	**SO WE KNOW** why **AFTER passing** through the insect gut ||
4.25	why fungal spore viability **AFTER passage** through the insect gut is either reduced or unaffected (Dromph, 2000; Devaranjan & Suryanarayanan, 2006; Nakamori & Suzuki, 2009; Pupitel et al, unpublished data).	fungal spore viability is reduced or unaffected ||
4.26	The **ability** for fungal spores to withstand such processes may be **due to** intrinsic characteristics of the fungal spore,	intrinsic characteristics of the fungal spores **make** them **to be able to** withstand such processes.
4.27-28	IN PARTICULAR spore size may **EXPLAIN** why some fungal spores retain their viability WHILST other spores lose viability (Pupitel et al, unpublished data)	IN PARTICULAR 4.27 **BY** observing spore size 4.28a **WE MAY KNOW** why some fungal spores retain their viability 4.28b WHILST other spores lose viability
4.29	We propose a model,	We propose a model
4.30	whereby smaller fungal spores are more likely to retain integrity and viability, after ingestion and passage through the insect gut, than larger spores, **DUE TO** the **ability** for [[smaller spores to more easily avoid maceration by insect mouthpieces]]	4.30a. (that is) smaller fungal spores are more likely to retain integrity and viability after ingestion and passage through the insect gut, than larger spores 4.30b. **BECAUSE** smaller spores **are** more **able to** easily avoid maceration by insect mouthpieces ||
4.31	This model was tested	
4.32	(BY) using dung fungal spores	

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4.33	AND (BY) examining their passage through the gut of the Australian plague locust, Chortichocetes terminifera.	
4.34	The Australian plague locust, *Chortichocetes terminifera*, ingests large amounts of biomass	
4.35	AND travels over a large geographical range,	
4.36	(<u>THEREFORE</u>) making such a study ecologically realistic and important (Walker *et al*, 2007).	
4.37	<u>IN PARTICULAR</u>, different developmental stages of *C. terminifera* have mandibles of different sizes,	
4.38	YET consume the same food,	
4.39	<u>(THEREFORE)</u> this insect is ideal to test our model of fungal spore size affecting viability after ingestion and passage.	
4.40	Coprophilous fungal spores were used as a model	
4.41	<u>**ON ACCOUNT OF**</u> their **specialization** to survive passage through the guts of herbivorous animals (Dix & Webster (1995)).	<u>**BECAUSE**</u> that they are **specialised** to survive passage through the guts of herbivorous animals
4.42	The fungal taxa – *Absidia, Penicillin, Isaria, Podospora* and *Phycomycetes* – were chosen on the basis of the adaptations associated with their ecological niche,	
4.43	<u>THAT IS,</u> the ability to pass unharmed through the chemical environment [[found in the digestive tract of herbivores]]	<u>THAT IS,</u> **being able to** pass unharmed through the chemical environment [[found in the digestive tract of herbivores]]
4.44	<u>AS</u> these fungi also vary in spore size	
4.45	the **use** of [[dung fungi to test this model]] is ideal.	it is ideal that we **use** dung fungi to test this model
4.46	Applying the model above to the system of dung fungi and C. terminifera	
4.47	it is likely that the viability of spores will be dependent on both the size of fungal spores and the size of the insect mouthpiece.	

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6) (non-lexicalised connexions)

4.48	It is predicted that small spores will retain viability after ingestion by both second and fifth instar C. terminifera	
4.49	WHILST larger spores will lose viability after ingestion by either fifth instar *C. terminifer* only or both developmental stages.	
	Materials and Methods	
4.50	Species of *Penicillium, Podopspora, Absidia, Isaria* and *Phycomyces* were isolated from possum faeces (Table 1).	
4.51	The fungi were cultured on 3.5% Potato Dextrose Agar (PDA).	
4.52	Plates of each fungus were flooded with 0.02% Triton-X	
4.53	AND the mycelium agitated	
4.54	(IN ORDER) TO remove the spores.	
4.55	Individual spore suspensions were inoculated	
4.56	(IN ORDER) TO surface sterilized wheat, with five replicates of each fungus and a control (0.02% Triton-X solution).	
4.57	The **effectiveness** of **inoculation** was checked	We checked [[whether it is **effectively inoculated**]]
4.58	BY spraying a fresh PDA plate with spore solution	
4.59	and monitoring spore germination	
4.60	Thirty second instar and thirty fifth instar larvae of gregarious phase *C. terminifera* were starved for 24 hours.	
4.61	Individual locusts were placed on one of the six treatments	
4.62	AND allowed (we allowed them to) to feed for a period of 24 hours.	
4.63	Individual locusts were THEN moved to clean containers	
4.64	AND all faeces were collected.	
4.65	The gastrointestinal tract of each locust was removed	4.65a The gastrointestinal tract of each locust was removed

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	FOLLOWING collection of the faeces.	4.65b **AFTER** the faeces **were collected**.
4.66	Faceal samples were macerated in 50 or 100ul of sterile de-ionised water for fifth and second instar samples respectively	
4.67	BECAUSE the quantity was much greater from the larger insects.	
4.68	A one in ten dilution of each collection was THEN prepared	
4.69	AND plated onto dung extract agar with antibiotics (2% agar, 20 pellets of possum dung per litre of media, 25mgL-1 Penicillin G, 25mgL-1 Streptomycin Sulphate in tap water to provide trace elements).	
4.70	Samples of digesta from the GIT were diluted one in twenty	
4.71	AND plated out on dung extract agar.	
4.72	The plates were observed over a period of 4-14 days	
4.73	AND any colonies unique to treatment plates were identified.	
	Result	
4.74-75	A positive result for spore viability after ingestion determined when the target fungi was isolated from three or more of the five replicates.	
4.76	Additional growth on treatment plates was compared to non-target fungal growth [[present on control plates from the spore-free controls]].	
4.77	Growth of *Absidia*, *Penicillium* and *Isaria* on dung extract media, from the faecal and gastrointestinal tract samples of their respective treatments, for both second and fifth instar C. terminifera was positive (Table 1 and 2).	
4.78	*Phycomyces* was absent from the faeces of the second instar locusts,	

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4.79	BUT was successfully isolated from the second instar crop and the fifth instar crop and faeces.	
4.80	*Podospora* spores were not re-isolated from any of the extracts of any individual.	
	Discussion	
4.81	*Penicillin, Isaria* and *Absidia* spores retained viability after ingestion by and passage through the gastrointestinal tract of both second and fifth instar *C. terminifera* (Table 1 and 2).	
4.82	IN COMPARISON, the larger spores of *Podospora* (14-20um) did not retain their viability (Table 1 and 2).	
4.83	Smaller mandibles fracture material into smaller fragments,	
4.84-85	SO it **<u>STANDS TO REASON</u>** that larger fragments would be more susceptible to **damage** by mandibular action (Clissold, 2008).	**<u>SO WE KNOW</u>** larger fragments would be more susceptible to be **damaged** by mandibular action
4.86	The **retention** of viability by the small spores can be **<u>EXPLAINED</u>** in relation to our model [[initially proposed, in that spore size affects the viability of spores]].	4.86a we proposed (the model) at the beginning that spore size affects the viability of spores
		4.86b **<u>SO WE KNOW</u>** the viability **is retained** by the small spores
4.87	The **absence** of *Podospora* from the crop is **<u>EVIDENCE</u>** for mandibular **damage** to the spores (Table 2b).	4.87a *Podospora* **was absent** from the crop
		4.87b **<u>SO WE KNOW</u>** mandibular **damaged** the spores
4.88	The crop is early in the digestive sequence,	
4.89-90	so the **early absence** of *Podospora* **<u>INDICATES</u> ||** that the spores were inviable||	4.89 *podospora* **was absent** early
		4.90 **<u>SO WE SUPPOSE</u>** that the spores were inviable
4.91	BEFORE entering the gut	
4.92-93	The results suggest that mandibular **manipulation** of [[ingested]] material **DETERMINES** the level of **damage** [[sustained by the [[ingested]] material, rather than physical and/or chemical activity [[that occurs later within the gastrointestinal tract of C. terminifera]]]].	4.92-93a The results suggest mandibular **manipulate** the [[ingested]] material
		4.93b **SO** the ingested material determines how bad it is damaged

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4.94	Such findings are consistent with current understanding of food processing by members of the Acrididae, **WITH fractionation** of material with teeth or mandibles in the primary mechanism of food processing (Clissold, 2008).	4.94a Such findings are consistent with current understanding of food processing by members of the Acrididae, 4.94b **BECAUSE** material with teeth or mandibles in the primary mechanism of food processing **fractionate**
4.95	Although the foregut is lined with sclerotised spines (Hochuli, *et. al.*, 1994; Uvarov, 1966)	
4.96	this is thought to **<u>aid</u>** in peristalsis and **separation** of material from digestive enzymes, rather than in the mechanical **degradation** of ingested material (Clissold, 2008; Hochuli, *et. al.*, 1994).	4.96a It is thought (Hochuli, *et. al.*, 1994; Uvarov, 1966) that foregut help with peristalsis 4.96b and **help** material to **separate** from digestive enzymes, 4.96c rather than helping ingested material to be **degraded** mechanically
4.97	The resident microbiota and digestive enzymes are also thought to **have little involvement** in the digestive process,	it is also thought resident microbiota and digestive enzymes **did not involve** in the digestive process,
4.98	SINCE the passage time of the ingested food is extremely short (Charnley et. al., 1985; Clissold, 2008; Uvarov, 1966)	
4.99	The literature and our findings support for the model [[that **loss** of fungal spore viability is mediated by mandibular maceration]].	The literature and our findings support for the model [[that mandibular maceration mediated fungal spore to **loss** its viability]].
4.100	Mandibles play a crucial role in the digestive process of the locust	
4.101	BY fragmenting ingested plant material	
4.102	TO release the nutritious cytoplasm (Clissold, 2008).	
4.103	**Fragmentation** of materials **REQUIRES** a fracture [[to be initiated and propagated through the material]]	4.103a a fracture **needs** to be initiated and propagated 4.103b **SO** the materials can **be fragmented**
4.104	Fracture **initiation is dependent upon** the fracture stress and **toughness** of the material (Clissold, 2008; Samson, 2006; Samson *et. al.,* 2001).	fracture stress and [[how **tough** the material is]] can **initiate** the fracture

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4.105-106	We propose that size also becomes a determining factor **IN** fracture **initiation** where fungal spores are concerned	4.105-106a We propose that size (of spores) also becomes a determining factor
		4.106b **WHEN** fracture is **initiated**
		4.106c where (as long as) fungal spores are concerned,
4.107	SINCE the **probability** of a mandible encountering a spore to initiate a fracture **is dependent upon** the circumference of the spore.	4.107a SINCE the circumference of the spore can allow (make it possible for) a mandible to encounter a spore
		4.107b AND THEN/SO THAT initiate a fracture
4.108	The **survival** of small but not large spores in this study **SUPPORTS** the **importance** of size in fracture initiation dynamics.	4.108a the small but not large spores **survived** in this study,
		4.108b **SO WE KNOW** the size in fracture initiation dynamics is **important**.
4.109	The results for *Phycomyces* indicated a **loss** of viability between the crop and the faeces in the second instar individuals.	The results for *Phycomyces* indicated that viability between the crop and the faeces in the second instar individuals was lost
4.110	The **loss** of viability as a result of passage through the gastrointestinal tract was unexpected,	(HOWEVER) it is unexpected that viability is **lost** as a result of passage through the gastrointestinal tract
4.111	especially BECAUSE all other small fungal spores remained viable after passage through the gut of *C. terminifera* (Tables 1 and 2).	
4.112	SINCE *Phycomyces* belongs to a different fungal taxa (Zygomyces) to the other isolates,	
4.113	it is possible that intrinsic structural **differences** such as the constituents of the spore wall could **INCREASE susceptibility** of the spores to antifungals and digestive enzymes of the locust gut.	4.113a it is possible that **BECAUSE** intrinsic structure such as the constituents of the spore wall are different
		4.113b the spores **become more susceptible** to antifungals and digestive enzymes of the locust gut
4.114	Spore viability may therefore be dependent not only on spore size, but also other intrinsic characteristics of the fungal spore	
4.115	HOWEVER, two of the five second instar *C. terminifera* replicates for *Phycomyces* treatment died during the treatment.	

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4.116	No faecal material was recovered	
4.117	AND the crops [[obtained from these individuals]] discarded.	
4.118	THUS, the **loss** of viability between the crop and faeces is probably not significant,	THUS, it is probably not significant that viability is lost between the crop and faeces
4.119	SINCE the sample number was three rather than five locusts.	
4.120	AS the young locusts were found to be quite delicate,	
4.121	further **investigations** would **BENEFIT FROM** the **use** of a larger sample size	4.121a **IF** we **investigate** further, 4.121b **THEN** it would be **beneficial to use** a larger sample size
4.122	TO **allow for** unexpected **deaths**.	IN ORDER TO allow samples to die
4.123	The **capacity** [[to interpret the **absence** of *Podospora* in the crop and faeces]] is somewhat **limited**,	we are **less able** to interpret why *Podospora* in the crop and faeces is **absent**.
4.124	SINCE there was no **progression** of spore sizes between 6-14 microns [[through which to evaluate the size at which viability was lost]].	SINCE spore sizes didn't **progress** between 6-14 microns [[through which to evaluate the size [[at which viability was lost]]]].
4.125	Without other results to corroborate the **loss** of viability at 14-20 microns,it is impossible to be sure that the loss of viability in Podospora was size related and not due to some other feature of the spore, such as cell wall composition	4.125a no other results corroborate that viability is lost at 14-20 microns 4.125b it is impossible to be sure that the size made Podospora lose its viability but not some other features of the spore, such as cell wall composition.
4.126	Future studies would benefit from [[resolving a more defined point [[at which spores cease to become viable]]]],	it would be beneficial for future studies that we resolve a more defined point at which spore cease to become viable.
4.127	AS this would inform the **design** of fungal biocontrols.	AS this would inform how to design fungal biocontrols
4.128	No **correlation** between the developmental stage of the insects and the size [[at which spores lost their viability]] was observed.	We didn't see that the developmental stage of the insets **correlate** to the size [[at which spores lost their viability]].

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4.129	The effect of developmental stage on spore size and viability could have been resolved	
4.130	IF a more comprehensive **spread** of spore sizes had been used, especially in the 6-14 micron range.	IF we have used spore sizes [[which are more comprehensively **spread**, especially in the 6-14 micron range]].
4.131	The potential for false positive results was considered	
4.132	and carefully controlled for in the experimental procedure.	
4.133	A key **concern** was [[to **avoid** the inadvertent **transmission** of spores on the locust cuticle between the feeding and 'spore-free' containers]].	it was concerned [[that spores on the locust cuticle was not **transmitted** inadvertently between the feeding and 'spore-free' containers.]]
4.134	The **CONSEQUENCE** of non-specific **transmission** is [[that spores could be isolated from the locust	4.134a **OTHERWISE** spore could be isolated from the locust
	WITHOUT having passed through the mandibles and gastrointestinal tract]].	4.134b WITHOUT having passed through the mandibles and gastrointestinal tract,
4.135	The **recovery** of spores from the crop was **<u>CONFIRMATION</u>** [[that spores has been ingested rather than being transported between containers on the locust exoskeleton]].	4.135a spores **recovered** from the crop
		4.135b **<u>SO WE KNOW</u>** spores has been ingested
		4.135c rather than being transported between containers on the locust exoskeleton]]
4.136-137	It was also noted that individuals preparing to moult ceased to eat	
4.138	which had **<u>IMPLICATIONS</u>** for the numbers of spores [[consumed]] and therefore the spore concentration in the crop and faeces.	4.138a **SO WE KNOW** the numbers of spores that are consumed 4.138b and <u>THEREFORE</u> **WE KNOW** the spore concentration in the crop and faeces.
4.139	[[Varying spore concentrations]] would have **AFFECTED** the **chances** of [[a spore being plated from the serial dilutions]].	4.139a **IF** the spore concentrations are varied
		4.139b **THEN** it is possible that [[a spore may not being plated from the serial dilutions]]
4.140	[[Fasting prior to moulting]] and the associated potential bias in data could be **avoiding**	We could avoid fasting prior to moulting and the associated potential bias in data

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4.141	BY selecting individuals at exactly the same stage of their lifecycle	BY selecting individuals at exactly the same stage of their lifecycle
4.142	Interestingly, none of the test organisms exposed to *Isaria* - a known entomopathogen – appeared to have contracted an infection.	
4.143	The **lack** of pathogenicity cannot be **ATTRIBUTED TO** a **loss** of spore viability,	4.143a there is **not enough** pathogenicity 4.143b **NOT BECAUSE spore lost viability**
4.144	SINCE viable spores were recovered from both the crop and faeces in all treated individuals.	
4.145	The **absence** of *Isaria* pathogenicity can be explained in two ways.	We can explain why Isaria pathogenicity was **absent** in two ways
4.146	Resident microbiota in the gut of the Desert Locust *(Schistocera gregaria)* have produced an antifungal compound [[that inhibits the germination of fungal spores invivo and invitro]] (Dillon & Charnley, 1985; Dillon & Charnley 1995).	
4.147	HOWEVER GIVEN THAT the *Isaria* spores were viable after passage through the gut,	HOWEVER, GIVEN THAT the Isaria spores were viable after passage through the gut
4.148	the antifungal would need to be fungistatic **IN** its **action**.	4.148a the antifungal would need to be fungistatic || 4.148b **WHEN** it is **acting** ||
4.149	The literature provides evidence [[that the compound is fungicidal]].	
4.150	The **ALTERNATIVE EXPLANATION** for the **absence** of colonization by *Isaria* is [[that the locust initiated some physiological response [[that prevented colonization]]]].	4.150a. **ALTERNATIVELY,** colonization by *Isaria was* absent 4.150b. **BECAUSE WE KNOW** the locust initiated some physiological response [[that prevented colonization]]
4.151-152	Evidence from *Locusta migratoria* has indicated that some locusts have an **ability** to induce a fever that **reduces** the **incidence** and **severity** of fungal infection by Metarhizium anisopliae	4.151-152a Evidence from *Locusta migratoria* has indicated some locusts are able to induce a fever; 4.152b THEN the fever can **make** fungal infection by Metarhizium anisopliae **happen less**

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		4.152c AND **make** the fungal infection **less severe**. ||
4.153	(<u>THEREFORE</u>) IF entomopathogens are to be developed towards a biocontrol, ||	
4.154	there are a number of fungal-insect interactions beyond physical spore destruction [[that **require consideration**]].	a number ways in which fungal and insect interact beyond physical spore destruction **needs to be considered**.
4.155	[[Understanding spore viability in an entomopathogen/host context]] is a crucial aspect of autodissemination, a biocontrol strategy [[that employs insects to introduce a fungal pathogen into a population]] (Ignoffo, 1977; Dromph, 2003; Meyling *et. al.* 2006).	
4.156-157	Our results indicate that the **success** of an autodissemination strategy [[involving ingestion]] will **REQUIRE** [[that spores are sufficiently small to survive ingestion]].	4.156-157a our results indicate that spores **need** to be sufficiently small to survive 4.157b **SO THEN** an autodissemination strategy [[which involves ingestion]] can be **successful**
4.158	A number of invertebrate hosts have been shown to aid fungal spore dispersal, including aphids (Meyling *et. al.* 2006), grasshoppers (Devarajan & Suryanarayanan, 2006) and snails (Dromph 2001, 2003).	It has been shown that a number of invetebrate hosts aid fungal spore dispersal, including aphids (Meyling *et. al.* 2006), grasshoppers (Devarajan & Suryanarayanan, 2006) and snails (Dromph 2001, 2003).
4.159	The dissemination of spores may hold **IMPLICATIONS** for the structure of higher plant and animal communities (Devarajan & Suryanarayanan, 2006; Vernes & Dunn, 2009)	4.159a **BY** knowing the dissemination of spores 4.159b **WE MAY KNOW** the structure of higher plant and animal communities (Devarajan & Suryanarayanan, 2006; Vernes & Dunn, 2009)
4.160	<u>AS</u> many fungal taxa are implicated in the **health** of ecological systems.	4.160a <u>AS</u> many fungal taxa are implicated 4.160b (IN/BY) whether the ecological systems are **healthy**
4.161	<u>FOR EXAMPLE</u>, grasshoppers (Acrididae) transfer the spores of fungal endophytes between plants in rainforest communities	

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4.162	THEREBY contributing to the diversity of endophyte communities (Devarajan and Suryanarayanan, 2006).	
4.163	The extent [[to which Acrididae-mediated dissemination occurs]] is possibly limited by the size of the spores,	
4.164	SINCE dissemination would be futile	
4.165	IF the spore were rendered inviable by the mandibles **IN THE PROCESS OF** [[macerating the leaf [[containing the spores]]]].	4.165a IF the spore were rendered inviable by the mandibles 4.165b **WHEN** mandibles macerate the leaf [[containing the spores]]
4.166	Fungal spore size appears to correlate to spore viability after ingestion and passage through the gastrointestinal tract of the Australian plague locust, *C. terminifera*.	
4.167	The results of this investigation contribute to a growing body of literature [[documenting the role of insects in transporting fungal spores]].	
4.168	AS **transport** of fungal spores has **<u>IMPLICATION</u>** to the **health** and diversity of animal and plant species, as well as the structure of higher plant and animal communities,	4.168a <u>AS</u> **IF WE KNOW** how fungal spores is transported 4.168b **WE WOULD KNOW** whether animal and plant species **are healthy** 4.168c and (**WE WOULD KNOW**) the diversity of animal and plant species, as well as the structure of higher plant and animal communities,
4.169	an **understanding** of the **relationship** between fungal spore viability would be beneficial **IN applications** of biocontrol, ecology and environmental management.	4.169a it would be beneficial to **understand** how fungal spore viability are **related** to each other 4.169b **WHEN** we **apply** it in biocontrol, ecology and environmental management.

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6) (non-lexicalised connexions)

Appendix C Orbital and serial structures

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
Text 1	**Introduction**																	
	1.1a				calibrate	a pipette	we											
	1.1b			so	could determine		we					theoretical volumes are related to the volume we obtained						purp
	1.2a		it is necessary		make the experiment	consistent			we									man
	1.2b			(by)	making the measured value and the set value	highly and consistently accurate			(we)									
	1.2c			and	making the measured values	highly and consistently precise			(we)									add
	1.3			in order to	make the experiment	less variable			(we)									purp
	1.4			and	make... more reproducible	(the experiment)			(we)									add
	1.5				were calibrated	a Finnpipette, and a Bio-Rad P2oo pipette		in this experiment										
	1.6			(by)	using	three methods	(we)											man
	1.7			and (then)	compared	these method	(we)											succ
	Methods																	
	1.8				was pipette	set amount of water	(by us)	into a container										
	1.9a			and	was measured	the weight of the water	(by us)											succ
	1.9b			and	was recorded	the weight of the water	(by us)											succ

					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	1.10				were pipetted	set amounts of dye	(by us)	into 1mL cuvettes										succ
	1.11			and	was added	water	(by us)											
	1.12			to	give	a total volume of 1mL												purp
	1.13			(and then)	was mixed	each solution	(by us)											succ
	1.14			and	were read	absorbances	(by us)											succ
	1.15			(by)	using	a spectrophotom eter	(we)											man
	1.16				were pipetted	set amounts of radioactive C-14	(by us)	into vials										
	1.17			and	were added	5mL of scintilliant	(by us)											succ
	1.18			then	was measured	the radioactive content of each vial	(by us)											succ man
	1.19			(by)	using	a specialised spectrophotom eter	(we)											
	Results																	
	1.20a		the weight of water method showed									the theoretical pipette and experimental value are closely correlated						consq
	1.20b										becaus e	the values	are not variable					
add	1.21	also	the method displayed									theoretical and experimental values are related linearly						
	1.22		because we see									the correlation coefficient is 0.9999						consq
	1.23		so we suppose									the pipette	is both accurate and precise		throughout its range			consq

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	1.24		according to this method									the pipette	was fairly inaccurate					
succ	1.25	further more										the pipette	became less accurate		towards the larger end of the pipette's range			
add	1.26										(and)	the readings	were minimally variable					
	1.27		so we know									the pipette	was fairly precise					consq
	1.28-29a		radioactivity method suggested									the pipette	was highly accurate throughout this range					
	1.29b										because	the set and measured volumes are different						consq
conc	1.30a	however										the readings	were significantly variable					
	1.30b		so we know									the pipette	was highly imprecise					consq
	Discussion																	
	1.31											the three methods did not agree upon the pipette's calibration						
i.e.	1.32	(that is)	the weight-of-water method suggested									the pipette	was highly accurate and precise throughout its range					
simil	1.33-34	similarly	spectrophotometry suggested									the pipette	was precise					
conc	1.35-36	however	it also suggested									the pipette	became less accurate					simul

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit								outer orbit					
					inner orbit								inner orbit					
					nucleus								nucleus					
					centre								centre					
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	1.37										as/when	increased	the set volumes					
conc	1.38-39	whilst	radioactivity suggested									the pipette	was moderately inaccurate and highly imprecise					
conc	1.40	while										seems to make...calibrate the best	pipette	by us		the weight-of-water method		
	1.41											there were a number of limitations						
	1.42a	firstly										the balance	was not sensitive enough					consq
consq	1.42b										because	only measures and detect	things larger than 1mg	the balance				
	1.43	thus			could be used	the balance	(by us)											
succ	1.44			when	calibrating	a P20and to some extent a p200												simul
	1.45a	secondly										the balance	was imprecise					
	1.45b										because if	is interfered externally	the balance					consq
succ	1.46											can fluctuate by 1-2g	the reading					cond
consq	1.47	(and)										this method	was time consuming					
	1.48a	(therefore)										the method	was the least useful					simul
conc	1.48b										when	pipette	calibrate	we				
add	1.49	however										the method	was easy to perform					
add	1.50	and										the equipment	was inexpensive					
	1.51a	(and)		if	use	calibrating tools...	we											cond
	1.51b			then								this method	could be more efficient					

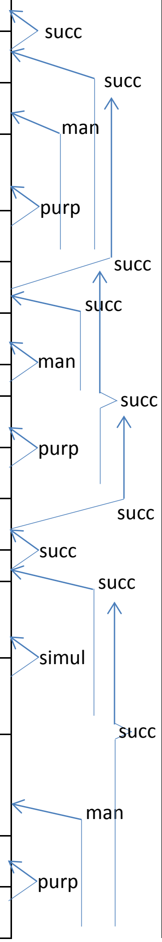
					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
add	1.52											were able to measure more accurately	the other two methods					
	1.53	(and)										could be used	(the other methods)	(by us)				
	1.54										when	calibrate	all three pipette	(we)				simul
consq	1.55	so										(the other methods)	significantly advantageous					
	1.56											the methods	are accurate to different degrees					
	1.57		so we know (why)									obtained	such different calibration results	we				consq
conc	1.58	(firstly) while										the radioactivity method	was fairly accurate					
succ	1.59											took a long time	it (the method)					
e.g.	1.60-61	secondly										our readings	were highly variable					
	1.62	such as										not depressing	the pipette	we	to the first stop			
alt	1.63	or										sucking up	air bubble		in the pipette			
conc	1.64a	(however)		if	repeat…more times	the method	we											
	1.64b			then	could make	minimal errors	we											cond
succ	1.65a	(thirdly)			spend	lots of money	we											
	1.65b			because	use	C-14 glucose and the specialised spectrophotometer	we	in this experiment										consq
consq	1.65c	(so)			would be effectively spent	the money	(by us)											
succ	1.66			if	use regularly	the method												cond
	1.67a	further more			must consider	safety hazards	we											
	1.67b			because	use	radioactive C-14 glucose	we											consq

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
succ e.g.	1.68a	and			must consider…in advance	some other things	we											
	1.68b	for example			are used	the gloves and the fume-cupboard	(by us)											
succ	1.69	in comparison										the readings in the spectrophotometer	were much less variable					
	1.70a	also										spectrophotometer	is highly sensitive					
consq	1.70b										even when	vary	the volumes					simul
	1.70c	so			can be used	spectrophotometer												
	1.70d			when	calibrate	all three pipette	we											simul
succ conc	1. 71	in addition										the readings	are variable		due to things such as fingerprints on the cuvette			
	1.72	however			can make the readings	less variable			we									
succ	1.73			by	(we)	being more careful												man
conc	1.74	(furthermore) although									at the beginning	the equipment	would have been expensive					
	1.75a			if	use frequently	the equipment	we											
succ	1.75b			then	would be more effectively spent	the money												cond
	1.76	additionally										provided	results [[that were easily and efficiently obtained]]	the spectrometer				

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	Conclusion																	
	1.77a	in conclusion			used	different methods	we											purp
	1.77b			to	calibrate	pipette												
	1.77c											these methods	were inaccurate to different degree					
	1.78	although	it was simple and inexpensive		to use	weight-of-water method												
conc	1.79											did not make the pipette	accurate and precise			the method		
simil; i.e.	1.80a	similarly										radioactivity method has disadvantages						
add	1.80b	that are										costs	more money	the method				
	1.80c	and										needs to be prepared for longer time	the method					
contr	1.81a	instead										provided	results [[that are precise and accurate]]	the spectroscopy				
add	1.81b	and										the method	is safe, quick and efficient					

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
Text 2	**Introduction**																	
	2.1											can be controlled	the activity of proteins					man
	2.2										through	influencing	levels of gene expression					alt
	2.3a										or (through)	activating/deactivating	proteins					
	2.3b										when	they (the proteins)are present			in the cytosol			simul
	2.4				was studied	the activity of B-galactosidase, an enzyme which breaks down lactose		in this experiment										
	2.5-6a		it is known								when	there is lactose						
	2.6b											increases	B-galactosidase activity					simul
	2.7a		this experiment aims to determine								if	is induced	the B-galactosidase					consq
	2.7b										then because	is produced	enzyme		through gene expression			
	2.7c										or because	is activated	enzyme					alt
add	2.8	(in addition)			investigate	the effect of [[adding glucose, and alternative food source to lactose]]	we											
	2.9				was achieved	this												man
	2.10-11			by	analysing							induce	B-galactosidase		in E.coli colonies [[which is exposed			

				FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
				outer orbit								outer orbit					
				inner orbit								inner orbit					
				nucleus								nucleus					
				centre								centre					
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity
															to...]]		
	Method																
	2.12				were cultured	E. coli bacteria		in a glycerol medium									
	2.13			(and then)	was added to the bacterial culture	one of the six treatments											
	2.14			(and then)	was monitored	Bacterial growth											
	2.15			by	measuring	absorbance at 600nm of samples											
	2.16			(in order to)	make sure	the logarithmic growth											
	2.17			(and then)	were taken	samples		at 0, 10, 20, 35 mins									
	2.18a			and then	were stopped	cellular reactions											
	2.18b			by	adding	Z Buffer SDS…											
	2.19			(and then)	was carried out	an ONPG assay											
	2.20			in order to	determine	the amount of B-galactosidase											
	2.21			(and then)	were incubated	the samples											
	2.22			and then	was added	ONPG											
	2.23			(and then)	was stopped	the reaction		with sodium carbonate									
	2.24			once/when	had been produced	a significant amount of visible O-NP		in one of the samples									
	2.25			(and then)	was measured spectroscopically	concentration of O-NP and hence B-galactosidase											
	2.26			(by)	taking	absorbance		at 420nm, and 550nm									
	2.27			(in order) to	allow for	turbidity correction											



					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	Discussion																	
	2.27											the control flask with nothing added demonstrated a basal level of B-galactosidase activity						consq
	2.28a		so we know		obtained	the results	we											consq
	2.28b			because	used	the treatment	we											
	2.29											the control flask containing lactose demonstrated a higher level of B-galactosidase activity			in comparison to the control flask with nothing added			consq
	2.30		so we know									the previous knowledge [[that lactose induces B-galactosidase activity]]	is true					
consq	2.31											the flask containing IPTG, a non-metabolised inducer demonstrated a significantly higher level of B-galactosidase activity			in comparison to the flask containing lactose			
	2.32	because										does not run out	the IPTG, unlike the lactose					consq
	2.33										as	is never metabolised	it (the IPTG)					
	2.34											the flask containing lactose as well as 5-FG or			in comparison to the flask			

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
												Chloramphenical, inhibitors of transcription and translation respectively demonstrated a lower level of B-galactosidase activity			containing just lactose			
	2.35-36		so we know									controls	B-galactosidase activity		gene expression			consq
	2.37										if	the alternative hypothesis [[that activating the already present B-galactosidase induces activity]]	was correct					cond
	2.38										then	the falsk containing lactose as well as 5-FG or Chloramphenicol would have demonstrated a similar level of B-galactosidase activity						
consq	2.39	because										does not affect	B-galactosidase activity	inhibiting transcription and translation				
	2.40										as	is not activated	it (B-galactosidase)		in this way			consq

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY							
					outer orbit								outer orbit						
					inner orbit								inner orbit						
					nucleus								nucleus						
					centre								centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	2.41											the flask containing lactose and glucose, a preferred simpler food source, demonstrated a lower level of B-galactosidase activity			in comparison to the flask containing lactose			
	2.42										then	sharply rose	the level of B-galactosidase activity		after a period of time			succ; consq
	2.43-44		so we suppose									was only activated	the B-galactosidase					
	2.45										once/ when	was depleted	the alternative food source					simul
	2.46											the data in this experiment	is highly variable					
	2.47										because	there are large error bars						consq
consq	2.48	because			are dealing with	living systems which are subject to be variable	we											
succ	2.49	also			the equipment such as the spectrophotometer could have problems													
succ	2.50a	lastly			collected	the data	many student groups											
	2.50b			so	the data	can be more variable												consq

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	Conclusion																	
	2.51a		it has been shown									is induced	B-galactosidase					consq
	2.51b										because	is controlled	it (B-galactosidase)	by gene expression				
	2.51c										instead of	activating/deactivating	the already present B-galactosidase					consq
	2.52a		because we know								when	there is lactose						
	2.52b											promotes	transcription or translation of B-galactosidase	lactose				simul
	2.52c										by	removing	a repressor					man
add	2.53a	also	it was demonstrated								when	a more preferable food source, glucose is present						
	2.53b											decreased	B-galactosidase activity					simul
	2.54a		it is possible because								if	glucose is present						consq
alt	2.54b										then	represses	B-galactosidase activity	it (glucose)				cond
	2.54c		or								if	glucose is absent						cond
	2.54d										then	is activated	B-galactosidase activity					

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit								outer orbit					
					inner orbit								inner orbit					
					nucleus								nucleus					
					centre								centre					
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
Text 3	**Abstract**																	
	3.1											the phylum Chytridiomycota contains many ecologically important species						
	3.2	In particu lar										some symbiotic species play an essential role in animal herbivory						
	3.3										(by)	aiding	the digestion of fibrous plant material ingested by the animal	(some symbiotic species)	through both mechanical and enzymatic action			man
	3.4	Whilst			have been observed	chytrids within the microflora of the irregular sea urchin	by Thorsen (1999)											
	3.5	and	it is thought		chytrids	are essential for herbivory												
conc	3.6a				has been done	little work												
	3.6b			to	identify and characterise	chytrids within the Echinoidea												
succ	3.7				aimed to investigate	methods of dissection of sea urchins	This prelimin ary study											
	3.8			as well as	present	some evidence [[that chytrids are present within...]]	This prelimin ary study											
	3.9											Small, round and motile structures may represent zoospores and sporangium.						
	3.10a				observe	these samples	We											
	3.10b		so we know it is									chytrid are present within						consq

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
			possible									the Echinoidea.						
	Introduction																	
	3.11											The Chytridiomycota are considered the most primitive phylum of the fungi						
	3.12											They are characterised by motile, usually uni-flagellate, zoospores which function in reproduction and propagation						
	3.13										althou gh	require… to survive	water	chytrids				
	3.14		(James *et. al.* 2006, Shearer *et. al.* 2007)									chytrids are found in both aquatic and terrestrial habitats and in diverse range of temperate zoones						conc
	3.15											Members of this phylum	are ecologically important					
add	3.16	and	(Webster & Weber 2007)									(members of this phylum) include plant and animal parasites, as well as the ruminant symbionts						

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit	outer orbit	outer orbit	outer orbit	outer orbit	outer orbit		outer orbit	outer orbit	outer orbit	outer orbit	outer orbit	outer orbit	
					inner orbit	inner orbit	inner orbit	inner orbit				inner orbit	inner orbit	inner orbit	inner orbit			
					nucleus	nucleus						nucleus	nucleus					
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.17											Ruminant fungi, and other microbial members of this community, play a significant role in animal nutrition						
i.e.	3.18	(that is)										help…to degrade	fibrous plant materials		within the rumen	ruminant fungi, and other microbial members …		succ
	3.19		(Douglas 1994)								and (then)	providing	a source of readily digestiable short chain fatty-acids and amino-acids		uminant fungi…			
consq	3.20	in particular	(Douglas 1994, Webster & Weber 2007)									help…to degrade	fibrous plant materials			chytrids	through physical and chemical processes…	
	3.21				has been studied significantly	ruminant symbiosis												
	3.22			yet	there has been little work as to the role of chytrids in marine invertebrate hosts													conc

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.23		Thorsen (1999) reported									chytrid is present in the digestive system of the irregular urchin *Echnocardium cordatum*						
conc	3.24	however			there has been no work													succ
	3.25			since	has elaborated on these findings		Thorsen (1999)											
	3.26a		this project aims to confirm									members of the chytrids are present within different species of sea urchin						simul
	3.26b		this project attempts to understand (why)	and								such organisms were present						
	3.27				aimed to determine	the most practical methods	the preliminary study											purp
	3.28			(in order) to	to be attempted	the project, in particularly collection and dissection methods												simul
	3.29a			also	aimed to provide	some evidence [[that chytrids are present within sea urchin]]	this preliminary study											man
	3.29b			through/ by	observing	the species		through microscopy										simul
	3.29c			and	using	culturing methods												

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
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					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	Methods																	
	3.30				were collected	Three species of regular sea urchin...		from the rocky-intertidal region...										add
	3.31			also	were collected	Specimens of the irregular urchin,	by SCUBA	...Watsons Bay										succ
	3.32a			then	were dissected,	These												man
	3.32b			(by)	following/using	the model presented by Thorsen (1998).												succ
	3.33			then	were taken	Samples		from the coelomic cavity and digestive tract of the sea urchins										succ
	3.34			and	were viewed			at 10 and 40 times magnificati on										man
	3.35			(by)	using	a light microscope												succ
	3.36			(and)	were stored	Samples taken from *E. heliocidaris* and *P. phyllacanthus*		at four degrees Celsius for a week										succ
	3.37			before	being plated	(the samples)		onto 3.5% salt agar media										succ
	3.38			then	were stored	(the samples)		at four degrees Celsius for a week										succ
	3.39			before	incubating aerobically	(the samples)		at room temperatur e										

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	Results																	
	3.40a				successfully dissected	both regular and irregular sea urchin species	we											
	3.40b			by	cutting	around the equator of the test												man
	3.41a				observed	the coelomic fluid of *E. Heliocidaris* and *P. phyllacanthus*	we	with microscopy										
	3.41b		then we saw									bacterial species, protists – such as *Paramecium* –, sea urchin haemocytes and other eukaryotic cells						succ
	3.42		we also saw									Round, motile, zoospore-like structures and structures that were similar in morphology to sporangium						add
	3.43			(and)								The coelomic fluid from the heart urchin, *E. cordatum*, contained eukaryotic organisms, including protists and a bi-flagellate organism						add
	3.44		we also observed									A number of round cells						add
conc	3.45	however										the round cells	did not to appear to be motile					

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
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					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.46											Samples [[..]], as well as a frozen sample, contained lower numbers of microorganisms and cell debris						
conc	3.47		we did not see									motile zoospore-like structures						
	3.48	But										there were a number of small asymmetrically shaped organisms that appeared						simul
	3.49										and	moved a little against the Brownian current	the small asymmetrically shaped organisms					
	Discussion																	
	3.50	(Firstly)	we saw									both prokaryotic and eukaryotic organisms, including bacteria cells, protists (...) within the samples						
add	3.51	and			examined	digestive tract of all species of regular sea urchin	we											
simil	3.52	similarly	we saw									both prokaryotic and eukaryotic organisms						
conc	3.53	however										the composition of this sample appeared to be varied to those [[observed in the regular urchins]].						

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.54										whilst	the sample sizes	are much too small to provide significant evidence					
	3.55		it is unusual									the compositions	are different					conc
	3.56										as	the diet and habitat of regular and irregular urchins	are different significantly					consq
	3.57a		it has been demonstrated									microbial activity is present in both regular and irregular sea urchins						
	3.57b		it is thought (da Silver et. al. 2006, Sawabe et. al. 1995, ...)								(since)	aid	host digestion and nutrition	the microbial community	through both physical and chemical methods			consq
simil	3.58a	in particular	it is likely (da Silver et. al. 2006, Sawabe et. al. 1995, ...)								when	bacteria is present						
	3.58b											may produce	fatty acids					simul
	3.58c										(so then)	would be unable to synthesise	fatty acids	the host				succ
	3.58d										and	may produce	enzymes	the bacteria				succ
	3.58e										(so then)	help...to degrade	the ingested material			the enzymes		succ
	3.59										also	may help fix	nitrogen			Some bacteria		add
	3.60		(Harris 1992)								so that	successfully thrive	on diets	their hosts can	with a high carbon-to-nitrogen ratio			purp

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.61											These aquatic microorganisms may play a similar role to terrestrial gut symbionts						
i.e.	3.62a	(that is)	(Harris 1992, Webster & Weber 2007)									aid	host digestion and nutrition	these aquatic microorganisms				
	3.62b										in order to	constantly supply	nutrients		within a homeostatic environment			purp
	3.63	(secondly)	we saw									Small circular cells, which appeared to oppose the direction of the Brownian current...						
	3.64										as	moved against the current	they					
	3.65		it is likely									these cells	were motile					consq
	3.66		so we suppose									flagella were present						consq
conc	3.67	however			the microscopic resolution	was not enough to allow us to observe the simple or multiple flagella												
conc	3.68	(nonetheless)										they have apparent motility and shape						
	3.69		so we suppose									that these organisms could						consq

	FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
				outer orbit							outer orbit						
				inner orbit							inner orbit						
				nucleus							nucleus						
				centre							centre						
no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
											be chytrid zoospores						
3.70a	(furthermore)										the structures were morphologically similar to sporangium						
3.70b		so we are more certain									these organisms were chytrid zoospores						consq
3.71				have not been reported	Such findings in regular sea urchins		previously										
3.72	in contrast	we didn't see									motile zoospore-like structures in specimens of *E. cordatum*						
3.73				was not expected	this finding												
3.74-75		as previous findings by Thorsen (1999) showed									the motile zoospore-like structure were present in the anterior and posterior caecum of the digestive tract.						consq
3.76		as described in Sparrow (1960)		the different findings	is likely to be due to problems with the sampling methods and the individual sea urchins …												
3.77				would be followed closely	Such taxonomic identification	in future studies.											

	FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
				outer orbit							outer orbit						
				inner orbit							inner orbit						
				nucleus							nucleus						
				centre							centre						
no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
3.78	(furthe rmore)	we saw									Prokaryotic organisms, likely to be bacteria, in these samples						
3.79			whilst	were not identified	these organisms												conc
3.80		it is likely									they included the bacterial taxons *Bacteroidetes, Firmicutes* and *α-Proteobacteria*						consq
3.81		(da Silver et. al. 2006)	(since)	have been found in E. cordatum	all of which (the bacterial taxons)												
3.82											provided	some information as to the composition of the microflora	Plating samples				
3.83											These included filamentous fungi, possibly species of *Penicillium* or *Aspergillus* – BUT not chytrids.						
3.84											*Penicillium* and *Aspergillus* are abundant fungal taxon in terrestrical environments						conc
3.85		but it has also been shown (Morrison-Gardiner, 2002)									inhabit	*Penicillium* and *Aspergillus*		in a wide range of hosts within marine environme nts,			consq
3.86		as such we would expect									*Penicillium* and *Aspergillus* are present						

		FIELD OF RESEARCH										FIELD OF OBJECT OF STUDY						
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					inner orbit								inner orbit					
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					centre								centre					
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	3.87		(Morrison-Gardiner (2002))									Other members of the geofungi...may also be present within sea urchins...						
	3.88											The densities of these colonies	were much less than were expected from the high densities of microbes					
	3.89a											the density	became less					consq
	3.89b			because	stored	the sample at six degrees	we	for long time										succ
	3.89c			before	plating													
	3.90										so	only the more resilient organisms	remain viable					consq
conc	3.91	althoug h	it was possible									that chytrids were present within the samples used						
	3.92											none were present in culture						
add	3.93a			because	extend	the time of storing these samples at low temperatures	we	for a week										consq
	3.93b			also because	the conditions [[we used]]	may be problematic												
	3.94		(Trinci *et. al.* 1994, Webster & Weber 2007)									Members of the Neocallimastigo mycota are obligate anaerobes						

	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	3.95		as it has only been documented									chytrids within the Echinodermata are within the anaerobic environment…						
	3.96		it is probable									that any chytrids [[present within…]] would also be obligately anaerobic						consq
	3.97		(Thorsen 1999)								and	would not be	viable on cultures [[grown under aerobic conditions]]					add
	3.98-99a	further more	as mentioned previously									only resilient microbes would have remained viable						
	3.99b			after	are stored			for extended periods										succ
	3.100											The body of sea urchins are open systems						
consq	3.101	(so)									if	chytrids were present within the Echinoidea						
	3.102		it is possible									that they may be transient, not symbiotic, members.						cond
simil	3.103a	in particular	it is possible									chytrids are present within the coelomic fluid…						
	3.103b		because									have been ingested	algae					consq
e.g.	3.104	for example										may have been ingested	*Chytritium polysiphoniae*, a parasite of	by the urchins	via normal feeding mechanism			

					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
													brown algae		s			
	3.105		(James *et. al.* 2006, Webster & Weber 2007)								and (/so then)	may not be present as part of the normal flora						consq
	3.106				should be investigated	The possibility [[that it is transient]]	in future experiments											
	3.107											Members of the Chytridiomycota may be involved in symbiosis with the Echinoidea						
	3.108											Host-microbial relationships may include parasitism, commensalism and symbiosis						
	3.109										as	there did not appear to be any defects in the urchins						consq
	3.110		it is likely									the microbes were either commensal or symbiotic organisms.						
	3.111		(Douglas 1994, Trinci *et. al.* 1994, Webster & Weber 2007)									produce	enzymes [[...]]	Members of the Chytridiomycota				
	3.112a										(so then)	causes to... degrade physically	the substrates			hyphal growth		purp
	3.112b										so that	are more readily degraded	materials	by fungi and bacteria				purp

	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
					FIELD OF RESEARCH						FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	3.113		(Trinci *et. al.* 1994)									Anaerobic chytrids play essential roles in terrestrial herbivores						
	3.114										as	regular sea urchins are herbivorous						
	3.115		it could be assumed									can help… to degrade	plant material	the gut		chytrids in sea urchins' gut		consq
	3.116										and	acquire	nutrient	the gut		chytrids in sea urchins' gut		simul
conc	3.117	howev er	it is necessary		confirm	this/hypothesi s	further study											
	3.118a				were unaddressed	a number of aspects	in this report											
	3.118b			<u>and</u>	should be accounted for	(a number of aspects)	in future studies											
alt	3.119a	firstly	it remains unclear whether									the zoospore-like structures were chytrids						
	3.119b	or										they belonged to another fungal group						
	3.120				could analyse further.	it (the structures)	we											man
	3.121			(by)	using	biochemical tests or molecular sequencing methods, such as DNA sequencing												
	3.122			(in order) to	identify	these organisms [[present to a species specific level]].												purp

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					outer orbit							outer orbit					
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					nucleus							nucleus					
					centre							centre					
no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
3.123a			if	observe	the gut wall structure	we											man; cond
3.123b			by	using	a scanning electron microscope or higher resolution microscopy												
3.123c			then	could identify	the host-microbe relationship	we											simul
3.123d			and	understand further	the host-microbe relationship												
3.124a	secondly	(da Silva *et. al.* 2006, Thorsen 1998, Thorsen 1999)									the components of the digestive tract and coelom of sea urchins	vary greatly					consq
3.124b										because	each section has different roles and environmental conditions						consq
3.124c										so that	the microbial composition and activity	vary accordingly					
3.125a				was not considered	[[that they are different]]		within this preliminary work,										consq
3.125b			because	are taken	samples		from an [[unidentified]] section of the gut.										
3.126	(therefore)			sampling methods	need to be more specific		in further study										consq (3.125–3.127); man
3.127			(by)	taking into account	this variation in microhabitats												
3.128a		it is		identify	microorganism												

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					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
			significant ...for a number of reasons			s within sea urchins												simul
	3.128b			and	attempt to understand	their role in such a relationship												
	3.129	(firstly)		as	there has been limited research on [[identifying microbes]] and (studying) its role within the Echinodermata													
	3.130				would provide	information on an area [[where the current knowledge is not enough]].	such research											consq
	3.131		although it is unclear whether									these possible chytrids are related to those [[found in the rumen of terrestrial herbivores]]						
	3.132a			by	understanding	these relationships												conc
	3.132b				could understand	the ecological and evolutionary relationships between animals and microorganisms	we											man
succ	3.133	secondly										the Chytridiomycota are a polyphyletic taxon						
	3.134											Chytridiomycota						

					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
												are characterised by the fact [[that flagellated zoospores are present]]						
add	3.135		it is thought									This characteristic has been present in the common ancestor of the fungi						
	3.136a	and			used	this plesiomorphic character	we											
	3.136b			in order to	classify	the organism												purp
consq	3.137	so that	(James *et. al.* 2006)		only weakly allows...to be classified.	this phylum			the phylogenetic analysis									
	3.138a			if	sample	a greater diversity of environments, including within the Echinoidea	we											
	3.138b			then	could understand further	about phylogenetic diversity and how Chytridiomycota relate to each other	we											cond
	3.139		(James *et. al.* 2006)	so that	can classify	such organisms	we											purp
succ	3. 140	further more	it has been shown									make...to be taken up more efficiently	nutrient			symbiotic microorganisms, including		

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					inner orbit								inner orbit					
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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
																anaerobic fungi		add
	3.141		(Douglas 1994, Trinci et. al. 1994, Webster & Weber 2007)								and	symbiotic microorganisms may be necessary for herbivory						
add	3.142	also										Microbe-host interactions in marine invertebrates	are economically important					consq
	3.143		(Harris 1992)								as	can make animals including shellfish	healthy			Microbe-host interactions		
consq	3.144a	therefore	it would be beneficial		to identify	components of the normal microbial community in sea urchins	(we)											
	3.144b			and	understand	such relationships	(we)											add
	3.144c			if/when	establish	conservation and aquaculture projects	we											cond

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
Text 4	**Abstract**																	
	4.1											may be determined	The viability of fungal spores…	by the effect of the physical and chemical processes…				
e.g.	4.2	in particular										could damage	fungal spore integrity	mandibular maceration				
	4.3										so that	lose	their viability	spores				purp
	4.4				The purpose of this study was [[to determine…]]							affects	spore viability after **passing** through the gastrointestinal tract …	the size of fungal spores was a factor				
	4.5				was tested	The effect of spore size on viability												
	4.6			(by)	using	five genera of dung fungi – *Absidia*, *Isaria*, *Penicillin*, *Phycomycetes* and *Podospora*												man
	4.7				were fed to	whose spores	either second or fifth instar *C. terminifera*											
	4.8											were recovered	*Absidia*, *Isaria* and *Penicillin* spores		from both the faecal and gut samples from second and fifth instars			
	4.9			and then	were fed	they (*Absidia*, *Isaria* and *Penicillin* spores)	by *C. terminifera*	on wheat inoculated with fungal spores										cond

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.10											was not recovered	*Phycomyces*		from faecal material obtained from second instars			
	4.11										but	*Phycomyces* was present in all other samples						conc
	4.12											were not recovered	*Podospora* spores, 20um in diameter,		from any of the samples			
	Introduction																	
	4.13											interact	Insects and the health and diversity of fungal communities		in a complex way			
	4.14		(Slater, 1992)									interactions, such as the symbiotic relationship	are beneficial					
	4.15											may also aid…either externally or internally	the dispersal of fungal spores	Insects				
	4.16a										(so then)	increasing	the ecological niche [[in which fungal species may inhabit]]					purp
	4.16b										(so then)	potentially affecting	higher plant and animal diversity					purp
	4.16c										through	spreading	symbiotic mycorrhizal fungi or entomo- and entero-pathogens					man
conc	4.17	however										insect-fungi interactions	may also be detrimental to both groups					consq

			FIELD OF RESEARCH								FIELD OF OBJECT OF STUDY							
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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.18a		as it has been shown (Quedraogo, 2002)									is effectively used	fungal entomopathogens		in biocontrol			
add	4.18b	also because										is lost	spore viability		in some fungal taxa after ingestion…			
	4.19											can make… lose	their integrity and viability	fungal spore	after ingestion and passage through the insect gastrointestinal tract	physical processes, chemical processes, or both of them		
e.g.	4.20	(that is)										could cause…to fracture	spores			physical processes such as maceration …		
	4.21										and then	cause…to lose	their integrity	spore		(physical processes…)		succ
simil	4.22	similarly										could cause…to lose	their viability	spores		chemical processes including…		
	4.23										whilst	retaining	their integrity	spores		(chemical processes…)		conc
	4.24		so we may know (why)								after	passing through	(fungal spore)		the insect gut			consq
	4.25		(Dromph, 2000; Devaranjan & Suryanarayanan, 2006; …)									is reduced or unaffected	fungal spore viability					succ
	4.26											make… to be able	=+ such			intrinsic		

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
simil												to withstand	processes; (+ fungal spores);			characteris tics of the fungal spores		
	4.27	in particu lar		by	observing	spore size												man
	4.28a		we may know (why)									retain	their viability	some fungal spores				
	4.28b										whilst	lose	viability	other spores				conc
	4.29				propose	a model	we											
e.g.	4.30a	(that is)										are more likely to retain	integrity and viability	smaller fungal spores	after ingestion…			consq
	4.30b										becaus e	are more able to easily avoid	maceration by insect mouthpieces	smaller spores				
	4.31				was tested	this model												
	4.32			(by)	using	dung fungal spores												man
	4.33			and (by)	examining	their passage through the gut of the Australian plague locust, Chortichocetes terminifera												add
	4.34											ingests	large amounts of biomass	The Australian plague locust				
	4.35										and	travels	The Australian plague locust		over a large geographic al range			add
consq	4.36	(theref ore)	(Walker *et al*, 2007)		making such a study	ecologically realistic and important												
simil	4.37	in particu lar										different developmental stages of *C. terminifera* have						

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
												mandibles of different sizes						
	4.38										yet	consume	the same food	different developmental stages of *C. terminifera*				conc
consq	4.39	(so that)	it is ideal		to test	our model [[...]]	(we)	this insect										
	4.40				were used	Coprophilous fungal spores; as a model	(by us)											
consq	4.41	because	(Dix & Webster 1995)									they are specialised to survive	=x passage through the guts of herbivorous animals; + Coprophilous fungal spores					
	4.42				were chosen	the fungal taxa – *Absidia, Penicillin, Isaria, Podospora* and *Phycomycetes*		on the basis of the adaptations										
i.e.	4.43	that is										being able to pass unharmed	the fungal taxa – *Absidia, Penicillin, Isaria, Podospora* and *Phycomycetes*		through the chemical environment			
add	4.44	as also										these fungi	vary in spore size					
consq	4.45	(therefore)	it is ideal		use…to test	this model	we	dung fungi										
	4.46				applying	the model above		to the system of dung fungi and C. terminifera										
	4.47		it is likely									the viability of spores will be dependent on						

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no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
											both the size of fungal spores and the size of the insect mouthpiece						
4.48		it is predicted									will retain	viability	small spores	after ingestion...			
4.49										whilst	will lose	viability	larger spores	after ingestion...			conc
Materials and Methods																	
4.50				were isolated	species of *Penicillium, Podopspora, Absidia, Isaria* and *Phycomyces*	(by us)	from possum faeces										
4.51			(and then)	were cultured	the fungi	(by us)	on 3.5% Potato Dextrose Agar (PDA)										succ
4.52			(and then)	were flooded	plates of each fungus	(by us)	with 0.02% Triton-X										succ
4.53			and	agitated	the mycelium	(by us)											succ
4.54			(in order) to	remove	the spores	(we)											purp
4.55			(and then)	were inoculated	individual spore suspensions	(by us)											succ
4.56			(in order) to	surface	sterilized wheat with five replicates of each fungus...	(we)											purp
4.57			(and then)	checked	[[whether it is effectively inoculated]]	we											
4.58			by	spraying	a fresh PDA plate	(we)	with spore solution										man succ
4.59			and	monitoring	spore germination	(we)											succ
4.60			(and then)	were starved	thirty second instar and	(by us)	for 24 hours										succ

					FIELD OF RESEARCH							FIELD OF OBJECT OF STUDY						
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					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
						thirty fifth instar larvae of gregarious phase *C. terminifera*												
	4.61			(and then)	were placed	individual locusts	(by us)	on one of the six treatments										succ
	4.62			and	allowed…to feed	individual locusts		for a period of 24 hours	(we)									succ
	4.63			then	were moved	individual locusts	(by us)	to clean containers										succ
	4.64			and	were collected	all faeces	(by us)											succ
	4.65a			(and then)	was removed	the gastrointestinal tract of each locust	(by us)											succ
	4.65b			after	were collected	the faeces	(by us)											succ; succ
	4.66			(and then)	were macerated	Faceal samples	(by us)	in 50 or 100ul of sterile de-ionised water…										
	4.67			because	the quantity was much greater from the larger insects													consq
	4.68			then	was prepared	a one in ten dilution of each collection	(by us)											succ
	4.69			and	plated	(a one in ten dilution of each collection)	(by us)	onto dung extract agar with antibiotics										succ
	4.70			(and then)	were diluted one in twenty	samples of digesta from the GIT	(by us)											succ
	4.71			and	plated out	(samples of digesta from the GIT)	(by us)	on dung extract agar										succ

		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit							outer orbit						
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					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.72			(and then)	were observed	the plates	(by us)	over a period of 4-14 days										succ
	4.73			and	were identified	any colonies unique to treatment plates	(by us)											succ
	Results																	
	4.74-75		a positive result for spore viability after ingestion determined when		was isolated	the target fungi		from three or more of the five replicates										
	4.76				was compared to	additional growth on treatment plates; non-target fungal growth	(by us)											
	4.77											Growth of *Absidia*, *Penicillium* and *Isaria* on dung extract media...	was positive					
	4.78											*Phycomyces* was absent from the faeces of the second instar locusts						
	4.79			but	was successfully isolated	*Phycomyces*		from the second instar crop and the fifth instar crop and faeces										conc
	4.80				were not re-isolated	*Podospora* spores		from any of the extracts of										

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					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
								any individual										
	Discussion																	
	4.81											retained	viability	*Penicillin, Isaria* and *Absidia* spores	after ingestion…			
contr	4.82	in compa rison										did not retain	their viability	the larger spores of *Podospora*				
	4.83											fracture	material; into smaller fragments	Smaller mandibles				
	4.84-85		so we know									would be more susceptible to be damaged	larger fragments	by mandibular action				consq
	4.86a			at the beginnin g	proposed	the model [[that spore size affects the viability of spores]]						affects	the viability of spores	spore size				
	4.86b		so we know									is retained	the viability	by the small spores				consq
	4.87a											*Podospora* was absent from the crop						
	4.87b		so we know									damaged	the spores	mandibular				consq
	4.88											The crop is early in the digestive sequence						
	4.89											*podospora* was absent early						consq
	4.90		so we suppose									the spores	were inviable					
	4.91										before	entering	the spores		the gut			succ
	4.92-93a		the results suggest									manipulate	the [[ingested]] material	mandibular				
	4.93b										so	determines	[[how bad it is damaged]]	the ingested material				consq
	4.94a				Such findings	are consistent												

no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
				outer orbit							outer orbit						
				inner orbit							inner orbit						
				nucleus							nucleus						
				centre							centre						
					with current understanding ...												
4.94b		because we know (Clissold, 2008)									fractionate	material with teeth or mandibles in the primary mechanism of food processing					consq
4.95		(Hochuli, *et. al.*, 1994; Uvarov, 1966)								although	the foregut is lined with sclerotised spines						conc
4.96a		It is thought (Hochuli, *et. al.*, 1994; Uvarov, 1966)									help with	peristalsis	foregut				
4.96b										and	help... to separate	material		from digestive enzymes	foregut		succ
4.96c										rather than	helping...to be degraded mechanically	ingested material			foregut		contr
4.97		it is also thought (Charnley et. al., 1985; Clissold, 2008; Uvarov, 1966)									did not involve	resident microbiota and digestive enzymes		in the digestive process			consq
4.98										since	the passage time of the ingested food	is extremely short					
4.99				support for	the model [[...]]	The literature											

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					outer orbit							outer orbit						
					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
							and our findings											
	4.100		(Clissold, 2008)									mandibles play a crucial role in the digestive process of the locust						man
	4.101										by	fragmenting	ingested plant material	mandibles				
	4.102										to	release	the nutritious cytoplasm	mandibles				purp
	4.103a											needs to be initiated and propagated	a fracture					
	4.103b										so	can be fragmented	the materials					purp
	4.104		(Clissold, 2008; Samson, 2006; Samson *et. al.*, 2001)									can initiate	the fracture	fracture stress and [[how tough the material is]]				
	4.105-106a		We propose that									size (of spores) also becomes a determining factor						
cond	4.106b										when	is initiated	fracture					simul
	4.106c	as long as/where			are concerned	fungal spores												
consq	4.107a	since										can allow… to encounters	a spore	a mandible		the circumference of the spore		
	4.107b										so then	initiate	a fracture	a mandible				purp
	4.108a											survived	the small but not large spores		in this study			
	4.108b		so we know									the size in fracture initiation dynamics	is important					consq

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					inner orbit							inner orbit						
					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.109		The results for *Phycomyces* indicated									viability is lost	between the crop and the faeces in the second instar individuals					
conc	4.110	(however)	it is unexpected									is lost	viability; =as a result of passage through the gastrointestinal tract					
	4.111										especially because	all other small fungal spores	remained viable		after passage through the gut of *C. terminifera*			consq
	4.112										since	*Phycomyces* belongs to a different fungal taxa to the other isolates						
	4.113a		it is possible								because	intrinsic structure such as the constituents of the spore wall	are different					consq
	4.113b											the spores	become more susceptible to antifungals and digestive enzymes of the locust gut					consq
consq	4.114	therefore										Spore viability may be dependent not only on spore size, but also other intrinsic characteristics…						
conc	4.115	however										died	two of the five second instar *C. terminifera*		during the treatment			

	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
		FIELD OF RESEARCH									FIELD OF OBJECT OF STUDY							
					outer orbit / inner orbit / nucleus / centre							outer orbit / inner orbit / nucleus / centre						
													replicates					
	4.116										(and)	was recovered	no faecal material					add
	4. 117										and	discarded	the crops [[obtained from these individuals]]					add
consq	4.118	thus	it is probably not significant									is lost	viability		between the crop and faeces			
	4.119										since	the sample number was three rather than five locusts						consq
	4.120	as	it was found									the young locusts	were quite delicate					
	4.121a			if	investigate further		we											
	4.121b		it would be beneficial	then	to use	a larger sample size												cond
	4.122			in order to	allow…to die	samples	(we)											purp
	4.123		we are less able to interpret why									*Podospora* in the crop and faeces is absent						
	4.124										since	didn't progress	spore sizes		between 6-14 microns			consq
	4.125a		no other results corroborat e									is lost	viability		at 14-20 microns			
	4.125b		(so) it is impossible to be sure									made…lose	its viability	Podospora		the size; but not some other features…		consq
	4.126		it would be beneficial for future studies		resolve	a more defined point at which spore cease to become viable	we											consq

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				inner orbit							inner orbit						
				nucleus							nucleus						
				centre							centre						
no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
4.127			as	would inform	how to design fungal biocontrols	this											
4.128		We didn't see									the developmental stage of the insets correlate to the size						
4.129				could have been resolved	the effect of developmental stage on spore size and viability												cond
4.130			if	have used	spore sizes [[which are more comprehensively spread...]].	we											
4.131				was considered	the potential for false positive results												
4.132			and	carefully controlled			in the experimental procedure										
4.133		it was concerned		was not transmitted inadvertently	spores on the locust cuticle	(by us)	between the feeding and 'spore-free' containers										conc
4.134a										otherwise	could be isolated	spore		from the locust			simul
4.134b										without	having passed	spore		through the mandibles and gastrointestinal tract			

no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
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				outer orbit							outer orbit						
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				nucleus							nucleus						
				centre							centre						
4.135a											recovered	spores		from the crop			consq
4.135b		so we know									has been ingested	spores					contr
4.135c										rather than	being transported			between containers on the locust exoskeleton			
4.136-137		It was also noted									ceased to eat	individuals preparing to moult					consq
4.138a		so we know									the numbers of spores [[consumed]]						consq
4.138b		and so we know									the spore concentration in the crop and faeces						
4.139a										if	the spore concentrations	are varied					cond
4.139b		it is possible		may not being plated	a spore		from the serial dilutions										
4.140				could avoid	fasting prior to moulting and the associated potential bias in data	We											man
4.141			by	selecting	individuals at exactly the same stage of their lifecycle												
4.142		interestingly									appeared to have contracted an infection	none of the test organisms exposed to *Isaria*					

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.143a											there is not enough pathogenicity						conc
	4.143b										not becaus e	lost	viability	spore				
consq	4.144	since										were recovered	viable spores		from both the crop and faeces in all treated individuals			
	4.145		We can explain (in two ways)									Isaria pathogenicity was absent						
	4.146		(Dillon & Charnley, 1985, 1995)									have produced	an antifungal compound…	Resident microbiota in the gut of the Desert Locust				
conc	4.147	howev er									given that	the Isaria spores	were viable		after passage through the gut			cond
	4.148a											the antifungal	would need to be fungistatic					simul
	4.148b										when	is acting	the antifungal					
	4.149		The literature provides evidence									the compound	is fungicidal					
alt	4.150a	alterna tively										colonization by *Isaria was* absent						

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					nucleus							nucleus						
					centre							centre						
	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
	4.150b		we know									initiated	some physiological response	the locust				
add	4.151-152a	(and also)	Evidence from *Locusta migratoria* has indicated									are able to induce	a fever	some locusts				
	4.152b										then	can make... happen less	fungal infection by Metarhizium anisopliae			the fever		simul
	4.152c										and	the fungal infection	make...less severe			the fever		simul
consq	4.153	(therefore)		if	are to be developed	entomopathogens		towards a biocontrol										cond
	4.154				needs to be considered	a number ways in which fungal and insect interact beyond physical spore destruction												
	4.155				[[Understanding spore viability in an entomopathogen /host context]]	is a crucial aspect of autodissemination												
	4.156-157a		our results indicate that									spores	need to be sufficiently small to survive					purp
	4.157b			so	an autodissemination strategy	can be successful												
	4.158		It has been shown that (Meyling *et. al.* 2006; Devarajan &									aid	fungal spore dispersal	a number of invetebrate hosts including...				

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
			Suryanarayanan, 2006)															
	4.159a			by	knowing	the dissemination of spores												
	4.159b		(Devarajan & Suryanarayanan, 2006...)		may know	the structure of higher plant and animal communities	we											man
consq	4.160a	as										are implicated	many fungal taxa					man
	4.160b										(by)	the ecological systems	are healthy					
e.g.	4.161	for example										transfer	the spores of fungal endophytes	grasshoppers (Acrididae)	between plants			consq
	4.162		(Devarajan and Suryanarayanan, 2006)								thereby	contributing to	the diversity of endophyte communities	grasshoppers (Acrididae)				
	4.163											is possibly limited	The extent [[to which Acrididae-mediated dissemination occurs]]	by the size of the spores				consq
	4.164										since	dissemination	would be futile					
	4.165a										if	the spore	were rendered inviable			by the mandibles		cond
	4.165b										when	macerate	the leaf...	mandibles				simul
	4.166											Fungal spore size appears to correlate to spore viability...						
	4.167				contribute to	a growing body of literature	The results of this investiga											

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	no	int conx	ext conx + dim/post	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	ext conx	event /entity(=entity)	=+ entity; + quality/entity	+x entity	x entity	xx entity	xxx entity	
							tion											
	4.168a			if	know	how fungal spores is transported	we											
	4.168b			then	would know	whether animal and plant species are healthy	we											cond
	4.168c			and	would know	the diversity of animal and plant species...	we											simul
	4.169a		so it would be beneficial		understand	how fungal spore viability are related to each other												consq
	4.169b			when/if	apply	(the understandings)	we	in biocontrol, ecology and environmental management.										simul