1-1-2013

A Word is Worth a Thousand Pictures: A Systemic Functional and Multimodal Discourse Analysis of Intersemiotic Evaluation in University Science Textbooks

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Intersemiotic Evaluation in University Science Textbooks

A Thesis to be submitted to
the Graduate College of
Marshall University

In partial fulfillment of
the requirements for the degree of
Master of Arts

in

English

by

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Marshall University
May 2013

ACKNOWLEDGMENTS

I would like to take this opportunity to express my gratitude to the friends and family who have offered me encouragement and distraction during the process of completing my Master's degree. I would like to single out Camio and Yumiko for making me laugh during their poorly timed phone calls, and my aunt Linda who has always been an inspiration to me. This research is dedicated to my mother, Denise Smith, who has devoted so much of her time supporting me and my pursuits.

To the LEAP/INTO staff: Mollie McOwen, Sumeeta Patnaik, Ben White, Meike Stein, Leah Green, Sue Cooke, Siham El Ougli, and Amine Oudghiri; thank you for sharing your views on education and for keeping the office funny. I am also deeply grateful to Masaki Shibata and Davina Kittrell for the insightful conversations on linguistic theory as well as the late nights watching bad horror movies, without which this entire process would have been impossible.

As pioneers in multimodality, I am grateful for the correspondence from both Monika Bednarek and Kay O'Halloran. I am in debt to Brent Patterson for twisting my research with a fresh perspective on art as communication, which rightly shifted my research direction. In particular, I would like to sincerely thank Dr. Jun Zhao for guiding me through my first year in the program, as well as for her considerable knowledge and advice on the educational side of this research.

Ultimately, I would like to express my deepest gratitude to Dr. Hyo-Chang Hong, whose expertise, cruel mockery, and contagious passion for Systemic Functional Linguistics would completely revolutionize my views on language and my direction for Ph.D. studies. His impact on my education, pedagogy, and my future, is immeasurable and for that I am forever grateful.

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ABSTRACT

A Word is Worth a Thousand Pictures:

A Systemic Functional and Multimodal Discourse Analysis

of Intersemiotic Evaluation in University Science Textbooks

by Leo Roehrich

Images are an invaluable medium in science textbooks for clarifying confusing concepts and establishing a visual foundation for field related topics. The integration of image and language within a single unit of discourse builds a larger meaning than the two semiotic forms are capable of producing separately. Visual representations are chosen for their functional value in aiding linguistic explanation and also for their aesthetic value in textual enhancement. Aesthetic choice is a matter of subjective opinion. Although science writing is generally classified as objective, authors embed personal opinion in written and visual discourse. The choice of visual medium has a profound effect on the author's linguistic choices, which manipulates the reader's interpretation of discourse. Through the application of the Systemic Functional Linguistic framework in conjunction with Systemic Functional Multimodal Discourse Analysis to university undergraduate level science textbooks, analysis indicates that not only do science textbook authors use images to evaluate in-text subjects, but also to reference images with heightened subjectivity. Findings further demonstrate that science authors use evaluative language to direct reader interpretation of the image using patterns of evaluation which is contingent upon the medium of the image and the functional relationship between image and language.

1. INTRODUCTION

From the earliest cave paintings to modern print, images have been used to construct meaning. “[W]riting systems have evolved from images” (Martin & Rose, 2007, p. 46). In reviewing the history of writing systems, the communicative capabilities of image and written text are convergent. Conventionally, the two have been artificially separated, making the written word divergent from images in regards to meaning-making (Berger, 2009; Martin & Rose, 2007; McCloud, 1994); however, in academic writing, image and text are integrated, by necessity, to illustrate broader points, clarify confusing concepts, and even maintain reader interest. University textbooks at the undergraduate level employ various media for the purpose of conveying information and expanding meaning; text and image are used together within a single text as crucial factors in the overall discursive goal and to achieve the author’s intention of introducing topics clearly and meaningfully. Construing meaning and expressing meaning in various forms and for specific purposes is rarely explicitly taught, making academic writing a difficult genre to produce successfully (Cook, 2008; Lirola. 2010; Schleppegrell, 2004). This thesis addresses the patterns of image integration in academic writing, and patterns in structure for the introduction of images in academic register from a multimodal perspective.

1.1 SYSTEMIC FUNCTIONAL LINGUISTICS AND MULTIMODAL DISCOURSE

Through the lens of Systemic Functional Linguistics (SFL), combined with Systemic Functional Multimodal Discourse Analysis (SF-MDA), meaning construction patterns are revealed by examining the formation of media integration and the enhanced meaning created by the interplay between image and text. SF-MDA offers insight not only into the meaning of a text, but also into the interpretation of n image, and ultimately into the independent construction of a complete text (Libo, 2004; Martin & Rose, 2009; Martinec, 1998; O'Halloran, 2011). A Systemic Functional view of language situates modes of communication within social contexts, and takes into account the functions of language in the formation of meaning (Halliday, 1994; Martin & Rose, 2007).

Text and image converge in communication to create meanings which are impossible with only one medium; the inter-media semantic relationship, or intersemiosis, can be divergent; however, intersemiotic semantics are mostly convergent (Berger, 2009; Martin & Rose, 2007). To illustrate this parallel semantic pattern, Figure 1 explains an example from Berger (2009):

Figure 1. Korenveld Met Kraaien (Van Gogh, 1890)

In looking at Figure 1, each individual viewer reads the image, and interprets its meaning decontextualized. Observers will note the interpersonal elements such as color, use of space, and brushstrokes; additionally, they will note the experiential elements: birds flying, wind blowing, field, and sky. An image, comprised of its experiential elements, i.e. processes, participants, and circumstances, also has meaning derived from the context of viewing, such as the book in which it is printed or the venue in which it is displayed, whereas the intra-medium context is informed by individual and interpersonal interpretation. All of these elements directly and indirectly affect the final interpretation of meaning. In taking time to examine art integrated with text, as in Figure 2, the meaning becomes redirected.

Figure 2. Korenveld Met Kraaien (Van Gogh, 1890)

Although the caption's validity is debatable, the viewer is nonetheless redirected by the text toward a new interpretation of the image, one which is determined by the author. (Berger, 2009) The marriage of linguistic and artistic expression allows for one form to elaborate on, enhance, and extend the other (Halliday, 1994; McCloud, 1994; Martinec, 1999; O'Halloran, 2009).

For each expansive use of image, there are linguistic choices available for description and subjectivity which are integral for the author to direct reader interpretation of an image, or, in the reverse situation, image directs interpretation of text. Authors implicitly include subjective description in text to divert reader attention without explicitly expressing opinion. This function of subjectivity is especially true when introducing images. In academic contexts, Diagrams, photographs, and other visual media are frequently context dependent, relying on textual explanation, as well as an interpretive direction in which to view the image. For example, Figure 3, without text, is merely a jumble of fossils, wherein there are, what appears to be, a pair of dinosaur fossils juxtaposed.

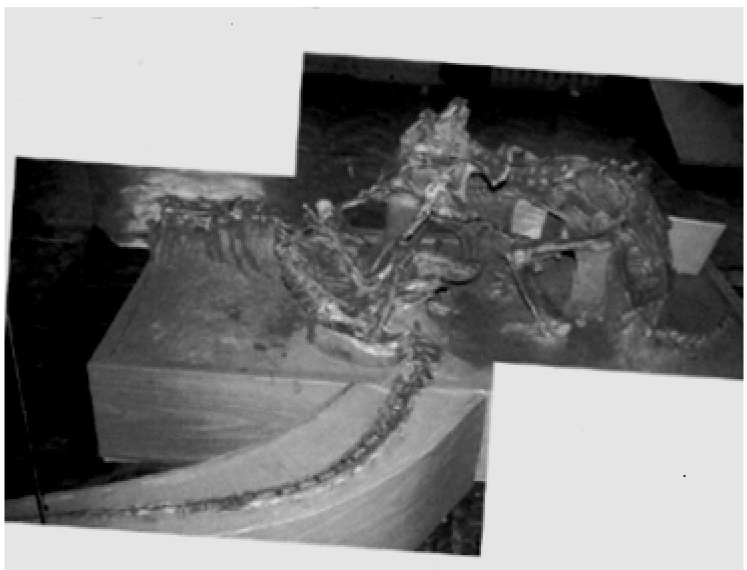


Figure 3. The Famous Fighting Dinosaurs (Fastovsky & Weishampel, 2009)

But when described in the caption “The famous fighting dinosaurs,” readers are given a prescribed interpretation of the image, which not only forces the reader to view the image as a “fight” but also to accept the author’s subjective belief that this fossil sample is “famous.”

1.2 RATIONALE

Both textbooks for university writing and English as a Second or Foreign Language textbooks rarely address the integration and introduction conventions of images in academic reading and writing (Bezemer, 2008; Hull & Nelson, 2005; Jewitt, 2005); an issue central to understanding the purposes of image introduction, affecting the ability to comprehend images, the purpose of passages, and the text as a whole (Berger, 2009; Lirola, 2006; Martinec, 1998; McCloud, 1994).

Graphs, charts, maps, photographs, and artists' depictions are just some of the media utilized for the purpose of illustrating hard-to-explain concepts within a textbook. Science writing relies on empirical images, artistic renderings, graphs, diagrams, and maps, to articulate concepts difficult to verbally describe. In the sciences, especially in theoretical sciences and areas of Biology, grasping the concepts of quantum foam or cellular structure would be nearly impossible to comprehensibly describe without a visual representation. For students, the ability to interpret textual description of images, follow the purpose of an image, as well as introduce images in writing is paramount for reading and writing in an academic environment. For the purposes of instruction in academic writing, image integration merits a clear investigation as to the conventions of visual aid incorporation in text.

To determine the conventions of multimodal integration in science, the connecting elements that form medium integration, or intersemiosis, are categorized according to the integrated text/image relationship. This relationship is the vehicle for an author to direct the reader's attention to target areas of the photo, or direct an interpretation that suits the authors' purpose (Cheong, 2004; Fei 2004). Logico-semantic relationships, the dominant nature of one media or the equal cooperation of both, between the image and text plays a vital role in determining the power of image, and its role in explaining scientific concepts (Fei, 2004; McCloud, 1994). Image interpretation also hinges on the use of evaluative language in image-introductory text. Evaluative language is used by authors intersemiotically to describe the referenced image, and direct the formation of reader opinion on a given topic in relationship to an image (Bednarek & Martin, 2010; Halliday, 1994; Libo, 2004; Lirola, 2006; Martin and Rose, 2009; O'Halloran, 2009).

1.3 RESEARCH PURPOSE

Although SF-MDA is an emerging field, with a considerable amount of research being developed within the framework, little research has been directed specifically toward the effective production and integration of explanatory images in academic writing. This research seeks to initiate the process of closing the knowledge gap by answering the following questions:

1. What is the functional purpose of an image in science writing?

2. Does an author use evaluative language to direct image interpretation? Does the Visual medium influence language use?

3. Is there a connection between image purpose type and evaluative language?

This study seeks to accomplish these goals by examining the use of images in undergraduate textbooks to determine intersemiotic conjunction between different media, and describe implications for the production of text within the register of university writing. Writers choose both text and image for their unique communicative purposes; and while the medium of conveyance and the production processes are, in fact, divergent; both media convey similar information for interpersonal purposes, express an ideological perspective and communicate through textual organization within the produced work (Berger, 2009; Cheong, 2004; Fei, 2004; Martin & Rose, 2007; Martin & Rose, 2009; McCloud, 1994; O'Halloran, 2009; O'Halloran, 2011).

2. REVIEW OF RELEVANT LITERATURE

2.1 SYSTEMIC FUNCTIONAL LINGUISTICS OVERVIEW

The history of SFL provides the rationale for SFL as the theoretical framework for this study. Before the development of functional linguistics, an anthropologist named Malinowski made a groundbreaking observation when studying the indigenous population of the Trobriand Island of Papua New Guinea. In his exchanges with the fishermen of the village, he posited that their language was primitive, believing their use of language to be unfit for complex, abstract communication, being confined to times of necessity, of "doing." His initial findings, that the majority of verbal exchanges shared by the locals was "doing" related, would eventually lead him to see that "doing" is not exclusively the purpose of so-called-primitive language at all (Malinowski, 1926); rather it constitutes the purpose of all language, whether expressing interest, love, or immediate physical need, such as the fishing commands of the Trobriand people (Bloor & Bloor, 2004; Malinowski, 1922).

Functionalism, the theory of language used as a social tool, was further developed as a linguistic theory by Malinowski's London University colleague, J.R. Firth (Bloor & Bloor, 2004; Firth, 1957). Malinowski's "context of situation," as it relates language use to social function, would prove to be a catalyst for the functional movement. Firth argued that linguistic knowledge is subdivided into two categories: the literal meaning and its use in social context. For example, a simple interrogative such as “Can you open the door” has the literal meaning: “Are you capable of opening the door?” however, this interrogative generally carries a meaning different from the literal realization: the imperative “Open the door!” These examples are not meant to claim that language is an easily definable system where only two meanings are considered (Bloor & Bloor, 2004); in fact, Firth argued that language is polysystemic, a system of systems, where speakers are faced with “a set of options together with an entry condition, such that if the entry condition is satisfied one option from the set must be selected” (Halliday, 1972, p. 42).

Having SFL as a framework helps with the understanding of why a written text is used in the way it is. It does so by paying attention to its context and textual organization as this “enables an in depth study of the construction of meaning in the text” (Lirola, 2006, p. 251). The Systemic Functional model of language situates spoken and written language within the realm of social interaction wherein a series of choices are made in response and in reference to social context. Halliday further developed Firth’s model into a Systemic Functional theory of linguistics (Bloor & Bloor, 2004).This study utilizes the Systemic Functional approach to language “because of the interrelationship between language, text and the contexts in which those texts occur, and because it includes a social perspective in the study of language” (Lirola, 2006, p. 250).

To briefly introduce SFL, Halliday is the founder (1994). His theory evolved in opposition to the traditionally held views of language as a series of formula which are decontextualized from use and situation; Halliday has shown that language is a social semiotic system which is inseparable from context and the functions from which language is meant to perform. Language, as a social semiotic system, is the product of a complex system, which includes integrated perspectives; formal structure being just one of multiple perspectives with which to inform the interpretation of meaningful communication (Bloor & Bloor, 2004).

SFL provides a framework which permits language to be analyzed through its functions and abstraction strata to interpret an intended meaning. In performing an analysis of this type, structure and its realized meaning are interpreted contextually to understand the purposes of a text, explore the potentials of meaning inherent in linguistic production, and find the deeper connections between elements within a given discourse production (Bednarek & Martin, 2010).

2.2 STRATA OF ABSTRACATION AND THE THREE METAFUNCTIONS

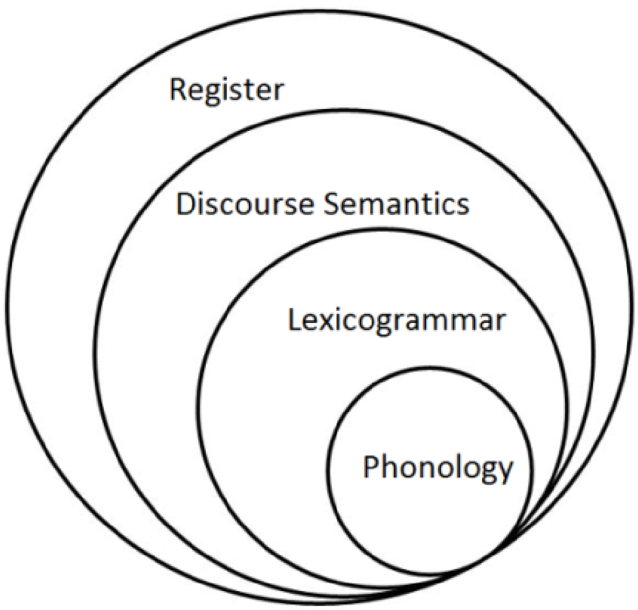


Figure 4. Strata of Abstraction. Each circle is subsumed by and incorporated into the higher levels. (Adapted from Martin & White, 2005)

As outlined in Figure 4, language is stratified, increasing in abstraction from grammar and lexicon (lexico-grammar), developing through each stratum into genre, or cultural context, within which every level of abstraction incorporates each successive strata of lower delicacy

(Martin & Rose, 2009). Each stratum is comprised of the three integrated metafunctions: interpersonal, textual and experiential. The metafunctions together describe the multiple functions and purposes of language use at each stratum (Figure 5).

The meaning conveyed to an interlocutor is described by the Interpersonal metafunction, which indicates what a speaker intends to convey, as well as how it is to be received. The Textual metafunction is concerned with how that information is communicated, in terms of how a text is organized and conveyed. Topic, or field, is realized linguistically; this realization is described by the Experiential metafunction, which is concerned with the ways in which language relates experience in addition to the interactions between language with the real world. (Bloor & Bloor, 2004; Halliday, 1994; Martin & Rose, 2007).

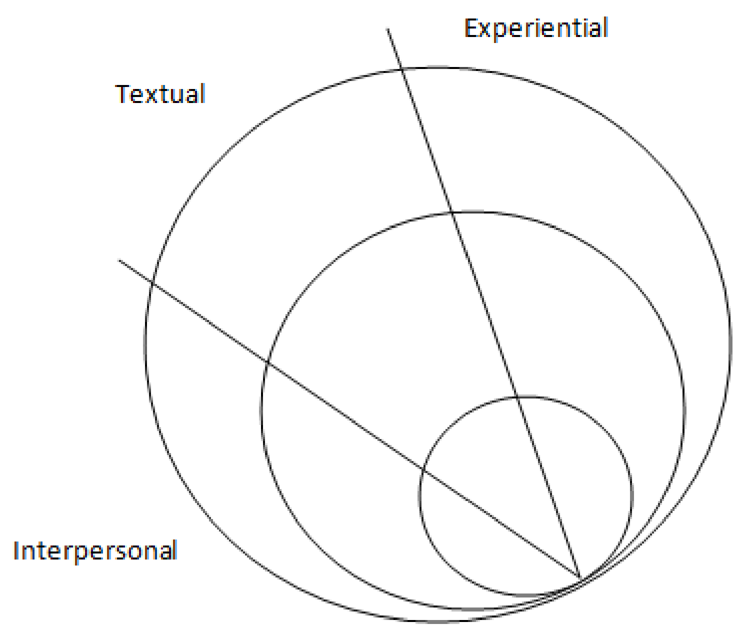


Figure 5. Metafunctions. Each metafunction integrates to form each stratum. (Adapted from Martin & White 2005)

The lowest stratum considered for the purposes of this analysis is lexico-grammar. Lexico-grammar is an element of language analysis which incorporates all of the ways in which meaning can be made through lexicon and grammar, including the stratum of phonology and graphology which concerns phonetics, and phonemics (Figure 5). The stratum of lexico-grammar is highly concrete in its observability, with the constituent elements being the most delicate. Divided into three metafunctions, this area of language consists of clauses and their summative parts; including words, punctuation, and grammatical structures, all of which constitute the clause, with the three metafunctions interacting in meaning construction. The Textual metafunction**,** at the level of lexico-grammar, describes the organizational patterns within a given text. The purpose of the Interpersonal metafunction illustrates speaker meaning by considering how the text is meant for interaction with an interlocutor, in terms of how grammar constructs declaratives, interrogatives, and imperatives. The third metafunction, Experiential, analyses the text according to what participants performed what processes and under what circumstances with the intention of understanding the relationships inherent within the clause. The meaning that a clause conveys is contingent on a variety of factors; the clause or sentence which precedes and follows, the author's intended meaning in production, how the clauses are organized overall in a text, the purpose of the produced language and the social context within which the clause was made. The interplay between all of these factors determines the total meaning of each clause, in essence, discourse semantics (Martin & Rose, 2007; Martin & Rose, 2009).

Increasing in abstraction from lexico-grammar, the discourse semantics stratum studies language according to all of the realizations of meaning possible, as derived from lexico-grammar. Grammar can, of course, make meaning, but the same grammatical form may be used to produce multiple meanings. "Can you dance?" in different contexts may have different meanings. This sentence may be a question regarding ability after an injury: ‘Can you dance?’ while the same question, at an audition, could also serve as a command: ‘Dance for me.’ In viewing language from the discourse semantics stratum, language can be understood and derived congruently or incongruently from its formally actualized meaning in context. (Halliday, 1994; Martin & Rose, 2007; Meyerhoff, 2006). The differences between grammatically actualized utterances and their meaning make the discourse semantics stratum focused on meaning and purpose “above the clause.” For the purposes of this study, discourse semantics (Figure 6) is the highest stratum of analysis (Martin & White, 2005).

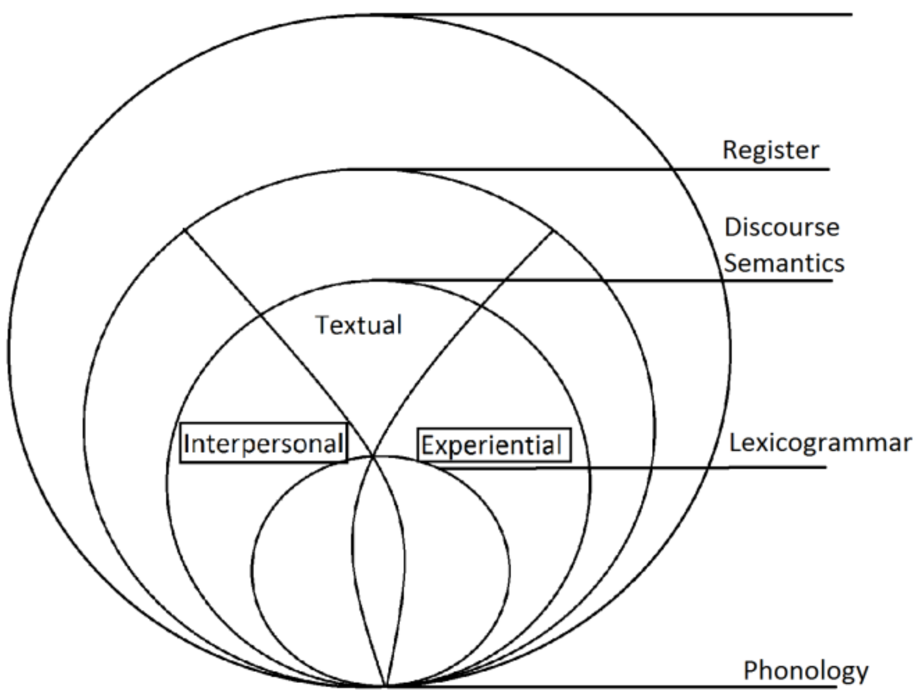


Figure 6. SFL Network. The SFL network is made up of multiple levels of abstraction, each of which incorporates each lower stratum. In addition, the levels up to and including discourse semantics are realized by the integration of the three metafunctions: Interpersonal, Textual, and Experiential. (Adapted from Martin & White, 2005)

2.3 SYSTEMIC FUNCTIONAL MULTIMODAL DISCOURSE ANALYSIS

The Systemic Functional framework, in describing language at different strata and their effects on each word produced in discourse, permits language to be observed alongside other media. Any medium of communication is subsumed under the paradigm of Systemic Functional Multimodality. Various scholarly reports have been written on the innumerable non-linguistic means of communication, e.g. architecture, rhythm, and images (Bednarek & Martin, 2008; Cheong, 2011, O'Halloran, 2011; O'Toole, 2004). Like sentences, images also depict processes, participants in those processes, and the circumstances in which the two are manifested (Bednarek & Martin, 2010; Berger, 2009; Libo, 2004; Martin & Rose, 2007; McCloud, 1994; O'Halloran, 2009).Visual media produce meaning through these individual parts, combining holistically for the viewer to translate into meaning. Field, tenor, and mode are the components of image meaning that create: image purpose in text; how that purpose is realized within the image itself; and how its parts some together to construct the final product, respectively (Berger, 2009; Fei, 2004; McCloud, 1994; O'Halloran, 2009). The social context, or genre, in which the communicative purpose of the image aids in realizing the overall meaning of a text, situates the image into a meaningful place in which the image, rather than being an independent construct, becomes included in the finished discourse, making it not a separate medium, but an integrated communication medium that works in conjunction with the linguistic text to enhance meaning in discourse (Bednarek & Martin, 2010; Berger, 2009; Fei, 2004; Libo, 2004; Martin & Rose, 2007; McCloud, 1994; O'Halloran 2011).

The intersemiotic relationship between image and text, in which meaning is made in the semiotic space between image and text (Figure 7), has profound implications when viewed from a Systemic Functional perspective. Systemic Functional Multimodal Discourse Analysis (SF-

MDA) looks at this integrated communication in order to interpret the meaning potential of an image as it is used in conveying information (O'Halloran, 2009).

Images and written text are, in essence, the same, when viewed from the register and genre strata of communicative analysis. The two media diverge in grammar when viewed in terms of their content and formal makeup, but remain within the same semiotic space.

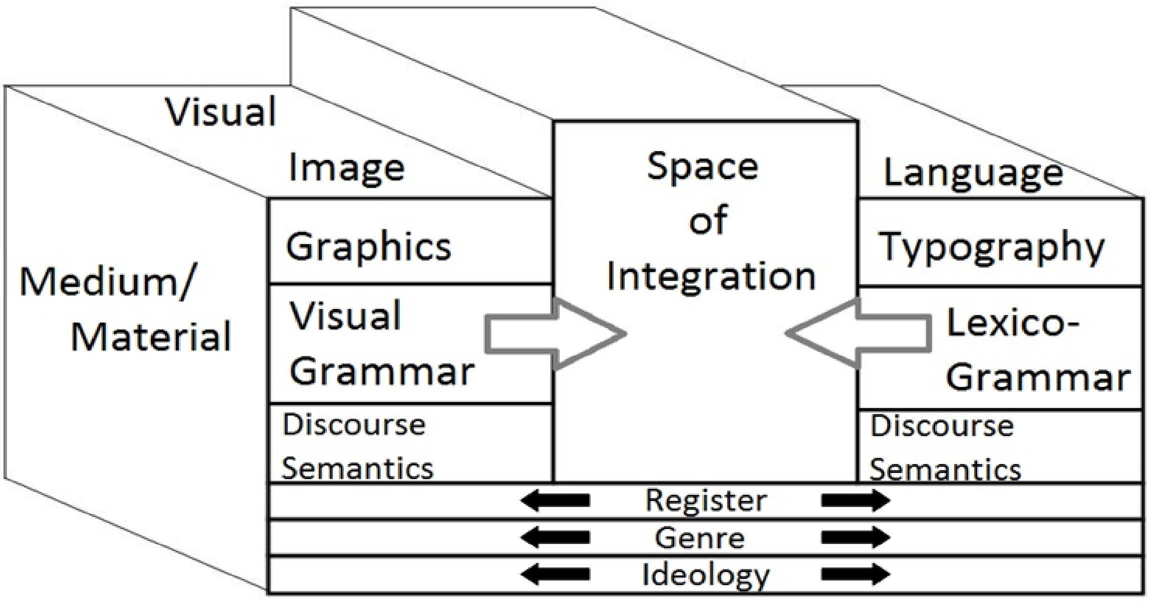


Figure 7. Media Integration. Both visual and written communications require different semiotic grammars and conventions; however, at higher levels of abstraction, they converge in function and meaning. Combined, they are capable of meaning which is impossible to make separately. (Adapted from Fei, 2004)

As is evident from Figure 7, not only do both media integrate in semiotic space, they expand this semiotic space, co-creating meaning on a much larger scale than single-mode styles of communication than either can individually (Berger, 2009; Fei, 2004; Martin & Rose, 2007; McCloud, 1994; O'Halloran, 2009). Figure 7 also illustrates parallel semiotic production at the discourse semantics level.

The multimodal approach to Systemic Functional Linguistics (SF-MDA), specifically in regards to the integration of text and image, allows discourse to be looked at as a whole, analyzing and accounting for the meaning produced by each component of the text. This integration is called intersemiosis, which is concerned with the separate but integrated nature of image and text, and how the two work together to constitute meaning. Its counterpart, intrasemiosis, accounts for all of the elements within an image, including text which is fully integrated into the image at inception.

Initially, the distinction between intra- and intersemiosis is blurry in regards to linguistic elements. The reason for this difficulty in determining whether or not text is intrasemiotic or intersemiotic is due to the various ways that a picture, or text on paper with an image, can be interpreted. A whole textbook page, with both text and diagrams, could be interpreted to be one cohesive image, but from a micro-perspective, not all of the text references image, thus distinguishing them as separate entities.

According to Libo (2004), a multimodal analysis, focusing on images, in certain situations in corporates text as part of the image.. The framework laid out in Libo's study includes title and caption in the analysis of visual communication. As previously noted, in the example of captioning Van Gogh's *Wheatfield with Crows* (1890), the juxtaposition outlined the importance of a caption in an author's meaning-making goals (Berger, 2009; Libo, 2004; McCloud, 1994). For the purposes of intersemiotic analysis, these intra-image textual forms, embedded language, title, and caption, are all integral parts of intrasemiotic analysis. In analyzing text-referential language, the caption shares more semiotic space with the image, and is the foundational context for interpreting an image. This intra-image text stands in contrast to the intersemiotic integration of image external text. In textbooks, this is the language used to reference an image, or referenced by the image, in larger scale writing. Image referential language is embedded in the overall organizational structure of written text (Libo, 2004). By making equivalencies between graphic analysis and linguistic analysis, the collective meaning is compounded to unveil the linguistic elements of image presentation in writing. To more clearly explain the intersemiotic relationship, the painting, *The Treachery of Images* by Magritte (1929), provides a simple insight into the way in which an image can be analyzed integrated with text (Berger, 2009; McCloud, 1994). Translated from the original French, Figure 8's surrealist painting displays a pipe on a relatively mute background with the integrated caption: "This is not a pipe."

Figure 8. The Treachery of Images (Magritte, 1929)

The juxtaposition of what is interpreted from the image as separated from the text which explains the image gives viewers an initial jolt, forcing a reevaluation of the image according to a seemingly Divergent Semiotic Metaphor (Cheong, 2004), which indicates a hypotactic, or (α) dominant-(β) subordinate, relationship between the text and image where α(image)^ xβ(text) (McCloud, 1994; O'Halloran, 2011). The text, in this situation, depends on the image to provide a reference point in which to determine the total meaning. In being dependent, or additive (McCloud, 1994), the text expands the meaning by providing an alternative means of interpretation (Berger, 2009).

In Table 1, both the image and the text are deconstructed into their experiential elements. The text and the image are, apparently, divergent in meaning where the identified value, "This", is identified in one semiotic form as the identifier token: image of a pipe. In the linguistic semiotic form, the token and value have negative polarity. The image and text are described and categorically defined according to their functions in meaning based upon their functional parts (Martinec, 1998; McCloud, 1994).

Table 1

The Treachery of Images Transitivity Analysis

	Process	Participant	Participant
Image (+α)	(relational/existential) is	(image of a pipe)	(image of a pipe)
Text (β)	(relational) is	This (painted image of a pipe)	not a pipe

The seemingly divergent meanings, when viewed experientially, directly show the author's message by taking an ideational approach, examining the literal interpretations and extracting the abstract meaning intended. "This" (the image of a pipe) is not a pipe. The image of the pipe is not a pipe, which is further exemplified when the title is considered as well: *The Treachery of Images*. In spite of the initial interpretation, the text and the image are, in fact, saying the same thing.

2.4 THEORETICAL FRAMEWORK

LOGICO-SEMANTIC RELATIONSHIPS

Within a given text, clauses work together to cohesively construct discourse. Logico-semantics investigates and describes this cohesion. The logical relationship first asks whether the clauses in a clause complex are equal, paratactic, or if one is subordinate to the other, hypotactic. A clause complex wherein neither clause is dependent on the other is paratactic (Bloor & Bloor, 2004, Halliday, 1994).

Table 2

Parataxis (Bloor and Bloor, 2004)

1	The lines will be clearer
2	(and) there will be fewer faults.

As evidenced by Table 2, the two clauses are independent; separated they have meaning [1] [2], and reversed they have meaning. This 1^2 relationship stands in contrast to hypotactic relationships, where one clause depends on another to provide context or frame of reference (Bloor & Bloor, 2004, Halliday, 1994).

Table 3

Hypotaxis (Silk, 2001)

β	If we have to bend the map,
α	Lilliput cannot be flat.

The β clause depends on the α clause to determine condition. If the two clauses were to be separated, the β clause would be without referent. These logical relationships can be further categorized by the ways in which the paratactic (2) clause or the hypotactic (β) clause expand upon their clause complex counterpart (Bloor & Bloor, 2004, Halliday, 1994). Expansion types explain the means by which connected clauses work together to construct meaning.

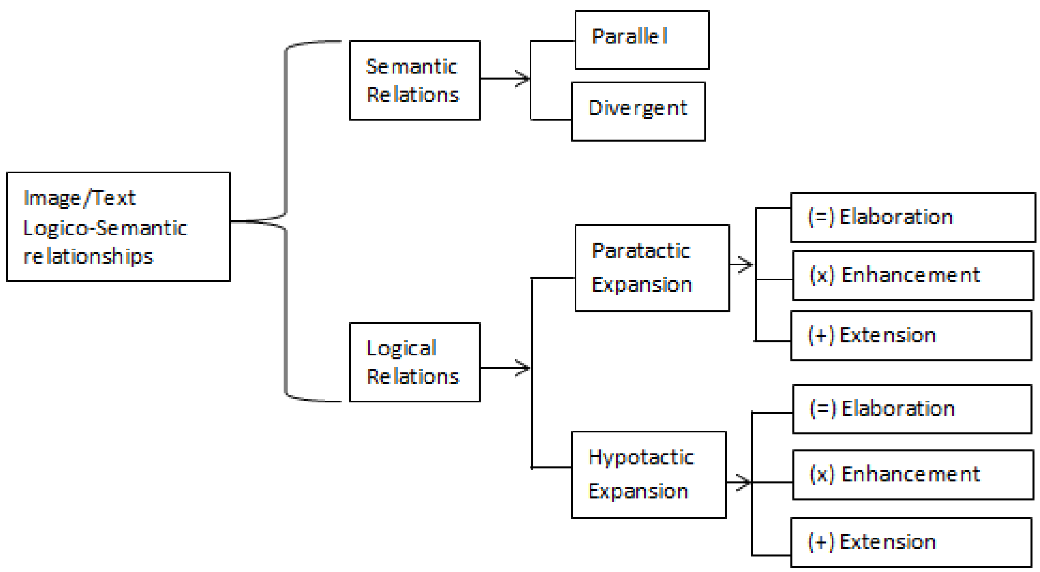


Figure 9. Intersemitotic Logico-Semantic Network[1]

Elaboration	(=)	Restates, details, exemplifies, or comments on the α clause.
Extension	(+)	Expands beyond the α clause by adding new information, giving exception or offering alternatives.
Enhancement	(x)	Qualifies or embellishes the α clause with time, place, condition, or cause.

[1] Network extrapolated from Halliday 1994; Martin & Rose, 2007; and McCloud, 1994.

Elaboration, denoted by (=), expands the dominant clause in a sentence, not by causing a reevaluation of the original clause, but by reinforcing it with additional information.

Table 4

Elaboration (Silk, 2001)

α	Imagine communicating with a Lilliputian
= β	who tells us how to draw a map of his homeland.

The = β elaborates on the main clause by continuing the original clause with information which further clarifies the information by a form of reiteration (Bloor & Bloor, 2004, Halliday, 1994).

This relationship is also manifested intersemiotically (Halliday, 1994; Martin & Rose, 2007; McCloud, 1994). The most direct means of exemplifying intersemiotic expansion is through serial images.

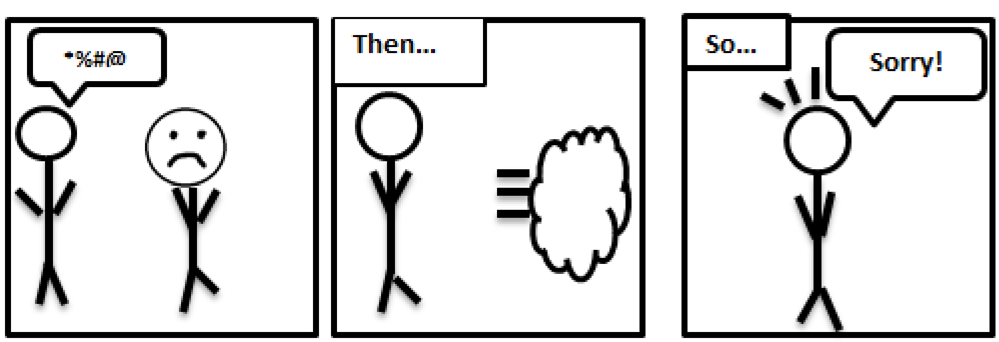


Figure 10. Multimodal Expansion (adapted from Halliday, 1994)

As evidenced in the sequence presented in Figure 10, an action occurs which has logical connection between frames. Readers interpret that action rendered in drawing, as well as the linguistic elements, as one logically cohesive text, wherein the actions proceed temporally, while the language depicted in each frame acts as clarification of the action in progress.

Academic texts do not have the advantage of a simple temporal expansion of ideas. Images are used in a myriad of ways to assist in clearly constructing difficult to describe concepts through the integration of visual and language. In Table 5, a common form of intersemiotic expansion is outlined.

Table 5

Intersemiotic Elaboration. (Unsöld & Baschel, 2002)

α	= β
…a comet consists of a nucleus (which is seldom clearly recognizable), often having a diameter of only a few kilometers.	

In this case, the image is a form of elaboration. By illustrating the statement made in the α medium, this elaboration provides an example of the previously stated point (Martin & Rose, 2007; McCloud, 1994).

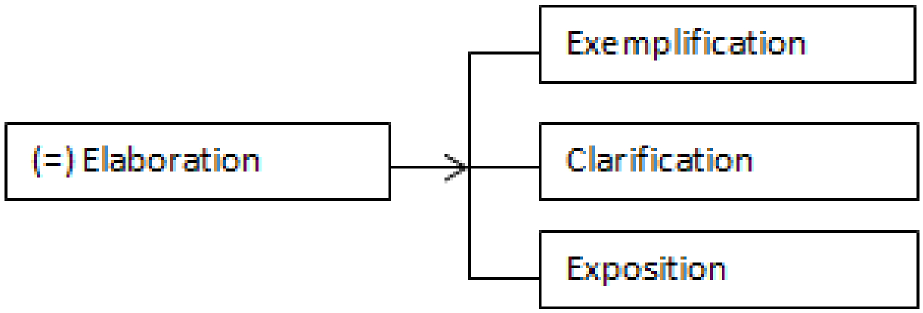
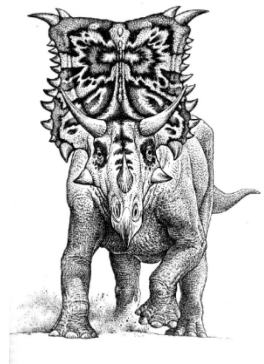
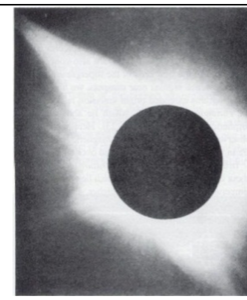
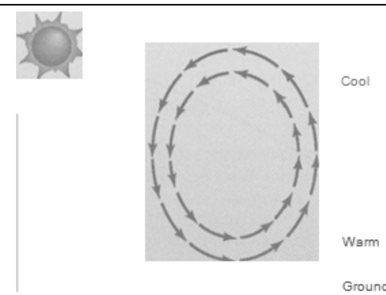


Figure 11. Elaboration. Elaboration is divided into three types: Exemplification, Clarification, and Exposition.

Elaboration is further sub-categorized into three main areas: Exemplification, Clarification, and Exposition (Figure 11). Each can be manifested linguistically or intersemiotically for the purposes of text expansion. Exemplification is an elaboration type that uses examples to further explain related media. In Table 6, the image is used as an example within a text explaining irregular galaxies. In this case, the relationship is clear, with a linguistic marker explicitly indicating the connection between the text and the image.

Table 6

Examples of Intersemiotic Elaboration

Elaboration Type	α	= β
Exemplification	The large nasal and brow horns of ceratopsians functioned primarily during territorial defense and in establishing dominance.	
Clarification	The corona at maximum has a more rounded shape	
Exposition	Convection in the atmosphere is the consequence of differences in air density.	

Note. The Exemplification image is explicitly referenced directly, with a visual example (Fastovsky & Weishampel, 2009). In Clarification, the image is used not as an example but to give visualization to an aspect of the text. (Unsöld & Baschel, 2002) In exposition, the image presented is a restatement in different terms. (Moran & Morgan, 1997)

Clarification is used either to comment on the adjoining medium using evaluative language, or give further explanation which was not previously included. Clarification redefines the information portrayed in the α medium. The Clarification row in Table 6 shows a solar eclipse in photograph which visually illustrates the information presented in the α clause, providing a clear definition of the information presented by summarizing the previously stated information. The forms of elaboration are completed by Exposition, which restates the main idea of the α clause and reinforces the α medium, while presenting a new means of interpretation for the information presented in the α clause. The example of Exposition in Table 6 shows a fresh perspective on the information introduced in the text. In essence, the image is a visual restatement of the main thesis of the text.

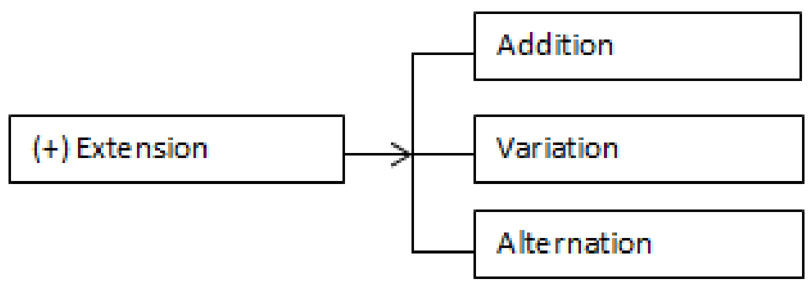


Figure 12. Extension. Extension is comprised of three types: Addition, Variation, and Alternation.

At its core, extension, marked as (+), reinterprets the (1) or α clause. In the example presented in Table 9, the author introduces a close similarity between dinosaur and iguana teeth, with the second clause introducing an element that expects the reader to return to the (1) clause and reexamine the original statement according to the newly introduced aspect, which, in this clause complex, changes the overall appearance of the initially stated description of the fossil (Bloor & Bloor, 2004, Halliday, 1994).

Table 7

Extension (Fastovsky & Weishampel, 2009)

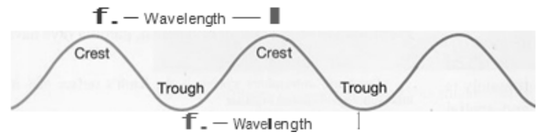
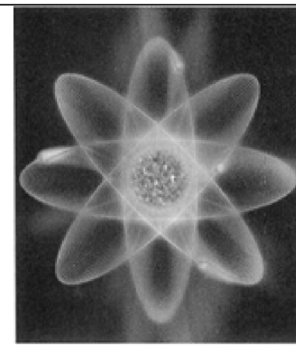
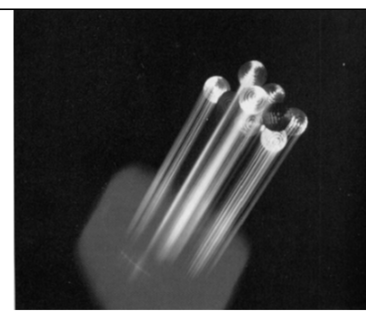
1	[T]he teeth looked very much like those of the living herbivorous lizard Iguana,
+2	but were ominously much, much bigger.

Intersemiotically, Extension expects a reevaluation of either the image or the text. In Table 10, the image is the α medium, and the text introduces an unrelated element which, much like the Van Gogh painting, expects the reader to apply the new information to the image, and newly interpret the process taking place. Extension is divided into 3 types: Addition, Alternation, and Variation (Martin & Rose, 2007; McCloud, 1994).

Addition is characterized by the conjunction "and." Two clauses have connected meaning when strung together with an additive conjunction and due to the juxtaposed nature of both clauses, they are interpreted as logically connected, and readers construct the combined meaning from context. Table 10 illustrates the additive nature of intersemiotic addition. In this Addition example, there is an unclear connection between the two, wherein, as readers, the image is interpreted as somehow related to the text, regardless of the lack of direct linguistic reference between the two.

Table 8

Examples of Intersemiotic Extension

Extension Type	α	+ β
Addition	Passage of one complete wave is called a cycle, and a frequency of 1 cycle per second equals 1.0 hertz (Hz)	
Alternation	This simple picture of the atom makes a nice corporate logo, but the idea of an atom with electrons orbiting a nucleus as planets orbit a sun was discarded nearly a century ago.	
Variation	The atoms could be surface impurities emitted by thermal excitation, or they may even be ions emitted in the presence of a strong applied electric field.	

Note. In Addition, the connection is implicit. (Serway, 1992)

The atom captured in artistic rendering, in the Alternation row, is presented as an alternative to the modern understanding of the atom. (Serway, 1992)

Variation uses the image as a pivot point, where various perspectives are applied to the content and multiple perspectives are permitted for interpretation. (Serway, 1992)

Alternation differs from Addition due to the clear relationship between the two media. Alternation introduces a new, connected idea as an alternative to the initial statement. Characterized by “if not x, then y,” intersemiotic Alternation indicates that image meaning is related to the text with inverse correctness. The final form of extension, Variation, offers one of multiple interpretations of the α clause. As outlined in the final row of Table 8, the image is unfathomable without a means of interpretation; however, the interpreting text does not offer a single interpretation, instead offering multiple interpretations, and implicitly indicating the existence of unstated interpretations, allowing the reader to extrapolate individual interpretations from personal schema.

Table 9

Enhancement

	Carcasses are commonly disarticulated,
xβ	after a bit, the carcass will likely deflate (sometimes explosively),

Note. Note the temporal embellishment, adding a sequential element to the α clause. (Fastovsky & Weishampel, 2009)

The final overall expansion type, Enhancement, (x) adds circumstantial or conditional embellishment to the α clause. Enhancement paints a larger picture within which the dominant clause is played out. In Table 9, the β clause explains a series of events sequentially, creating a time period within which the entire process occurs. This circumstantial enhancement gives the reader added context to further clarify the α clause (Bloor & Bloor, 2004, Halliday, 1994).

In terms of the image-to-text relationship, an image or text can act as a qualifier of the dominant medium by circumstantially amplifying the main idea. Often Enhancement can be rephrased linguistically as a circumstantial adjunct. Enhancement extends the meaning in five primary ways: Manner, Spatial, Temporal, Causal and Conditional (Figure 13); this paper does not address Conditional Enhancement, due to its absence within the sample.

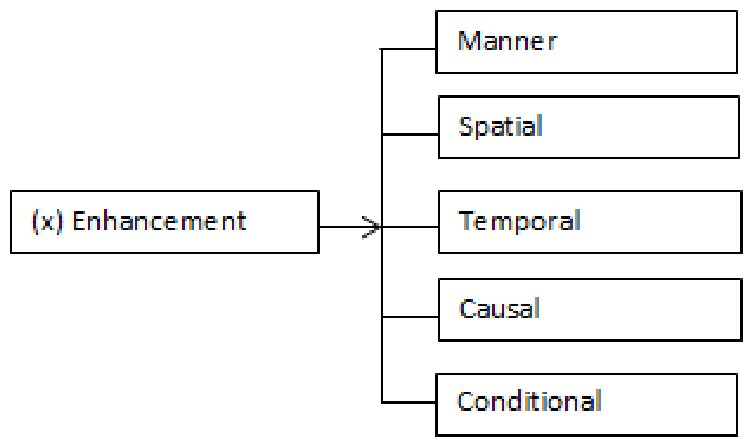
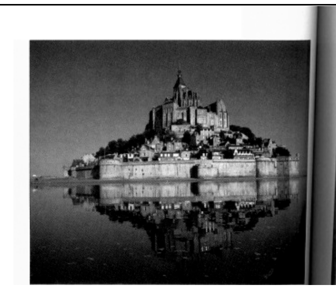
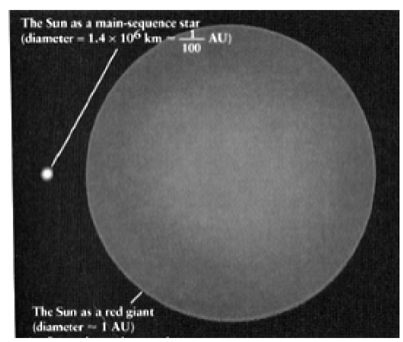


Figure 13. Enhancement

Manner enhances the textual meaning by adding information about how the process takes place. Table 10, Manner row, outlines the way in which the dramatic reflection is manifested visually. The choice of a photograph exemplifies the real life implications of the conceptual nature of the text with added “dramatic” elements to not only explain light refraction, but also add a beautiful means of showing light refraction.

Table 10

Examples of Intersemiotic Enhancement

Enhancement Type	α	x β
Manner	Dramatic photograph of Mont-Saint-Michel in France and its "mirror" reflection in water.	
Spatial	Because water vapor concentrations are very high, even the slightest cooling during the early morning hours results in dew or fog, which gives such a region a sultry, steamy appearance.	
Temporal	Today the Sun's energy is produced in a hydrogen-fusing core whose diameter is about 200.000 km. When the Sun becomes a giant. It will draw its energy from a hydrogen-fusing shell surrounding a compact helium-rich core.	
Causal	Clear-cutting involves removal of wide blocks of trees.	

Note. Manner: Note the evaluative language used to describe the manner in which reflection takes place. (Serway, 1992) Spatial: The image is merely a setting for the text to take place, acting as the prepositional phrase “in the rainforest.” (Smith & Smith, 2006) Temporal behaves much like a comic, showing a period of time passing between the action in the text and image. (Comins & Kaufmann, 2005) Causal: (Smith & Smith, 2006)

Spatial Enhancement describes the location where presented information occurs; intersemiotically, the locale is represented visually, where a photographer or artist displays the location to give readers a clear representation of the setting. (Table 10) In essence, Spatial Enhancement behaves as a marker of setting, where the location is not the focus of the total meaning; instead, it sets the overall topic in a physical space, acting as a prepositional phrase. Temporal Enhancement demonstrates the occurrence of information in time, whether at a specific time or over a period of time. In the example presented in the third row of Table 10, the action takes place serially. The visual representation of time period in this example works similarly to a comic, without the use of frames. The image, through serial visual depiction, illustrates the process of an average star becoming a giant, with the visual process reading left to right. The final form of Enhancement included in this discourse analysis, Causal, connects two ideas through a cause and effect relationship. In terms of visual representation expanding upon textual description, the α medium describes a cause, and the β medium illustrates the effect or effects of the α. Row 4 of Table 10 demonstrates how, in this instance, the textual medium defines clear-cutting with the image further illustrates the linguistic information by redefining clear-cutting with a visual of rampant deforestation.

To conclude, one medium can affect the other in through Enhancement, Extension or Elaboration, and in determining the α medium for that particular discourse the logico-semantic realization of the β medium can give great insight into the purposes of image use in textbooks, and their effective production (Martin & Rose, 2007; McCloud, 1994). To determine the intersemiotic expansion type, four probing questions were consistently applied to both the text and image: The probe applied was to verify which medium carried the larger meaning or if they were restatements of one another. Second, by asking whether the image can be interpreted from the text as ‘in other words,’ ‘for example,’ ‘in this kind of situation,’ ‘in sum,’ etc. or, conversely, by asking whether the text could be interpreted from the image by applying the same circumstantial probing.

APPRAISAL: ATTITUDE

An overly simplistic description of Attitude would be the language of opinion in text. Attitude, as a means of Interpersonal communication, is expressed in a variety of ways, and for a variety of purposes. Prototypically, Attitude is expressed through the use of epithets, which describe a person, thing, or feeling according to the author’s perspective. Although science is widely considered to be a purely objective field of study, writers by necessity evaluate their subjects. In image introduction, text offers insight, interpretation, and evaluation for readers to interpret images according to the purposes of the author (Martin & Rose, 2007; Martin & White, 2005).

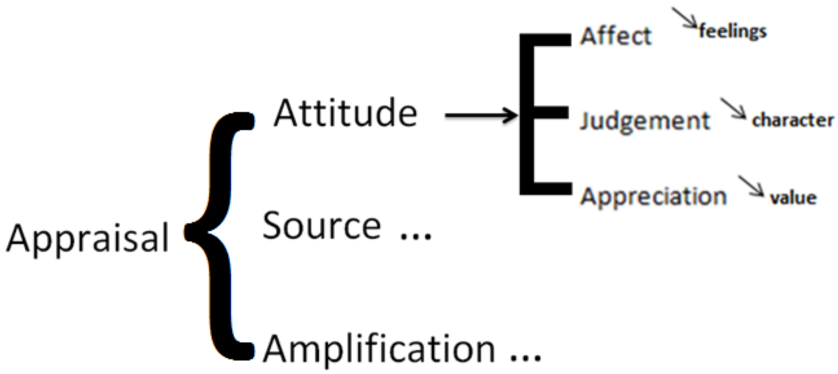
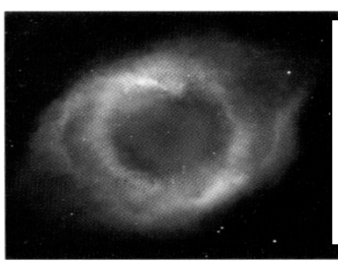


Figure 14. Appraisal. This study focuses on Attitude as part of the Appraisal network. [2] Adapted from Martin & Rose, 2007.

The three areas of Attitude -Appreciation, Judgement, and Affect, though related, describe different forms of appraisal within a text. Appreciation is a form of Appraisal that states an author's opinion of objects or things (Martin & White, 2005). For example, in *Discovering the Universe* (Comins & Kaufmann, 2005), the authors state:



The outer shells or dying low mass stars are ejected in a wonderful variety of patterns.

Figure 15. Opinion (Unsöld & Baschel, 2002)

[2] In SFL networks, angled and square brackets are used to show conjunctive and disjunctive relations, respectively.

This appreciation of dying low mass stars in Figure 15 clearly describes the author's belief in the "wonderful" nature of this nebula, without reference to measurable evidence, or scientific theory the author explicitly informs the reader the prescribed interpretation of the picture.

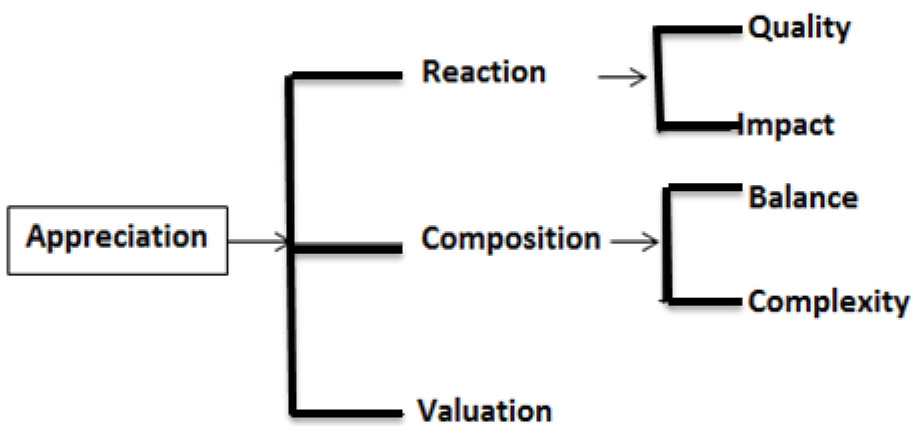


Figure 16. Appreciation

Appreciation consists of three subcategories: Reaction, Composition, and Valuation. Table 16 outlines the types of Appreciation with examples, including typical realizations, using epithets, and atypical, or token, realizations, where the unit of Appraisal is embedded in another form, such as: process, adjunct, noun group, etc.

Table 11

Appreciation

Appreciation Type	Typical Realization	Token Example Clause
Reaction: Quality "Did I like it?"	+ wonderful - bothersome	After a bit, the carcass will likely deflate (sometimes **explosively**)… (Fastovsky & Weishampel, 2009)
Reaction: Impact "Did it catch my attention?"	+ noteworthy - boring	**Note** the land bridge between Asia and North America (Fastovsky & Weishampel, 2009)
Composition: Balance "How is it put together?"	+ cohesive - random	The sun **drives** the atmosphere; (Moran & Morgan, 1997)
Composition: Complexity "How do I understand it?"	+ detailed - confusing	The famous fighting dinosaurs, Velociraptor **wrapped around** Protoceratops… (Fastovsky & Weishampel, 2009)
Valuation "Is it worthwhile?"	+ innovative - superficial	The culprit is **overexposure** to the ultraviolet portion of solar radiation. (Moran & Morgan, 1997)

Note. The congruent realizations are typically epithets, or descriptive words. The token, or atypical, realizations are realized in a variety of ways: processes, nominal groups, or even entire clauses. (Martin & White, 2005)

Judgement differentiates itself from Appreciation in that Judgement is reserved for people rather than things. Evaluative language is used to praise or disparage participants, and assert an opinion for readers to accept. These opinions are manifested within two subcategories: Social Esteem and Social Sanction. (Figure 17)

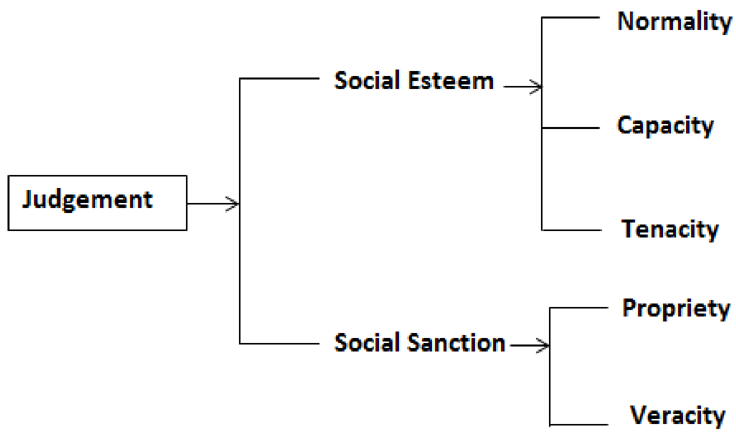


Figure 17. Judgement

Social Esteem describes the degree to which a person is exceptional, whether positively or negatively; this is further subdivided into the extremes of a person's Normality, Capacity, and Tenacity. Social Sanction marks a person's moral character, measuring either his or her Propriety, ethical nature, or Veracity, degree of honesty. (Martin & White, 2005)

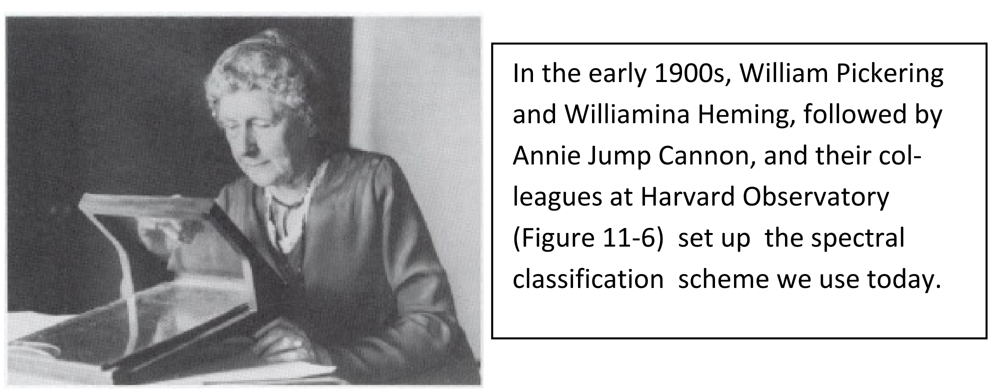


Figure 18. Normality (Unsöld & Baschel, 2002)

In Figure 18, the author presents a positive Judgement of the woman in the photograph by stating that she was instrumental in setting up “the spectral classification scheme we use today,” indicating that she is special due to her innovation and contribution to modern science. As readers, this interpretation demonstrates the author’s positive interpretation of the woman in the photograph, and directs readers to accept this interpretation

Table 12 provides further explanation and examples of each variety of Judgement in standard form, as well as demonstrations of Judgement tokens; i.e. non-standard realizations of Judgement taking the form of processes, nominal groups, or complete clauses (Martin & White, 2005).

Table 12

Judgement

Judgement Type	Typical Realization	Token Example Clause
Esteem: Normality "Is this person special?"	+ unique - eccentric	His equations **led him to conclude** that the orbits of some objects are parabolas and hyperbolas. (Comins & Kaufmann, 2005)
Esteem: Capacity "Is this person able?"	+ skilled - clumsy	Newton also **discovered** that some objects have nonelliptical orbits around the Sun. (Comins & Kaufmann, 2005)
Esteem: Tenacity "Is the person resolute?"	+ determined - listless	Halley **worked out** the details of the comet's orbit (Unsöld & Baschel, 2002)
Sanction: Propriety "Is this person good?"	+ helpful - selfish	**Social conventions of the time prevented** most women astronomers using research telescopes (Comins & Kaufmann, 2005)
Sanction: Veracity "Is this person trustworthy?"	+ direct - manipulative	They **concluded** this plasticity in bristle use had evolved to increase the efficiency of manatees as a generalist herbivore. (Hoelzel, 2002)

Note. The congruent realizations are typically descriptive words. The token, or atypical, realizations are realized in a variety of ways: processes, nominal groups, or even entire clauses. (Martin & White, 2005)

Affect, the third category of Attitude, is the manifestation of feelings being expressed by an evaluator, or Appraiser, which stands in contrast to Appreciation and Judgement due to the individual nature of emotion. Judgement and Affect are generally socially agreed upon evaluations, whereas Affect is the expression of an individually felt emotion, regardless of the social construct (Martin & White, 2005).

Figure 19. Affect (Moran & Morgan, 1997)

Figure 19 illustrates how “Most people” welcome the sunny weather. The people in the image are expressing a welcoming feeling toward the weather. The appraisers of the weather have come to the beach due to a physical manifestation of their fondness for sunny weather; they welcome sunny weather enough to leave their house and lie down in the sun. Although the group is collectively agreeing on the emotional state, if everyone within the society felt this surge of affect, the beach would have many more Appraisers to share in the sunny weather, making “welcome” a token of Affect rather than an Appreciation of the weather. Affect is also further subcategorized; however, this research does not address specific Affect types but considers Affect in general.

3. STUDY

3.1 DATA COLLECTION

The image samples gathered for this study of intersemiosis were chosen according to their incorporation into undergraduate level introductory science textbooks. Each image was selected at random from various textbooks, with the only criteria for selection being that no more than two images would be extracted from one chapter, so as to avoid subject matter specific bias. The written samples were selected based on the reference to a visual representation of textual content. The samples were chosen based on their direct reference by figure number in the text, with the entire paragraph encompassing figure reference being the sample selection. In some cases the image was not directly referenced by image external text and only the caption was used (Brady & Senese, 2004; Comins & Kaufmann, 2005; Fastovsky & Weishampel, 2009; Harden, 1998; Hoelzel, 2002; Martin, 2001; Moran & Morgan, 1997; Serway, 1992; Smith & Smith, 2006; Unsöld & Baschel, 2002).

3.2 METHOD OF ANALYSIS

LOGICO-SEMANTIC RELATIONSHIPS: EXPANSION

An analysis of intersemiotic logico-semantic relationships was conducted to determine patterns of intersemiotic relationships in science textbooks with particular focus on differentiating visual media, namely, photographs and artistic rendering. To determine the intersemiotic expansion type, three probing questions were consistently applied to both the text and image: the first probe applied was to see which medium carried the larger meaning or if they were restatements of one another. Second, by asking whether the image can be interpreted from the text as ‘in other words,’ ‘for example,’ ‘in this kind of situation,’ ‘in sum,’ etc. or third, by asking whether the text could be interpreted from the image by applying the same circumstantial probing. Expansion types were categorized and tallied, then presented in tables and graphs.

APPRAISAL: ATTITUDE

Systemic Functional Attitude analysis was applied to science textbooks to reveal patterns in evaluative language in reference to the visual medium as well as the use of Attitude in reference to Expansion types. Units of Attitude were labeled within the text and tallied for frequency. Frequency was calculated and presented in tables and graphs. Additionally, Appraisal frequency was cross-referenced with Expansion types and Appraisal per clause was calculated

VISUAL MEDIUM

This paper contrasts the use of visual medium and its uses in academic writing, comparing the uses of photographs and artistic renderings. For the purposes of this study, a photograph is a true two dimensional representation of a subject, while a rendering is an artist’s conceptualization. Both photos and renderings were analyzed according to Attitude and Expansion, and their results were contrasted.

3.3 ANALYSIS AND RESULTS

APPRAISAL: ATTITUDE

The three primary Attitude subcategories, Affect, Judgement, and Appreciation, are all used when referencing images in academic text. However, due to the subject matter discussed in science textbooks, mainly description of concepts and natural prcesses, Appreciation is ranked first in instances of Attitude, followed by Judgement, and finally by Affect, from the 538 total instances of Attitude used in the target analysis 86% were Appreciation (Table 13).

Table 13

Composition of Attitude Types

	Number of instances	% of 538 total instances
Affect	7	1%
Judgement	70	13%
Appreciation	461	86%
Total	538	100%

AFFECT

In comparing the use of Attitude in photographs to the use of Attitude in artistic renderings, clear differences in use, and patterns of production emerge. Affect, the expressed production of emotion in discourse, though used only seven times (Table 13) was used exclusively in photographs, indicating that photographs have a much higher potential for Affect production. The beach environment presented in Figure 20 exemplifies the emotionally directed interpretation of the image. The use of “cheer” and “energize” direct the emotional atmosphere of the image.

Bright sunny skies not only permit a wide variety of outdoor activities, but they also seem to energize and cheer us.

Figure 20. Affect in Photographs (Moran & Morgan, 1997)

JUDGEMENT

Because Judgement refers to social evaluation of people, and the focus of science writing is the behavior of subjects, Judgement plays a minor role in science writing. However, people are the researchers, active participants in the process of scientific discovery, making them an integral, if linguistically absent, aspect of the process. When authors opt to stress the human element, contributors to scientific progress typically receive praise,whereas those groups that prevent or assist progress receive evaluation, whether positive or negative.

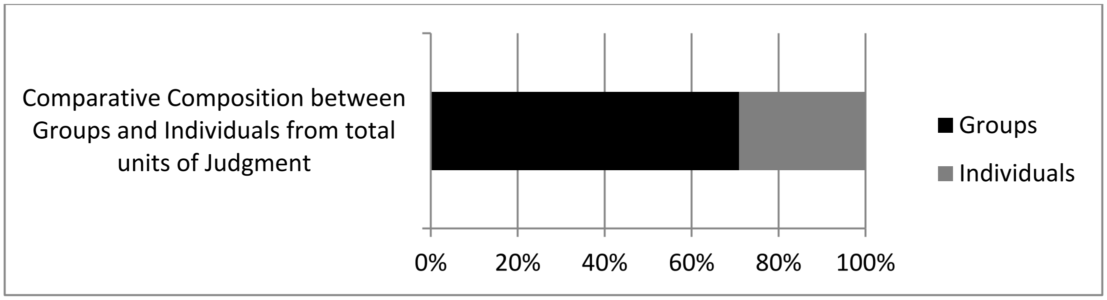


Figure 21. Percentage of Group versus Individual Judgement. This figure shows the total composition of Judgement comparing the use of evaluative language on groups versus individuals.

Generally, Groups receive more Judgement overall than individuals (Figure 21); furthermore, in the introduction of an individual, often this individual is exceptional in some capacity and judged favorably. The number of positively evaluated individuals, such as Newton or Einstein, greatly exceeds negative evaluation.

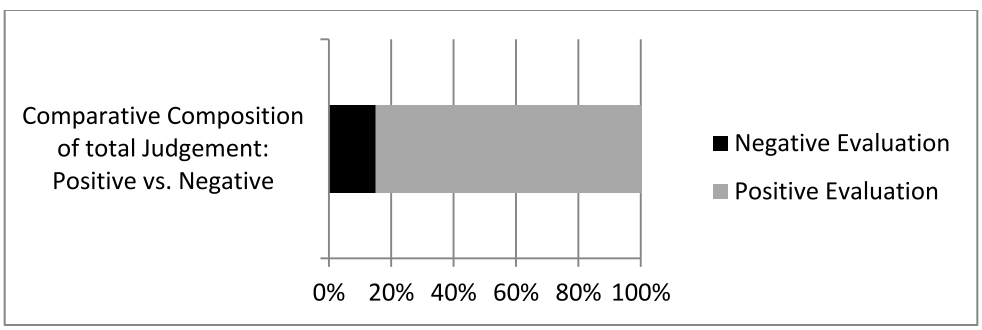


Figure 22. Evaluation of Individuals. Graph showing the total composition of positive versus negative evaluation directed toward individuals.

Statistically, groups receive more balanced Judgement than individuals, hovering at around 50% for both positive and negative Attitude. With near even evaluation, groups do not have a necessarily clear statistical pattern for use of Appraisal in image-referential science writing. However, looking more closely at the appraised people, patterns emerge (Table 14).

Table 14

Polarity in Judgement of Groups

Positive	Negative
Modern Scientists	Pre 80’s Scientists
Modern Astronomers	19th Century Scientists
Harvard Astronomers	Foresters
People today	Einstein’s Contemporaries
We	
Current Biologists	LA Citizens
Image Donors	People today
	Doctors
	Sunbathers

Overall, positive Judgement is meant to glorify modern science, and, in many cases, to condemn the work of past researchers and those who were not as exceptional as Einstein or Newton. Positive evaluation of modern scientists lends credibility to current research. Additionally, the disparaging of previous research further validates the work of the modern researcher. Essentially, the negative evaluation of past research indirectly evaluates current scientists in a positive way. Furthermore, a minor pattern emerges when judging modern day people. The general populace was referenced in outlining human involvement in acts of environmental pollution. Realized incongruently, the authors place blame for smog and deforestation implicitly, using such phrases as: “…Restricted visibility caused by photochemical smog in Los Angeles” (Moran & Morgan, 1997) and “Roadways, such as this one through the Tijuca Forest in Brazil, can function as both a barrier to dispersal and source of mortality for many species.” (Smith & Smith, 2006) These indirect Judgments blame human interaction for the negative effects caused by “roadways” and “smog.”

In terms of the disparity between Renderings and Photographs, there is a lack of conclusive data. A gap exists but not enough to be statistically relevant (Figure 23).

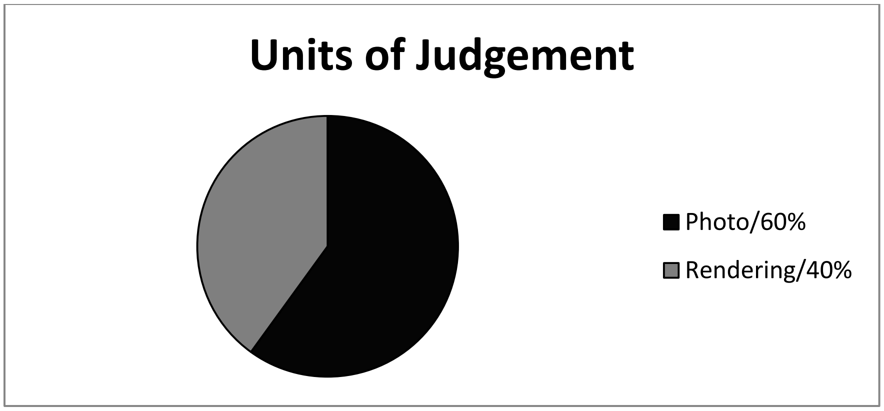


Figure 23. Judgement in Visual Media. Photo-referential text carried 60% of total Judgement.

Subcategories of Judgement reveal more specific uses of Judgement in image related text. In Figure 24, Esteem is clearly the dominant form of Judgement; however, in terms of the disparity between photos and renderings, photographs carried more than double the instances of Sanction, evaluative language related to ethics and honesty, than renderings.

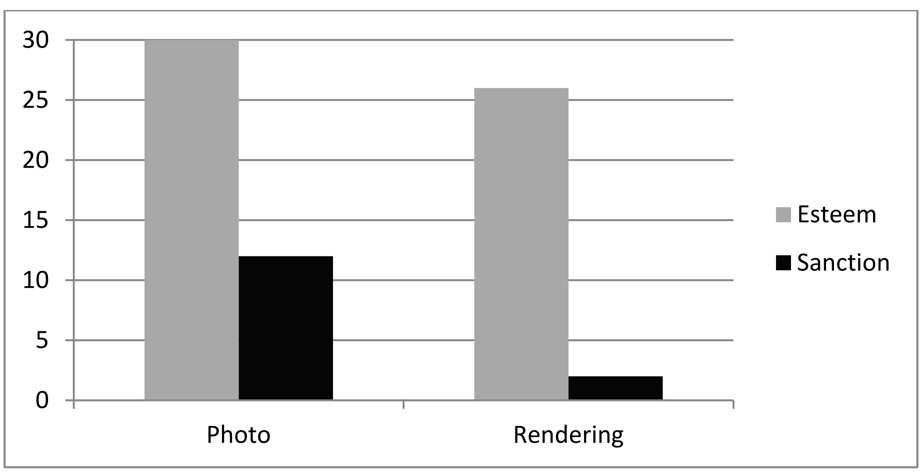


Figure 24. Sanction and Esteem in Visual Media.

APPRECIATION

The most common form of Attitude used in science writing is Appreciation with 86% of all Units of Attitude being realized as Appreciation. Out of the total instances of Appreciation, the most used form is Quality, which is to be expected in science textbooks, as the quality and attributes of a concept are the focus of writing. The remaining Appreciation categories, in order, are: Impact, Valuation, Balance, and Complexity. Figure 25 demonstrates the focus on reactionary evaluation in science writing. Impact is significant due to the fact that Impact is a reaction to an object or process, making it a carrier of opinion (Martin & White, 2005).

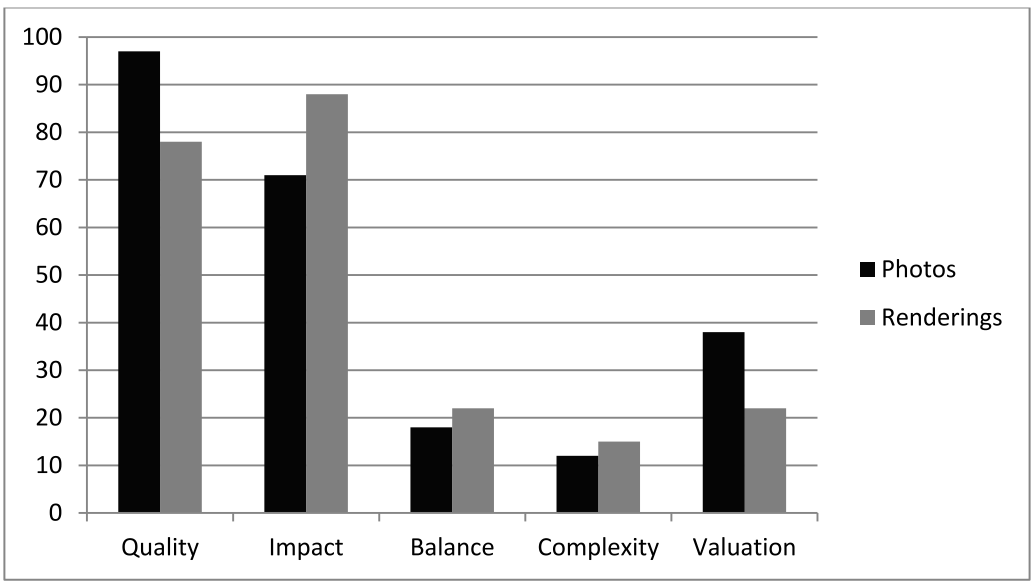


Figure 25. Instances of Appreciation.

For both images and renderings, evaluative language is a necessary tool to direct interpretation. Out of a total number of 872 clauses, with a total of 538 instances of Attitude, the ratio of Attitude per clause is 62%, meaning that for clause written in reference to an image, there is over a fifty percent chance that the language of evaluation is present. Added to this, every image had at least two clauses in reference, making Attitude consistently incorporated in the process of intersemiotic production.

EXPANSION

At face value, photographs and artistic renderings are similar in composition between the expansion types: Elaboration, Enhancement, and Extension (Figure 26). Clearly, Elaboration is the expansion of choice in science writing. The frequency of Elaboration use is relevant for two reasons: first, images are consistently used as a means of heightening specificity; second, in the production of academic writing, writers are able to have explicit knowledge of the conventions of image function, and use this knowledge for greater effectiveness when utilizing visual media in writing.

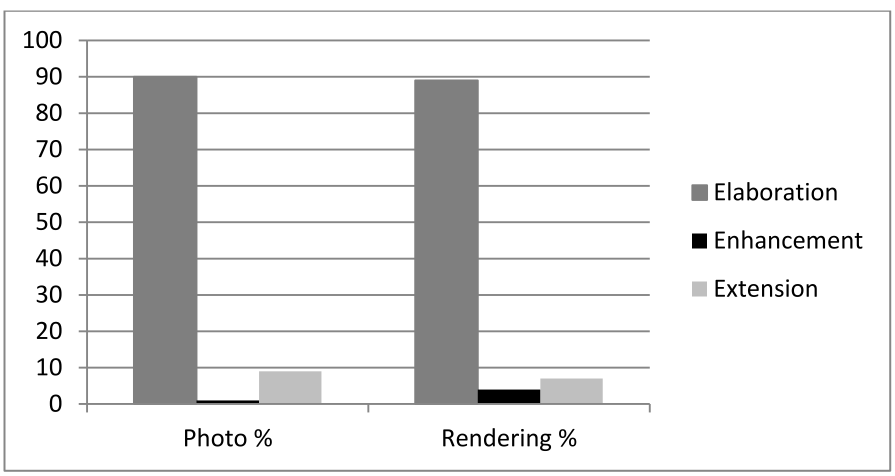


Figure 26. Similarities in Expansion between Visual Media. Elaboration is the most frequently used form of intersemiotic expansion.

Out of a total of 112 expansions in photos, 101 were elaboration, making elaboration the conventional form of expanded intersemiotic meaning. Renderings have a similar composition, dominated by Elaboration (Fig. 27). These similarities in composition indicate a norm; images are used as elaboration, to exemplify, restate, or clarify concepts that text alone is insufficient for thorough explanation.

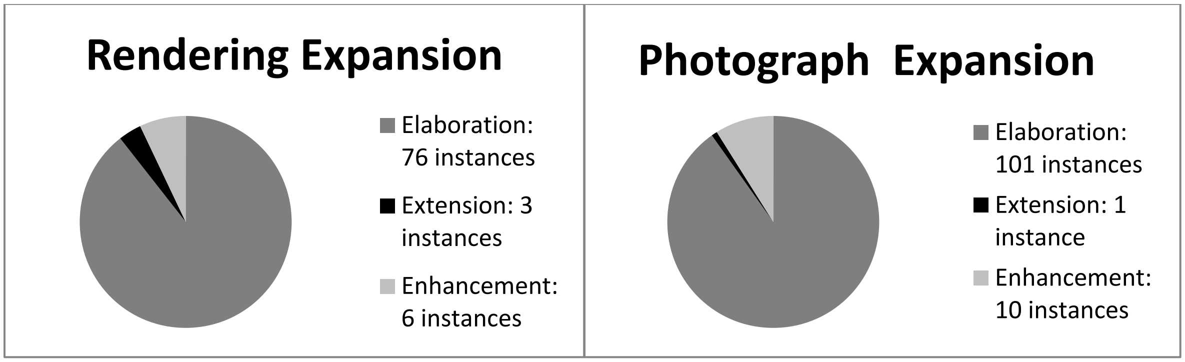


Figure 27. Elaboration Contrast between Photos and Renderings. Note the similarities in composition.

Photos and renderings serve different purposes in meaning expansion. Images take on an elaborative role in expanding meaning. The convention is evident; however, when Elaboration is subcategorized, into Exemplification, Clarification, and Exposition, the two media, photos and renderings, are found to have different elaborative purposes within discourse.

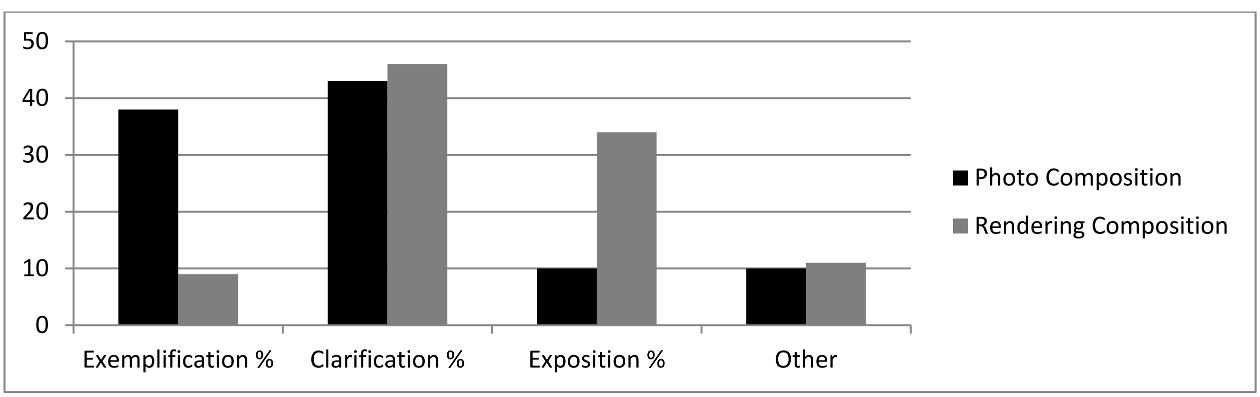


Figure 28. Elaboration Conventions in Photographs and Renderings. The mutual use of Clarification shows a generalized use of images in writing. The reverse relationship in use of Exemplification and Exposition demonstrates individualized function.

Photographs and renderings appear to have overwhelming consistency when produced in academic writing. Convergently, both are used as Clarification to support understanding in science writing by providing further definition through visual paraphrase. Divergently, both media have specific secondary roles in academic writing. According to Figure 28, photographs are conventionally used in Exemplification, as examples, or members of a class, to demonstrate specificity for reader understanding. Renderings, when used as Exposition, are restatements of the textual information, repeating the text in a visual form. Additionally, these data indicate that renderings demonstrate a greater capacity for meaning, while photographs are relegated to being subcategorized in class/member relationships. Renderings, therefore have a greater versatility in form and function, whereas photographs have a more focused purpose in academic writing.

ATTITUDE USE IN EXPANSION

Having examined the use of evaluative language to introduce an image and the means of intersemiotic integration through Expansion, it is necessary to explore the correlation between the two. Intersemiotic Expansion clauses yield powerful implications for image introduction and integration when analyzed according to their use of Attitude, and divided by their visual media. Image referential text, as presented in Table 15, is likely to use at least on unit of Attitude for every two clauses. These data indicate that in introducing an image in academic writing, authors conventionally use evaluative language for the purpose of directing the reader toward a specific interpretation of the image in context.

Table 15

Comparison of Evaluative Language Use in Photo- and Rendering- Referential Text

	Units of Attitude	Number of Total Clauses	% of Attitude per clause
Photo	276	443	53%
Rendering	262	429	52%

When these Attitude figures are categorized according to their occurrence in Elaboration and Enhancement types, by dividing the units of Appraisal by the total number clauses, analysis demonstrates that certain expansion types express opinion more than others. (Fig. 29)

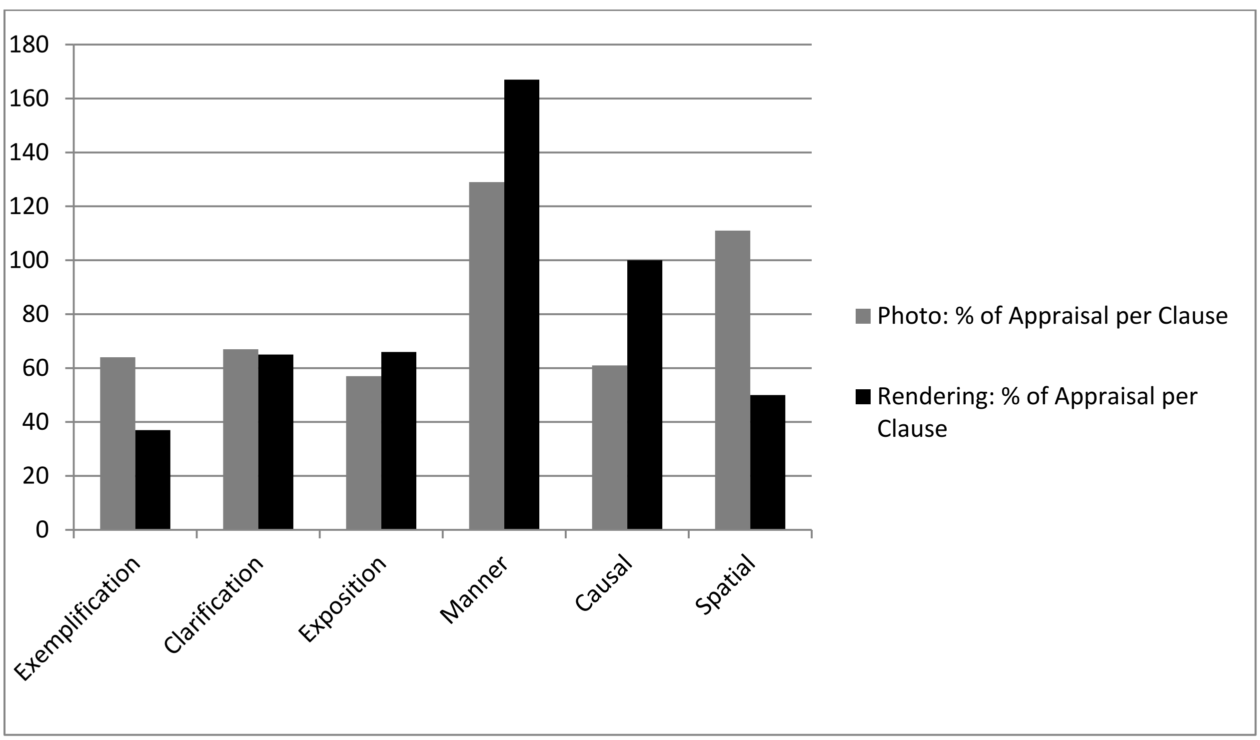


Figure 29. Attitude Potential Across Expansion Types.

Figure 29 illustrates the frequency of evaluation for the six most commonly used Expansion types. Manner, having the most Appraisal per clause, at 167% for renderings, or 1.67 units of Attitude per clause, has the most potential for embedding opinion in academic writing. The use of Manner intersemiotically allows writers to mold the reader's opinion through the use of image, in conjunction with evaluative language, making Exemplification a more objective expansion type. Referring back to Figure 28, with photographs as commonly used for the purpose of Exemplification, it can be extrapolated from these findings that photographs carry less potential for evaluation.

In combining the Elaboration types: Exemplification, Clarification, and Exposition; and as well as the Enhancement types, the graph reaches a more generalizable state.

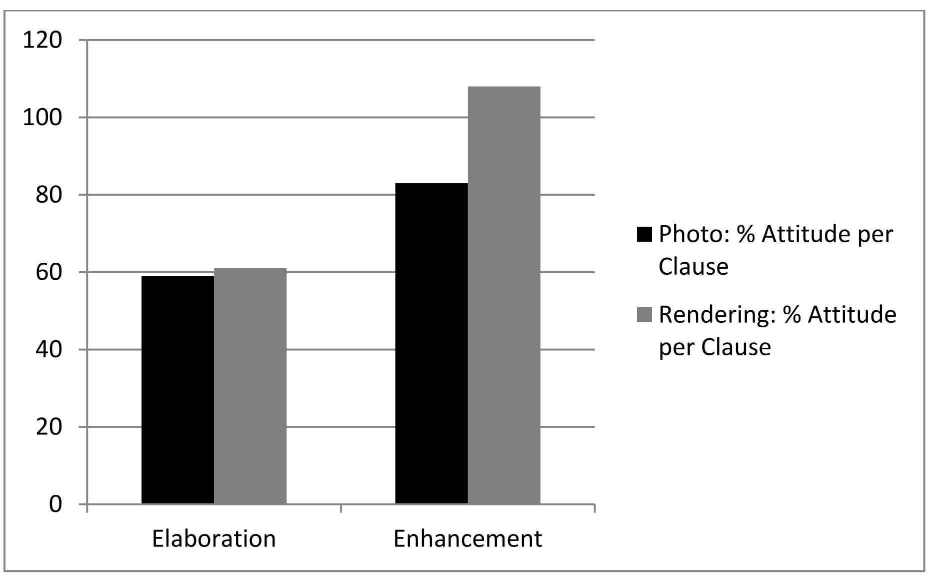


Figure 30. Potential for Evaluation in Elaboration and Enhancement Across Media. Enhancement has a comparatively higher ratio of Attitude per clause, which gives it a higher potential for subjectivity.

In the example demonstrated by Table 16, the Manner expansion type image uses a photograph for the purposes of shifting reader interpretation of radiation. Radiation, commonly believed to have negative effects on the human body and the environment, is redefined in this intersemiotic expansion, to reflect a more scientific view of radiation, taking on a neutral role.

Table 16

Enhancement as Reevaluation (Moran & Morgan, 1997)

α	x β (Manner)
The most intense portion of the solar energy that reaches the Earth's surface is visible as sunlight…The sun ceaselessly emits energy to space in the form of electromagnetic radiation.	

4. PEDAGOGICAL IMPLICATIONS & DISCUSSION

As multimodal discourse analysis is an emerging area of linguistic research, further study on intersemiosis in academic writing merits further investigation. The findings presented only analyze multimodal discourse in academic writing from the perspectives of Appraisal and logico-semantics; the myriad of perspectives with which academic multimodal discourse can be analyzed will offer exceptional insight into the successful incorporation of charts, tables, pictures and other visual media into academic writing, and the comprehension of visual expansion in reading.

The results of this analysis illustrate patterns of intersemiotic expansion as well as image introduction through Appraisal in science writing. In Composition and ESL academic writing instruction, little attention has been paid to the use and introduction of images in writing. Images are incorporated but often remain linguistically unintegrated in college level and ESL academic writing. This lack of clear integration is likely due to a fundamental lack of understanding of the generalized linguistic means of image introduction through Attitude and the functional purposes of intersemiotic expansion; findings indicate patterns for production of image referential text. When science writers make visual choices in production of academic writing, these data indicate that, contextually, the visual medium serves a specific purpose in expanding meaning often as elaboration. This purposeful expansion is significant as the uses of Elaboration are essentially example, paraphrase, and summary. Knowledge of intersemiotic integration styles may increase the effectiveness of charts, graphs, tables, photographs, etc. Additionally, the visual medium has a specific role in writing: photographs generally act as forms of exemplification whereas artistic renderings behave as visual restatements.

Furthermore, although science is commonly considered to be without evaluative language, the results of this analysis show that, not only does science use evaluation in certain circumstances, but, evaluation is also necessary in providing fresh perspectives on topics which readers may have preconceived opinions. In the use of images in academic writing, the use of Attitudinal language is essential to integration of images. By introducing an image with evaluative language, authors increase the effectiveness of image use for achieving their communicative purpose. Explicit instruction on image introduction can lend assistance in the formation of image/text cohesion as well as afford writers the skills to competently apply a new set of communicative tools in written discourse. This approach allows writers to build meaning through purposeful intersemiosis, an outcome which could not be achieved through one medium alone.

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APPENDICES

APPENDIX A:

MARSHALL UNIVERSITY®
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Office of Research Integrity

March 7, 2013

Leo Roehrich
622 1/2 Hal Greer Blvd
Huntington, WV 25701

Dear Mr. Roehrich:

This letter is in response to the submitted thesis abstract titled "A Word is Worth a Thousand Pictures: Intersemiotic Evaluation in University Science Textbooks. A Systemic Functional and Multimodal Discourse Analysis." After assessing the abstract it has been deemed not to be human subject research and therefore exempt from oversight of the Marshall University Institutional Review Board (IRB). The Code of Federal Regulations (45CFR46) has set forth the criteria utilized in making this determination. Since the information in this study only involves a textual analysis it is not considered human subject research. If there are any changes to the abstract you provided then you would need to resubmit that information to the Office of Research Integrity for review and a determination.

I appreciate your willingness to submit the abstract for determination. Please feel free to contact the Office of Research Integrity if you have any questions regarding future protocols that may require IRB review.

Sincerely,

Bruce F. Day, ThD, CIP
Director
Office of Research Integrity

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APPENDIX B:

#	Clause	αβ
	appreciation judgement affect	
	Meteorology	

2.1 Title: Radiation

pg 32 2.1 caption

The sun supplies the energy that drives the atmosphere 's
1 circulation.

The most intense (t: +qual) portion of the solar energy that reaches the Earth's surface is visible as sunlight. [Photograph by
2 J. M. Moran]

2.1 text

3 The sun drives (t: + bal) the atmosphere;

4 that is, the sun is the source of energy

5 that drives (t: + bal) the circulation of the atmosphere

6 and powers winds and storms.

The circulation of the atmosphere ultimately (t: +impact) is responsible (+complex) for weather and its temporal and spatial
7 variability.

C: cα^iβ exemplification =

The sun ceaselessly (t: +valu) emits energy to space in the
8 form of electromagnetic radiation.

T: cα^iβ manner =

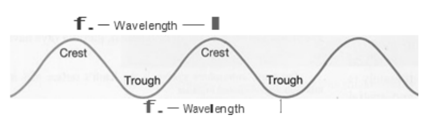
A very small (-qual) portion of that energy is intercepted (t:
9 compl) by the Earth atmosphere system*

10 and is converted into other forms of energy

including, for example, heat and kinetic energy of the
11 atmosphere's circulation.

2.2 pg. 33 Caption

The wavelength of an electromagnetic wave is the distance between successive crests or, equivalently, the distance between
12 successive troughs.



2.2 Text

13 Electromagnetic radiation travels as waves,

14 which are usually described in terms of wavelength or frequency.

Wavelength is the distance between successive wave crests
15 (or, equivalently, wave troughs),

C: 1^2 exposition =

16 as shown in Figure 2.2.

T: iα^tβ addition +

17 Wave frequency is defined as the number of crests (or troughs)

that pass a given point in a specified period of time, usually 1
18 second.
19 Passage of one complete wave is called a cycle,
20 and a frequency of 1 cycle per second equals 1.0 hertz (Hz)

Fig 1 Caption pg. 48

Sunbathers run the risk of excessive exposure (t: -
21 esteem:normality) to solar ultraviolet (UV) radiation,
22 which can cause health problems. (Photograph by 1. M. Moran)

Fig 1 Text

Most people welcome (t: +happiness: cheer) sunny (+qual)
23 weather.

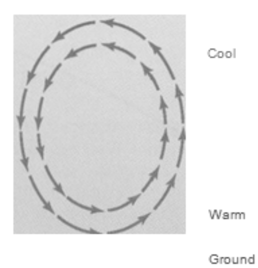
Bright (+qual) sunny (+qual) skies not only permit a wide variety of outdoor activities,
24
but they also seem to energize (t: +happiness: cheer) and cheer (t
25 +happiness: cheer) us.
During warm (+qual) weather, many people spend as much time
26 as possible in the sun.
some of them sunbathing for hours in order to develop a dark
27 (+qual) tan (Figure I).
28 However, mounting (t: -qual) evidence indicates
that too much sun (t: -esteem: normality)can cause serious health
29 problems,
including skin cancer and cataracts of the eye. c: cα^iβ
30 manner/spatial

The culprit (t: -valu) is overexposure (t: -valu) to the ultraviolet
31 portion of solar radiation. t: tα^iβ manner x

3.7 pg. 76 Caption

Convection currents transport heat from near Earth's surface into
32 the troposphere.

3.7 Text



Convection in the atmosphere is the consequence of
33 differences .in air density.
34 Cooler (+imp) air is denser (+imp) than warmer (+imp) ai
As heat is conducted from the relatively warm (+imp) gr
35 to the cooler (+imp) overlying air,
36 that air is heated
37 and expands. c: 1^2 exposition =
38 Cooler (+imp), denser (+imp) air from above sinks t: 1^2 exposition

39 and forces the warmer (+imp), less dense (-imp) air at the ground to rise.
40 (This is similar (+comp) to what happens
41 when cold tap water flows into a tub of hot (+qual) water;
42 that is, the cold (+qual) denser (+imp) water sinks
43 and forces the hot (+qual) less dense (+imp) water to rise.)
44 Ascending warm (+qual) air expands
45 and cools
46 and eventually sinks back to the ground.
47 Meanwhile, the cooler (+imp) air now in contact with the warm ground
48 is heated
49 and rises.
50 In this way, << >>, a convective circulation of air transports heat vertically from the Earth's surface thousands of meters (t: +imp) into the troposphere.
51 << as illustrated in Figure 3.7 >>

3.8 pg. 77 Caption
52 The contrast in specific heat (t: +imp) is one reason
53 why the sand is hotter (+imp) than the water. [Photograph by J. M. Moran]

3.8 Text
54 Water has the greatest specific heat (+imp) of any naturally (t: +qual) occurring substance.

55 For example, its specific heat is about five times that of dry sand (t: +imp).
56 Hence, 1 cal of heat will raise the temperature of 1 gram of water 1 Celsius degree,
57 whereas 1 cal will raise the temperature of I gram of sand about 5 Celsius degrees.
58 This is one reason why

c: cα^iβ spatial X

59 in summer the sand at the beach feels hot relative to the water (+imp) (Figure 3.8).

t: tα^iβ exemplification

13.3 Caption pg. 310
60 A shelf cloud such as this one may develop along a thunder storm gust front.
61 Often, shelf clouds are accompanied by strong and gusty surface winds

62 and may be associated with a severe thunderstorm.
63 [Photograph by Arjen and Jerrine Verkaik/SKYART]

13.3 Text

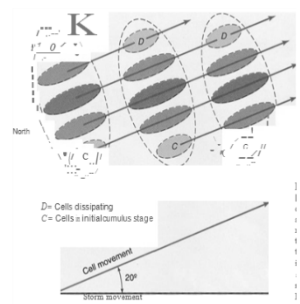
64 A shelf cloud, << >> is a low (+qual) , elongated cloud
65 << also called an arcus cloud, >>
66 that is wedge-shaped with a flat base (Figure 13.3).
67 This cloud appears at the edge of a gust front and beneath
68 and attached to a cumulonimbus cloud.
69 A shelf cloud is thought to develop as a consequence of uplift of stable (+qual) warm (+qual) and humid (+qual) air along the gust front.

c&t: α^iβ exemplification =

70 Damaging (t: impact) surface winds may occur under a shelf cloud,
71 and sometimes this cloud is associated with a severe (-impact) thunderstorm.

13.6 pg. 312 Caption

72 In this idealized (+imp) situation, individual (+bal) thunderstorm cells, << >> travel at about 20 degrees to the direction of movement of the multicellular thunderstorm.
73 << viewed from above,>>
74 As they move,
75 the individual (+bal) cells progress through their life cycle.
76 [After K.A. Browning and F. H. Ludham,"Radar Analysis of a Hailstonn,"Technical Note No. 5, Meteorology Department, Imperial College, London]



13. 6 Text

77 For example, << >>, a thunderstorm tracks from west to east,
78 << as illustrated schematically (t: +qual) in Figure 13.6>>
79 whereas its five component cells head off toward the northeast

c: 1^2 exposition =
t: iα^tβ exemplification =

80 In this idealized case, new cells continually (t: +qual) form in the southern sector of the storm,
81 mature (+qual) cells occur near the middle of the cluster,
82 and old (-qual) cells continually (t: -qual) dissipate in the northern sector.

18.1 Caption pg. 442

83 Luxuriant (+valu) tropical rainforests grow

84 where rainfall is abundant (+qual)
85 and temperatures are relatively high (+imp) throughout the year

18.1 Text

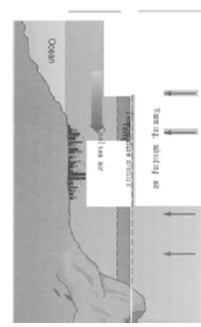
Convective rainfall, << >>, typically peaks (t: +bal) in
86 midafternoon, the warmest (+imp) time of day.

c: cα^iβ
exemplification =
t: tα^iβx spatial

87 <<controlled by insolation>>
88 Because water vapor concentrations are very high (+qual),
even the slightest (+bal) cooling during the early morning hours
89 results in dew or fog,
which gives such a region a sultry (+qual), steamy (+qual)
90 appearance.

17.9 pg. 411 Caption

Prevailing atmospheric circulation patterns and topographic features combine to give Los Angeles an unusually high (-qual)
91 air pollution potential (t: -qual)



17.9 Text

Figure 17.9 shows the air circulation and topographic features
92 that influence air quality in that city.

Weather in the Los Angeles area, << >> is strongly (+bal) influenced by the eastern edge of the semipermanent Pacific
93 anticyclone.
94 << like the weather throughout much of California,>>
This subtropical high is responsible (t: -valu) not only for
95 California's famous (+valu) fair (+qual) weather
96 but also for air that gently (t: -impact) subsides over Los Angeles.

c: iα^cβ= clarification
t: iα^tβ
exemplifictaion=

17.10 Caption pg. 411

Restricted (t: -imp) visibility caused by photochemical smog in
97 Los Angeles (t: -sanction:prop)

17.10 Text

The exceptionally high (+qual) incidence of temperature inversions over Los Angeles is aggravated (-valu) by topogr bar riers.
98
99 The city is situated in a basin
100 that opens to the Pacific
101 and is rimmed on three sides by mountains.

Cool (+qual) breezes that sweep inland from the ocean are unable
102 (t: -esteem:capacity) to flush pollutants out of the city.

c: α^iβ clarification =

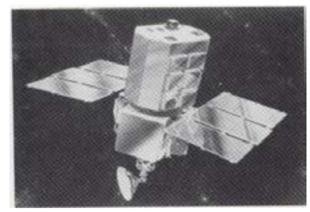
Mountains and a temperature inversion aloft thus encase the city
103 in its own fumes,

t: α^iβ= exemplification

and within this crucible (t: -sanction: propriety) a complex photochemistry takes place that produces photochemical smog
104 (Figure I 7.10).

20.3 pg. 473 Caption

An artist's conception of NASA's Solar Maximum Mission
105 Spacecraft.



Instruments aboard this satellite, in a 55 km (340-mi) high (+qual) orbit around the Earth, provided de1ruled measurements
106 of solar energy output. [NASA graphic]

20.3 Text

Until 1980, scientists had been unable (esteem: capacity) to
107 monitor small-scale changes in the solar constant.

Older ground-based (-qual) instruments lacked the necessary
108 sensitivity, (t: -esteem:capacity)

c: α^iβ x spatial

and high-resolution instruments aboard satellites had not been
109 operating long enough to provide reliable (t: +qual) records.

t: α^iβx causal

This situation began to change on 14 February 1980 (t: +esteem: capacity) with the launch of NASA's Solar Maximum Mission (SMM) satellite into orbit 550 km (341 mi) above the Earth's surface (Figure 20.3).
110

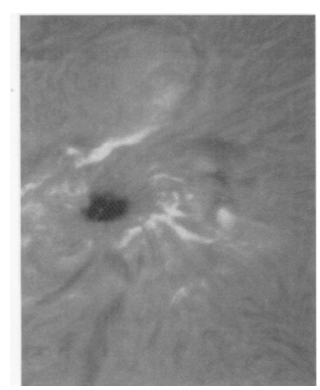
20.4 pg. 474 Caption

111 A sunspot.

Climate changes on Earth may be linked to variations in number
112 of sunspots on the sun.

Although sunspots are relatively cool (+qual), dark (+qual)areas
113 in the sun's photosphere,

there is an interesting correlation between periods of reduced sun spot activity and cool episodes on Earth. [Courtesy of Dr. Donat
114 G. Wentzel, University of Maryland at College Park,



20.4 Text

Both the popular (+qual) and technical (+qual) literature contain much speculation (t: -esteem: veracity) on a possible (-
115 qual) link between Earth's weather and climate and sunspot

activity.

116 A sunspot is a relatively large (+qual) (typically thousands of kilometers in diameter (t: +imp)) dark (-qual) blotch (t: -valu)

117 that appears on the face of the sun (Fi gure 20.4).

c: α^iβ exemplification =

t: α^iβ= clarification

118 lt is caused by a strong (+qual) magnetic field

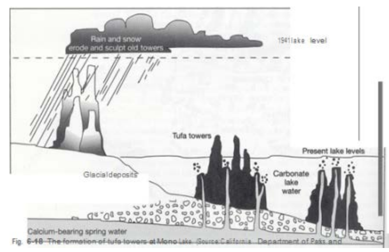
119 that suppresses the flow of gases

120 transporting heat from the sun's interior.

121 A sunspot consists of a dark (+qual) central region, called an umbra,

122 ringed (t: +bal) by an outer, lighter (+imp) region, termed a penumbra.

Cali Geology



6.18 pg. 104 Caption

123 Fig. 6-18 The formation of tufa towers at Mono Lake. (Source:California Department of Parks and Recreation.In California Geology, 1992.)

C; α^iβ clarification =

t: α^iβ = exemplification

6.18 Text

124 The towers are a form of calcium carbonate known as tufa.

125 Tufa forms in zones

126 where water from springs that discharge into the lake mixes with the lake water.

127 The two waters differ (t: +imp) in their chem istry:

128 the springs carry dissolved (t: -bal) calcium from nearby rocks,

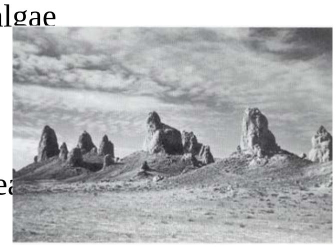
129 and the alkaline lake water contains abundant (+imp) carbonate.

130 The mixed water is saturated (+bal) with calcium and carbonate,

131 leading to the crystallization (t: +bal) of the mineral calcite (CaC03) .

132 Some tufa contains cells of algae,

133 indicating that the process may be aided (t: +valu) by the algae (Fig. 6-18).



6.19 pg. 105 Caption

134 Tufa towers along the edge of Pleistocene Searles Lake, near Trona.

6.19 pg. 105 Text

The Pinnacles near Trona, along the southwestern shore of
135 Searles Lake, are another example of tufa in Califomia.

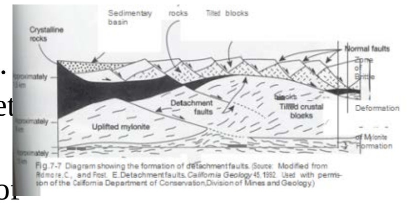
The towers stand more than 30 meters above the now-dry (-qual)
136 basin (Fig.6-19).

Tufa can also be found along the ancient (+impact) shores of Pleistocene lakes at Honey Lake, Indian Wells Valley, Panamint
137 Valley, the Salton Sea, and in Nevada.

c: α^iβ = clarification

t: α^iβ = exemplification

7.7 pg. 119 Caption



138 Diagram showing the formation of detachment faults.
(Source: Modified fromPridmore,C., and Frost. E.Det
139 faults.California Geology 45,1992.

Used with permissoi n of the California Department of
140 Conservation,Division of Mines and Geology.)

c: iα^cβ clarification =

t: iα^tβ = exposition

7.7 Text

141 Recent (+imp) studies have demonstrated (t: +esteem: capacity)

that many of southeastern California's normal faults are steep (-
142 qual) at the surface

143 but dip (t: -qual) at a more shallow (-qual) angle at depth.

144 In some areas, multiple normal faults converge

145 or are cut off (t: -qual) along a single,gently dipping fault surface.

Rocks on the upper surface move over those on the lower plate
146 along these master faults,

147 which geologists refer to as detachment faults (Fig. 7-7).

7.9 pg. 120 Caption

View of a detachment fault, northern Mesquite Mountains
148 to south).

Dark (-qual) craggy (-qual) areas at the top of the hills are
149 Cambrian rocks of the upper plate.

Proterozoic lower plate metamorphic rocks are snow-covered.
150 (Source:McMackin,M. San Jose State University.)

c: α^iβ exposition =

t: α^iβ x manner

7.9 Text

In areas where mylonite is now seen at the Earth's surface along
151 detachment faults,

geologists can conclude (t: +esteem: tenacity)that 8 to 15
152 kilometers of overlying rock must have been removed (Fig. 7-9).

10.2 A pg. 207 Caption

Effects of the 1964 flood on the town of Orick,Humboldt
153 County.

10.2 A Text

Another important (+imp) and often overlooked (-imp) aspect of California's climate is the normal (+imp) cyclic (+comp)
154 occurrence of both flood and drought.

Prolonged, (-qual) severe (-qual) droughts are part of this
155 recurrent, variable pattern;

during 1928 to 1934, 1976 to 1977, and 1987 to 1992, insufficient (-qual) water supplies have stressed the states ability
156 to meet the demand for water.

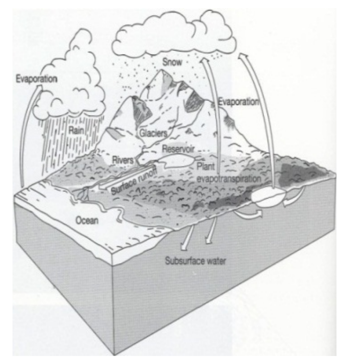
c: α^iβ exposition=

By contrast (t: -imp), damaging (-valu) floods produced by extremely high (-qual) rainfall occur somewhere in the state at
157 least once in every decade (t: -imp) (Fig. 10-2).

t: α^iβ causal x

10.3 pg. 208 Caption

158 The hydrologic cycle.



10.3 Text

Of all the precipitation that falls over California, only about 35 (-
159 imp) percent becomes the runoff to streams and lakes.

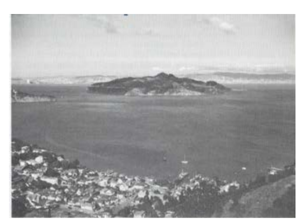
Because of California's relatively high (+imp) temperatures, evaporation from the land surface takes up much of the precipitation, and transpi ration by the vegetation uses another
160 substantial portion (Fig. 10-3).

c: 1^2 = exposition

t: iα^β x causal

12.16 pg. 269 Caption

Angel Island, San Francisco Bay,with the city of Tiburon in the
161 foreground and the Berkeley Hills on the far horizon.



12.16 Text

The steep hills that pop up from the flat (+qual) streets of San
162 Francisco

163 remain in the minds (t: +imp) of visitors from all over the world.

c: α^iβ = clarification

The city's landscape is a striking (imp) example of

t: α^iβ =exemplification

164

165 how geology shapes topography.

166 The hills are more resistant (+bal) blocks of Franciscan rock;

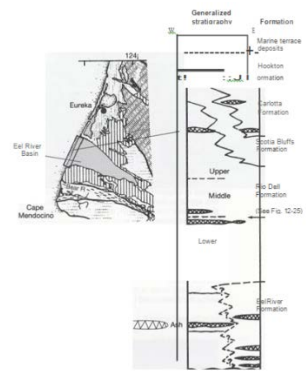
167 for example, Tele graph Hill is resistant greywacke.

Twin Peaks a sequence of radiolarian chert and basalt, and in the Bay, Angel Island contains metamorphosed Franciscan
168 greywacke and chert (Fig. 12-16).

12.23 pg. 275 Caption

A simplified (+qual) geologic map and strati graphic column
169 showing formations of the Eel River basin, Humboldt County.

The approximate positions of Fig. 12-22 and Color Plate 7 are
170 lhown in the cross section



12. 23 Text

Because of recent faulting, compression, and uplift near the
171 Mendocino Triple Junction,

pa1t of the Eel River Basin in northwestern California now lies
172 on land.

173 The sedimentary rocks which were deposited in the basin

174 have been highly folded (+qual) and faulted (+qual).

Along the beach south of the mouth of the Eel River, the rocks
175 have been tilted (Fig. 12-22).

c: α^iβ = clarification

The tilting of the originally (+valu) horizontal layers makes a walk along the beach from south to north a tour through the
176 basin's history.

t: α^iβ = exposition

177 One can "see" the Eel River basin

fill with sediment as younger sedimentary formations represent
178 increasingly shallow (+qual) water deposits (Fig. 12-23).

13.14 pg. 303 Caption

Liquefaction of sandy sediments along the Pajaro River resulted
179 in the collapse of the Highway 1 bridge.

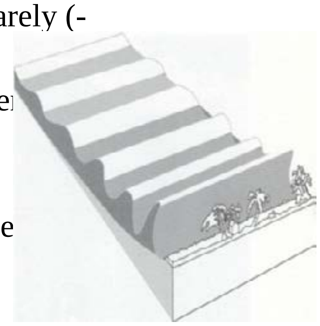
Note (t: +imp) that the bridge pilings punched up (t: +qual)
180 through the pavement on the right side of the photo.

α^iβ causal x

13.16 pg. 305 Caption

181 Fig. 13-16 Creation of a tsunami.

In the deep (+bal) ocean (rear of the diagram), tsunamis barely (-
182 qual) raise the sea surface,



and the crests of successive waves can be up to 30 kilometer
183 apart. (t: +imp)

184 When the waves reach shallower (+imp) water,

the wave bases are slowed (t: -qual) by interactions with the
185 floor (see Chapter 15).

13.16 Text

186 Areas along California' s coast are vulnerable (-bal) to tsunamis.

c: α^iβ = clarification

A tsunami is created when an earthquake ruptures (t: -imp) the
187 ocean floor,

t: α^iβ = exposition

or as a result of huge (+qual) submarine land slides or volcanic
188 eruptions.

Earthquakes with vertical displacement cause the water above the
189 sea floor to be displaced.

A series of long (+qual) waves radiates outward from the point of
190 rupture (t: -qual).

191 The waves are long (+qual) and low (-qual)in the open ocean,

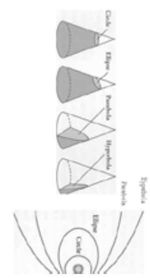
but they can pile up (t: +bal) along the shoreline to create a wall
192 of water more than 30 meters high (t: +imp) (Fig. 13-16).

193 Because they may originate anywhere in the Pacific Ocean,

tsunamis can arrive at the California coast without warning (t: -
194 imp).

Disco Universe

2.13 Caption pg. 56



Conic Sections A conic section is any one of a family of curves
195 obtained by slicing a cone with a plane.

196 as shown in this figure.

The orbit of one body about another can be an ell ipse, a parabola,
197 or a hyperbola.

198 Circular orbits are possible

because a circle is just an ellipse for which both foci are at the
199 same (+imp) point.

c&t: α^iβ
exemplification =

2.13 TEXT

Newton also discovered (t: +esteem: capacity) that some objects
200 have nonelliptical orbits around the Sun.

His equations led him to conclude (t: +esteem: normality) that the orbits of some objects are parabolas and hyperbolas (Figure
201 2-13).

For example, comets hurtling (t: +qual) toward the Sun from
202 the depths of space often follow para bolic or hyperbolic orbits.

2.14 Caption pg. 56

Halley's Comet Halley's Comet orbits the Sun with an average
203 (+qual) period of about 76 yea rs.

During the twentieth century. the comet passed near the Sun
204 twice,
205 once in 1910 and again.
206 shown here. in 1986.
207 The comet will pass close to the Sun again in 2061.
208 While dim (-qual) in 1986.
it nevertheless spread more than 5 across the sky (t: +imp), or 10
209 times the diameter of the Moon (t: +imp). (Harvard College

2.14 Text

In the spirit of the scientific method (+valu), Newton's laws and mathematical techniques were used to predict new (+imp)
210 phenomena.

c: α^iβ = exemplification

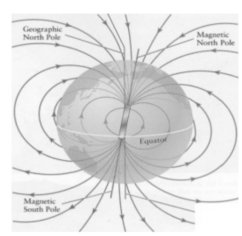
Newton's friend (t: +sanction: propriety), Edmund Halley, was
211 intrigued (+satis: interest) by historical records of a comet

t: α^iβ = clarification

212 that was sighted about every 76 years.
213 Using Newton 's methods,
Halley worked out (t: +esteem: tenacity) the details of the
214 comet's orbit
215 and predicted (t: +esteem: capacity) its return in 1758.
216 It was first sighted on Christmas night of that year,
and to this day the comet bears Halley's name (t: +esteem:
217 normality) (Figure 2 l4).

6.8 Caption 146

218 FIGURE 6-8 The Earth's Magnetic Field
<a) The magnetic field of a bar magnetis revealed by the
219 alignment of iron fillings on paper



220 .{b) Generated in the Earth's molten. metallic core.
221 the Earth's magnetic field extends far into space. (t: +qual)
Note (t: +imp) that the field is not aligned (-qual) with the Earth's
222 rotation axis.
By convention, The magnetic pole near the Earth's north rotation
223 axis is called the magnetic north pole

α^iβ = clarification

224 even though it Is actually the south pole on a magnet! (t: imp)
We will see similar (+imp) misalignments and flipped magnetic
225 fields
226 when we study other planets. Ca:Jules Bucher/Photo Researchers)

6.10c pg. 147 Caption

(c) Aurora Borealis in Alaska. The gorgeous (+imp) aurora seen
227 here is mostly glowing (t: +qual) green

228 due to emission by oxygen atoms in our atmosphere

229 .Some auroras remain stationary (qual)for hours.

230 while others shimmer. (t: +qual)

231 like curtains blowing in the wind. (t: +qual) = exemplification

11.6 pg. 303 Caption

232 Classifying the Spectra of Stars

The modem classification scheme for stars based on their spectra was developed at the Harvard College Observatory (t: +esteem: capacity) in the late nineteenth century.
233

Women astronomers.<< >> and Williamina Fleming, standing
234 in (a).

<< initially led by Edward C. Pickering (not shown) >>(t:
235 +esteem: normality)

236 and then by Annie Jump Cannon (t: +esteem: normality)

(b), analyzed hundreds of thousands of spectra.(t: +esteem:
237 tenacity)

Social conventions of the time prevented most women astronomers (t: -sanction: propriety) from using research
238 telescopes

or receiving salaries comparable to those of men (t: -sanction:
239 propriety)

α^iβ = clarification

α^iβ = clarification

11.6 pg. 303 Text

In the early 1900s, William Pickering and Williamina Heming, << >> and their col leagues at Harvard Observatory (Figure 11-6) set up (t: +esteem: normality) the spectral classification
240 scheme

241 << followed by Annie Jump Cannon,>>

242 we use today. (t: +valu)

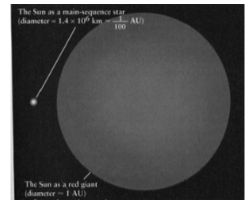
12.22 pg. 335 Caption

243 FIGURE 12 22 The Sun Today and as a Giant

(a) In about five billion years. when the Sun expands to become a
244 giant.

its diameter will increase a hundredfold (t: +bal) from what it is
245 now.

246 while Its core becomes more compact. (+bal)



Today. the Sun's energy is produced in a hydrogen-fusing core
247 whose diameter is about 200.000 km.

When the Sun becomes a giant. it will draw its energy from a
248 hydrogen-fusing shell

249 surrounding a compact helium-rich core.

α^iβ temporal x

The helium core will have a diameter of only 30.000 km. (t:
250 +imp)

t: α^iβ = exemplification

251 The Sun's diameter will be about 100 times bigger.(t: +imp)

and it will be about 2000 times more luminous (t: +imp) as a
252 giant than it is today.

(b) this composite of visible and infrared images shows red giant stars in the open cluster M60 in the constellation of Monoceros (the Unicorn). (T. Credner and S.Kohic. Astronomical lnstitute of the University or Bonn)
253

12.22 Text

Although the surface of a giant is cooler (+qual) than that of the
254 main-sequence star

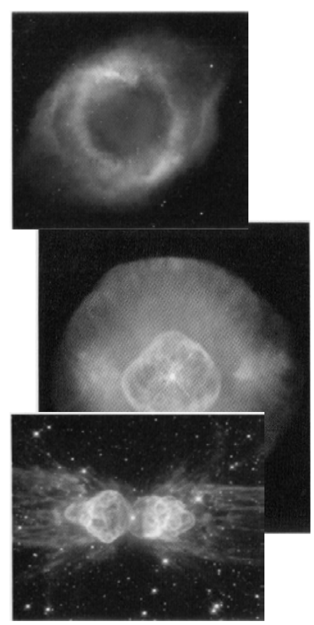
255 from which it evolved,

256 the giant is more luminous: (+qual)

257 It can emi t more photons each second

258 because it has so much more surface area. (t: +imp)

As a full-fledged (+bal) giant (Figure 1 2-22), our Sun will
259 shine 2000 ti mes more brightly (t: +qual) than it does today.



13.4 pg. 353 Caption

260 Some Shapes of Planetary Nebulae

The outer shells or dying low mass stars are ejected In a
261 wonderful (+imp) variety of patterns.

(a) NGC 7293. the Helix Nebula. is located in the constellation
262 Aquarius.

263 The star that ejected these gases

264 is seen at lhe center of the glowing (t: +qual) shell.

This nebula,located about 700 ly (215 pc) from Earth. has an angular diameter equal to about half that of the full Moon. (t: -
265 imp)

266 b) NGC 6826 shows jets of gas (in red)

267 whose orignin is as yet unknown. (t: -comp)

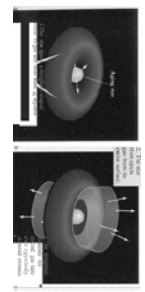
(c) ML 3 (Menzel3). In the constellation Norma (the Carpenter's
268 Level). is 3000 ly (900 pc) From Earth.

The dying (-valu) star. creating these bubbles of gas.

c&t: α^iβ
exemplification =

269
270 may be part of a binary syslem.

13.5 353 Cpation
271 Formation of a Bipolar Planetary Nebula Bipolar
272 planetary nebulae may form in two Sleps.
Astronomers hypothesize (capacity) that (a) first, a doughnut-shaped (+qual)cloud of gas and dust is emitted from the star's
273 equat
274 Or.(b) followed by outflow
275 that Is channeled
by the original (+valu) gas to squirt out (t: -qual) perpendicular to
276 the plane of the doughnut (qual) .



(c) The Hourglass Nebula appears to be a textbook example of
277 such a system.
The bright (qual) ring is believed to be the doughnut-shaped
278 (+qual) region of gas
279 lit by energy from the planetory nebula.
The Hourglass is located about 8000 ly (7.500 pc) from Earth.
280 (c:R. Sahai and J. Trauer. JPL:WFPC-2

13.4 and .5 Text
The outflowing gases ejected in a planetary nebula are turned
281 into a breathtaking (+imp) variety of shapes

c: 1^2 exposition =

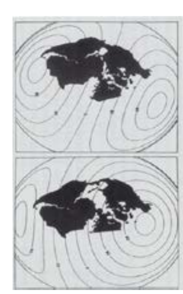
when they interact with gases surrounding their stars, with
282 companion stars, and with the stars' magnetic fields,

t: α^iβ = clarification

which are often 10 to 100 times stronger (t: +imp) than the Sun's
283 field (Figures 13-4 and Figure J 3-5).
The Hourglass Nebula (Figure 13-5c) appears initially to have
284 shed mass in a doughnut shape (t: +qual) around itself
.In the star's final death throes (t: -valu), this gas and dust forced the final (valu) out flow to go in two directions perpendicular to
285 the plane of the doughnut, (t: +qual)
286 creating what is called a bipolar planetary nebula.

New Cosmos

Pg 56. 3.3 The continental drift. (Caption)



The positions of the con tinents around the Atlantic ocean (in
287 relation to North America) at different (imp) times.
288 The continents move apart with velocities of 2.5 to4cmyr- 1 •

(With the kind (+valu) permission of the Wissenschaftliche
289 Verlagsgcsellschaft, Stuttgart)

(Text)

On the average, America and Europe have moved apart by a few
290 centimeters per year in the intervening time (Fig. 3.3).

In the 1950's, paleomagnetic investigations thus provided strong
(+imp) evidence (t: +esteem: capacity) in favor of the continental
291 drift theory,

which had-previously been the subject of controversy (t: -imp)for
292 many years

; then, in the 1960's, they provided an insight (t: +esteem:
293 capacity)into the basic mechanisms of the continental motion: c&t: α^iβ = clarfication

it had been noticed (t: +esteem: tenacity) from the paleomagnetic
measurements that directly adjacent layers of minerals often
indicate diametrically opposed (t: +comp) directions for the
294 magnetic field.

. Detailed (+comp) investigations of precisely (t: +imp) dated
series of layers showed that this was due not to a spontaneous
295 (+qual) remagnetization of the rocks,

296 but rather to a reversal of the entire magnetic field of the Earth

297 This no longer seems so surprising (+valu)

298 if one considers

that in the self-exciting dynamo, the direction of the cur rent is
determined by the random (-comp) weak magnetic fields present
299 when the machine is started up.

Fig.3.27. Caption

Cornet C/1957 PI Mrkos in a photograph made with the Mount
300 Palomar Schm idt camera (1957).

Above, we see the extended (+qual), richly (+qual) structured
type I or plasma tail; below, the thicker (+qual), nearly featureless
301 (-qual) type IT or dust tail.

Text

Photographs taken with a suitable (+valu) exposure time (Figs.
3.27, 28) show that a comet consists of a nucleus (which is
302 seldom clearly recognizable (+imp)),

303 often having a diameter of only a few kilometers. (t: -comp)

It is surrounded by the coma which is like a diffuse (+comp),
304 misty (-qual) shroud

that usually takes the form of a series of parabolic shells or rays
305 stretching out (t: +imp) from the nucleus.

c&t: α^iβ exemplification =

The nucleus and the coma together are called the head of the
306 comet;
307 its diameter is in the range of 2· l 04 to 2 ·105 km.

Roughly within the orbit of Mars,cometsdevelop the well-known
308 tail which,

in its visible portion, can atta1n a length of 107 and sometimes
309 even 1.5·108 km = I AU. The

brighter (+imp) comets can be observed in the ultraviolet region
310 of the spectrum from satellites
311 and i t is found that

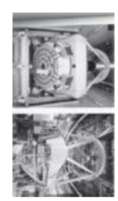
the head is surrounded by a halo out to a distance of several 107
312 km,
313 consisting of atomic hydrogen
314 which radiates strongly (t: +qual) in the La line at A.= 121 .6 nm.

pg. 133 5.11 Caption

The New Technology Telescope (NIT) of the Eu ropean Southern
315 Obcservatory (ESO) on La Silla (Chile).
316 In th1s telescope, completed in 1989,

the shape of lhe 3.5 m mirror is optimized (t: +bal) by 78
317 transducers under computer control.

5.11 Text



Active Optics. ln this method, the surfaces of the telescope mirrors themselves are corrected for mechan ical, thermal and optical defects by computer-controlled transducers (Figs.5.11,
318 12).

These corrections are much slower than (+imp) the turbulent
319 variations of the wavefronts-

so that the adjustments can be carried out on a time scaleof the
320 order of1s,

and thus even the primary mirrors of large telescopes can be
321 corrected in this way (t: -imp).

t: α^iβ clarification =

c: α^iβ = exemplification

pg 134 5.13 Caption

Fig.5.13a,b. The Multiple Mirror Telescope (MMT) on Mount
322 Hopkins, Arizona.

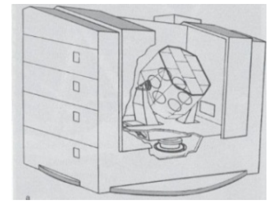
(a) Schematic drawing of the tele scope with its six mirrors. is
323 mounted azimuthally in its building.

(b) Light-ray paths for a pair of oppositely-mounted 1.8 m mirrors in a Cassograin optical system with a common (+imp)
324 focus.

In the central axis, there is a 0.76 m guide telescope for pointing
325 the MMT and steering the main mirrors.

These mirrors were replaced (t: -valu) in 1998 by a single 6.5 m
326 mirror.

(With the kind (+esteem: propriety) permission of the American
327 I nstitute of Physics, New York, and of the authors)



c: α^iβ clarification =

t: α^iβ clarification =

5.13 Text

The precursor of the new (+qual) generation of large tele· scopes was the multiple-mirror telescope or MMT on Mount
328 Hopkins in Arizona,

which has been used since 1979 for optical and infrared
329 observations (Pig. 5.13).

Six identical (+comp) mirrors, each with a diameter of 1.8 m, are
330 mounted together with a common axis;

the light from each mirror is redirected by a secondary mirror
331 onto the common (+imp)quasi-Cassegrain focus.

pg. 228 7.18 Caption

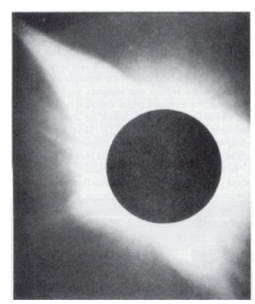
332 Fig.7.18. The solar corona, near the sunspot.

Taken during the solar eclipse in Khartoum in 1952 by G. van
333 Biesbroeck.

The corona at minimum exhibits extended "rays" (t" +imp) in the
334 region of the sunspot zones;

335 above the polar regions, there are finer (+imp) "polar brushes".

336 The corona at maximum has a more rounded (+imp) shape



7.18 Text

During the totality of a solar eclipse or using the Lyot coronagraph on a high (+qual) mountain with the clearest (+valu)
337 air possible,

the solar corona can be observed out to several solar radii (Fig.
338 7.18).

Its form (flattening, radial structure, etc.) and brightness (t: +qual)
339 are functions of the 1J year cycle.

c: α^iβ clarification =

t: α^iβ = exemplification

Spectroscopic analysis distinguishes the following phenomena, which we shall in part attempt (t: -esteem: capacity) to explain
340 immediately (t: +qual):

pg. 254 7.35 Caption

341 Fig.7.35. A model of a cataclysmic binary star system.

The geometric relationships correspond to those of the dwarf nova ZCam. E.L. Robinson, Ann. Rev. Astron. Astrophys. 14,119
342 (1976).

(Reproduced with the kind (+esteem: normality) permission of
343 Annual Reviews Inc., Palo Alto)

7.35 Text

. More precise observations (t: +esteem: tenacity), especially of several favorable (+valu) cases of eclipsing binalies (Sect. 6.5.2),
344 yield the following picture (Fig. 7.35):

in the cataclysmic bi· nary star systems whose periods lie in the range or about 1.3 to 15 h, the matter ejected from the secondary component, due to its angular momentum, does not fall directly
345 into the white dwarf, c: α^iβ clarification =

but instead forms a rapidly (t: +qual) rotating accretion disk
346 around the dwarf. t: α^iβ clarification =

347 In this disk, the marter loses angular momentum through friction and thus gradually (t: +qual) moves inwards to the suJface of the
348 white dwarf.

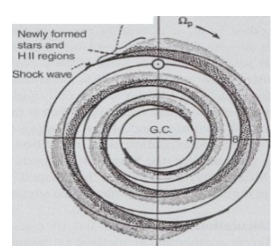
At the point where the gas flow meets the disk, a "hot spot" is
349 formed.

The main contribution to the luminosity (t: =qual) comes not from the white dwarf but, depending on the particular case, from
350 the disk or the hot spot.

pg. 391 Fig. 11.13 Caption

351 Fig. 11.13.The spiral structure of our galaxy (0 =Sun).

The quasistationary (-qual) spiral density wave according to C.C. Lin et al. (two arms) moves around at an angular velocity
352 of QP :::::: 13.5 km s-1kpc-1 •



It is thus conti nually (t: +qual) overtaken by the galactic matter,
353 which moves about twice as fast (: +imp)(gas, stars, ...).
This matter is compressed in the region of the potential well of
354 the density wave.

In the gas, dark (-qual) clouds are produced by the compression,
as well as an increased inten sity of synchrotron radiation and a
355 shock wave (solid curve).

In the course of I07 yr, young (+qual) bright (+qual) stars and
356 HIT regions arc formed in this "shocked" gas

c: α^iβ clarification =

. At a larger (+imp) distance from the shock wave,older (+imp)
357 stars follow.

t: α^iβ clarification =

The major (+imp) portion of the potential well is filled with
neutral hydrogen (HI; 21 em radiation). From W.W. Roberts
358 (1969)

11.13 Text

The observable spiral arms (Fig. 11.13) are then produced,
359 according to W. W. Roberts (1969), by the fact

that the interstellar gas Rows along the density wave from the
360 concave edge (in our case at l15 km s-1).

A compression occurs in going towards the potential (-qual)
361 minimum,

362 and it can be recognized initially by means of interstellar dust.

The compression of the gas (and of the magnetic field)
furthermore leads to the appearance of a spiral-shaped shock
363 wave,

which in tum promotes Jeans instabibties (Sect. 10.5.3) and
364 thereby the formation of young srars and HI I regions.

A narrow (-qual) strip is indeed observed at the convex edge of
365 the shock wave,

366 containing bright (+qual) blue stars and H II regions.

It is followed by a broad (+qual), diffuse (-comp) band with
367 older stars and star clusters;

finally, the old (-qual) disk population is distributed nearly
368 homogeneously. (+imp)

Quantitatively,Lin estimates the amplitudes of the gravitational
369 fluctuations,

and those of the gas and stellar densities, to be about 5% of thei r
370 average values.

pg. 406 12.4 Caption

Fig.12.4. The elliptical galaxy NGC 4697, of type ES. Pho tograph made with the 5 m Mt. Palomar telescope, from the
371 Hubble Atlas of Galaxies.

12.4 Text

The elliptical galaxies, EO to E7, have rotationally symmetrical
372 (+qual)shapes without noticeable structure (Fig12.4).

The observed el lipticity is naturally (t: +imp) in part a result of
373 the projection of the true (+bal) spheroid onto the celestial sphere,

374 as seen by the observer.

c: 1^2 = exposition

t: α^iβ = exemplification

pg. 407 12.6 Caption

Fig.12.6. The amorphous galaxy M 82 (frr II). A (negative) HCI photograph taken by A.R. Sandage (1964) with the 5 m telescope
375 on Mount Palomar

Text 12.6

A.Sandage and R. Brucato (1979) redefined the group of the
376 irregular galaxies,introducing a type called amorphous galaxies,

which is characterized (in blue-sensitive photographs) by a
377 smooth (+qual), unresolved (-bal) shape without spiral arms,

378 sometimes interrupted by dust absorption structures

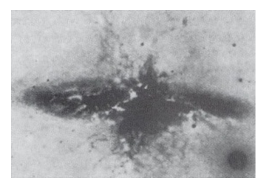
379 .Occasionally, weak filaments can also be seen.

380 For example, M 82 (Fig. 12.6) belongs to this type.

381 In recent times, it has become clear that (imp)

the amorphous and other particular (imp) galaxies emit most of
382 their radiation in the far infrared.

383 We shall return to these infrared galaxies in Sect. 1 2.2.1.



c: 1^2 = exposition

t: α^iβ = exemplification

pg. 427 12.16 Caption

Fig.12.16. The synchrotron radiation from a relativistic
384 electron in a magnetic field B

12.16 Text

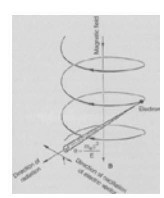
385 This radiation cone passes the observer (t: +qual) rapidly,

386 like • the light beam from a lighthouse,

387 so that it produces a series of light flashes, each of duration Lt.

The spec·tral decomposition or, mathematically (t: +comp) speaking, the Fourier analysis of this spectrum, taking the
388 relativistic Doppler effect into account (4.18),

yields a continuous (t: +qual) distribution, with its maximum
389 (valu) at the circular frequency



c: 1^2 = exposition

t: α^iβ = clarification

Chem

1.13 pg. 23 Caption

390 The internal structure of an atom.

An atom is composed of a tiny nucleus that holds all the protons
391 and neutrons,
392 plus electrons that fill (t: +bal) the space outside the nucleus.

1.13 Text

The properties of the subatomic particles are summarized in Ta
393 ble 1.3, c: α^iβ = clarification
and the general (+comp) structure of the atom is illustrated in
394 Figure 1.13. t: α^iβ exposition =

pg. 30 - Rockefeller Caption

The sta tue of Prometheus that stands above the skating rink in
395 Rockefeller Center in New York City
396 is covered by a thin (+qual) decorative (+imp) layer of gold leaf.

Text Rockefeller

You probably know (t: +esteem: capacity) a metal when you
397 see one.

Metals tend to have a shine so unique (+imp) that it's called a
398 metallic luster.

Pg 122 Fireworks Caption

The reaction of phosphorus with oxygen that gives P4010
produces a brilliant (+imp) light, that gives P4010 produces a
399 brilliant (imp) light, c: α^iβ clarification =
often used in fireworks displays. (t:imp) t: α^iβ exemplification =
400

Fireworks Text

Within chemical compounds, moles of atoms always combine in
401 the same ratio as the individ ual atoms themselves

This fact let(t: +valu) us prepare mole-to-mole conversion factors
402 involvi ng clements i n compounds
403 as we need them.
404 For example, in the formula P 4010, the subscripts mean
405 that there are 4 mol of P for every 10 mol of 0 in this compound

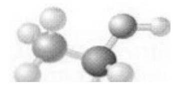
c: α^iβ exemplification =

pg. 139 Ethanol Caption t: α^iβ clarification =

Notice (t: +imp) tha t i n both the "be fore" and "after" (t: +comp) views of the reaction, 46

the numbers of carbon. hydrogen. and oxygen atoms are the same. 407

Ethanol Text



408 We've seen that balanced chemical equations can tell us

that balanced chemical equations can tell us how to mix reactants together in just the right proportions to get a certain amount of product. 409 c: α^iβ = clarificaton

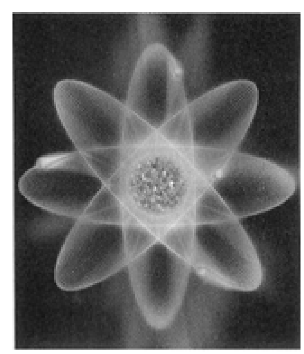
For example, ethanol, C2H50H,is prepared industrially as follows: 410 t: α^iβ = clarification

pg. 303 Caption Atom

This simple (+imp) picture of the atom makes a nice (t: -valu) corporate logo, 411

but the idea of an atom with electrons orbiting a nu cleus as planets orbit a sun was discarded nearly a century ago. (t: -esteem: normality) 412

Atom Text



But how can viewing the atom as a core nucleus surrounded by electrons explain why one element is different from another? 413

414 Why are some elements metals, while others are nonmetals?

Why do metals form positive ions, while nonmetals form negative ones? 415

Why do the properties of the elements repeat when they are arranged in order of increasing (+bal) atomic number? 416

And why do elements combine in certain ratios with other elements? 417

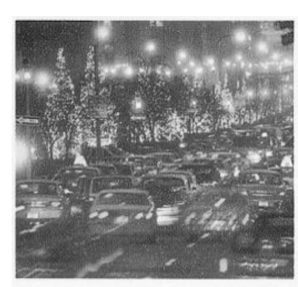
418 Why, tor example, is water's formula H20 and not H30 or HO? c&t: α^iβ alternation +

Our simple (-valu) model of the atom can not answer these questions. 419

Park Avenue Caption pg. 312

Park Avenue in New York City is brightly (+valu)lit by sodium vapor lamps in this photo 420

421 taken during the Christmas season



Park Avenue Text

422 The golden (+valu) glow (t: qual) of streetlights in scenes l ke that shown in the photograph at the right

423 is from this emission line of sod ium,

424 which is produced in high-pressure sodium vapor lamps.

425 There is another,

426 much more yellow light emitted by low-pressure sodium lamps

427 that you may also have seen. (t: +esteem: normLITY)

c: α^iβ = clarification

t: α^iβ exemplification =

pg. 957 motorcycle caption

428 This motorcycle sparkles (t; imp) with chrome

429 plating that was deposited by electrolysis.

430 The shiny (+imp) hard (+qual) coating of chromium is both decorative and a barrier to corrosion.

Motorcycle Text

431 Electroplating, << >> is a procedure i n

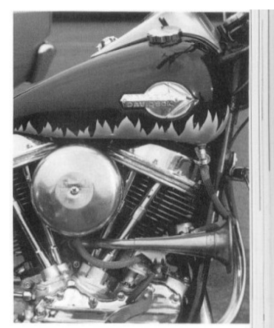
432 <<which was mentioned in Example 21.14,>>

433 which elec trolysis is used to apply a thin (+qual) (generally 0.03 to 0.05 mm thick) ornamental (+imp) or protective (+bal) coat ing of one metal over another.

434 It is a common (+valu) technique for improving the appearance (t: +qual) and durability (t: +bal) of metal objects

435 .For instance, a thin, (+qual) shiny (+imp) coating of metallic chromium is applied over steel objects to make them attractive (+qual)

436 and to pre vent rusting (t: qual).



c&t: α^iβ exemplification =

21.21 pg. 957 Caption

437 FIGURE 21.21 Apparatus for electroplatitlg silver.

438 Si lver dissolves at the anode,

439 where it is oxidized to Ag+.

440 Silver is deposited on the cathode (the fork),

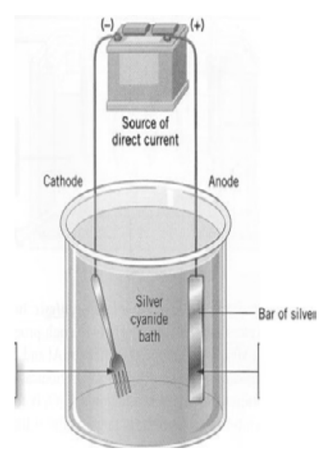
441 where Ag+ is reduced.

21.21 Text

442 Figure 21.21 illustrates a typical (+valu) apparatus used for plating silver.

443 Silver ion in the solution is reduced at the cathode,

444 where it is deposited as metallic silver on the object to be plated.



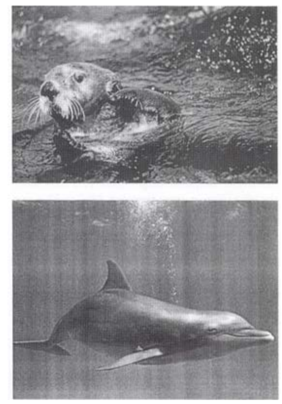
445 At the anode, silver f rom the metal bar is oxidi zed,

446 replenishing the supply of the silver ion i n the sol ution.

447 As time passes, silver is graduall y (t: +qual) transferred from the bar at the anode onto the object at the cathode. c&t: 1^2 exposition =

Marine Bio

Caption: pg. 89 3.10



448 Fig. 3.10 Two types ofinsulation in marine mammals.

449 (a) Sea otters rely on dense pelage for remaining warm (qual) in water while cetaceans \

450 b) and seals utilize a thick (+qual) layer of bl u bber.

451 The bl ubber layer also provides body streamlining (t: +valu) and an energy store for marine mammals.

3.10 Text

452 Small (+qual) Semiaquatic mammals including the water rat and mink

453 show a progressive decrease in core body temperature when immersed,

454 and must shuttle (t: +qual) between cooling periods in water and warming periods on land (Williams 1986). c&t: α^iβ exemplification =

455 In contrast sea otters spend most of their lives in water

456 and rely exclusively (t: +valu) on fur for insulation (Fig. 3.l0a).

457 This is made possible by an exceptional, (+valu) waterproof fur coat

458 that is the densest (+valu)of any mammal measured

Caption: pg. 91 3.11

459 Fig.3.11 External strucn1re of the mammalian kidney.

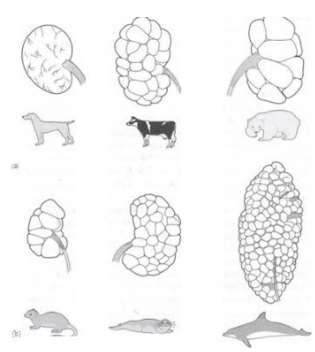
460 (a) Terrestrial mammals (dog, cow, bear) are compared (t: -imp) to (b) semiaquatic (river oncr) and marine (seal, dolphin) mammals.

461 Note (t: +imp) the increased (+qual)number of lobes (reniculi) for the kidneys ofmarine living mammals. (Redrawn from Slijpcr 1979.)

Text 3.11

462 The size and structure of the kidneys of marine mammals reveal the morphological solution to the problem of water bal ance

463 when livin g in highly (t; +qual) saline environments



464 . In general (t: +valu), the kidneys of marine mammals are larger (+imp) than found in terrestrial mammals of similar body mass

465 The ratio of kidney to body mass ranges from 0.44% in the fin whale to 1.1% in the bottlenose dolphin and white-sided dolphin.

466 This compares (t: +imp) wi th the relatively small (t: -Iimp) kidney to body mass ratio of terrestrial mammals

467 which ranges from 0.3% in elephants to 0.4% in humans, deer and zebras (Siijper 1979).

c: α^iβ exemplification =

468 Another difference between marine and terrestrial mammals is the number of lobes, termed reniculi, that comprise each kidney.

t: α^iβ clarification =

469 Rather than a single, smooth (+qual) lobe as found for humans and horses,

470 the kidneys of many species of marine mammal are highly subdivided

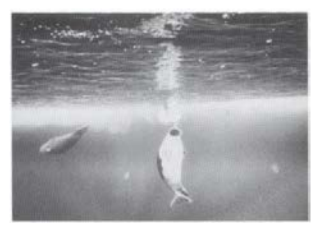
471 with each reniculus often serving as a complete (+imp) miniature (+qual) kidney with a cortex, medulla, papilla and calyx (Fig. 3.11).

472 The number of reniculi is larger (+imp)in cetaceans than observed for cattle.

473 Thus, we find over 450 reniculi in the kidney of the bottlenose dolphin, and more than 3000 reniculi in mysticetc whales

474 .Elephants, bears,West Indian manatees and otters have 6-8 reniculi in each kidney, while cattle may have 25-30 reniculi.

Caption 6.1 pg 145



475 Fig.6.1 Underwater exhalation of air is a common (+valu) acoustic and oprical display in marine mammals.

476 (a) Adult male harp seal (Pifgopbilusgroetlltmdiws) releasing air bubbles

477 (b) Adult while vocalizing in threat.(From Merdsoy et at.1976).

478 male humpback whale (Megaptera tlovaeat gliae) producing a stram of bubbles

479 wh i le challenging another male for access to a female in a com petitive (-bal) group (Tyack & Whitehead1983).(©D. Glockner-Ferrari, Center for Whale Studies)

Text 6.1

C: α^iβ exposition =

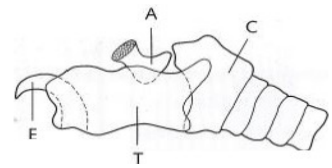
t: **α^iβ** exemplification =

480 During the breeding season, humpback whales form groups

481 in which males compete for access to a female (Tyack & Whitehead 1983).

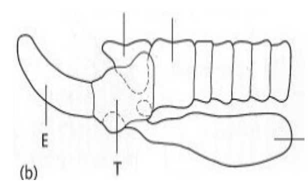
Males in these competitive (-bal) groups produce streams of
482 bubbles up to 30m long (Fig. 6.1b).
483 When marine mammals exhale forcefully, (t: -imp)
they also create a non-vocal sound as the bubbles rise to the
484 surface.
Presumably, (t: -imp) air bubbles thus constitute a com bined
485 optical and acoustical display.

Pg. 148 6.4 Caption
486 Fig.6.4 Laryngeal anatomy in: (a) a terrestrial ungu.late (horse)



b) a mysticete, and in rwo odontocete cetaceans, (c) a narwhal and (d) a pilot whale. A, arytenoid cartilage;C,cricoid cartilage; D, diverticulum; E, epiglottis; T, thyroid carTilage. (From Slijpcr 1979.)
487

Text 6.4



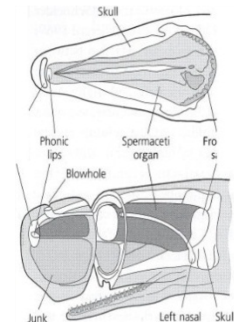
The larynx of baleen whales is simi lar to that of terrestrial
488 mammals,
489 as can be seen in Fig. 6.4,
which compares the larynx of a terrestrial ungulate (the horse)
450 with mysticete and odontocete cetaceans.
Over two centuries ago, Hunter (1787) noticed (t: +esteem: normality) an unusual (+valu) l aryngeal sac, <<>> on the lower
451 side of the mysticcte trachea,
452 <<called the divert iculum,>>
connected to the respiratory tract by an opening on the lower
453 side of the thyroid cartilage
454 (marked 'D' in Fig. 6.4b).
Aroyan ct at. (2000) modelled sound production in the blue
455 whale (Balaenopteramttsettlm)
456 , and suggested
that this laryngeal sac and the nasal passages may act as a
457 resonator.
Odontocctes have a larynx that differs from ter restrial
458 mammals in that
the arytenoid and epi glottal cartilages arc elongated to form a
459 beak like (+comp) structure
that is held in the nasal duct by a sphincterlike (+comp) palatopha
460 ryngeal muscle (Fig. 6.4c, d).

c: 1^2 exposition =

t: α^iβ clarification =

Caption 6.5 pg. 148

Fig.6.5 Functional anatomy of sound production in two odontocete cetaceans: (a) the bottlenose dolphin, Tursiopsuncatrts,and (b) d1e sperm whale,
461 Physetennacrocephaltts.(Adapted from Au 1993;Cranford 2000.)



Text 6.5

Odontocetes also have a complex (+comp) and specialized (+bal)
462 upper respiratoty tract (Fig. 6.5).

463 Since Norris et al. (1961) first (t: +esteem: normality) proposed it,

464 a growing group of biologists have suggested (t: +esteem: normality)

465 that the nasal passages may be the source of most odontocete vocalizations (Cranford 2000).

c: 1^2 exposition =

t: α^iβ clarification =

Caption 7.3 pg. 190

466 Fig.7.3 Telemetry devices attached to (a) a beluga and (b) a grey seal. (Courtesy ofSMRU.)

Text 7.3

467 Radiosignals are attenuated under water and

468 thus tracking is limited (-valu) to those times

469 when the animal is at the surface.

470 Location may be obtained

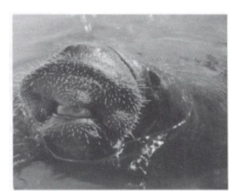
471 using handheld directional aerials or automatic receiving stations within a limited (-valu) line of sight range (usually< 30 km)

c: α^iβ exposition =

t: α^iβ clarification =

Caption 8.3 pg. 221

472 Fig.8.3 Perioral brisde fields (modified vibrissae) of a Florida manatee adapted to feeding on both su rfucc and bottom vegetation. (Courtesy of G. Worthy.)



Text 8.3

473 They concluded (t: +sanction: veracity) that this plasticity in bristle use had evolved to increase the efficiency of manatees as a generalist herbivore.

c: α^iβexposition =

t: α^iβ clarification =

Caption 8.4 pg 221

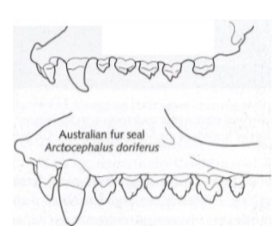


Fig.8.4 Comparative tooth structu re of rhrcc pinnipcd
474 species.(After King 1983.)

Text 8.4

Crab cater seals(Lobodon carcitzophagus) appear to specializc on
475 krill,

476 a cuphausiid that occurs in dense swarms.

The importance (t: +imp) of kri.ll in the diet of this species is
477 evidenced by the highly modified structure of maxillary dentition c: 1^2 exposition =

(Fig. 8.4) that appears to be an adaptation to some form of filter
478 feeding (Laws1984). t: α^iβ = clarification

Caption 8.5 222

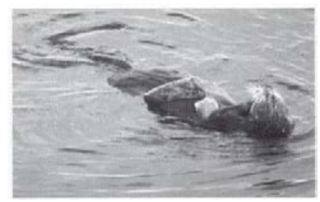


Fig. 8.5 A sea otter with a rock tool on its abdomen. (Courtesy of
479 Friends of the Sea Otrcr, Carmel, California.)

Text 8.5

Both the. behaviour and dentition of sea otters arc h1ghly modified for feeding on hard-shelled (+qual) benthic
450 invertebrates such as gastropod and bivalve molluscs. c: 1^2 exposition

In contrast with the carnassial1l (>hearing) form of the molars
451 and premolars is all other otters and nearly all other carnivores, t: α^iβ exemplification

the sea otter has heavy (+qual) bunodont (crushing) molars amd
452 vestigial premolars,

453 thus facilitating comumption of their hard-shelled (qual) prey.

In addition, sea otters commonly (t: +valu) carry rocks from the
454 sea floor to the ocean surface

455 to assist in breaking into heavy shelled (+qual) prey (fig. 8.5).

Caption 12.4 pg 361

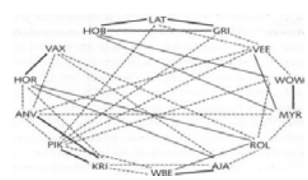


Fig. 12.4 Contrasting (+imp) patterns of male alliance formation
456 in Shark Bay,Western Austr:llia.

Sociograms depicting alliance formation between males in: (a)
457 three stable alliances (one pair and two uios)

458 that associated on a regular basis,

and (b) a large (+qual) 'superalliance'of J 4 males (lines con nect
459 males)

that shared association coefficients of at least 10,on a scale of 1-
460 100; α^iβ exposition =

461 th icker (+imp) bars reflect stronger associations).

462 Males in the l4·membcr superalliancc formed trios and pairs with many other group members

463 to consort femles

464 and joined forces against teams of stable alliances.(FromConnor et al. 1999,courtesy of Macmillan Magazines Ltd.)

Ecology

8.1 pg. 164 Caption

465 The freshwater hydra reproduces asexually by budding.

8.1 Text

466 Hydras, << >> reproduce by budding,

467 <<coelenterates that live in freshwater (Figure 8.1),>>

468 a process by which a bud pinches off (t: +comp) as a new individual.

469 In spring, wingless female aphids em€rge from eggs

470 that have survived the winter

471 and give birth to wingless females without fertilization,

472 a process called parthenogenesis (Greek parthenos,"virgin"; Latin genesis,"to be born").

c: α^iβ exemplification
=
t: α^iβ exemplification

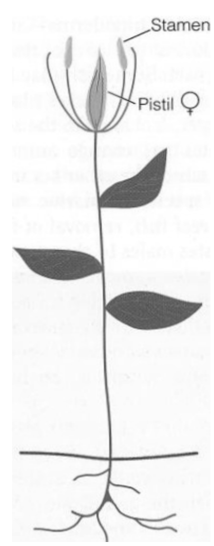
8.2 pg. 165 Caption

473 Floralstructure in (a) dioecious plant (separate (+bal) male and female individuals),

474 (b) her maphroditic plant possessing bisexualflowers,

475 and (c) monoecious plant possessing separate (+bal) male and female flowers.

8.2 Text



476 Sexual reproduction takes a variety (+bal) of forms.

477 The most familiar involves separate (+bal) male and female individuals.

478 It is common (+valu) to most animals.

479 Plants with that character istic are called dioecious (G reek di, "two," and oikos, "home");

480 examples are holly trees (flex spp.) and stinging nettle (Urtica spp.) (Figure 8.2a).

481 In some species, individual organisms possess both (male and female organs.

482 They are hermaphroditic (G reek hermaphroditos).

483 In plants, individuals can be hermaphroditic
by possessing bisexual flowers with both male organs (stamens) and female organs (ovaries), such as lilies and buttercups (Figure
484 8.2b).
485 Such flowers are termed perfect.
Asynchronous (+bal)timing of the maturation of pollen and
486 ovules reduces the chances of self-fertilization. c: α^iβ = exposition
Other plants are monoecious (G reek mon, "one," and oikos,
487 "house"). t: α^iβ clarificatiom
488 They possess separate male and female flowers on the same plant, as do birch (Betula spp.) and hemlock (Tsuga spp.) trees (Figure
489 8.2c).

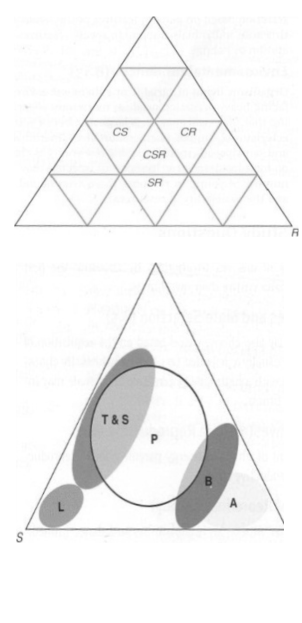
8.15 pg. 180 Caption

IThe (a) spotted (Ambystoma maculatum) and (b) redback
490 (Piethodon cinereus) salamanders found in eastern North America
provide an example of contrasting (t: -Imp) life hsi tory
491 strategies.
The spotted salamander lays a large number of eggs (t: +imp) that
492 form an eggmass,
493 which it then abandons. (t: -valu)
In contrast the redback lays only few eggs, (t: -imp) which it
494 guards until they hatch.

8.15 Text

The spotted (Ambystoma maculatum) and redback (Plethodon
495 cinereus) salamanders found i n eastern North America
provide such an example of contrasting (t: -imp) life history C&t: α^iβ
496 strategies (Figure 8.15). exemplification =

8.16 Caption pg. 181



IGrime's modelof life history variation in plants based on three primary strategies: ruderals (R),competitive (C), and stress-
497 tolerant (S).
498 (a)These primary strategies define the three points of the triangle.
Intermediate strategies are defined by combinations of these three
499 (e.g.,CS, CR,CSR,and SR).
(b) Grime's assessment of life history strategies of most trees and shrubs (T & S), lichens (l),biennialherbs (B),perennialherbs
500 (P),and annualherbs (A).(Adapted from Grime 1977-)

8.16 Text

The plant ecologist J. Phillip Grime of Sheffield, Eng land, used a similar framework to that of MacArthur and Wilson to develop a life history classification for plants based on three primary
501 strategies (R,C, and S)

502 that relate plant adaptations to different habitats (Figure 8.16).

C: α^iβ clarification =

t: α^iβ causal x

19.22 pg. 420 Caption

(a) Block clear-cutting in a coniferous forest in the western United States.Such cutting fragments (t: -sanction: propriety) the
503 forest.

504 (b) Unless carefully managed (t: - sanction: propriety),

clear-cutting can cause severe (t: -sanction: propriety) disturbance
505 to a forest ecosystem (see Chapter 27).

19.22 Text

Clear-cutting involves removal of wide blocks of trees (Figure
506 19.22),

favoring (t: +qual) reproduction of shade-intolerant species of
507 trees.

However, unless foresters manage these cleared areas carefully,
508 (t: -sanction: propriety)

509 erosion can badly disturb the ecosystem, (t: -sanction: propriety)

impacting not only the recovery of the site, but adjacent aquatic
510 communities as well. (t: -sanction: propriety)

c: α^iβ exemplification =

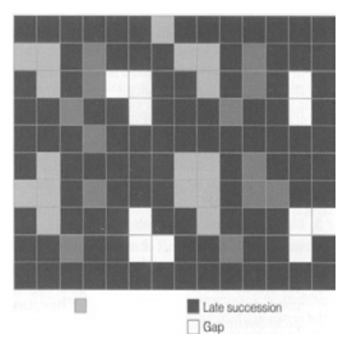
t: α^iβ causal x

9.23 pg. 421 Caption

Representation of a forested landscape as a mo saic of patches In
511 various stages of successional development.

512 Although each patch is continuously (t: +bal) changing

,the average (+valu) char· acteristic of the forest may remain
513 relatively (+imp) constant-in a steady state.



9.23 Text

The term steady state is a statistical de scription of the collection
514 of patches, the average state of the forest.

In other words, the mosaic of patches shown in Figure 19.23 is
515 not static.

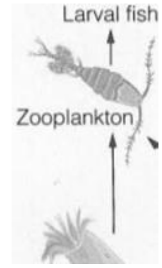
516 Each patch is continuously (t: +bal) changing.

Disturbance (t: -sanction: propriety) causes the patches in the
517 mosaic << >> to revert back to early successional.

c&t: α^iβ exemplification =

518 <<that are currently classified as late successional >>

519 Patches currently classified as early successional undergo shifts in species composition,



520 and later successional species will come to dominate.

521 Al though the mosaic is continuously (t: +comp) changing,

522 the average composition of the forest (average over all patches) may remain fairly constant-(+qual) in a steady state.

24.20 pg. 540 Caption

523 Diagrammatic representation of the microbial loop and its relationship to the plankton food web.

c: 1^2 exposition =

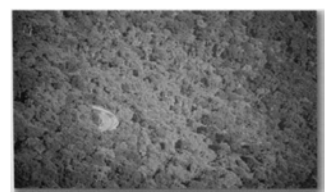
524 Autotrophs are on the right side of the diagram and heterotrophs are on the left.

t: α^iβ clarification =

24.20 pg. 599 Caption

525 The annualcatch of the Pacific sardine along the Pacific Coast of North America.

526 Overfishing ,environmental changes,and an increase in the population of a competing fish species,the anchovy,resulted in a collapse (t: -sanction: propriety) of the population. (Adapted from Murphy 1966.)

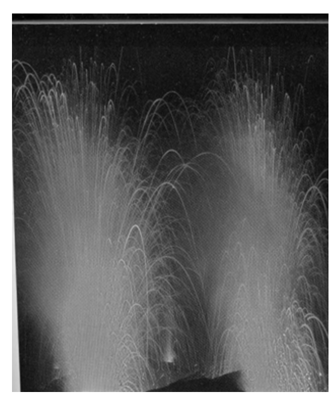


pg 607 judgey road Caption (chapter theme)

527 Roadways,such as this one through the Tijuca Forest in Brazil,can function as both a barrier (t: -sanction: propriety) to dispersa and source of mortaltiy (t: -sanction: propriety) for many species

α^iβ = exemplification

Physics



pg. 59 Volcano Caption

528 In a volcanic eruption in Mt. Etna, Sicily, the lava particles from the eruption follow parabolic paths as one would expect, (t: +esteem: capability)

529 since they are projectiles falling in the presence of gravity. (© Otto Hahn,Peter Arnold, Inc.)

Volcano Text

530 If the velocity vector makes an angle 80 with the horizontal,

531 as shown, then the initial x and y components of velocity are given by vxo = vOcos theta0 and Vyo = vo sin theta0

532 In order to analyze projectile motion,

we shall separate the motion into two parts, the x (or horizontal) motion and the y (or vertical) motion, 533

c&t: α^iβ
exemplification =

534 and solve each part separately.

3.13 pg. 61 Caption

To an observer on the ground (t: +imp), a package released from the rescue plane 535

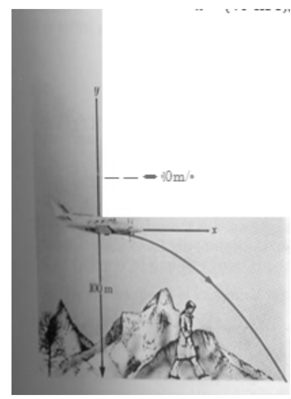
536 travels along the path shown.

537 (This .figure is not drawn to scale.)

3.13 Text

The coordinate system for this problem is selected as shown in Figure 3.13, 538

with the positive x direction to the right and the positive y direction upward. 539



540 Consider (t: +imp) first the horizontal motion of the package.

541 The only equation available to us is x = vz0t

The initial x component of the package velocity is the same as the velocity of the plane 542

543 when the package was released, 40 m/s.

544 Thus, we have x = (40 m/s)t

545 If we know t, the length of time the package is in the air,

546 we can determine x,

547 the distance traveled by the package along the horizontal.

548 To find t,

549 we move to the equations for the vertical motion of the package.

550 We know that at the instant the package hits the ground

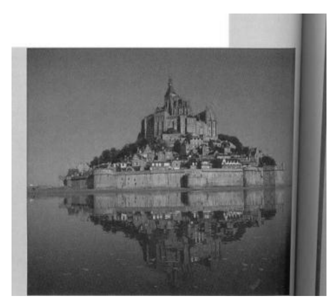
551 its y coordinate is-100m.

c: 1^2 exposition
t: α^iβ = clarification

552 We also know

that the initial velocity of the package in the vertical direction, vyO, is zero 553

because the package was released with only a horizontal (t: -qual) component of velocity. 554



Mirror Water pg. 748 Caption

Dramatic (+valu) photograph of Mont-Saint-Michel in France and Its "mirror" reflection In water. 555

Mirror Water Text

Until the beginning of the 19th century, light was considered to be a stream of particles (t: -esteem: capacity)

c: α^iβ manner x

that were emitted by a light source

t: α^iβ exempification =

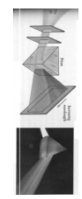
and stimulated the sense of sight upon entering the eye.

The chief architect of this particle theory of light was Newton.

With this theory, Newton was able to provide a simple (t: +esteem: capacity) explanation of some known (t: +esteem: normality) experimental facts

concerning the nature of light, namely. laws of reflection and refraction.

24.18 pg. 761 Caption



Dispersion of white light by a prism.

Since n varies with wavelength,

the prism disperses the white light into its various (+bal) spectral components.

(b) The various colors (t: +bal) are refracted at different (+imp) angles

because the index of refraction of the glass depends on wavelength.

The blue light deviates the most, (+imp)

c: 1^2 exposition =

while red light deviates the least. (+imp)

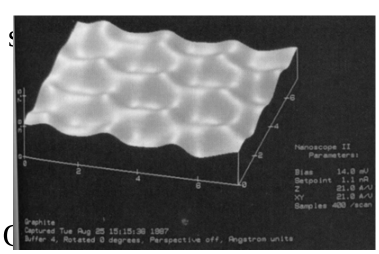
t: α^iβ exemplification =

courtesy (t: +esteem: normality) of Bausch and Lomb)

quantum pg. 913 Caption

The surface of graphite as "viewed" wfth a scanning tunneling microscope,

discussed in the essay in this chapter.



This technique enables scientists to see small details on s (t: +esteem: capacity) , with a resolution of about 2 A.

The contours seen here

represent the arrangement of Individual atoms on the crystalsurface. (

Roger A Freednum and Paul K. Hansma,Unioersity of C at Sa.nta Barbara)

quantum text

c: α^iβ exemplification =

In the previous chapter, we discussed

t: α^iβ clarification =

why Newtonian mechanics must be replaced by Einstein's special theory of relativity (t: +esteem: capacity)

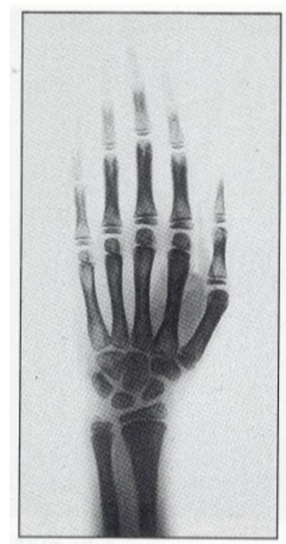
when we are dealing with particles

whose speeds are comparable (+imp) to the speed of light.

Although many problems were indeed resolved by the theory of relativity (t: +esteem: capacity) in the early part of the 20th century,

many experimental and theoretical problems re mained unsolved. (t: -esteem: capacity)

Attempts to apply the laws of classical physics to explain the behavior of matter on the atomic level were totally unsuccessful. (t: -esteem: capacity)



29.13 pg. 924 Caption

X-ray photograph of a human hand.

29.13 Text

As noted earlier

x-rays are extremely penetrating (qual)

and can produce burns or other complications

if proper precautions are not taken by anyone exposed to them. (t: -esteem: normality)

Between 1930 and 1950, an x-ray device << >> was widely used in shoe stores to examine the bone structure of the foot.

<< called a fluoroscope>>

Physicians cians used similar (+imp) devices to examine the skeletal structure of their patients.

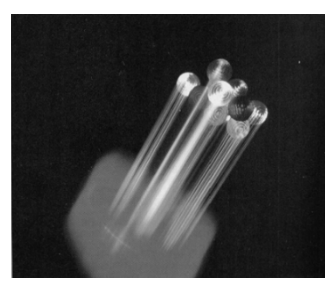
c: 1^2 = exposition

Such devices are no longer in use (-valu) since they are now known to be a health hazard. (t: -esteem: capability)

t: α^iβ clarification =

An x-ray photograph of a hu man hand is shown in Figure 29.13

pg 946 flying balls Cpation



This futuristic (+valu) picture might represent an artist's version of atomic species

being emitted by a solid.

The atoms could be surface Impurities emitted by thermal excitation, 596 or they may even be Ions emitted In the presence of a strong (+qual) applied electric field.

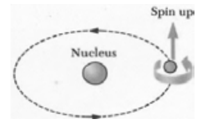
30.11 pg. 962 Caption

c: α^iβ variation +

597 As an electron moves in its orbit about the nucleus,

598 its spin can be either (a) up or (h) down.

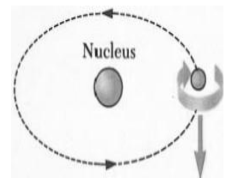
30.11 Text



599 If the direction of spin is relative to its orbital motion,

600 as shown in Figure 30.11a,

601 the electron is said to have "spin up."



602 If the direction of spin is relative to its orbital motion, as in Figure 30.11b,

603 the electron is said to have "spin down."

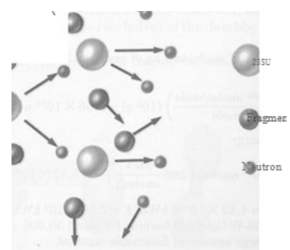
604 The energy of the electron is slightly different (+qual) for the two spin directions.

c&t: 1^2 exposition =

33.2 Caption pg. 1042

605 A nuclear chain reaction.

33.2 Text



606 We have seen that, when 235U undergoes fission,

607 an average of about 2.5 neutrons are emitted per event.

608 These neutrons can in turn trigger other nuclei to undergo fission,

609 with the possibility of a chain reaction (Fig. 33.2).

610 Calculations show

611 that if the chain reaction is not controlled

c: α^iβ = clarification

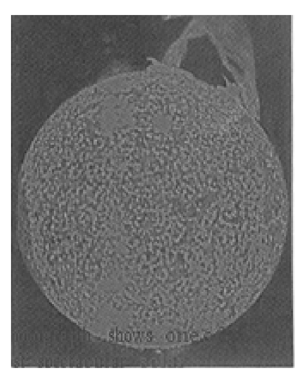
612 (that is, if it does not proceed slowly),

t: α^iβ exemplification

613 it could result in a violent (-valu) explosion, with the release of an enormous (+qual) amount of energy, even from only (t: -imp) l g of 235U.

Solar Flare pg. 1047 Caption

614 This photograph shows one of the most spectacular (+valu) solar Bares ever recorded;



615 it spanned (+qual) more than 588,000 km (367,000 mi) of the Sun's surface.

616 The flare gives the distinct (+imp) impression of a twisted sheet of gas

617 in the process of unwinding itself.

618 During solar flares, which may occur several times a week,

619 an enormous (qual) amount of energy is released, partly in the form of electromag netic energy. (Courteof NASA)

Solar Flare Tetx

620 All stars generate their own energy through fusion processes. (t: +comp) c&t: α^iβ clarification =

621 About 90% of the stars,<< >> fuse hydrogen

622 << including our own Sun, >>

623 while some older (+qual) stars fuse helium or other heavier (+imp)elements.

Dinosaurs: Natural

Figure 1.1, pg. 5. Text

624 Consider (t: +imp) what might happen to a dinosaur - or any land-dwelling vertebrate after it dies.

625 Carcasses are commonly (+valu) disarticulated (dismembered) (t: -imp), often by predators (t: -valu)

626 and then by scavengers ranfing from mammals and birds to beetles.

627 After a bit, the caracass will likely deflate (sometimes explosively), (t: +qual)

628 and then dry out, c: α^iβ exemplification =

629 leaving bones, tissues, ligaments, tendons, and skin hard (+qual) and inflexible(+qual) t: α^iβ clarification =

630 Figure 1.1, pg. 5. Caption

631 Bones. A wildebeest carcass, partly submerged (-bal) in mud and water

632 and on its way to becoming permanently buried and fossilized.

633 If the bones are not protected from scavengers, air, and sunlight,

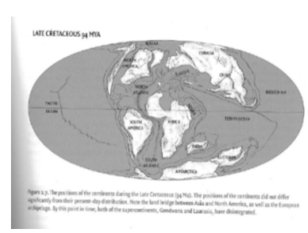
634 they decompose rapidly (t: -qual) and are gone in 10-15 years.

635 Bones destined to become high-quality (+imp) fossils must be buried soon after the death of an animal.

Figure 2.7, pg. 27. Text

636 The global positions of continents during the Late Cretaceous would be familiar to us (+imp)(figure 2.7).

637 Figure 2.7, pg. 27. Caption



638 The positions of the continents during the Late Cretaceous.

The positions of the continents did not differ significantly from
639 the present-day distribution.

640 Note (+ imp) the land bridge between Asia and North America,

641 as well as the European archipelago.

By this point in time, both of the supercontinents, Gondwana and
642 Laurasia, have disintegrated.

c: α^iβ exposition =

t: t: α^iβ clarification

Fig. 5.10 pg 94 Text

As we have learned,(t: +esteem:normality) the majority of stegosaurs had at least (-imp) one row of osteoderms along the
643 dorsal margin of of each side of the body.

And these osteoderms generally (t: +valu) take the form of spines,
644 spikes, blunt cones, or plates.

In all cases, at the end of the tail were pairs of long (+qual)
645 spines.

Fig. 5.10 pg 94 Caption

c: α^iβ clarifiaction =

The skeleton of Kentrosaurus, a spiny (+qual) stegosaur from the
646 Late Jurassic of Tanzania

t: α^iβ exemplification

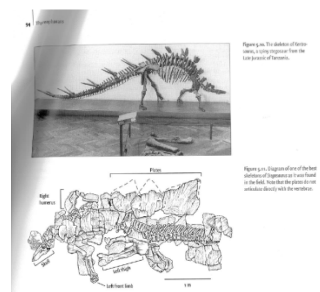


Fig. 5.11 pg 94 Text

647 All of these, like all osteoderms, were embedded in the skin.

648 What purpose might they have served?

Originally, the idea was that they were all about protection and
649 defense. (t: -esteem: normality)

Fig. 5.11 pg 94 Caption

Diagram of one of the best (+imp) skeletons of Stegosaurus as it
650 was found in the field.

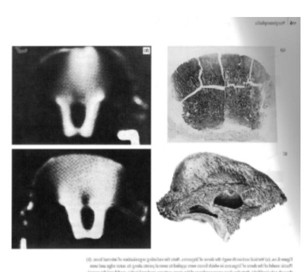
c: α^iβ manner x

Note (t: +imp) that the plates do not articulate directly with the
651 vertebrae.

t: α^iβ clarification =

Fig. 6.10 pg 116 Text

Internally, the structure of the dome is very dense (+qual) , with the bone fibers oriented in colmns approximately perpendicular to
652 the external surface of the dome.



Using special (+imp) clear (+qual) plastic cut to resemble a cross-section of the high-domed pachysephalosaur Stegoceras, paleontologist H.-D. Sues stressed the model in away that
653 simulated head-butting.

The stress lines, seen under ultraviolet light, mimicked the orientation of the columnar bone, reinforcing the suggestion hat the fibrous columns evolved to resist streses induced by head-
654 butting. c: α^iβ clarifiaction

Fig. 6.10 pg 116 Caption t: α^iβ manner x

655 (a) Vertical section through the dome of Stegoceras.

(b) Plastic model of the dome of Stegoceras in which forces werr applied to several points along its outer edge and seen through
656 polarized light.

Note (t: +imp) the close (+imp) corespondence of the stress patterns produced in this model and the organization of bon
657 indicated in © The left side of the skull of Stegoceras.

Fig. 6.25 pg 126 Caption

A nest of hatchling (t: +qual) Protoceratops from the late
658 Cretaceous of Mongolia.

Inset: Reconstruction of one of the babies as it would have
659 appeared in life.

c: α^iβ exempification

Fig. 6.26 pg 127 Caption

660 "Back off" (t: +imp)

661 Frill display in Chasmosaurus.

The very long frill (+imp) could have provided a very prominent
662 (+ imp) frontal threat (+imp) display,

663 not only by iclining the head forward

664 but also by nodding or shaking the head from side to side

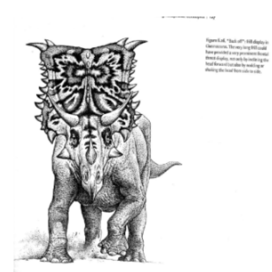


Fig. 6.26 pg 127 Text

665 Using modern (+imp) horned animals as analogs,

666 current thought suggests that

the large (+qual) nasal and brow horns of ceratopsians functioned
667 primarily during territorial defense c: α^iβ clarification

668 and in establishing dominance. t: α^iβ exemplification

Similarly, the development of elaborate (+imp) scallops and spikes along the frill margin in many of the more highly derived
669 (+imp) ceratopsians

670 separates one species from another

Thought of this way, the remarkable (+imp) variations in the horns and frills in ceratopsians could be used for interspecific
671 identification
672 as well as the establishment of intraspecific dominance.

Fig. 9.22 pg 201 Text
673 With all the variation in therapodes,
674 prey surely varied.

The most dynamic (t: +esteem: normality)and irrefutable (t: +sanction: veracity)evidence about the preferred prey of Velociraptor is the so-called "fighting dinosaurs" (t: +bal)
675 specimen:
Velociraptor with its hind feet half into the belly of a subadult Protoceratops and its hands grasping (t: +imp), << >>, the jaws of the soon-to-be victim.
676
677 << or being held in >>

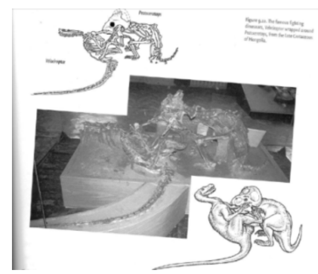


Fig. 9.22 pg 201 Caption
The famous (+imp) fighting dinosaurs, Velociraptor wrapped around (t: +comp) Protoceratops, from the Late Cretaceous of
678 Mongolia.

I: c: 1^2 exposition

t: : 1^2 exposition

P: c: α^iβ clarification

t: α^iβ clarification

Fig. 12.5 pg 258 Text

Fossil bone may preserve fine (+qual) anatomical details
679 visible under a microscope.
680 To see details,
681 a thin slice can be mounted on a glass slide,
and ground down so thin (+bal) that light can be transmi
682 through it.

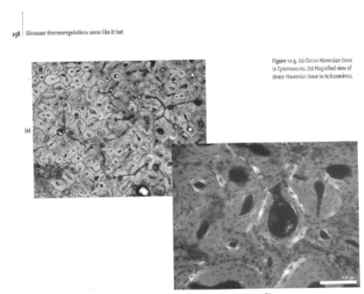


Fig. 12.5 pg 258 Caption
683 (a) Dense Haversian bone in Tyrannosaurus.
684 (b) Magified view of dense Haversian bone in Archaeomimus.
685 Fig. 12.6 pg 259 Caption
686 When remodeling occurs,
a type of Haversian bone known as dense secondary Haversian
687 bone is formed.
688 This bone has a distinctive (+imp) look about it.

c: α^iβ exemplification

t: α^iβ clarification

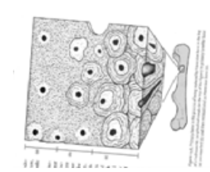
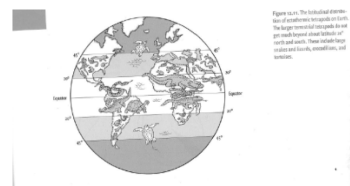


Fig. 12.6 pg 259 Text
Primary bone in the process of being replaced by Haversian bone
689 in the leg of a hadrosaurid.

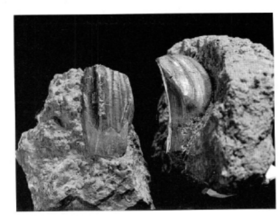
Longitudinal canals (at the top of the figure) in primary (+comp)
690 lamellar bone (a) are reabsorbed (b) c: α^iβ clarification
691 and then reconstituted as Haversian bone ©. t: α^iβ clarification
Fig. 12.11 pg 262 Text

The distribution of dinosaurs around the globe far exceeds the
692 current distribution of modern ecothermic vertebrates,
which are generally not found above and below, respectively,
693 laitudes 45 north and 45 south.



large (+qual) modern (+imp) ecotherms rarely occur (-imp) above
694 latitude 20 north and below latitude 20 south.
695 Correcting for continental movements,
Cretaceous dinosaur-bearing deposits have been found close to
696 latiudes 80 north and 80 south of the equator. c: α^iβ exposition =
Fig. 12.6 pg 259 Caption t: α^iβ clarification
697 The latitudinal distribution of ecothermic tetrapods on Earth.
The larger (+imp) terrestrial tetrapods do not get much beyond
698 about latitude 20 north ad south.
These include large (+imp) snakes and lizards, crocodilians, and
699 tortoises.

Fig. 14.2 pg 294 Text
700 Gideon was something of a fossil collector, (t: -esteem: capacity)
701 and the discvery baffled him, (t: -esteem: capacity)



because the teeth looked very much like those of the living
702 herbivorous lizard Iguana, (t: +complex)
703 but were ominously (t: -valu) much, much bigger.
Fig. 14.2 pg 294 caption
704 Mantell's Iguanadon teeth. c: 1^2 exposition =
Fig. 14.3 pg 294 Text t: α^iβ clarification
But of course (+imp) Mantells' weren't the first humans to see
705 dinosaurs fossils(t: +esteem: capabilty);
however, they may have been the first to interpret them
meaningfully (t: +esteem: normality) in a Western scientific
706 context.

Fossils of all types have been remarked (+imp) upon for as long
707 as there have been humans.
Fig. 14.3 pg 294 caption
708 a griffin

Intro to Dinosaurs

6.3 pg. 129 Caption c: 1^2 exposition =

Taphonomic infor mation derivable from an unidentifiable (-
709 comp) bird (possibly a blue jay). t: α^iβ x manner

Bird was dead from unknown (-qual) causes after nearly one
week, on author's porch in Atlanta, Georgia, January, 1998,
710 during an unusually warm (+imp) month.

Body cavity is open, possibly caused by avian or mammalian
711 scavengers,

712 and infested with (t: - comp) maggots;

713 large (+qual) fly was inspecting the body,

714 and some ants were in close proximity. (t: +qual)

Noticeable (+imp) effluvia was associated with the body,
715 probably(t: -esteem:capability) from aerobic bacterial decay.

6.3 Text

The rates and processes of decomposition and scavenging of large
modern mammals (such as elephants) or other vertebrates that are
716 anatomically similar (+imp) to dinosaurs

717 and have comparable (+imp) body sizes

718 have been observed,

719 some of which died in environments similar to c: α^iβ clarification =

those interpreted for containing dinosaur remains (Fig. 6.3). t: α^iβ exemplification =

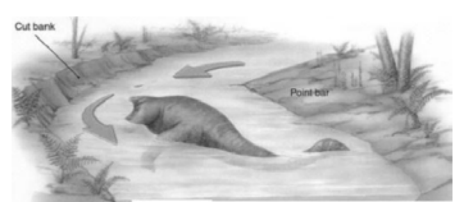
720

6.5 Caption pg. 131

Dinosaur bones rlemonstrating their behavior as sedimentary
721 particles.

722 Suspension astralagus; Saltation-scapula; Traction- humerus.

Floating sau ropod (with an apparent (t: +imp) density of less
723 than 1.0 glee) for scale.



6.5 Text

724 By water or wind, sediments are moved through traction

725 (dragged (t: -qual) along a surface)

726 or in suspension

727 (lifted into the fluid medium above a surface).

An intermediate form of movement, where a particle "jumps" (t:
728 =qual) intermit tently, c&t: α^iβ clarification =

729 is called saltation.

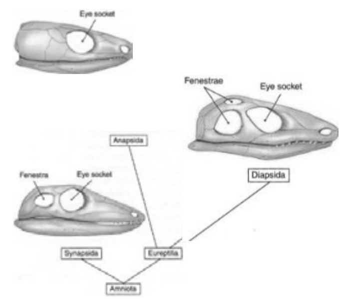
The combina tion of sediment moved through traction and
730 saltation constitutes the bedload,

and suspended particles are the suspended load of a stream (Fig.
731 6.5).

10.5 Caption pg. 230

Three skull types, with positions of temporal fenestra outlined, characterizing (t: +imp) the Anap sida, Synapsida, and Diapsida
732 in the context of a cladogram

733 showing their hypothesized (t: -valu) evolutionary relationships.



10.5 Text

The ma jor (+qual) basis for recognition (t: +imp) of their
734 diversifi cation,

735 expressed through further phylogenetic classification,

736 is seen in the arrangement of skull bones,

specifically with relation to (t: -imp) the presence and positions of
737 temporal fenestrae.

Amnitotes can be subdivided into three major (+qual) clades on this basis and other characteristics:Anapsida, Synapsida, and
738 Diapsida (Fig. 10.5).

c: α^iβ exposition

t: α^iβ clarification

10.6 Caption pg. 230

Dimetrodon, << >>but definitely was not a dinosaur (t: -qual).

739 Denver Museum of Natural History, Denver, Colorado.

740 << a Per mian synapsid and pelycosaur that was carnivorous,>>

10.6 Text

Some lineages of synapsids during the Permian included large herbivorous

741

742 and carnivorous reptiles << >> called pelycosaurs.

743 << (often confused (insecurity: disposition) with dinosaurs) >>

744 Pelycosaurs had elongated (+qual), dor sal vertebral spines

745 that formed sail-like (+qual) structures,

which along with their body size (as long as 3 meters) gave them
746 a formidable (+valu) appearance

c: α^iβ clarification =

that understandably (t: + esteem: normality) resulted in their popular but mistaken (t: -esteem: capability) grouping with dino
747 saurs (Fig.10.6)

t: α^iβ exemplification

12.7 pg. 284 Caption

748 The Middle Jurassic cetiosaurid Bellusaurus, a smaller (-imp) sauropod than most.

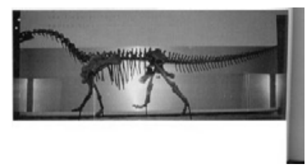
749 Temporary dis play at Fernbank Museum of Natu ral History, Atlanta, Georgia

12.7 Text

750 Cetiosaurids are considered primitive (-imp) sauropods

751 because of several characteristics, including their nearly solid (non-pleurocoelous) vertebrae.

752 Barapasaurus of India, Haplocanthosaurus of North America, Patagosaurus of Argentina, Rhoetosaurus of Australia, and Chinese forms Datousaums, Sunnosaurus, and Bellusaurus (Fig. 12.7) are other examples of cetiosaurids.



753 One of the hopes of paleontologists who specialize in the study of sauropods

754 is that what are now called "cetiosaurids"

c&t: α^iβ exemplification

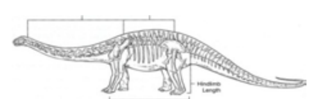
755 will some day be resolved into existing or new clades with the discovery

756 of more and better (+valu) preserved sauropod material.

12.2 pg. 276 Caption

757 . Important characters for Clade Sauropodomorpha:

758 distal part of the tibia covered by an ascending process of the astralagus, short hindlimbs in comparison to the torso length, spatula-like (+qual) teeth with bladed and serrated crowns, 10 elongated cervical vertebrae along with 25 15 dorsal vertebrae (25 pre sacrals), large digit I on manus.

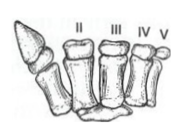


c: α^iβ clarificatio =

t: α^iβ exemplification =

12.2 Text

759 Likewise, those sauropodomorphs that were obligate quadrupeds (some prosauropods and all sauropods) should have had stout (-qual) metacarpals and phalanges on the manus



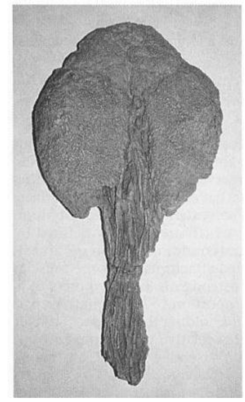
760 adapted for bearing weight.

761 In contrast, if any of the phalanges on the manus seem more delicate (+qual) a nd adapted (+qual) for grasping,

762 then the sauro· podomorph was more likely bipedal or at least facultatively (-imp) bipedal.

14.3 pg. 328 Caption

763 Tail club of the Late Cretaceous ankylosaurid Ankylo saurus,
composed of paired osteo derms. Denver Museum of Natural
764 History, Denver, Colorado.



14.3 Text

At the other end of these dinosaurs, the tails were also quite
765 different (-imp) in the two clades.
766 Ankylosaurids had long processes of the distal caudal vertebrae
that reinforced the tail to provide a handle for a bony club
composed of two pairs of large (+qual) and small (-qual)
767 osteoderms (Fig. 14.3).

c: α^iβ exposition =

t: α^iβ exemplification =

15.6 pg. 347 Caption

Styracosaurus, a Late Cretaceous ceratopsian from North
America that apparently could never have had enough (t: +imp)
768 horns.
769 Dinosaur Adventure Mu seum, Fruita, Colorado.

15.6 Text

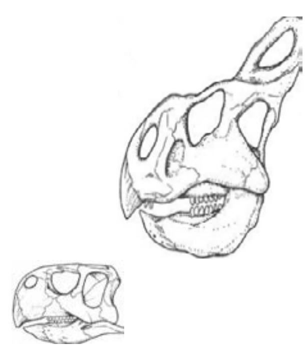
770 People who know anything about dinosaurs (t: +esteem: capacity)
771 think of horns when they think of ceratopsians (Fig. 15.6).
772 Indeed, the prominent (+qual) horns of Tricera tops were
what first caught the attention (satisfaction: interest) of 0. C.
773 Marsh
774 when he saw its skull in 1887,
leading him to first identify it as a fossil bison. (t: +esteem:
775 normality)

c: α^iβ exemplification =

t: α^iβ manner x

15.7 pg. 348 Caption

Comparative (+imp) anatomy between skulls of two small (-qual)
776 ceratopsians. (
A) Early (+qual) Cretaceous psittacosaurid Psittacosaurus of
Asia, the oldest known (t: +esteem: normality) ceratopsian and
777 namesake of its clade.
778 (B) Late Cretaceous neoceratopsian Protoceratops, also of Asia
779 .Compare predentary and dentary of latter with Figure 15.3A.



15.7 Text

780 Ceratopsia is split into two sister clades,
Psittacosauridae << >>a nd Neoceratopsia, which includes all
781 other ceratopsian species.
782 << (based on only one genus, Psittacosaurus) >> c&t: α^iβ clarification =
The oldest (+imp) ceratopsian known (t: +esteem: normality) ,
Psittacosaurus represents a small (less than 2 meters long)
783 ceratopsian species
that occurs abundantly (t: +imp) as near complete (-valu) or
784 complete (+valu) specimens in Lower Cretaceous rocks of Asia.
It can be distinguished (+imp) from other ceratopsians through
785 its nares
786 (which were elevated away from the rostral),
787 a loss of digit V on its manus
788 (leaving it with only (+imp) three fingers),
789 and a loss of its antorbitai fenestra (Fig. 15.7A).