Spring 2017

Discovering Conceptual Metaphors In High School Biology To Instruct English Language Learners

Nancy R. McCurdy

Hamline University

DISCOVERING CONCEPTUAL METAPHORS IN HIGH SCHOOL BIOLOGY TO INSTRUCT ENGLISH LANGUAGE LEARNERS

by

Nancy R. McCurdy

A capstone submitted in partial fulfillment of the
requirements for the degree of Master of Arts in Education.

Hamline University

St. Paul, Minnesota

May, 2017

Primary Advisory: Bonnie Swierzbin
Secondary Advisor: Feride Erku
Peer Reviewer: Dinorah Sapp

To my family for their love and support: Robbie, Sean, Mom, Dad, Allen and Ma'Ree. I especially want to thank my sons, Robbie and Sean, for their patience throughout this project. Thank you to my friends for their guidance, and support: Carla Carr, Susan Rutledge, and Jianxia "Jane" Xue. I would also like to thank Dr. Swierzbin for her committed support in helping me see this project to the end. Finally, I would like to thank my capstone committee for their time and effort in guiding me through the writing of this capstone.

"We dissect nature along the lines laid down by our native languages ...We are thus introduced to a new principle of relativity, which holds that all observers are not led by the same physical evidence to the same picture of the universe, unless their linguistic backgrounds are similar, or can in some way be calibrated."

-B.L. Whorf, (1940, pg. 229-231)

TABLE OF CONTENTS

CHAPTER ONE: INTRODUCTION

Academic language is widely used in oral instruction and written academic texts in middle school and high school content area subjects (Fang, 2006; Christie, 2007; Schleppegrell, 2004). Some of the most noted research findings have concluded that fully understanding abstract academic language is the most problematic reading comprehension skill in science for English Language Learners (ELL) (Snow, 2010). Academic language is comprised of many elements including "grammatical embeddings, sophisticated and abstract vocabulary, precision of word choice, and use of nominalizations to refer to complete processes" (Snow, 2010, p. 452). Despite extensive research of academic language, questions linger about how to create deep comprehension of terminology used to describe abstract processes in science across languages. The field of Cognitive Linguistics is creating a strong argument that the comprehension complexities of abstract processes may be explained by conducting a conceptual analysis of linguistic forms. For example, abstract nouns such as *carnivore*, *herbivore,* and *consumer* are "merely a surface manifestation of a conceptual metaphor" (Yu, 1998, p. 32). Conceptual metaphors provide us with a subconscious framework we can use to rationalize about the world around us. The term metaphor as used in this capstone is not simply a literary device, but a conceptual mapping of an abstract idea onto a concrete idea so that we can conceive of the abstract notions (Lakoff and Johnson, 1980a). In order to understand the abstract noun's meaning with depth, it is necessary to know its context. This is why understanding the conceptual metaphor that created the context for the abstract noun is so important.

According to research conducted within Cognitive Linguistics, conceptual metaphors underlie abstract noun terminology in many fields (Drury, 2005; Chi, 1994; Gómez-Moreno, 2011; Cuadrado & Durán, 2013a). Quite often scientists make use of conceptual metaphors common to their life experiences to create an understanding of their new theories. Terminology will often be a reflection of the conceptual metaphor the scientist used to reason about his/her new paradigm. Within Cognitive Linguistics, labeling of conceptual metaphors is written in capital letters. For example, in geology, the conceptual metaphor ROCKS ARE HUMAN BEINGS is used to create the concepts in terms such as *parent rock*, *parent material*, and *mother rock*. By using conceptual metaphors, we give 'life' to an abstract idea. We make a connection in some way to ourselves (Lakoff & Johnson, 1980a). Science terminology may be a representation of conceptual metaphors. Scientific terminology allows us to use abstract scientific concepts as a cornerstone to build further abstract concepts. These cornerstones of prior scientific belief may be unfamiliar to the beginning science student because of cultural assumptions used in the building blocks of the abstract scientific concepts. For example, this has been shown to be the case in Chinese vs. Western medicine systems that investigated treatments used in psychology/biomedicine (Pritzker, 2003).

A comprehension disconnect between a novice science learner and an expert may occur when the student is trying to comprehend metaphors commonly used in science by the instructors. These students may not be well versed in scientific metaphor to comprehend complex processes. "When such metaphors are unavailable, or transcend readily available experiences, as for instance when scientists speak of "curved space", then it is most difficult for the layperson to follow the progress of knowledge, and a gulf develops between those who understand and other who do not" (Unschuld, 1998, p. 24). Conceptual metaphor comprehension may be essential in order to understand the connections between what seem to be bits and pieces of random scientific facts and a larger understanding of scientific concepts. Prior to planning instruction of abstract biology nouns to ELLs, it may be helpful for instructors to investigate which conceptual metaphors students are held accountable to know and comprehend.

This study will focus how abstract noun terminology is related to specific scientific conceptual metaphors. For this study, I will use the definition from http://dictionary.cambridge.org that defines an abstract noun as "a noun that refers to a thing that does not exist as a material object." I will analyze a set of abstract nouns used in one of Mississippi's high school standardized biology practice assessments to determine the prominent conceptual metaphors. The guiding question for this capstone project is *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?*

Quite often on-demand topic instruction becomes the norm when several different ELL students come into the ESL classroom with different assignments. This requires the ESL teacher to be knowledgeable about a wide range of topics at a moment's notice. Analyzing the language used in the Mississippi Department of Education's required state biology assessment may help educators determine what essential biology content needs to be the center of instruction in the ESL classroom. Focusing instructional time on the most complex, abstract scientific terminology may be the most efficient use of time in the ESL classroom. In my experience, helping students organize complex information into simplistic, less-cognitively demanding categories results in students' retention of more academic information. It is the job of the ESL teacher to comprehend how scientific content is organized and explained in high school so that language acquisition instruction is effective and purposeful. One manner of doing this may be to determine patterns of language used for abstract scientific concepts. An investigation of conceptual abstract noun formation may lead to a systematic, detailed description of specific conceptual steps required to fully understand abstract scientific concepts in terminology. This description may be used as a guide to determine comprehension breakdown areas for ELLs in biology. Quite often, in my observations of science classrooms, textbooks are put aside and are replaced with teacher-created Power Point presentations of scientific concepts and terminology. Oral language instruction, along with visual supports of diagrams and charts, are the dominant instructional tools used to convey scientific concepts and terminology. Because of inconsistent use of scientific instructional materials across science classrooms in Mississippi, it became necessary in this project to identify which, if any, printed material is used consistently to assess student knowledge of scientific terminology. For these reasons the Mississippi subject area biology practice test was the most practical resource to use to determine what biology terminology Mississippi high school students will be held accountable to comprehend to graduate from high school in Mississippi.

Two of WIDA's Guiding Principles of Language Development (2010) may apply to my study of academic language in science. Two of these guiding principles, Principles Three and Eight, emphasize the need for educators to understand and expand ELL students' cognitive functions of academic language. Principle Three states, "Students draw on their metacognitive, metalinguistic, and meta-cultural awareness to develop proficiency in additional languages," and Principle Eight indicates, "Students' academic language and academic content knowledge is an inter-related process" (2010, WIDA). Making content comprehensible through the teaching of conceptual metaphors in science may help students increase their proficiency level of topic-specific language. In order to diagnose where the comprehension breakdown occurs for ELLs, it will be helpful to understand the image schemas and conceptual metaphors used in concept creation that are manifested in metaphorical expressions such as abstract nouns. Comprehending basic biology terminology is a basic skill needed to pass the Mississippi Biology Subject Area Test. This is one of the requirements that ELL students must accomplish independently in English without any paraphrasing of test items in Mississippi. Therefore, it is necessary to prepare the ELL students significantly with comprehension of biology terminology before being faced with this written assessment.

The remainder of this chapter introduces basic concepts and terminology that surround conceptual metaphors, which will be explained in more detail in Chapter Two. According to one of the main tenets of Cognitive Linguistics, language is *embodied* (Lakoff & Johnson, 1999). We use metaphors from our own experiences as humans to understand the unknown. One way of understanding a new abstract idea is to categorize the thought through a metaphor known to our human experience. The *embodiment hypothesis* (Lakoff, 1987) suggests we conceptually map *image schemas* to more complex concepts in order to comprehend abstract thought. However, "bodily experience can only tell what are possible metaphors. Whether these potential metaphors are actually selected in a given culture is largely dependent upon cultural models shared by individual living in this culture" (Yu, 1998, p. 43).

Lakoff (1987) proposes reasons why bodily experience plays an important role in abstract reasoning and concepts. Objects, substances, containers (known as *image schemas* in cognitive linguistics) provide the initial pre-linguistic structures that are common to the human experience across languages.

The primary conceptual domains of reference we each use for conceptual metaphor comprehension may be identified by underlying image schemas related to the human experience in general, or by culture specific reference cues such as culture specific conceptual metaphors. *Primary conceptual domains* are the concrete experiences we use subconsciously in metaphor mapping when trying to comprehend a new abstract idea. We map the abstract idea onto the more concrete idea, such as recent historical events or cultural beliefs, with which we are already familiar. Each time a conceptual metaphor is identified, either as a primary metaphor or a new, complex metaphor, it is written in capital letters. This practice is adopted in the current study as well. For example, CATEGORIES ARE CONTAINERS is a conceptual metaphor that may be applied to the expression of being in a group, such as, "Are tomatoes *in* the fruit or vegetable category?" We conceptually apply these categories to abstract ideas according to how we perceive that things belong together because of their common location, origins, functions or properties (Lakoff & Johnson, 1999, pg. 51) in order to make sense of them.

The misconstrual of abstract ideas may occur at the conceptual level when an abstract idea becomes more specific within the context of a specific conceptual metaphor. It has been shown that image schemas motivate conceptual metaphors differently across cultures in order to fit the needs of different communities to communicate in ways that are in alignment with their perspective of common cultural experiences. "Conceptual metaphors and their cultural context can all be put to useful work in the study of cultural variation in the conceptualization of TARGET concepts ….They enable us to see with considerable clarity precisely where and how cultural variation occurs both cross culturally and within a culture" (Kövecses, 2010, p. 227).

Within everyday language and science some of the more specific conceptual metaphors that have been identified such as machines, transportation, or computers communicate more complex conceptual ideas of time and space and how we move within them. According to Langacker (1987b, 1991b, 2000), we conceptually categorize abstract nouns into space and time. The manner in which we communicate how we move around in space, our focal point within that space, and how we conceive of time passed can be represented within the abstract noun.

As cited in Kövecses (2005), Lakoff and Johnson (1999) define how Cognitive Linguistics views metaphor. They have suggested the following basic assumptions:

> *Thought is largely unconscious.* This means that we cannot help thinking in the ways we do. We are not consciously aware of the way we think and reason, and we cannot think just anything. *Abstract concepts are largely metaphorical.* This means that most of our nonphysical (social, psychological, etc.) reality is conceptualized via physical reality, that is, in terms of physical domains of experience. *The mind is embodied*. This means that concepts derive their meaning through sensorimotor experience – either directly or indirectly (i.e., via metaphor). (Kövecses, 2005, p.10)

According to Lakoff (1987) image schemas are common, known structures we humans used as a base to create conceptual metaphors. For example, the basic bodily experience of moving from start to finish has the image schema SOURCE-PATH-GOAL. This schema then allows us to create conceptual metaphors such as LIFE IS A JOURNEY and use and understand metaphorical expressions such as “He’s *without direction* in his life” (Kövecses, 2005, p.10). We continually use our bodily experience of movement through space and time as our concrete experience in life with image schemas. Lakoff (1987, p. 282) claims that the image schemas “CONTAINER, SOURCE-PATH-GOAL, LINK, PARTWHOLE, CENTER-PERIPHERY, UP-DOWN, and FRONT-BACK” not only formulate our thoughts about space but they also structure our concepts. According to Lakoff (1987), these image schemas, which are common to our human experience, help us understand abstract ideas that are formulated to explain different phenomena. In order to speak of these new phenomena, metaphorical language appears and is understood within a common speech community. We map a common embodied, concrete experience onto a more abstract one.

Lakoff's and Kövecses' earlier methods of extracting the conceptual metaphor from a larger body of text are also used in the area of science. Drogosz (2013) identifies underlying conceptual metaphors within the early manuscripts of Darwin’s *Origin of the Species.* When Darwin first introduced his theory of Natural Selection, he needed to use current day examples of physical objects and people so that the general public could understand his viewpoint. For example, Drogosz (2013) reveals that Darwin used the conceptual metaphor A LIVING ORGANISM IS A MACHINE to move the general public’s belief away from God-like forces having a hand in the phenomenon of survival to a more mechanistic model of the accumulation of power as being the reason for certain organisms surviving versus other organisms.

Within science, we can look at how metaphor was used in original scientific manuscripts to explain new theories. We can also examine how metaphor is used to convey new scientific information to the general public. As shown with Drogosz' example, it has been revealed that the machine metaphor was used extensively during the 19th century to explain many scientific theories that we use today. Conceptual metaphors, or themes, discovered in ecology, cell theory, and modern genetics have also been studied and will also be discussed further detail in Chapter Two. After learning conceptual metaphors to use as a framework, the learner may able to move forward to comprehend more complex conceptual metaphors within specific scientific fields.

The metaphor strategies of *objectification, reification and personification* have been used to explain and discuss abstract scientific ideas and can be revealed in different conceptual planes such as theoretical frameworks and cultural and sub-cultural ideologies. When an abstract idea is explained by comparing its characteristics to that of an object, the *objectification* strategy is being implemented, such as the example of AN ORGANISM IS A MACHINE, where the complex structure and purpose is a specific object, such as a machine, is used to explain its existence. More generally, when an abstract idea is *reified*, the abstract notion is conceptually transferred from a process category, which has a beginning, middle, and end, to another category such as a noun, which is a "thing" that has a defined conceptual space, such as a container, and can take on additional qualities such as opacity, color, or size. For example, *energy* is a chemical, physical event reified into an abstract noun in order to discuss it or refer to it.

Personification was also widely used within Darwin's initial biological concepts to explain how nature reproduces and takes care of itself. By endowing human qualities to a phenomenon by adding verbs or adjectives typically reserved for human interaction, we can conceptually conceive nature as something personal or human. NATURE IS A BREEDER/GARDENER was a conceptual metaphor employed quite often in Darwin's writings (Drogosz, 2013). These metaphorical concepts are manipulated through grammatical twists and turns to meet the discourse needs of the speaker. As shown above, comprehending abstract ideas, or new paradigms, may be very difficult unless we have a concrete notion to compare it to, which is why many scientists will use creative metaphors to describe their theories and following taxonomies. Further research of Cuadrado and Durán (2013a, 2013b) has also revealed how to identify conceptual metaphors used within scientific terminology. While this research is still relatively new, I propose a new method in Chapter Three of how to categorize conceptual metaphors used in various categories of biology terminology.

Some of the most easily identifiable metaphors used within science are polysemous words that may carry one meaning in one subject area, such as *table* and *body*, and carry a different meaning in another subject area. We use the metaphor of common language such as *table* and *body* because they are familiar concrete examples we have in our English vocabulary that can transfer their physical characteristics onto something abstract so that we can comprehend the abstract noun's physical composition, function or purpose. The same method is used when creating new scientific theories and taxonomies for the newly created theory as shown by Darwin's previous examples.

In addition to the cognitive demand that is placed onto the student to understand scientific theoretical frameworks, grammatical changes can cause a cognitive delay as well. Reification is the process of making something concrete. Encountering reification while reading may lead to cognitive difficulty, but the reification itself isn't defined as a difficulty. When a verb, adjective, adverb, or phrase is turned into a noun, we are conceptually making this process more abstract by bringing it over to the noun category. When we re-categorize a verb process into a noun, we endow it with the conceptual characteristics of a noun. A noun is something that can instantiate an entity which may have physical boundaries and take on additional characteristics, such as color, density, opacity, etc.. When we give an abstract process membership to the noun category, we are giving it a defined existence. This is also referred to as having *ontology* (Radden & Dirven, 2007). When we give something an existence, we use the conceptual makeup of a known thing to create an *ontological metaphor.* Abstract nouns are commonly referred to as ontological metaphors. In addition to the conceptual change from process to object, some ELLs may have comprehension difficulties with abstract concepts because conceptual, ontological metaphors have been shown to have significant cultural differences between languages (Cuadrado et al., 2016).

In addition to Lakoff's description of container and substance metaphors, Chi (1994) reveals a new category of cognitively demanding ontological metaphors specific to scientific terminology called *Constraint Based Interactions* (CBI). Within her research Chi (1994) maps out how CBI ontologies can be problematic for students due to incorrect common metaphors used to teach basic scientific concepts. Chi (1994) states that there are three categories of science ontologies: matter, states and processes. Using conceptual categories of cognitive science, matter is categorized as OBJECTS, states can be OBJECTS or SUBSTANCES, and processes can be OBJECTS or SUBSTANCES. Discovering which TARGET and SOURCE DOMAINS are used as OBJECTS or

SUBSTANCES within conceptual metaphor creation of abstract scientific terminology is the motivation of this capstone.

It may be possible that young ELLs that interact with English speaking children and adults may gain firsthand knowledge of context-dependent metaphors used in casual language that may be created by cultural conceptual metaphors as suggested by Christopher Johnson's (1997) work of conflation experiences as cited in Lakoff and Johnson (1999), It might be possible that it is through casual language that children learn the underlying metaphoric system used during instruction in American classrooms. However, later on, when experienced ELLs encounter more and more academic language, the conceptual blockade may appear. This may be due to incorrect metaphors used during primary and secondary academic instruction, as suggested by Chi (1994) or conflicting cultural, conceptual metaphors within the students' experience. As children move onto the secondary school level, the gap of academic language knowledge widens for some ELLs. There may be a disconnection between common experience and academic concepts for some ELLs. It may be that they need to have the more complex content specific conceptual systems, or have the conceptual systems not obvious to them explicitly taught to them. The scaffolding of conceptual metaphor concepts may help ELLs understand academic concepts.

ELLs in the United States are learning language at the same time as content. Therefore, they need explicit instruction to comprehend the conceptual notions behind the language structures in order to fully comprehend content area-concepts. Fang, Schleppegrell, and Cox (2006) have remarked that without knowledge of content area vocabulary students will have a very difficult time mastering the content area knowledge.

When teaching content driven language instruction, it is necessary to know how language instruction differs for ELLs than for mainstream monolingual students.

Research to compare conceptual metaphors is still in the initial information gathering stages within L1 linguistic studies. However, it is possible to break down the concepts of an abstract noun as being classified as an object or substance. This will allow initial concept development to begin. One example of an abstract noun that is an object would be *disease*. Disease is classified as an episodic state that is an object because it is a count noun that has a defined beginning and end, whereas *knowledge* would be a substance because it is steady state and is a non-count noun. I believe that students will most likely be able to directly translate *disease* or *knowledge* because they have causal agents or a progression. However, according to Chi (1994), when event processes (substances) such as *evolution* or *electrical current* come into discussion, they become problematic because these abstract nouns do not follow the normal conceptual patterns of an object or substance. They are a subcategory of processes, which are categorized under substances and are defined as constraint-based interactions. It is these complex ideas which are specific processes transformed into nouns that create a cognitive disconnect, perhaps because they require a different visual scene or an unknown paradigm. When we categorize these problematic abstract nouns based upon their conceptual content, we can then move forward with designing appropriate instruction of abstract nouns in science that may be problematic for English learners. Both the subculture of science and background cultural metaphor of a student's L1 may interfere with concept acquisition within science. Chi (1994) shows how students consistently confuse a process as being a thing because of its grammatical category as a noun.

Learning abstract scientific terminology through the lens of conceptual metaphor creation may allow ELLs equitable access to the science content that embeds academic English and the western scientific belief system. Understanding the student's cultural belief systems and life experience and having a solid understanding of the conceptual metaphors used in scientific terminology may help teachers better understand how abstract, academic nouns may be problematic for ELLs.

In sum, abstract scientific nouns may create concept confusion that may impede comprehension. It is necessary to investigate what is deemed essential conceptual biology knowledge of abstract nouns so that students have the tools needed to be successful with further studies or assessments. It is a common practice in ESL to analyze grade level language structures used in textbooks and assessments because this will guide direction of intervention instruction. Analyzing the language that is used in one of the Mississippi high school biology practice assessments may help determine how much, if any, abstract nouns are being used as a tool to assess student mastery of the biology content required to graduate from a Mississippi high school. It is the goal that the essential knowledge that will be gained from this study will be passed on so that teachers can better understand the bigger picture of what our ELLs face while learning a new language and mastering the content at the same time. This research will give ESL and general education teachers a broader perspective that can inform their daily instruction for English Language Learner students by investigating *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?*

Chapter Two will address in depth the most recent research which uses the Cognitive Theory of Metaphor as a base to identify conceptual metaphors in various biology fields. Emphasis will be placed on the conceptual metaphors used to create the conceptual frameworks of several major biology theories. Connections will then be made between the conceptual metaphors used in the original scientific theory and how they affect abstract noun conceptual formation. Lastly, specific emphasis will be given to Constraint Based Interactions because they place valuable insight into a focused group of abstract noun terminology found in biology.

CHAPTER TWO: LITERATURE REVIEW

The Cognitive Theory of Metaphor within the field of Cognitive Linguistics suggests that metaphorical thought is essential in controlling and creating our comprehension of abstract concepts (Lakoff & Johnson, 1980a). In this literature review I will investigate abstract nouns as being one of the grammatical manifestations of metaphorical thought in scientific language to answer my capstone question *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?*

Nominalizations (abstract nouns) are one of the most difficult areas of scientific academic vocabulary for L2 learners to acquire (Snow, 2010). Research that provides answers to explain comprehension difficulties of abstract nouns is just beginning to surface within L2 research. The Cognitive Linguistics perspective attempts to identify these comprehension difficulties using a Cognitive Linguistics model that equates meaning with conceptualization (Cuadrado & Duran, 2013b; Gomez-Moreno, 2011; Langacker 2002). Studies have revealed that abstract noun comprehension in science technical terms requires a comprehensive understanding of the conceptual influences that underlie the creation of technical abstract nouns in science (Cuadrado & Duran, 2013b; Gomez-Moreno, 2011).

Within different science and technology fields, researchers have unveiled *conceptual metaphors* that are deeply entrenched in technical terms (Cuadrado Esclapez, Duque García & Durán Escribano 2007, Cuadrado & Durán 2013a). Learning scientific technical terms requires an understanding of the metaphorical model, the conceptual metaphor, being applied to the mental experience. The Cognitive Theory of Metaphor by George Lakoff and Mark Johnson (1980a) and Lakoff, (1993) can be used as frameworks to understand which conceptual metaphor is being applied in scientific text. Within the CTM framework 'metaphor' refers to a "cross-domain mapping in the conceptual system" (Lakoff, 1993, p. 1). Metaphorical expressions "refer to a linguistic expression (a word, phrase, or sentence) that is the surface realization of such domain mapping" (1993, Lakoff, p. 2).

Lakoff (1987) has also suggested that in order to fully understand how to think scientifically it is necessary to know which metaphorical conceptions to apply to different scientific concepts. In addition, Nayak (2011) has suggested that metaphor acquisition is an important aspect of language acquisition and that we should learn abstract concepts first because later they are expressed linguistically as grounded concepts. This strategy would allow for deeper understanding of the conceptual metaphor that is embedded in abstract nouns found in scientific terminology. Langacker (1991a) states that once you have a view of the cognitive processing that underlies the meaning of the nominalized word (abstract noun), that is when comprehension is fully realized.

In order to teach abstract vocabulary and concepts, Chi (2004, 2013) has offered strategies to fill comprehension gaps of abstract scientific concepts, which are represented as abstract nouns. To comprehend the path that was used to create abstract terminology, it is necessary to discover the conceptual mappings used to get there. Hopefully, in understanding the examples used in metaphorical SOURCE DOMAINS of different terminology, comprehension for L2 learners could be facilitated more efficiently and with deeper comprehension.

In the first part of Chapter Two, I will discuss metaphors used in everyday language within the framework of the Cognitive Theory of Metaphor and the Contemporary Theory of Metaphor. In the second part of Chapter Two I will discuss conceptual metaphors in scientific language and how these have influenced scientific thought. Then, I will discuss conceptual, ontological metaphors within abstract nouns as polysemous words and nominalizations in scientific terminology. Finally, I will conclude Chapter Two with a discussion about conceptual metaphor instruction.

The literature review presented in this chapter will help contextualize the research question investigated in the capstone: *Which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?* The results from the study are expected to be beneficial in examining conceptual metaphors in an effort to scaffold comprehension of biology terminology for L2 learners.

The Cognitive Theory of Metaphor

The Cognitive Theory of Metaphor (CTM) offers a framework to comprehend abstract noun creation. Abstract nouns are a manifestation of underlying conceptual metaphors found in various scientific theories. According to Lakoff (1993), the majority of our general language is metaphorical. We think metaphorically, and words, phrases and sentences are interconnected to underlying conceptual, metaphorical thought. CTM incorporates psychological processing of the human experience and the ontology of the original discourse as the main concepts necessary to comprehend the abstract concept. Conceptual metaphors allow us to understand how the abstract nouns are connected semantically to the scientist's original theoretical explanations. Conceptual metaphors create a metaphorical model to comprehend the abstract concepts within scientific terminology. CTM offers explanations describing how and why abstract noun constructions were created to examine not the "surface linguistic criteria, but to underlying cognitive processes involved in the scientific conceptual system and the mind's mental projections when creating new terms" (Cuadrado & Durán, 2013b, p. 2).

The Cognitive Theory of Metaphor (Lakoff & Johnson, 1980a) provides an explanation of the metaphorical concepts that we use to govern our thought as evidenced by the language that we produce. The Cognitive Theory of Metaphor is based upon these concepts of metaphor and the mind (Lakoff & Johnson, 1980a, p. 272-273):

1. Metaphors are fundamentally conceptual in nature
2. Metaphorical language is secondary
3. Conceptual metaphors are grounded in everyday experience.
4. Abstract thought is largely, though not entirely, metaphorical
5. Metaphorical thought is unavoidable, ubiquitous, and mostly unconscious
6. Abstract concepts have a literal core but are extended by metaphors, often by many mutually inconsistent metaphors
7. Abstract concepts are not complete without metaphors
8. We live our lives on the basis of inferences we derive from metaphors

All of these key concepts have driven and shaped research of conceptual metaphors today. The term *conceptual metaphor* broadly refers to any conceptual mapping where a known body of knowledge (a SOURCE DOMAIN) is used to comprehend an abstract idea (a TARGET DOMAIN). The products of these mappings are represented through specific linguistic expressions. “Metaphor is not just a matter of language but of thought and reason. The language is secondary. The mapping is primary, in that it sanctions the use of SOURCE DOMAIN language and inference patterns for TARGET DOMAIN concepts” (Lakoff, 1993, p. 208). Lakoff describes metaphors as conceptual structures that organize our everyday language and abstract thought.

According to Lakoff (1993), metaphor is not understood as one thing in terms of another, but metaphor is one conceptual box of knowledge being composed onto another conceptual box of knowledge. He calls these boxes of knowledge *sets of conceptual correspondences*. For example, with the conceptual metaphor LOVE IS A JOURNEY we will see the mapping to demonstrate lexical item comprehension. The conceptual metaphor is not only used to “talk about love but for reasoning about it as well” (Lakoff, 1993, p. 206). For example, when we talk about and think about love we may use these expressions. “Look how *far* we’ve come. It’s been a *long, bumpy road*. We can’t *turn back* now. The relationship *isn’t going anywhere*.” (Lakoff, 1993, p. 206).

Further research on conceptual metaphors in specialized language has shown that conceptual metaphors are also compacted into technical language. While the above examples may show how the conceptual metaphor is obvious once demonstrated, it is not as apparent in technical terminology because the conceptual metaphor is deeply entrenched in the definition of the terminology. Within scientific terminology, we will observe conceptual metaphors which take on conceptual shapes, such as *non-resemblance metaphors,* “metaphors that emerge from rich and abstract structures not involving physical or behavioral patterns” (Lakoff and Turner, 1989, p. 91 as cited in Ureña, J.M. and Tercedor, M., 2011, p. 218). For example, two of the-most common conceptual metaphors in marine biology are MARINE HABITATS ARE COMMUNITIES with the metaphorical expressions, *architecture, association, bacterial consortium, microbial consortium, colony,* etc. and MARINE COMMUNITIES ARE STRUCTURES THAT COMBAT OTHERS FOR SURVIVAL with metaphorical expressions such as *settle, colonize, associate, cohort, armament, intrusion,* etc., are non-resemblance metaphors because they compare abstract structures.

Embodied Language: The Human Experience

One of the principles of CTM is that language is embodied and that reality is based upon our human experience interpretation of it (Evans, 2013). We are able communicate because as humans we experience the world in the same way to some extent based upon “our basic daily-life experiences with our body, physical environment and culture” (Hoang, 2014, p.1). How we perceive things going in and out of spatial areas, such as the human body; the physical structure of the body of having a head, a middle and appendages; the social nature of the human participating in a community; and the psychic nature of feeling emotions, philosophies, and religions, as described by Lakoff and Johnson (1980a), became central to human understanding.

Our common experiences are what make our cultural reference points. We cannot separate culture and language. Therefore, according to CTM, every thought is influenced by our environment. Within the Cognitive Theory of Metaphor our bodily experiences affect our cultural metaphors. Many human metaphors are common amongst humans around the world; however, there are metaphors that are culturally specific. Conceptual metaphors can come from a variety of sources. The most common conceptual metaphors are based in human, bodily experiences that are common for all human beings. However, other metaphors may be context dependent, time dependent or used based upon cultural or personal preferences. Also, if two languages share a lot of common conceptual metaphors, they most likely would be understood across languages with minor linguistic differences. Fortunately, research has begun to give us a guidebook of which metaphors occur more frequently in different languages.

Boers (2003) discusses two variations in conceptual metaphors that can cause miscommunication between native English speakers and English learners when learning idioms in a foreign language. The first is a cross-cultural variation whereas the SOURCE-TARGET mapping is similar; however, cultural experiences such as sport metaphors are emphasized and used. For example, baseball metaphors used in casual language, such as *Three strikes and you're out*, would be a difficult metaphor to translate unless your culture include baseball metaphors as well. "Such subtle variations in the productivity of shared metaphors may seem trivial at first, but there is some evidence to suggest that they do have an impact on learners' comprehension of L2 figurative idioms" (Boers, 2003, p. 234). Value judgments are another variation. "This type occurs due to differences in the value-judgments that are associated with the SOURCE DOMAIN, the TARGET DOMAIN, or the appropriateness of the metaphor as such. Cross-cultural differences of this kind carry the risk of learners' missing culture-specific "connotations of certain figurative expressions" (Boers, 2003, pg. 236). According to Littlemore (2003), as cited in Boers (2003), it is necessary for instructors to be aware of their own value based cultural metaphors because these may impede comprehension for learners during instruction.

Metaphors Evolving Into Terminology

Metaphors eventually move into accepted general terminology once they are accepted by a community as general beliefs **(**Charlton as cited in Johnson, 1981**).** According to Steen (2008) in Cuadrado & Durán (2013b) we were aware of the mappings that occurred when processing new scientific, conceptual ideas, but later as these concepts and ideas became widely accepted thought and treated as fact instead of opinion, these scientific terms became conventional metaphors and no longer required the user to apply conceptual mappings because these ideas are now readily available gestalts within the contemporary language users' conceptual language. Therefore, once the larger conceptual metaphor used to initially explain a new abstract idea becomes widely accepted as the new truth, we no longer need to refer to it with more metaphorical expression. It is now cemented into new scientific terminology such as *parent rock,* which used the conceptual metaphor ROCKS ARE HUMAN BEINGS to explain its status in that particular niche of rocks.

Conceptual metaphor evolution. Conceptual metaphors begin as a *generic* metaphor, also called an *image schema*. One of the most common image schemas employed for abstract processes is that of a container (Johnson, 1987). "So far, the vast majority of research on image schemas and their logics has been based on linguistic and conceptual analysis showing how, in languages all over the world, these basic structures (1) underlie the meanings of terms for physical entities, states, and relations, and (2) shape our understanding of and reasoning, via conceptual metaphor, about abstract concepts" (Johnson, 2015, p. 7).

Because cognitive processing happens quickly, we don't even realize it happens. Lakoff and Johnson (1980a) have attempted to break down our understanding of what happens in the brain when we use and comprehend metaphors. In doing so they explain that the process of metaphor is to first understand something as a generic metaphor, such as a container (Johnson, 1987).

When initially confronted with an experience, we conceptually categorize our perception according to a concrete structure with which we are familiar. "The image-schematic logic applies not just to physical containers or bounded spaces, but to abstract containers like *states* (being, hot, cold, etc.), mathematical sets (abstract realities contained within conceptual boundaries), and institutions (such as marriage), etc." (Johnson, 1987; Lakoff and Nunez, 2000) as cited in Johnson (2015, p. 7). There are hundreds of different image schemas that have been discovered. Image schemas are defined as conceptual pre-linguistic structures we use in multiple modalities including vision, hearing, and taste in order to reason about a new experience (Johnson, 2015). We then use image schemas to understand further abstractions. Our interpretation will depend upon our cultural conceptual metaphor employed. Conceptual metaphors specific to our environment can be called *specific* conceptual metaphors. The generic metaphor (or image schema), written as SOURCE DOMAIN IS THE TARGET DOMAIN, as seen in IDEAS ARE ENTITIES, is then expanded upon by another metaphor that may be culturally relevant and becomes a specific conceptual metaphor, such as ECOSYSTEMS ARE COMMUNITIES. The first step of the cognitive process is to understand the abstract as something tangible so that we can begin to comprehend it and the cognitive load can be lowered.

By analyzing the visual field that is projected by the abstract noun we can derive part of the generic ontological metaphor as either being a SUBSTANCE or OBJECT (Lakoff, 1980a). When observing the definition of an abstract noun, if the definition describes a conceptual space than it can be said to be an OBJECT. If it is defining movement within that space, it can be defined as a SUBSTANCE.

We can observe that the construction exists, but why this particular visual imagery occurs may be explained by other cultural phenomena such as current human ideologies of the time period, cultural norms or specific knowledge of a speech community which lead us to the specific conceptual metaphor. When trying to understand a phenomenon, it is easier to categorize a concept generically first, then to review the details. Then we can begin to construct our visual conception of a word and later build our understanding of its specific details. With the help of CTM we can create the generic category into a SUBSTANCE or an OBJECT to begin conceptualization of an abstract noun.

Generic metaphors. Abstract nouns represented as generic, ontological metaphors. Lakoff and Johnson (1980a) identified ontological metaphors as a generic metaphor that projects the "entity or substance status on something that does not have the status inherently" (Lakoff & Johnson, 1980b, p. 196). For example, IDEAS ARE ENTITIES and WORDS ARE CONTAINERS, as in "*It's hard to <u>get that idea across</u> to him. The ideas are <u>buried deep</u> in terribly dense paragraphs*" (Lakoff & Johnson, 1980b, p. 196).

Abstract Noun Origins

Underlying Conceptual Metaphors

When studying abstract nouns, it is necessary to know the context in which they are used. Generic metaphors define the conceptual metaphor used to define the context. In science, taxonomies of abstract nouns are conceptually linked to their originating scientific theory by sharing the SOURCE DOMAIN used in the initial specific conceptual metaphors (Drogosz, 2008). Many initial theories are used as a starting point for further metaphors. From these theories technical vocabulary is created. Then new definitions are created, which take the paradigms created by previous terminology to create new terminology (Cuadrado & Duran, 2013b). Boyd (1993) describes the complexity within scientific metaphor: "Scientific use of metaphor does double duty…it creates vocabulary to describe a new domain, and at the same time makes this new domain involved in the metaphor" (Boyd as cited in Travers, 1996, p. 36). For example, Darwin's objectification and personification of non-physical objects such as i*nstinct* and *variation* become thought of as physical objects once they were reified. From this point forward, additional terminology transpired.

Darwin wanted to demonstrate that *variation* is a concept that can be carried from one generation to the next. In order to do this, first he had to conceptually create the image that his theory of *variation* is an object. He gave the idea an ontological existence by manipulating grammar categories to his advantage and objectifying a process. He transferred his theorized process to a noun by calling it *variation*. In some ways, this transformation also legitimized his theory as an actual thing because it could be discussed and referred to because it was a noun. Also, because it was a noun, it could become a conceptually conceived object that could do things. In (2) we can see how he objectified the idea and compared it to a valuable object that can be preserved, inherited or transmitted, as discussed in Drogosz (2008, p. 99).

> (2) "No complex instinct can possibly be produced through natural selection, except by the slow and gradual accumulations of numerous, slight, yet profitable, variations"
>
> "…why should we doubt that variations in any way useful to beings, under their excessively complex relations of life, would be preserved, accumulated, and inherited"

Drogosz (2008) discusses how Darwin's initial objectification of *variations* became a starting point for further metaphors in science. As soon as Darwin objectified *variation,* it became available to be interpreted as a valuable object.

Because understanding context is essential in learning new vocabulary, this literature review will continue with the big picture of underlying conceptual metaphors and then describe how abstract nouns are derived from these initial metaphors such as the specific ontological metaphor commonly used in ecology, ECOSYSTEMS ARE COMMUNITIES. By grounding the abstract idea of ecosystems to something familiar to us humans, such as having relationships, we can begin to frame the abstract idea onto a familiar context and then connect more concrete, human experiences to more abstract ideas connected to the original specific ontological metaphor in order to understand the term *organism* and its purpose and function in the ecosystem

Partial Metaphors

Lakoff (1993) states that metaphorical understanding becomes commonplace "As soon as one gets away from concrete physical experience and starts talking about abstractions or emotions" (Lakoff, 1993, p. 205). Lakoff (1993) identifies a metaphor by describing the relationship between its two domains, the SOURCE DOMAIN and the TARGET DOMAIN such as LOVE IS A JOURNEY. In this model, THE TARGET DOMAIN (love) IS THE SOURCE DOMAIN (journey). Lakoff (1993) explicitly points out that the name of the mapping is not direct and concrete, but rather a *set of correspondences*. This means everything we know and infer about one abstract or concrete idea can be mapped on to everything or parts of the unknown concepts in order to talk about it and reason about it. Lakoff explains that there is not one perfect concrete example that would define all aspects of the abstract concept, for example, with the abstract notion of IDEA. IDEA can be explained by many different rich metaphors, each of which will define different aspects of IDEA. For example, the IDEAS ARE PEOPLE metaphor can be seen with the metaphorical expressions "*He conceived a brilliant theory of molecular motion. Cognitive psychology is still in its infancy*" (Lakoff & Johnson, 1980b, p.198). Another conceptual metaphor, IDEAS ARE PLANTS, may highlight a different attribute of the abstract concept by connecting it to the concrete example of plants, for example, "*His ideas have finally come to fruition. She has a fertile imagination. It will take years to come to full flower*" (Lakoff & Johnson 1980b p. 198-199). These natural language examples that come from IDEAS ARE PLANTS perhaps show how ideas can grow and are rich resource such as plants; however, IDEAS ARE

PEOPLE uses a personification strategy to define IDEA as being something living and breathing like humans.

Each of these metaphors provide some notions about the concept of *idea;* however, they do not consistently define the same aspect of the abstract concept of IDEA. Each metaphor gives a partial definition. When conceptual metaphors are used by scientists, their explanation may highlight only attributes or functions of their concrete SOURCE DOMAIN to map onto their abstract idea, thus creating only a partial definition of an abstract idea. In science, one example of a conceptual metaphor is EVOLUTIONARY CHANGE IS A JOURNEY, which comes from natural language usage in Darwin's *Origin of the Species*, with examples such as "Natural selection will always tend to preserve all the individuals varying **in the right direction**" (Drogosz, 2016, p. 36) and "I attribute the **passage** of a variety **from** a state in which it differs very slightly from a parent to one in which it differs more, to the action of natural selection in accumulating differences of structure in certain definite **direction**" (Drogosz 2016, p. 35). Each of these examples shows that the focus attribute of evolution is *change*, "modification of forms of species over time is the fundamental claim of the theory" (Drogosz, 2016, p. 36).

Lakoff and Johnson have shown examples of how everyday language expressions take advantage of metaphor to emphasize an aspect of an opinion. These partial metaphors fit the purpose of either describing the function or purpose of communication by the speaker. This strategy may be employed for technical abstract noun creation as well. As science evolves, theories are challenged and new metaphorical models are needed to explain abstract ideas. Currently we see this challenge with scientists arguing the conceptual definition of *species* (Mallet, 1998) because other metaphorical models, or conceptual ideas are being discovered which are requiring scientists to change their perspective.

Conceptual Boundaries Define Metaphors

Lakoff and Johnson's (1980a) initial concept that we as humans create mental, physical boundaries of abstract ideas so that we can reason about them has been exemplified in the clustering of the metaphorical expressions. When Lakoff and Johnson (1980a) examined the patterns of expressions used within specific contexts, they could derive the image schema being employed, such as the container schema. This image schema was then used to expand the abstract thought by using a metaphor to apply to the experience. For example, when we look at expressions from Lakoff and Johnson (1980a), we subconsciously understand the image schema that is being used, such as a machine, to create the conceptual boundaries so that we may understand or use metaphorical language to compare our mental metaphor of a machine to our experience. In these examples the physical boundaries of machine are imagined so as to understand and use these abstract emotional expressions. "*We're still trying to grind out the solution to this equation. My mind just isn't operating today. Boy, the wheels are turning now! I'm a little rusty today. We've been working on this problem all day and now we're running out of steam*" (Lakoff and Johnson 1980a, p. 27). The ontological metaphor used to describe the clustering of these metaphorical expressions would be THE MIND IS A MACHINE. The image schema and the conceptual metaphors are not obvious to us because we use them so freely without thinking. However, during a linguistic analysis, working backward from metaphorical expressions to conceptual metaphor to image schema reveals the origin of the abstract thought. This strategy will be adopted in this capstone project.

Ontological metaphors describe spatial boundaries. Lakoff and Johnson (1980a) describe spatial orientations that provide a backdrop for understanding many different concepts using ontological metaphors. We can describe parts of our mental experiences by using entities or substances of a uniform kind within the metaphor to discuss them in detail.

Defining the space and movement within the space. The notion that abstract ideas can be metaphorically represented as entities (defining the space) and substances (movement within the space) was first used to analyze metaphorical expression in longer text, such as the manuscripts of scientific theories (Drogosz, 2008). Terminology such as *short term memory*, *coding*, *storing* and *retrieval of information* show how concrete entities became abstract when they crossed over into other fields as new terminology.

Within Cognitive Linguistics studies, researchers have unveiled the over-arching conceptual metaphor used at the onset of different scientific theories. It is from the initial metaphors such as HUMAN MEMORY IS A COMPUTER that more abstract nouns are derived or carried over from other fields to explain the abstract processes that occur within that theory. It is important to understand the initial metaphor used in the scientific theory, because terms created later on may or may not connect strongly to the original metaphor and may carry a new abstract meaning such as the case with the computer metaphor. This is later shown in Cuadrado & Durán's (2013b) work of how a technical term has a gradable salience to the properties used in the original metaphor. Those which are more closely related to the concrete properties of the original metaphor may be more easily understood than those that have more tangential properties to the original metaphor, thus may be more difficult to comprehend.

The remainder of this literature review goes into more detail about abstract noun creation and gives a more detailed description of the life of an abstract noun. The cognitive processes that occur when making new abstract nouns in everyday language may be paralleled with abstract noun formation of scientific vocabulary. By identifying the conceptual metaphor used in the formation of the new abstract noun, we create a tool to scaffold comprehension of new abstract ideas.

Abstract noun creation: use of ontological metaphors. As noted earlier, *ontological metaphor* is a term used to describe the conceptual process that occurs in language when a concrete object is used to comprehend an abstract idea. Because it is a broad concept, ontological metaphor can be used to describe a framework of a scientific theory, such as ECOSYSTEMS ARE COMMUNITIES, or it can be found compacted within abstract nouns such as PROCESS IS A FUNCTION found in terms such as, *sedimentation, adaptation*, and *mutualism*.

When we express processes as abstract nouns, also known as *deverbal nominalizations*, the characteristics and privileges normally reserved for nouns are now authorized to be used with a verb stem, adjective stem or other noun. Conceptually, this allows us to rationally categorize an idea, quantify it or reason about it, for example, changing *move* to *motion*.

Within ontological metaphor there is an overlay of a primary domain and a TARGET. Ontological metaphors help us conceptualize "experiences in terms of objects, substances, and containers in general, without specifying further the kind of object, substance or container" (Kövesces, 2002, p. 251). Only when we analyze the initial conceptual building blocks of the metaphor, do we realize which elements are left out and upon which there is focus from the original domains. Lakoff and Johnson (1980a) conceptually identify ontological metaphors as a *substance* or an *entity*.

When analyzing abstract nouns and all of the elements that go into it to make it, it is necessary to be able to analyze the processes and parts. This can be done through different avenues, such as analyzing linguistic concepts (Evans, 2013) or by studying cultural conceptual metaphors' differences (Li, 2010; Kövesces, 2002) and how they apply to the abstract mapping within terminology. This mapping originates with entity or substance being part of the original image schema. It is from this point we work backwards, unveiling different abstract layers, to discover the abstract conceptual mapping that occurs within the abstract noun.

Using the same basic conceptual framework of abstract ideas as being either an *entity* or *substance,* we can begin to categorize these mental experiences to foster deeper comprehension of scientific terms. This analysis then goes further into identifying the semantic parts that were used to create the scientific term's framework, whether it fell into an *entity* or *substance* category. In order to categorize these terms it is necessary to know how an abstract term qualifies for one category or the other. What we see in front of us are the metaphorical expressions, one of these being abstract nouns.

Abstract Nouns as Ontological Metaphors

The strategy of using a conceptual metaphor and giving an abstract idea a concrete existence is used in a more compact manner in abstract nouns. Large ideas are condensed into one word. They are compacted into a conceptual shape.

According to Langacker (2000, 2002), there are several types of nouns that have gone through the same complex, cognitive mapping process of referring to a generic summary of time passed during an event, thus they are conceptually equivalent and compacted into the same conceptual shape. Some examples taken from Langacker (1991, 2000) are *deverbal nominalizations,* which designate a generic region of time such as *admiration*, and abstract nouns derived from verbs such as *hope, admiration* and *walking* because they require us to imagine an abstract region. Therefore, research within Cognitive Linguistics focusing on abstract nouns and nominalizations can be used concurrently because they both take the conceptual placeholder of a noun.

Another example of an ontological metaphor is *community*. *Community* is an abstract idea, but if we confine it psychologically with physical boundaries to create a generic metaphor then we can reason about it because it becomes a tangible object within our mind that we can hold, manipulate, and envision movement within it and around it. When we conceive the action of *commune* into a noun *community,* we then give it the characteristics of a noun, which is a thing we can connect to physically. When we are connecting a psychological experience to a physical experience, we are *embodying* the experience. This process of *language is embodied* connects the abstract world to our bodily experiences as humans. The abstract relationship of a *community* is compared to the human definition of relationships and is conceptually categorized as an *embodied thing,* or used to describe the process that occurs within abstract noun conception, where we give life to an idea by endowing it with human characteristics. We can then conceive of a more specific conceptual metaphor by connecting the generic metaphor to a familiar human experience, such as *relationship*, and we can then begin to comprehend the abstract idea because we now have something with which to compare it.

Conceptual Analysis of Ontological Metaphors. As previously mentioned, identifying the core, or the onset, of a specific conceptual metaphor requires identification of the generic ontological metaphor first. In doing so it is necessary to objectify the abstract concept first as a concrete object so that we may have a reference point to conceptualize and discuss. Within CTM abstract nouns can be categorized as a SUBSTANCE or an OBJECT.

The first step in scaffolding the concept of an abstract noun is to be able to identify how it was constructed. Once the abstract concept is objectified, further generalities about category descriptions can be used to move toward to identify the function and motivation of the abstract noun. The following layers will be used in the current study to identify how certain abstract nouns in biology are constructed: topological layer, motivational layer, and cultural layer.

Topological Layer: categorizing conceptual processes of abstract nouns.

The grammatical transformation that occurs when linguistically tagging an abstract idea as a noun, we endow it with an existence, which is reserved for objects. This is shown in examples of the reification process in Figure 1 by Radden (2007).

Figure 1 describes ontological metaphors that were created through four types of reification. Lexical items that are *reified* are items that have changed into another conceptual category such as verb to noun.

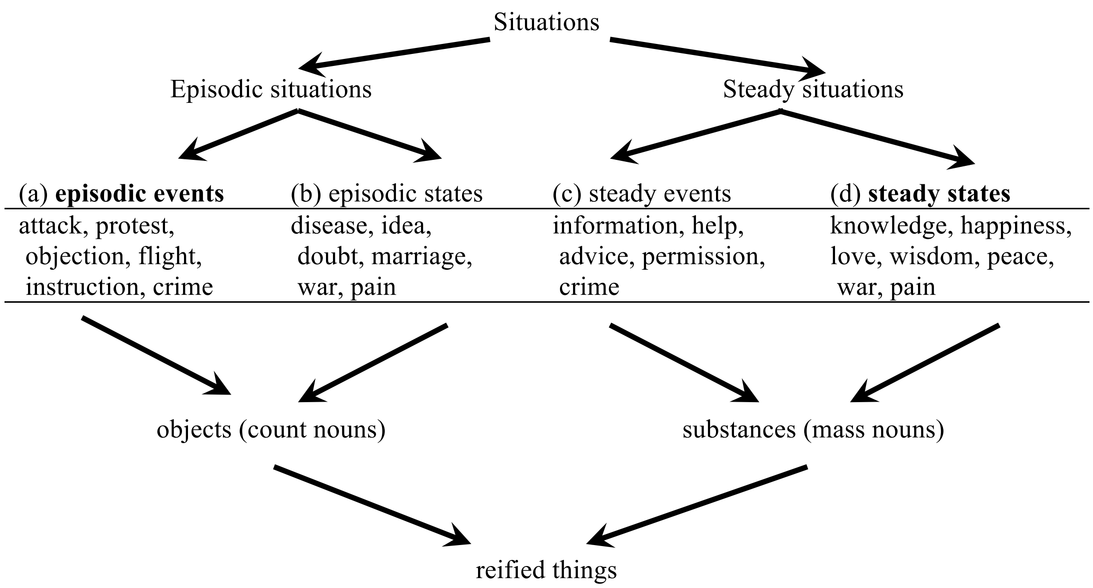

Figure 1. Ontological Metaphors Created Through Reification

The following four types of reification may be stated as ontological metaphor as taken from Radden (2007, p.82).

	ONTOLOGICAL METAPHOR:	Abstract Noun examples:
a.	EPISODIC EVENTS ARE OBJECTS:	They gave us no *instructions*.
b.	EPISODIC STATES ARE OBJECTS:	I have *doubts* about this.
c.	STEADY EVENTS ARE SUBSTANCES:	I need some *help*.
d.	STEADY STATES ARE SUBSTANCES:	I only have a little *knowledge* of computers.

The Cognitive Linguistics definition of *reification* may help to clarify mass and count nouns by way of the description of *reified things*. Using the knowledge that ontological metaphor is an extension of mapping the verb, adjective or noun referent onto the characteristics of a noun (an object or substance) we can then further delineate if the nominalization (abstraction) is referring to an *episodic situation* or a *steady situation*.

Purpose of existence layer: motivation and function.

According to Lakoff and Johnson (1980a), humans are motivated to create boundaries of abstract ideas so that they may carry out one of these purposes: to refer to the experience, to quantify it, to identify a particular aspect of it, to see it as a cause, to act with respect to it, and perhaps even believe we understand it.

Cultural layer: identify abstract noun motivation and function in science.

An analysis of the motivation of abstract noun formation can lead to a better understanding of the function of abstract nouns in text. Analyzing visual imagery became a more central strategy to observe scientific vocabulary because of its origins being based upon abstract ideas. Analysis of the primary and TARGET DOMAINS from which the metaphor is derived helps create comprehension of the visual imagery of the abstract noun (Radden and Dirven, 2007).

Typically the job of a metaphor is to overlay the abstract idea onto something that is concrete in nature in order for humans to conceptualize the idea. However, in defining the usage patterns of conceptual metaphors in science it was discovered that the concrete ideas may be overlaid on top of abstract ideas, which is the opposite purpose of using a metaphor (Cuadrado & Durán, 2013a). Scientific concepts themselves "share properties such as inanimate and inorganic, and are relatively concrete in nature"; however, the metaphors used to express these concepts (such as the technical names) are not concrete because they express animate and organic properties (Cuadrado & Duran, 2013b, p. 11).

By analyzing the relationship between language and reality, Cuadrado was able to highlight and name comprehension problems of scientific terminology.

Conceptual Metaphor Acquisition in Scientific Abstract Nouns

When we analyze the origins of a metaphor, we can begin to see generalized patterns of thought that are commonly used to express abstract ideas. This process is not only done in everyday language but it is also a strategy used with scientific terminology.

In order to expand upon the impact of metaphor creation in abstract noun terminology in science, I will discuss first the conceptual metaphors that influence major scientific theories in biology and then proceed to discuss how abstract nouns have been derived from these theories as ontological metaphors. With this examination laid out, we may be able to derive patterns of conceptual knowledge that can be used in the teaching of abstract nouns found in biology.

The Influence of SOURCE DOMAINS

Technical, scientific terms are part of a complex, conceptual mapping of semantic networks between the original conceptual metaphor of a scientific theory and the technical terms that followed in that specific field of science. The mapping of a conceptual metaphor is comprised of a larger metaphor, a SOURCE DOMAIN, a TARGET DOMAIN, and metaphorical terms. “The metaphorical lexical units are not isolated and independent one from another but in many cases constitute connected complex semantic networks” (Cuadrado Esclapez, Duque Garcia & Durán Escribano, 2007, p.21). Cognitive Linguistics research looks at how individual lexical units are connected semantically to determine the larger conceptual metaphor. On the one hand, we will see this demonstrated overtly with polysemous words that draw their SOURCE

DOMAIN from another field (Lakoff, 1993). On the other hand, we will see this more covertly with new technical terms that draw their SOURCE DOMAIN from the specific ontological metaphor of the initial scientific theory (Drogosz, 2008). In the current study, technical terms that are abstract nouns will be identified.

Polysemous words may be technicalized into a new field and carry new meaning. For example, within the field of telecommunications Cuadrado Esclapez, Duque Garcia & Durán Escribano (2007) explains that the conceptual metaphor TRANSFER OF INFORMATION IS TRANSPORT OF GOODS is identifiable by the specific terms used within this field, such as "circuit, pathways, routes, channel" (Cuadrado Esclapez, Duque Garcia & Durán Escribano 2007, p. 21).

Initially, metaphor study is carried out by comparing the definition of the term in simple English and then identifying how the definition changes when it is field-specific. For example, with the *terms, pathways, routes, channel*, these are terms that were originally derived from a simple, concrete definition and have become more complex when used in a specific field, such as telecommunications (Cuadrado Esclapez. G., Duque García, M.M. and Durán Escribano, P., 2007). These terms originally referred to concrete objects. When these concrete nouns are used within telecommunications, they are used to explain abstract processes.

Technical metaphors as terms

Cuadrado & Durán (2013a) have found a contradiction in scientific metaphor to that of metaphor found in everyday language examples in Lakoff and Johnson (1980a). Within this research, Cuadrado & Durán (2013a) have found that metaphor is not always used to explain something abstract through something concrete, such as Lakoff and

Johnson's examples of metaphor. However, within their research of scientific terminology in geology, they have found that concrete items, such as rocks, are understood with abstract domains, such as the metaphorical models of genetics and social relationships. This has led them to postulate that much of scientific terminology is based upon creativity and human experience rather than analogical reasoning.

Scientific technical terms can be deeply understood when we learn the evolution of the technical abstract noun's metaphor mapping, and the strategies used to get there. In order to explain the evolution of an abstract technical noun in biology, I will address abstract nouns as metaphors, metaphor categories and metaphor strategies in science. .

Within Cognitive Linguistics the two forces of the psychological and analytical are meshed together and analyzed. Drogasz (2008) and Cuadrado and Duran (2013a, 2013b) have focused upon scientific vocabulary and have further defined how metaphor is used in abstract, scientific language. By using Cognitive Linguistics' analytical tools of CTM's description of the social, cultural impacts on language, Ronald Langacker's conceptual, grammatical analysis (1987a, 1987b, 1991,1999, 2002) and Drogosz' (2008, 2009, 2013) epistemological research of the influence of metaphorical language used in science we can derive a formula to analyze abstract noun formation and scaffold those concepts into comprehensible input for English Language Learner students.

Specific ontological metaphors.

Different methodologies of scientific investigation have been employed throughout the centuries and these methodologies are based upon a scientists' view of how the world is organized. One such viewpoint that prevails in much of the biology terminology is the *reductionist* viewpoint (Merchant, 1980). The reductionist viewpoint employs the machine metaphor to explain biological phenomena, which still is current philosophy today (Fehr, 2004).

Merchant (1992) explains the evolution of western scientific thought and how nature had died, metaphorically speaking, because the machine metaphor became the new scientific reality during the seventeenth century and the sixteenth century belief that nature as a god-like force was on its way out. This mechanistic worldview was used to describe the "human manipulation and control of nature" (Merchant, 1992, p. 49) and was also aligned with the emergence of capitalism in Europe. We look at the philosophical underpinnings because it is from this perspective from which current scientific terminology is based upon. With a reductionist viewpoint you are essentially relating theories from different areas.

The building of theories based upon parts or whole of other theories typically leads to scientific explanation and progress in science. However, when there is terminology that is created during the time of one scientific theory and is carried over to another scientific theory, the terms carry different meanings (Kuhn, 1962). In order to understand underlying conceptual metaphors in scientific vocabulary, it may be necessary to find connections between the time period and cultural influences when the term was created and the language used to express the new scientific concept.

Specific Metaphors in Science

Cognitive Linguistics has focused on the ontological history of abstract nouns within science (Drogosz (2008), (2006), Hellsteen & Nehrlich (2011). Comprehension is expanded when studying a longitudinal perspective of the motivation, or purpose, of newly created linguistic forms. Ontology studies explain conceptual frameworks of abstract nouns that are derived from metaphors in scientific theories which umbrella terminology and explain their usage. Metaphor has been shown to exist in both underlying conceptual, scientific metaphors and taxonomies (Brookes & Etkina (2007), Cuadrado & Duran (2013a), Drogosz (2008), Knudsen (2003), Harrison (2013), and Hellsten & Nehrlich (2011).

The generic metaphors driving contemporary science are PRINTING, which includes mass production, INDUSTRIAL REVOLUTION, which exploits machines (Drogasz 2013; Merchant, 1980), and COMPUTERS, which exploit processing (Hellsten & Nehrlich, 2011).

Towards the end of the eighteenth century, the acceptance of mass production of printing spearheaded Linnaeus to document in an orderly fashion his observations of the natural world into taxonomies. PRINTING became a cultural metaphor for the drive to put forth knowledge to the masses in a stable, orderly fashion in new dictionaries, grammars, and taxonomies. (Robertson 2013, p. 52)

(Drogosz, 2013) discusses the reductionist viewpoint of science and with it the ontological metaphor that followed, NATURE IS A MACHINE, which governs the taxonomy of modern day evolutionary thought. During the seventeenth century, scientific metaphors and how scientists gathered information moved towards a mechanistic point of view (Merchant,1980). Scientists shifted from conceptualizing the natural world as a living body to conceptualizing the natural world as a machine**.**

Drogosz (2008, 2009, 2013) describes the underlying conceptual metaphors used in Darwin’s major scientific theories in the nineteenth century. Through the strategy of personification Darwin describes nature as NATURE IS A BREEDER/GARDENER.

Darwin then builds upon previous ontological metaphors that described cultural views of order in society and migrated these to build his scientific theory of Natural Selection. Within his theory, Darwin objectified the abstract ideas of *differences* and *traits* to take on more qualities that could accumulate *power*, thus creating the idea of Natural Selection being an accumulation of valuable traits. "Apart from personification of Nature and Natural Selection functioning as agents, there are examples of inanimate objects or natural phenomena such as climate, conditions life, instinct, habit, modification or change conceptualized as agents" (Drogosz 2013, p. 25).

By using the reification strategy where we map a process onto something concrete, the ontological metaphor LIVING ORGANISMS ARE INANIMATE OBJECTS describes how an organism that has desired traits and differences will be the survivor. "We believe that the metaphor A LIVING ORGANISM IS A MACHINE results naturally from personification of Nature in general, and the metaphors NATURE IS AN ARTISAN in particular" (Drogosz, 2013, p. 28). Drogosz (2013) also describes other ontological metaphors that map an abstract concept onto something concrete (OBJECT) to conceptualize it: LIVING ORGANISMS ARE INANIMATE OBJECTS, ORGANISMS ARE MACHINES. These metaphors show where Darwin attempted to move away from God like forces acting upon nature to prove that Nature is a force in its self.

Currently, there is terminology which is being challenged because of its original metaphor is no longer satisfying to describe scientific activity. Ahmad (2006) describes how the term *species* is being challenged because of the varying intricacies that have been discovered about different creature groups and the evolution of how their species came to be no longer fits the definition of *species* that Darwin originally intended.

Metaphor Strategies in Science

Different metaphorical imagery has been implemented to describe abstract theories within science. As described previously, scientists have used *personification, objectification* or *reification* to create comprehension of a new theory or paradigm (Drogosz, 2008). By identifying the metaphor strategy used during the inception of different scientific theories, we gain more identifying information about the specific conceptual metaphor used to ground the abstract scientific theory.

Personification. Within personification, abstract ideas would be given human qualities. Drogosz (2009) describes this with the ontological metaphor Darwin uses as his underlying conceptual structure NATURE IS A BREEDER/GARDENEER. In this way, Darwin explains the natural world as having human qualities of tending to and reproducing of its own plot (environment). NATURE IS AN ARTISAN. The SOURCE is nature and the TARGET is a human. Here it is implied that Nature is a human entity that has creative abilities. The personification strategy continued to be used in the creation of the field of ecology when the central theme became COMMUNITY. For example, within ecology, the notion of *niches* describes the organism or animals' status within the community. Status is a concept typically reserved for human relationships. However, the concept of status within the niche references the animals' or plants' status on the food chain that is determined by available food sources in the community called *food passage*. The food passage is also what holds together the community (Hagen, 1992). EVENTS ARE ACTIONS is the generic metaphor for personification. In order for personification metaphors to be effective the personified example and the abstract idea must have an common *event-shape*. (Lakoff, 1993, p. 27). An *event shape* consists of a causal structure and a structure of time.

In abstract noun formation, by attaching a verb, which shows human characteristics, to the abstract noun, you create an ontological metaphor structure via *personificatio*n. The SOURCE DOMAIN of personification is a human. Kövecses (2002) describes in more detail how ontological metaphor is personified because of its surrounding grammatical elements. "His theory *explained* to me the behavior of chickens raised in factories" (Kövecses 2002, p. 35). The abstract noun *theory* is given the human characteristic of *intellect* and *communication* when attaching the verb *explained* to the abstract noun *theory*.

Objectification. Objectification is another strategy applied to abstract noun creation in science terminology in order to comprehend an unknown phenomenon. In biology, Darwin's views that organisms have a structure of an object that has parts and there is an input and output of energy. Drogosz (2008) views Darwin's ontological metaphor as ORGANISMS ARE MACHINES. The SOURCE is organisms and the TARGET is an object. Objectification of abstract concepts within modern biology continues to be pervasive. In order to support how the Theory of Natural Selection would work Darwin built his argument upon previous ontological metaphors: DESIRED TRAITS ARE (VALUABLE) OBJECTS (objectification) and DIFFERENCES ARE (VALUABLE) OBJECTS (objectification).

Reification. Upon studying the Darwin's theory of the *Great Chain of Being*, reification is shown as conceptualizing living organisms in terms of *inanimate* objects.

When we conceptually transfer a process to another category, such as a noun category, we are then able to refer to it or discuss it as a whole thing rather than to discuss its parts. Therefore when we wish to discuss or refer to living organisms, which are by definition organizational systems, we can refer to them as objects in order to discuss them further. When we conceptually transfer this process to the noun category the ontological metaphor function is described as LIVING ORGANISMS ARE INANIMATE OBJECTS. The objectification strategy is evident in terminology when analyzing the definitions of terms. The conceptual description of space is within definition of a term than it can be said that the process was objectified into the noun category as an abstract noun.

As the preceding discussions and examples suggest, once the underlying conceptual metaphors of the scientific theory from which the taxonomy has been created and is understood, then the student may have a framework in which to conceptualize further metaphors such as those present in abstract noun terminology or phrases. While reading longer scientific text surrounding the same topic students will have a better chance at understanding idioms, analogies (Brookes & Etkina,2007), and nominalizations (Fang, 2004) which may come up to describe the unfolding of different scientific theories.

Metaphors in Science Education

Discourse analysis of metaphors reveals conventionalized metaphors in science education. Steen (2011) describes how some metaphors are conventionalized and taught in school settings as specific forms of reality. According to Steen (2011) this type of metaphor – the official metaphorical models – may be described as:

> *"Metaphors in thought that are officially instilled by formal education on the basis of explicit formulation in written or spoken texts a culturally*

sanctioned models of reality; these would include all accepted religious knowledge as well as scientific models of reality that are based on metaphor, such as the atom as a solar system, the mind as a computer, or the organization as a machine" (Steen, 2011, p. 56).

Very little metaphorical language is random. The majority of metaphorical usage is pre-conceived (Steen, 2011, p. 25).

Constraint Based Interactions

In addition to Cuadrado & Durán's (2013a) views about abstract ideas being the SOURCE DOMAIN for further abstract ideas, Chi (1994, 2013) states that erroneous initial instruction of ontological, scientific concepts compounds comprehension problems for students.

"Such Entity-based misconceptions not only occur for a variety of concepts across a variety of disciplines, but they are held across grade levels, from elementary to college students (Chi et al., 1994), as well as across historical periods (Chi, 1992). They may even account for barriers that were only overcome by scientific discoveries (Chi & Hausmann, 2003). In short, robust misconceptions of the ontologically miscategorized kind are extremely resistant to change, so that everyday experiences encountered during developmental maturation and formal schooling seem powerless to change them, even when students are confronted with their misconception." (Chi, 2013, p. 59)

Chi (1994) claims that many scientific concepts are often misconstrued because students will conceptually assign a concept to the incorrect ontological tree. Within Chi's research the conceptual categories are defined as trees. Chi further delineates specific

SUSBSTANCE processes into different Constraint-Based Interaction categories. This clarification defines more clearly misconceptions that can occur when SUBSTANCES are not further categorized within scientific concepts. Chi (1994) explains that Constraint Based Interactions are commonly misconstrued because we are still expecting these interactions to follow the physical laws that OBJECTS adhere to and ontological attributes that are typically associated with a SUBSTANCE.

With Constraint Based Interactions there must be another ontological branch on the tree of PROCESSES that need to occur. Figure 2 describes how "all entities in the world belong to one of the three (or more) trees: Matter, Process and Mental States" (Chi, 1994, p. 29).

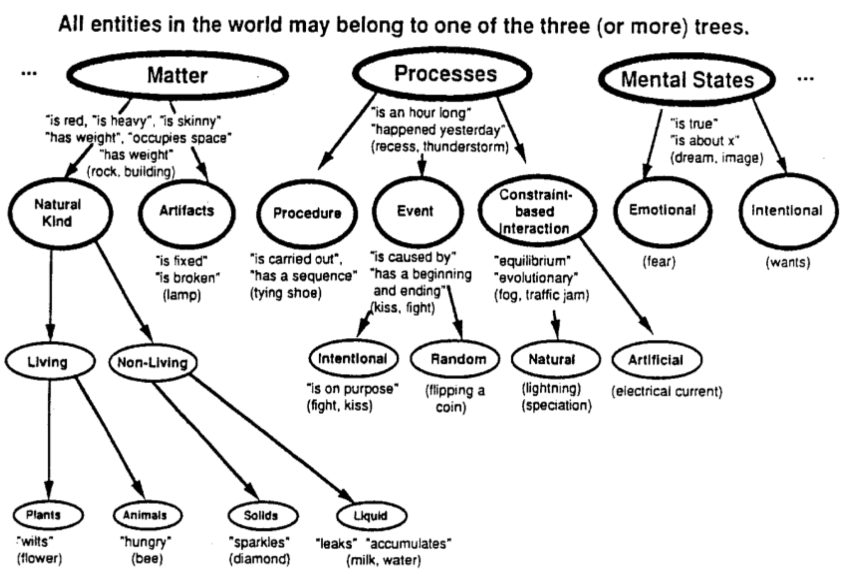

Figure 1. An epistemological supposition of the nature of our conceptions about the entities in the world. One possible categorization scheme. The three primary categories of MATTER, PROCESSES, and MENTAL STATES are ontologically distinct, and other subcategories on each tree, which are separated horizontally, may be as well.

Figure 2. Chi's (1994) Ontological Trees: Matter, Process and Mental States

Processes can be broken down into: procedures, events, and Constraint Based Interactions. It is the Constraint Based Interactions which proved the most difficult to comprehend because of previous misconceptions about how entities interact in the world (Chi, 2013). Therefore, she introduced a new ontological category of process (Chi, 1997) called *Constraint Based Interactions*. These interactions belong under the category of processes and are governed by a different set of physical laws usually designated to processes. For example, Constraint Based Interactions do not have an obvious beginning and an end. "No aspect can be pointed to as the beginning, and no specifiable aspect can be pointed to as nearing the end of the processes" (Chi, 1994, p. 31-32). There is not any "change in time or location, because the process is uniform and simultaneous everywhere" (Chi, 1994, p. 32). Therefore, according to Chi (1994, p. 31-32) you may not be able predict the end of a CBI event nor a progression. There is no causal agent for the event. It can be uniform, simultaneous, static, or on-going. It is random and multi-directional. Examples of terminology of Constraint Based Interactions are *equilibrium, evolutionary*, and *fog.*

Learning to use which conceptual model to understand a scientific theory is necessary when solving problems. For example, when learning about electricity, it is necessary to know whether to apply the model that electricity is an OBJECT or SUBSTANCE. When electricity is taught as a MATTER-based object that can flow like water, students may be inclined to attach other attributes that are normally reserved for MATTER. For example, they may assume that electricity can take on ontological attributes such as taking up space or having volume (Chi, 1994, p. 34). Because of this, quite often expressions such as "*it can be stored in the battery* or *it can be used up*" (Chi, 1994, p. 34.) will be used when describing electricity as being an object. Chi theorizes that students are required to put together these bits of knowledge together in order to comprehend concepts fully because they do not have one complete metaphor at their disposal that would describe all phenomenon of a concept and are required to use several metaphors to accomplish the comprehension task. This multi-metaphor usage lead Chi to her Theory of Variability and how description of CBI processes can offer a new category of comprehension. "the variability can be explained by the specific ontological attributes of the MATTER category that a student happens to attribute to his/her conception of any given PROCESS concept" (Chi, 1994, pg. 34). In order to identify which metaphor is used in scientific explanations students have to have various metaphors in their background knowledge in order to be flexible in their comprehension of a concept. Energy as a substance has been a common metaphor used to teach the concept of energy; however, recently other theorists suggest that students also understand energy as a location metaphor in order to comprehend how a substance can have negative potential energy (Dreyfus et al. in Dreyfus, 2015). Therefore, it may be necessary for students to comprehend at the onset what ontological attributes are being applied to which concept and in which context. By identifying processes as either CBI or not may help a learner conceptually categorize a concept for better comprehension.

Comprehension of the abstract noun used in scientific terminology may be dependent upon one's conceptual, metaphorical model they bring with them when learning and scientific concepts. Chi (1994) claims that it is more difficult to change your conception of an abstract idea if you are already committed to a different tree to conceive of the idea; however, if you simply need to change from a parallel branch within the tree, it may not be as difficult to teach a new concept.

It is important to have access to research about known conceptual differences that are embedded within scientific terminology in order for instruction to be most effective. Chi (2013) explains that teaching a student to shift their previous conceptual model to a new one cannot happen unless the students are taught explicitly the new category. This explicit instruction is necessary when the students have conflicting knowledge about a scientific concept. She describes the reasons for this conflict is one, or several, of the following: "false beliefs (at the statement level), flawed mental models (at the mental model level), category mistakes (at the categorical level), or missing schemas (at the schema level)" (Chi, 2013, p.50). For example, according to Chi (2013), many students have difficulty in understanding *heat transfer* is a process, not an entity, because they are readily familiar with heat moving from one room to another, thus their comprehension of the scientific explanation of *heat transfer* as being a process, and not a thing which moves from room to room is difficult to overcome. Therefore, the students are incorrectly categorizing a concept as being an *entity*, when it is a process (*substance*). Understanding both the ontological function of the of the term, such as being a substance or entity, and the connection to the conceptual metaphor used in the initial scientific theory, deeper comprehension of terminology may occur.

Chi (1994) states "all entities in the world may be categorized as matter, processes, or mental states" (Chi, 1994, p.29). It is within the category of processes that it may be broken down further to: procedures, events, and constraint-based-interactions. Chi claims that many students erroneously understand the basic scientific theories of *heat* and *light* to conceptually be assigned to the category of *matter* (Chi, 1994, p.50) and which as abstract nouns may also cause more confusion within scientific abstract noun terminology. Furthermore, when the substance is a Constraint Based Interaction and not an interaction with a causal agent, students have even more difficult understanding the core values of this concept, perhaps because it is not a conceptual category that that they are familiar with or that they frequently encounter.

Chi (1994, p.1) states that if initial instruction of a constraint-based-interaction, such as *light* is taught as the ontological category *entit*y (matter), instead of being taught as a Constraint-Based-Interaction (a process), this will determine the degree of difficulty for a student to learn the scientific concept. Chi and Slotto (2006) in Chi (2013) state that in order to build a student's new schema to understand the new category it is first necessary to teach students about specific properties of the new concept, then once they accept this new category you can move on to more direct instruction of the sequential processes of this new concept. (Chi 2013, p.68).

Conceptual Metaphor Instruction

Currently, very few adult EFL teaching materials address the use of metaphor, and when they do it has been focused on learning idioms in Business English (Hoang, 2014). There is a gap of field research about how to use conceptual metaphors to teach scientific terminology to English Language Learners. Some pedagogical research in the English as a Foreign Language (EFL) classrooms (Boers (2004), Littlemore and Low (2006A), Littlemore (2001C), Littlemore, Chen, Koester, and Barnden (2011), Nacey (2013), MacAruther and Littlemore (2011), in Hoang, (2014) has offered insight and experience about the complexities of teaching conceptual metaphor to English learners;

however, ELL classroom field research on this topic has yet to be offered.

One of the main principles of Cognitive Linguistics, that language is motivated, meaning, “the relations between form, meaning and use are not arbitrary...and language can be explained with links (or “motivations”, in cognitive linguistics term) to bodily or conceptual experiences” (Hoang, 2014, p.2). In my opinion, students need to know simple and clear connections between biology terminology and scientific theory.

Research conducted by Boers (2004), Kalyuga and Kalyuga (2008), Guo, (2007), Deignan, Gabys, and Solska (1997), Csabi, (2004) (as cited in Hoang, 2014) has shown a slightly positive impact on student achievement of students' learning metaphors through awareness raising activities in L2 classrooms learning idioms and polysemous vocabulary words in conjunction with conceptual metaphors from literature. However, these studies have also revealed that teaching metaphor is not a one shot deal. It must be taught over a long period of time and students need explicit instruction about metaphorical concepts found in terminology (Hoang, 2014). This information supports the need to teach underlying conceptual systems prior to vocabulary instruction. With this project the objective is to identify the conceptual metaphors that are essential to understand in biology so as to meet these curriculum needs.

“Learners who are aware of the motivated nature of language are more likely to learn it in a cognitively, affectively and pragmatically effective way (Boers & Lindstromberg 2006, 2008b)” (as cited in Hoang, 2014, p. 2). Deeper comprehension occurs because instruction focuses on analysis between form and meaning (Boers, 2013 as cited in Hoang, 2014). Approaches to teaching metaphoric processing of figurative language are of a trial and error at best when learning metaphorical expressions as shown in Hoang's (2014) review of current classroom research of Littlemore & Low, etc. which points to all the more reason of explicit teaching of conceptual metaphors of specific vocabulary words so that 'guessing' is not the main strategy students use.

Teaching of conceptual metaphors in the EFL classroom is still in its infancy stages and there is disagreement about what constitutes metaphorical competence in language acquisition. Kovesecs (2001) in Hoang (2014) states that the initial conceptual metaphors taught should focus on most prevalent SOURCE DOMAIN found in idioms, the human body. Research has shown that English fluency requires a high degree of conceptual fluency of figurative language, i.e. idioms which fall under the realm of conceptual metaphors. However, terminology in western science is specific to the cultural of evolutionary science. Most of Darwin's theories have been accepted by the scientific community as fact, and are no longer a language barrier but a cultural barrier for those unfamiliar with scientific content. Scientific terminology carries with it the history of the theory itself, thus making the terms ontological metaphors.

A study compiled by Hoang (2014) has shown that a large body of cognitive linguistics research is focused on the teaching of conceptual metaphors of idiomatic expressions and its relation to English language proficiency. However, there has been little success because of small focus groups within studies, various student experience background within focus groups, and lack of contextual knowledge to learn the conceptual metaphors. "The findings of current literature on metaphors have not been presented in a way that is systematic and teacher-friendly enough for metaphor-based teaching approach to be implemented to the full" (Hoang, 2014, p.8).

Conceptual metaphors can be used as a pedagogical tool to scaffold teacher language during instruction of academic biology terminology.

Therefore, in learning science terminology, instead of focusing on longer text or more casual language, we can focus teacher education using ontological metaphors as a scaffolding tool to build student knowledge of the culture specific language of science. Teacher education of linguistic patterns within their own field is necessary in order for the whole community of teachers to be capable of helping all students learn academic science vocabulary. To meet this need I will seek to answer my capstone question *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?* The capstone project methodology in Chapter 3 will be based upon knowledge about metaphor analysis following a Cognitive Linguistics perspective as described in the literature review of this chapter. In Chapter 3 I will implement a Cognitive Linguistics analysis of conceptual metaphors embedded within abstract nouns in biology.

CHAPTER THREE: METHODOLOGY

Conceptual metaphors that underlie scientific concepts have been identified by Drogosz (2008) and Durán (2013a) via analysis of metaphorical expressions within scientific text. An author's metaphorical motivation is described by imagery that is expressed by word choice and language structure. A conceptual metaphor conceived by metaphorical expressions can be surmised when identifying the visual field that is created when grouping together specific nouns, verbs, and adjectives attributed to a common theme. In this study I will examine the metaphorical science concepts embedded in biology terminology. In order to focus the investigation of abstract nouns, the following question is investigated in the current study: *Which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment*? The purpose of this investigation is to identify the conceptual functions of conceptual, ontological metaphors found in the Biology I SATP assessment to create instructional methods and/or strategies to foster deep comprehension of biology terminology.

Action Plan for Investigation of the Capstone Project

Data Collection

Because the literature search for this project revealed limited accessible information about the etymological, linguistic investigations of original scientific manuscripts, this project will focus only on the topics supported by previous research. Therefore, this project will focus on taxonomy that falls under evolution, cell theory, and ecology and genetics. The Mississippi State biology assessment is one example of what Mississippi deems essential knowledge of basic biology. Therefore, the analysis of the Mississippi Subject Area test serves as an exemplar text that demonstrates examples of essential, conceptual knowledge that is necessary for a high school diploma in Mississippi. A Mississippi biology Subject Area (SATP) practice test was downloaded from the Mississippi Department of education website. Of the sixty-eight questions present on the selected SATP biology practice test forty-eight test items fell under the categories of evolution, cell theory, ecology and genetics. Of these forty-eight test items: nine test items were about evolution concepts; ten test items were about cell theory; fifteen test items were about ecology, and fourteen test items were about genetics. The data compiled from this selection will be used for this investigation.

Pilot Study

A pilot study of 10 questions and answers from the Mississippi Biology Subject Area Practice Test has revealed that specific ontological metaphors can be surmised through individual intuition with specific text references, which is a practice commonly used in deriving metaphor patterns within Cognitive Metaphor Theory (Cuadrado & Durán, 2013a). From this pilot study, it was found that using the dictionary definitions from online dictionaries, http://www.dictionary.com and http://www.merriam-webster.com/dictionary, to aid in analyzing metaphor was essential. The dictionary definitions allowed for a longer text with nouns, verbs, and adjectives that described which image schemas are activated to define the metaphor. By using my intuition as to how word usage is being categorized within the definition I was able to surmise if the abstract idea was taking on characteristics of a human, machine, or other entity typically characterized within Cognitive Metaphor Theory as a basic, conceptual domain which is consistent of the human experience (Lakoff & Johnson, 1980a). While identifying the image schema I was able to identify the metaphor strategy used: personification, objectification, or reification (Drogosz, 2008). From this information I was able to create a generic ontological metaphor of the vocabulary word. A more specific ontological metaphor was made possible by combining known attributes of the general ontological metaphor of that specific field, such as *ecology,* and applying this to the SOURCE DOMAIN (the vocabulary word) and the TARGET DOMAIN (in this case *human*) to surmise a specific ontological metaphor which would be synonymous with the definition but in a more conceptually, simplified manner.

The pilot study revealed that the majority of the metaphor strategies used in the terminology examined were personification. By knowing the metaphor strategy it may be easier to explain the specific ontological metaphor in order to scaffold the complex idea of something unknown to something well-known, as is the intent of metaphors within science and technology (Cuadrado & Durán, 2013a). This pilot study was pivotal in revealing the long list of abstract nouns that were potentially problematic, such as constraint-based interactions, and also revealed the necessity for longer text, such as dictionary definitions, to aid in the comprehension and image schema categorization of each term.

Method of Inquiry

Overall, this capstone project is a mixed study of qualitative and quantitative aspects of a descriptive analysis of conceptual metaphors to describe metaphor concepts. This methodology was chosen because the study requires qualitative and quantitative measures to analyze how often various conceptual categories occur within abstract nouns in biology. Initially the project begins as a qualitative measure to group abstract nouns within biology to analyze. Once this is accomplished, a qualitative analysis continues with the quantitative data. Quantitative procedures include identification of conceptual processes by categorization of like terms based upon their area of origin in biology and then tabulation of the percentage of conceptual metaphor processes within each area of biology. Between these two steps a quantitative analysis is necessary to identify the conceptual mapping within the abstract noun in order to categorize like metaphors for tabulation.

Step 1: Categorize questions and answers into specific areas of biology.

Categorize abstract nouns by their area of biology conceptual framework to describe metaphor usage, motivation or purpose. Categorization of test items into biology categories was conducted with the guidance of a biology expert, Carla Carr, PhD.

Step 2: Identify abstract noun terminology from test questions and test items.

Locate abstract noun terminology found from each test item and list under the categories of ecology, cell theory, evolution or genetics.

Step 3: Locate/record scientific definition of abstract nouns

Use online dictionaries http://www.dictionary.com or http:/www.merriam-webster.com to locate scientific definition of abstract noun.

Step 4: Label ontological metaphor of original scientific theory or domain

Label ontological metaphor used by main scientific theorists that uses this term in its taxonomy according to the Chapter 2 literature search.

Step 5: Identify SOURCE DOMAIN

Identify term as being defined by its membership to the matter, process or CBI group. Use the description of term definition to determine if the abstract noun is defined by what it is and its attributes (matter), by what it does (process), or by what it does without a causal agent (CBI). If the SOURCE DOMAIN is identified as a substance, has no causal agent, and is a uniform, simultaneous, static or on-going process the SOURCE DOMAIN may be identified as a natural Constraint Based Interaction (CBI) or artificial CBI. Natural CBI is a process found within nature unprovoked by humans, whereas artificial is a man-made CBI process such as an electrical current.

The sixth through tenth steps of inquiry are qualitative descriptive analyses used in order to determine specific ontological metaphors of abstract nouns.

Step 6: Identify TARGET DOMAIN

Identify TARGET DOMAIN by analyzing attributes utilized in the dictionary definition which may be conceptually attributed to previously identified TARGET DOMAINS via verbs, adjectives, and nouns used in definition which help create the metaphorical expression. Within abstract nouns identify if the noun is being defined by its process, structure, localization, or destiny. If the noun is defined by what it does is defined as FUNCTION in the TARGET DOMAIN. If it is defined by how it is constructed, than it is labeled STRUCTURE. If it is defined by what it will be come, then it is defined bas DESTINY. Lastly, if it is defined by its location, then it will be labeled

LOCALIZATION in the TARGET DOMAIN. How an abstract noun is defined is essential to understand so that the abstract noun may be broken down conceptually into its generic metaphor. The generic metaphor in science is placed at the TARGET DOMAIN location in the CMT formula A is B, where A is the SOURCE DOMAIN and B is the TARGET DOMAIN.

Step 7: Identify metaphor strategy

Similar to strategies used by previous linguistic researchers to reveal underlying conceptual metaphors in original scientific manuscripts, a modified strategy may be used because of limited text available within the scientific definitions. By reviewing the verbs, adjectives, and nouns used in the scientific definition, informed personal intuition is applied to identify the strategy of the attributes used to either mimic that of a human (personification); to reveal a living thing is being classified as something that can be dominated by humans, that is, an object, has parts, or can demonstrate an in-and-out of energy flow (objectification); or finally, a concept is reclassified as an inanimate object in order to conceive abstract, spatial boundaries, and to refer to it as an entity (reification).

Step 8: Identify image schema activation

Within Cognitive Theory of Metaphor, the TARGET DOMAIN the image schema that is activated can be derived by using Lakoff' & Johnson's (1980a) strategy of categorizing; namely, in terms of objects, substances or containers. Thus, when viewing text using Lakoff' & Johnson's (1980a) strategy it is necessary to look at the words within context to determine the underlying ontological metaphor of the whole thought of the text.

Within Cognitive Grammar, Langacker (1991) describes the image schema that is activated by identifying the profile. With Cognitive Grammar analysis is done on the word or phrase level of text. Analysis of a word as a conceptual metaphor is done by analyzing the parts used in its conception. By identifying the parts of an episodic or steady situation, as identified in Chapter 2, it is possible to identify the SOURCE DOMAIN of generic metaphor as either an OBJECT or SUBSTANCE. Image schemas may be identified as one of the following in this project: EPISODIC EVENTS ARE OBJECTS, EPISODIC STATES ARE OBJECTS, STEADY EVENTS ARE SUBSTANCES, or STEADY STATES ARE SUBSTANCES.

Step 9: Identify metaphor purpose

Lakoff and Johnson (1980a) identify the purpose of conceptual metaphors to be one of the following: referring, quantifying, identifying aspects, identifying causes, setting goals and motivating action.

The metaphor purpose is revealed more generically after identifying the generic TARGET DOMAIN of the image schema. By categorizing the conceptual domains of an abstract noun to more generic schematization, it is easier to conceive of the its skeletal purpose, which would in turn be the actual starting point used for scaffolding instruction of the scientific concept embedded in the terminology.

Step 10: Identification of the common, conceptual ontological metaphor

Identify the mapping used in the abstract noun by combining the SOURCE DOMAIN and the TARGET DOMAIN within each area of biology. The function of the conceptual metaphor is represented by the common conceptual ontological metaphor in the Cognitive Theory of Metaphor formula of SOURCE DOMAIN IS TARGET

DOMAIN. The common conceptual metaphors may be MATTER IS A DESTINY, MATTER IS A FUNCTION, MATTER IS A LOCALIZATION, MATTER IS A STRUCTURE, PROCESS IS A DESTINY, PROCESS IS A FUNCTION, PROCESS IS A LOCALIZATION, PROCESS IS A STRUCTURE, CBI IS A DESTINY, or CBI IS A FUNCTION.

Data Analysis and Reliability

Given that informed intuition is applied in the quantitative measures and results of this project, some of the conclusions of the data may be tentative. In order to make informed decisions about conceptual mapping that occurs within the abstract nouns it is necessary to have background knowledge in Cognitive Linguistics' application of metaphor analysis as well as background knowledge in biology taxonomies and concepts.

The results of this study will be analyzed and presented in Chapter 4. A list of abstract nouns will be made in a spreadsheet labeling each category discovered from each step within each area of biology. The results obtained will be summarized and analyzed in Chapter 4 in order to determine the common conceptual metaphors in biology terminology in the Mississippi high school biology subject area assessment.

CHAPTER FOUR: RESULTS

Introduction

The goal of this project is to identify the conceptual metaphors that guide concept creation in biology terminology. The long-term objective beyond this capstone is to take this research information to implement into curriculum of vocabulary instruction in biology to high school English learners. My research question is *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology practice assessment?* This chapter presents the results of my linguistic investigation of biology terminology found on the biology practice test used for high school students in Mississippi.

As a result of information in the literature review, the biology topics that I have focused on in this project are not all encompassing of biology but focus on evolution, cell biology, ecology and genetics. It is within these biology areas where I have been able to find supporting evidence of conceptual metaphors present in original scientific manuscripts of biology theories which catapulted these areas of biology.

According to http://www.dictionary.cambridge.org an abstract noun is "a noun that refers to a thing that does not exist as a material object". While this definition of abstract nouns was used in this project, it became clear that *abstract* and *concrete* exist on a continuum, and not as clear-cut categories; therefore, some subjectivity is involved in selecting which nouns are abstract. This will be discussed further in Chapter 5. In this study, there are 122 biology terms that are categorized as abstract nouns as defined by this project. Chapter 4 will give an overview of the results organized according to the methodology steps described in the Chapter 3 to discover the conceptual metaphor most widely used within the Mississippi high school biology practice tests in the areas of evolution, cell biology, genetics and ecology. An analysis of the metaphorical mapping between SOURCE DOMAINS and TARGET DOMAINS within biology terminology is documented and categorized to reveal which mappings are most commonly used in high school biology terminology.

Results

The main conceptual metaphors represented by the scientific theories represented in the biology terminology of this project are ORGANISMS ARE MACHINES, ECOSYSTEMS ARE COMMUNITIES, DNA IS A TEMPLATE, and DESIRED TRAITS ARE VALUABLE. Within the biology terminology each of the conceptual metaphors are present in their respective taxonomies. ORGANISMS ARE MACHINES is highly visible in cell biology. ORGANISMS ARE MACHINES is also the most prevalent in evolution terminology along with DESIRED TRAITS ARE VALUABLE. Also, ECOSYSTEMS ARE COMMUNITIES is prominent in the field of ecology. In addition, DNA IS A TEMPLATE is a widely used conceptual metaphor within the field of genetics in the data for this study. One of the most important understandings of these conceptual metaphors is that FUNCTION and STRUCTURE underlie most PROCESS and MATTER concepts embedded in biology terminology.

Step 1: Categorize Test Questions and Answers into Specific Areas of Biology, Step 2: Identify Abstract Noun Terminology from Test Questions and Test Items and Step 3: Locate/Record Scientific Definition of Abstract Nouns

Biology terms were recorded as abstract nouns according to how the noun is being defined on http://www.dictionary.com. If a term is defined by its group membership to the categories of structure, function, destiny or localization it was selected for further analysis to determine the abstraction found within the definition of their group membership in these categories.

The categorization of 62 questions on the biology practice test reveals that seven are about evolution; 16 are about genetics, 18 are about cell biology and 21 are about ecology. The identification of biology terminology resulted in 122 terms to be analyzed. Of those terms, cell biology terms are the most prolific. 42 %, 51 terms, are identified as being in the cell biology category. Next, 25 %, 31 terms, were categorized as ecology. Then, 17 %, 21 terms, were categorized as evolution. Lastly, 16 %, 19 terms, are identified as belonging to genetics. Definitions for 122 biology terms were recorded from an online dictionary, http://www.dictionary.com. Within the definition of these terms there are also scientific definitions of the terms that were used.

Step 4: Label Ontological Metaphor of Original Scientific Theory or Domain

The results show that there are four dominating conceptual ontological metaphors in this study. The conceptual metaphor ORGANISMS ARE MACHINES is the most prevalent metaphor within 48 % of the terms; 59 terms. Next, ECOSYSTEMS ARE COMMUNITIES is embedded within 27 % of the terms; 33 terms. Then, DNA IS A TEMPLATE is within 16 % of the terms; 19 terms. Lastly, eight percent of the terms consist of the metaphor DESIRED TRAITS ARE VALUABLE, with 10 terms. The machine metaphor dominates most of the biology terminology in this study.

Step 5: Identify the SOURCE DOMAIN

SOURCE DOMAINS of abstract nouns are identified according to the noun's defined existence. Group membership to the different noun categories within science can be identified by the SOURCE DOMAIN abstraction found within each abstract noun. The noun's SOURCE DOMAIN may be defined by how or why a noun is grouped within matter, process or CBI categories. Within the SOURCE DOMAIN categories, a noun is defined as matter for different reasons. For example, a noun may be categorized as matter because of its structure, function or destiny definition. Therefore, group membership to the abstract noun category is first identified by the abstraction found in the SOURCE DOMAIN of this noun and then the relationship between the SOURCE DOMAIN and TARGET DOMAIN is identified to determine the conceptual metaphor within the biology. Therefore, the noun's existence may be categorized by group membership to matter, process or CBI category. Group membership is identified as the SOURCE DOMAIN of the abstract noun.

Within cell biology, the majority (71%) of the SOURCE DOMAINS belong to the matter category, as shown in Table 1. 29% contain process as the SOURCE DOMAIN. Within cell biology, there are not any SOURCE DOMAINS that are Constraint Based Interactions (CBI) or states categories. Within evolution, matter and process categories were almost equally represented with 20 %, 10 terms, and 18 %, 9 terms, respectively, as well as having two terms that used the CBI category as the SOURCE DOMAIN. For example, some terms in the evolution area of biology that have matter as a SOURCE DOMAIN, are *nucleotides, chloroplast,* and *beta globin*. Some examples of those with process as a SOURCE DOMAIN are *behavioral adaptation,* *mutation,* and *population growth*. Those with the CBI category as the SOURCE DOMAIN are *natural selection* and *evolution*. Within genetics, the matter category is represented by 42 % of the terms (eight terms), whereas the process category is slightly higher at 53%, 10 terms. Some examples of genetics terms with the matter category as the SOURCE DOMAIN are *offspring, chromosome*, and *traits*. Some examples of terminology in genetics that have the process category as the SOURCE DOMAIN are *chromosomal mutation*, *autosomal recessive condition*, and *inversion*. Lastly, ecology had a tie of matter and processes categories being represented in 48 % of the ecology terms, 30 terms, as the SOURCE DOMAIN. Some examples of those that have the matter category as the SOURCE DOMAIN are *decomposers, terrestrial biome*, and *gene pool*. Also, some ecology terms that have the process category as a SOURCE DOMAIN are *carbon cycle, absorption,* and *extinction.* There was one term in ecology that has the CBI category as a SOURCE DOMAIN, which was *energy*. In Chapter 5 a more detailed description of the group membership analysis of the matter category and its interpretation will be discussed.

Table 1
SOURCE DOMAINS as a Percentage of each Biology Category (Raw Data in Parentheses)

	Evolution (n = 21)	Genetics (n = 19)	Cell Biology (n = 51)	Ecology (n = 31)	Subtotal of SOURCE DOMAINS (n = 122)
CBI	10% (2)	0% (0)	0% (0)	3% (1)	2% (3)
Matter	48% (10)	47% (9)	71% (36)	48% (15)	57% (70)
Process	43% (9)	53% (10)	29% (15)	48% (15)	40% (49)
States	0% (0)	0% (0)	0% (0)	0% (0)	0% 0

Step 6: Identify TARGET DOMAIN

To determine more clearly the TARGET DOMAIN, the verbs and the terms' definitions were examined closely and the question was asked ‘Is this entity defined by what it is doing, or by something being done to it?’ This process allows terms to be categorized into the categories of structure, function, localization or destiny, as described by Vandaele (2002).

Highlighting of being verbs and action verbs as attributes was essential in analyzing TARGET and SOURCE DOMAINS. Discussion with the biology subject matter expert, Carla Carr, PhD, revealed that most biology vocabulary could be defined either by its structure or its function. Vandaele (2002) further divides this vocabulary into the categories function, structure, localization or destiny. Using this information, the TARGET DOMAINS are found to be mostly the structure or the function category;

however, destiny became a necessary category for those more difficult to define. For example, *atmospheric nitrogen, cancer cells, ATP (adenosine triphosphate)*, and *gametes* were identified as abstract nouns because they all have the destiny category as their TARGET DOMAIN. The matter or process category within these examples is defined by what they will become or will do, rather than by their current function or structure category. Therefore, the definition of their existence is abstract, and not concrete. For example, *gamete* is defined by "a cell whose nucleus unites with that of another cell to form a new organism. A gamete contains only a single (haploid) set of chromosomes" (http://www.dictionary.com). The gamete is defined by its union (a future event) and what it will do to become a concrete object (a new organism). Therefore, its potential relationship of a union and its outcome are the abstract notions referred to in this noun. *Gamete* is defined by abstract ideas.

In this investigation, as shown in Table 2, both FUNCTION at 45 % of the terms (55 terms) and STRUCTURE at 43 %, 53 terms, are the dominating TARGET DOMAINS in the biology terms analyzed, while the concept of DESTINY also has an 11% impact on biology vocabulary creation. Within the area of evolution FUNCTION is the most common TARGET DOMAIN at 48 % percent (ten terms) with STRUCTURE not far behind at 33 % percent of the terms (seven terms). While FUNCTION and STRUCTURE do encompass most of biology terminology, it is interesting is that four of the evolution terms were categorized as DESTINY with terms such as *natural selection*, *evolution, disease*, and *natural disaster*. Within genetics, STRUCTURE is a major theme at 68 % of the terms (13 terms). 21 % of the genetics terms (four terms) have FUNCTION as a TARGET DOMAIN and 11 % of the terms (2 terms) have DESTINY as the TARGET DOMAIN. Within cell biology, FUNCTION and STRUCTURE take the lead with 41 % of the terms, 21 terms, and 47 % of the terms, 24 terms, respectively. Within cell biology, the only term that has LOCALIZATION is identified in this area of biology. This may be due to the word 'site' which is given meaning because of its relationship of 'of protein synthesis' to make the abstract concept within the phrase, *the site of protein synthesis*. Within ecology, the dominating TARGET DOMAIN is FUNCTION at 65 % of the terms, 20 terms. Second to FUNCTION was STRUCTURE at 29%, nine terms, and six percent of the terms, two terms, are DESTINY.

Table 2
TARGET DOMAINS as a Percentage of each Biology Category (Raw Data in Parentheses)

	Evolution (21)	Genetics (19)	Cell biology (51)	Ecology (31)	Subtotal TARGET DOMAINS
DESTINY	19% (4)	11% (2)	10% (5)	6% (2)	11% (13)
FUNCTION	48% (10)	21% (4)	41% (21)	65% (20)	45% (55)
STRUCTURE	33% (7)	68% (13)	47% (24)	29% (9)	43% (53)
LOCALIZATION	0% 0	0% 0	2% (1)	0% 0	.8% (1)

Total Number of Actual Terms are 122.
% listed refers to % of terms within that area of biology

Within these areas of biology, ecology is conceptually mapped the most heavily onto FUNCTION as a TARGET DOMAIN, with terminology such as *herbivores, nutrients, biome, carbon cycle, absorption, metabolism, and mutualism*. Evolution comes in as a close second in mapping FUNCTION as a TARGET DOMAIN with 48% of its terms such as *predators, embryonic stage, ancestry, survival*, and *endosymbiosis* whereas 68% of genetics and 47% of cell biology terminology are mapped onto STRUCTURE as the TARGET DOMAIN with terms in genetics such as *phenotypes, genetic diversity, pedigree and chromosomal mutation* and terms in cell biology such as *phosphate ions, myosin filaments, plasma membrane*, and *monosaccharides*.

Step 7: Identify Metaphor Strategy of Theory

Once the TARGET DOMAIN, the SOURCE DOMAIN and the ontological metaphor typically used for a particular field of biology are understood, it is possible to identify the metaphor strategy that is being used either as personification, objectification or reification. As shown in Table 3, 72% percent of the terms use the objectification metaphor strategy. This is evident in terms such as *endosymbiosis, pollination, mitochondrion*, and *amino acids*. This is may be due to the fact that the MACHINE metaphor is commonly used to describe biology taxonomy in the fields of cell biology, genetics, and evolution. For example, within the definition of *endosymbiosis*, the verbs describe personification of the object as seen in the definition from http://www.dictionary.com, "A type of symbiosis in which one organism lives inside the other, the two typically behaving as a single organism."

The personification strategy is used heavily in 74% of the ecology terms to describe functions, structures and behaviors with the conceptual metaphor ECOSYSTEMS ARE COMMUNITIES within terms such as cellular *respiration, herbivores, nutrients*, and *mychorrhiza.* For example, within the definition of the term *mychorrhiza*, this abstract noun is defined by its behavior and function as shown with the verbs and nominalizations typically reserved for behaviors and functions of humans in "an association of a fungus and a plant in which the fungus lives within or on the outside of the plant's roots forming a symbiotic or parasite relationship" (http://www.dictionary.com). Reification is a designator for terms that do not have any specific connection to a biology theory as shown by only six percent of the total metaphor strategies used in terms such as *natural disaster, sedimentation, absorption,* In Chapter 5, I will discuss the findings which show that the majority of ecology terms are represented through personification, compared to other areas of biology in which objectification reigns as the metaphor strategy.

Table 3

Metaphor Strategies as a Percentage of each Biology Category (Raw Data in Parentheses)

	evolution (21)	genetics (19)	cell biology (51)	ecology (31)	Subtotal # of metaphor strategies (122)
Objectification	86% (18)	95% (18)	92% (47)	16% (5)	72% (88)
Personification	10% (2)	0% (0)	4% (2)	74% (23)	22% (27)
Reification	5% (1)	5% (1)	4% (2)	10% (3)	6% (7)

Step 8: Identify Image Schema Activation

In this discussion the reification, or objectification, of ontological metaphors that occur in the image schemas are identified as either EPISODIC EVENTS ARE OBJECTS, EPISODIC STATES ARE OBJECTS, STEADY EVENTS ARE SUBSTANCES, or STEADY STATES ARE SUBSTANCES. As shown in Table 4, of the 122 terms analyzed the dominating image schema is EPISODIC EVENTS ARE OBJECTS at 76% of the terms, 93 terms. This may be due to the fact that all matter can be categorized as OBJECTS such as *decomposers, carbon dioxide,* and *organisms,* and some processes may be categorized as OBJECTS, such as *mitosis, protein synthesis*, and *photosynthesis*, making this the largest conceptual category. Seven percent, nine terms, of the 122 terms are also categorized as OBJECTS but within the category of EPISODIC STATES ARE OBJECTS. This means that 84% of the terms could be categorized as count nouns if identification of abstractness is based upon conceptual boundaries of time and space within the definition of the noun as shown by the conceptual metaphor results of EPISODIC EVENTS ARE OBJECTS and EPISODIC STATES ARE OBJECTS. 16% additional terms, 20 terms, to this list are identified as SUBSTANCES. All of these were identified as having a SOURCE DOMAIN of processes and more specifically three of these terms are categorized as Constraint Based Interaction (CBI) processes as defined by Chi (1997). For example, *natural selection, evolution* and *energy* all have the image schemas of STEADY STATES ARE SUBSTANCES with CBI IS A DESTINY as the SOURCE DOMAIN. Also, *adaptation, mutualism*, and *endosymbiosis* all have STEADY STATES ARE SUBSTANCES as their image schema, with PROCESS IS A FUNCTION as the SOURCE DOMAIN.

Table 4

Image Schema Activation as a Percentage of each Biology Category (Raw Data in Parentheses)

	Total # of Image Schemas	Evolution (21)	Genetics (19)	Cell biology (51)	Ecology (31)
EPISODIC EVENTS ARE OBJECTS	76% (93)	57% (12)	63% (12)	92% (47)	71% (22)
EPISODIC STATES ARE OBJECTS	7% (9)	5% (1)	16% (3)	6% (3)	6% (2)
STEADY EVENTS ARE SUBSTANCES	10% (12)	24% (5)	16% (3)	2% (1)	10% (3)
STEADY STATES ARE SUBSTANCES	7% (8)	14% (3)	5% (1)	0% (0)	13% (4)

Within evolution, genetics, cell biology and ecology the majority of the image schemas that are activated are EPISODIC EVENTS ARE OBJECTS. This means that the conceptual metaphor mapping that is occurring within the majority of the biology terms is action events being conceptually conceived of as concrete entities. Therefore, abstract ideas are being projected onto concrete objects. This is shown by terminology such as *biome, gene pool, globin protein, and genotype*. This pattern of metaphor mapping concurs with Cuadrado and Duran's (2013a) account that abstract, creative ideas are used to explain concrete objects.

The next prominent image schema in evolution terminology, with fourteen percent, is STEADY EVENTS ARE SUBSTANCES. This indicates that 24% of evolution terms are abstract, continuous events that are being represented by abstract notions conceived of as SUBSTANCES. Therefore, abstraction is being used to describe abstraction. This is evident in terminology such as *inheritance, survival, dominance, pedigree, mycorrhiza* and *sedimentation.* Within the term *pedigree,* the steady event "an

Ancestral line of descent" (http://www.dictionary.com) refers to the action event over several years, possibly centuries, of a child being born, growing up to be an adult and then passing on their genes to a child and then the process repeats itself. These "steady situations such as, situations that are thought of as lasting indefinitely are converted into substances and hence coded as abstract mass nouns" (Radden & Dirven, 2007, p. 84).

The next area of prominence in genetics was a tie between EPISODIC STATES ARE OBJECTS with terms such as *offspring, karyotypes, traits*, and *thymine,* and STEADY EVENTS ARE SUBSTANCES with terms such as *inheritance, dominance*, and *pedigree*. Both of these image schemas are in 16% of the genetics terminology. Within ecology the next largest percentage shows an image schema of STEADY STATES ARE SUBSTANCES that are embedded within 13% of the ecology terms. This is evident in vocabulary such as *energy, adaptation, mutualism, and food web*.

Step 9: Identify Conceptual Metaphor Purpose

Identifying the purpose of the conceptual metaphor goes back to examining the definition of the entity and the TARGET DOMAIN. According to Lakoff and Johnson, (1980a, p. 26) the purpose of a conceptual metaphor is to refer, quantify, identify aspects, identify causes, set goals or to motivate action. For example, with the term *absorption* the purpose has been identified as 'referring' because *absorption* is defined by a reference to its function. *Absorption* explains a summary, episodic event (abstract) of what happens to a substance as it is being incorporated into another substance. It "profiles the component states as an abstract region" (Langacker, 2002, p. 98). This sequential event process is an abstract explanation. *Absorption* is a reference to a summary explanation of this sequential event. Therefore, the term *absorption* is a mapping of the relationship between an abstract process (what happened sequentially in this case) and an abstract function (how it is categorized conceptually by what it does).

"Abstract nouns describing episodic events may refer either to the process phase or to its result" (Radden & Dirven, 2007, p. 82). The word *adaptation* is an example of a term where the purpose of the conceptual mapping is referring, however, it is not referring to a sequential, episodic state of events within the process of the term, but to steady events. The term *adaptation* does not have clear boundaries of time as to when it started and/or finished. Therefore, it is unbounded and may appear to be more abstract than a bounded, count noun such as *absorption* because the image schema identified for this ontological metaphor would be STEADY EVENTS ARE SUBSTANCES because there is not a clear boundary of time that is inferred in the term or easily visualized. However, *absorption* has a more visible boundary of time passed and would be identified as EPISODIC EVENTS ARE OBJECTS. Purpose within metaphor may be multi-purpose and may be dependent upon the context within which they are used.

As shown in Table 5, the purpose for the majority of the conceptual metaphor mapping is to refer, with 79%, 96 of the terms, whereas identifying causes comes in second at 20%, 25 terms, of the terms in all biology areas examined. There appears to be a relationship between the purpose and the SOURCE DOMAIN of most the terms. All of the terms that have *identifying causes* as their purpose have process as their SOURCE DOMAIN.

Table 5

Purpose as a Percentage of each Biology Category (Raw Data in Parentheses)

	Evolution (21)	genetics (19)	cell biology (51)	ecology (31)	Subtotal of purposes (122)
Referring	67% (14)	74% (14)	82% (42)	84% (26)	79% (96)
Quantifying	0% (0)	0% (0)	0% (0)	3% (1)	.8% (1)
Identify aspects	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
Identifying causes	33% (7)	26% (5)	18% (9)	13% (4)	20% (25)
Set goals or to motivate action	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)

Step 10: Identification of the Common Conceptual Ontological Metaphors

The TARGET DOMAIN tells how the abstract is mapped onto something else. In some cases matter is mapped onto function and in other cases processes are mapped onto function. So in some instances a concrete notion is mapped onto an abstract notion and in others abstract notions are mapped onto other abstract notions. Therefore, to identify the purpose is to look at the relationship between the SOURCE DOMAIN and the TARGET DOMAIN to define what the ontological metaphor is doing to explain the abstract concept of the entity. Some of the findings of this study show that the abstract is used to define the concrete which is in agreement with Cuadrado & Durán,'s (2013a) findings that creative metaphors are used within terminology and that abstract notions are commonly mapped onto concrete notions in scientific terminology.

In Table 6, MATTER IS A STRUCTURE is the most predominant conceptual metaphor as shown within thirty-six percent of the terms. This conceptual metaphor can be found in terms such as *sickle-cells, species, thymine*, and *phenotypes*. PROCESS IS A FUNCTION is the second most dominant conceptual metaphor discovered at 26%, with terms such as *pH meiosis, nonsister chromatids*, *and translation*. Then, MATTER IS A FUNCTION followed at 18% with terms such as *aquatic protozoan, nucleotides, RNA*, and *xylem*. 11% of the terms have DESTINY as a TARGET DOMAIN with terms such as *natural selection, evolution, gamete* and *cancer cells*. 45% have FUNCTION as the TARGET DOMAIN and 43% have STRUCTURE as the TARGET DOMAIN with terms such as *adenine, nucleotides,* and *nutrients.* This would suggest that FUNCTION and STRUCTURE are embedded heavily into biology terminology.

Table 6
Subtotal of Common Conceptual Metaphors as a Percentage of each Biology Category (Raw Data in Parentheses)

	DESTINY	FUNCTION	LOCALIZATION	STRUCTURE
MATTER	2% (2)	18% (22)	.8% (1)	36% (44)
PROCESS	7% (9)	26% (32)	0% (0)	7% (9)
CBI	2% (2)	.8% (1)	0% (0)	0% (0)

Within the total compilation of common conceptual metaphors, the top three of each biology area is highlighted as shown by Table 7. Within the area of evolution, the most common conceptual metaphor is PROCESS IS A FUNCTION with 33% of the terms, followed by MATTER IS A STRUCURE with 29%, and MATTER IS A FUNCTION with 14%. Evolution terminology examples are given respectively: *endosymbiosis, chloroplast*, and *nuclear envelope.* Within the area of genetics, MATTER IS A STRUCTURE is the most common conceptual metaphor, followed by PROCESS IS A STRUCTURE with terms such as *chromosome* and *genotype*. Tied for third place in genetics are three different conceptual metaphors. Each metaphor is included in 11% of terms. These are MATTER IS A FUNCTION, PROCESS IS A DESTINY, and PROCESS IS A FUNCTION. Within the area of cell biology, the most common conceptual metaphor is MATTER IS A STRUCTURE with terms such as *plasma membrane* and *prokaryotic cell*. This is followed by PROCESS IS A FUNCTION with terms such as *cellular respiration* and *translation*, and MATTER IS A FUNCTION with terms such as *lactase* and *RNA*. Within the area of ecology, PROCESS IS A FUNCTION is the most prominent conceptual metaphor with terms such as *carbon cycle* and *metabolism*. These are followed by MATTER IS A FUNCTION with terms such as *producers* and *decomposers*. This is followed by MATTER IS A STRUCTURE at 23% of the terms with examples such as *enzyme* and *endoplasmic reticulum*.

Table 7

Total Common Conceptual Metaphors as a Percentage of each Biology Category (Raw Data in Parentheses)

	Evolution (21)	Genetics (19)	cell biology (51)	Ecology (31)	Subtotal Common Conceptual Metaphors (122)
MATTER IS A DESTINY	0% (0)	0% (0)	4% (2)	0% (0)	2% (2)
MATTER IS A FUNCTION	14% (3)	11% (2)	18% (9)	26% (8)	18% (22)
MATTER IS A LOCALIZATION	0% (0)	0% (0)	2% (1)	0% (0)	.8% (1)
MATTER IS A STRUCTURE	29% (6)	37% (7)	47% (24)	23% (7)	36% (44)
PROCESS IS A DESTINY	10% (2)	11% (2)	6% (3)	6% (2)	7% (9)
PROCESS IS A FUNCTION	33% (7)	11% (2)	24% (12)	35% (11)	26% (32)
PROCESS IS A LOCALIZATION	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
PROCESS IS A STRUCTURE	5% (1)	32% (6)	0% (0)	6% (2)	7% (9)
CBI IS A DESTINY	10% (2)	0% (0)	0% (0)	0% (0)	2% (2)
CBI IS A FUNCTION	0% (0)	0% (0)	0% (0)	3% (1)	.8% (1)
CBI IS A LOCALIZATION	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
CBI IS A STRUCTURE	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)

Analysis and Discussion

Within this section there will be a presentation of the number of conceptual metaphors discovered and their interpretation within in the areas of cell biology, evolution, ecology, and genetics of the sample text used in this study. One of the most profound results from this analysis is that most biology conceptual metaphors are created because of the mapping of FUNCTION or STRUCTURE onto PROCESS or MATTER concepts. The metaphor strategy that surfaces the most is the objectification strategy. The evidence of the proliferation of this strategy is underscored with the discovery that the image schema EPISODIC EVENTS ARE OBJECTS is the most frequently activated in this study in all areas of biology. The major purpose for these conceptual metaphors was identified as *referring*. The conceptual metaphors in biology are created to refer either to th*e FUNCTION or STRUCTURE* within the biology concept embedded into to the terminology. *Identifying causes* is shown to be the second most frequent purpose of the conceptual metaphors.

TARGET DOMAIN Discussion

The corpus of biology terms in this project has shown that FUNCTION and STRUCTURE are heavily embedded in the majority of the biology terms, while DESTINY does have a small impact on the number of terms. Even though the number of terms with the DESTINY TARGET DOMAIN is small, the specific terms that do have DESTINY may have a major impact on conceptual understanding of scientific frameworks within evolution and cell biology with terms such as *Natural Selection*, *evolution*, *extinction, pollination, natural disaster, disease,* and *inheritance,* While some of the specific biology terms themselves may be concrete in nature, the specific scientific concepts guiding them are abstract.

In this study, MATTER IS A FUNCTION, a more abstract conceptual metaphor, is represented by eighteen percent of the terms. The majority of these terms are in cell biology and ecology. MATTER IS A DESTINY was only present in cell biology. This may suggest that understanding MATTER as something other than an object you can see, hear, or touch in cell biology may need to be explicitly taught to students as having a slightly different definition than other terminology in cell biology that are defined as MATTER. This is shown in terms such as *xylem, mitochondrion, RNA*, *amino acids*, *ATP* and *gamete.*

Cell Biology

Cell biology typically carries with it the overarching metaphor that cells are machines (Behe, 1996). This refers to the cell being thought of and explained through the creative, visual concept of a machine and its function and purpose within biology. 47 of the biology terms fall into the category of cell biology. This is 32% of the terms presented in this study that carry the underlying conceptual metaphor ORGANISMS ARE MACHINES. Each area of biology studied has varying results as to the SOURCE DOMAIN and the TARGET DOMAIN used in the conceptual metaphors. In the area of cell biology, the majority of the conceptual metaphors have matter as the SOURCE DOMAIN and function or structure as the TARGET DOMAIN. This may indicate that the majority of the abstraction of the SOURCE DOMAIN is dependent upon its group membership to the MATTER category and whether this is mapped onto FUNCTION or STRUCTURE, with FUNCTION being the more abstract.

Evolution

Within the theory of evolution two of the conceptual metaphors commonly used are DESIRED TRAITS ARE VALUABLE and ORGANISMS ARE MACHINES. Both of these connect the terminology in evolution to the original scientific theory in this study. Within evolutionary biology objectification of abstract ideas is commonly used to describe the evolutionary process of cells, plants and animals. This is shown by the image schemas in this study, EPISODIC EVENTS ARE OBJECTS and STEADY EVENTS ARE SUBSTANCES . EPISODIC EVENTS ARE OBJECTS is the most common image schemas used within the biology terminology while STEADY EVENTS ARE SUBSTANCES, the more abstract image schema, is in 24% of the terms.

The metaphorical mapping within the terminology consisted mostly of SOURCE DOMAINS of matter and process and TARGET DOMAINS of FUNCTION and STRUCTURE. Within evolution terminology, a more abstract metaphor mapping PROCESS IS A FUNCTION is the most common conceptual metaphor found within 33% of the evolution terms.

Ecology

Only 25% of the abstract nouns analyzed for this study came from the field ecology. There are 35 terms that are in the ecology area of biology. Within this area of biology, ECOSYSTEMS ARE COMMUNITIES is the dominating conceptual metaphor. Ecology uses the personification metaphors strategy more heavily compared to the other areas of biology. This is shown in 74% of the ecology terms to describe functions, structures and behaviors with the conceptual metaphor ECOSYSTEMS ARE COMMUNITIES. This conceptual metaphor suggests that most ecology terminology is defined by its relationship within the ecological system and can be understood creatively when readers apply concepts of human relationships to events in an ecosystem. This is most evident in terminology such as *herbivore, consumer*, and *mycorrhiza*. The most prolific, common conceptual metaphor found with the ecology terminology that has the SOURCE DOMAIN and TARGET DOMAIN combinations is PROCESS IS A FUNCTION. This suggests that processes and functions within the ecosystem community is a heavily used perspective to define events and states within abstract nouns in ecology.

Genetics

The dominating conceptual metaphor of genetics theory of this study is DNA IS A TEMPLATE. Within the metaphor mapping of the genetics terminology, the most prevalent SOURCE DOMAINS are process, followed by a significant number of terms that had matter as the SOURCE DOMAIN. The majority of the genetics terms are mapped onto STRUCTURE as the TARGET DOMAIN as shown by sixty-eight percent of the genetics terms.

Underlying the most common conceptual metaphor mappings of PROCESS IS A STRUCTURE and MATTER IS A STRUCTURE in genetics terminology is the image schemas of EPISODIC STATES ARE OBJECTS and STEADY EVENTS ARE SUBSTANCES. These mappings indicate EVENTS and STATES are interpreted through metaphorical, structural OBJECTS within abstract noun definitions.

It may be suggested that the most abstraction occurs within the evolution and ecology terms because the frequency of the abstract notions of PROCESSES being mapped onto the abstract notions of FUNCTION is used to describe the noun's existence. This process embedded within the evolution and ecology terms of my study would be different than Cuadrado and Duran's (2013a) results which showed that abstract notions were mapped onto concrete notions, yet similar to what was discovered in the area of genetics of my study where abstract is mapped onto concrete notions. Both my results and Cuadrado and Duran's (2013a) results are different than the directionality of metaphor as described by CTM where concrete notions are used to describe abstract. As seen by the metaphor strategies results, the majority of the conceptual metaphors are used to refer. Whether it is referring to an abstract function, destiny, or structure could determine its degree of abstractness as well.

The Question of Directionality in CTM

Within this study, concreteness of the SOURCE DOMAIN was examined within the definition of the MATTER category. Concreteness versus abstraction with the SOURCE DOMAINS and the TARGET DOMAINS can be shown by whether or not the SOURCE or TARGET DOMAIN is represented as an OBJECT or SUBSTANCE in the image schema, and further defined within the science as to whether the SOURCE DOMAIN is a PROCESS, MATTER or CBI. Because of the investigation of the MATTER definition has shown that some of the terms defined as MATTER have a different degree of abstraction to them, I propose that the terms that have MATTER mapped onto FUNCTION or DESTINY may have an equal or higher degree of metaphoricity than those terms that are mapped as FUNCTION or CBI onto another

SOURCE DOMAINS. I say this because there seems to be a continuum of metaphoricity of the terms according to the conceptual mapping that has been discovered within the terms. This was also shown to be true in the work of Cuadrado & Durán (2013b, p. 11): "in science and technology, different metaphorical terms may present different degrees of metaphoricity when measuring the distance between the SOURCE DOMAIN and the TARGET DOMAIN". Therefore, for the sake of simplicity of concrete versus abstract, I would group together terms that have the mapping MATTER IS A FUNCTION (eighteen percent), MATTER IS A DESTINY (two percent) along with terms that have the mapping CBI IS A DESTINY (two percent), PROCESS IS A DESTINY (seven percent), and PROCESS IS A FUNCTION (twenty-six percent). All of these conceptual mappings appear to have the directionality of abstract, complex ideas onto abstract, complex ideas. Their degrees of metaphoricity vary within each term and within each area of biology. These abstract conceptual metaphors are represented by 55% of all the terms in this project. Next, on the continuum I would suggest that the mappings of complex, abstract ideas onto concrete, are simple ideas as suggested by Cuadrado & Durán (2013a). These ideas may be shown with the conceptual metaphor mapping of PROCESS IS A STRUCTURE, which is shown to be mapped onto only nine percent of those terms, most of which are in the field of genetics. This evidence would not completely concur with Cuadrado & Durán's (2103a, 2013b) work that scientific terms typically map in directionality from abstract to concrete in their conceptual metaphor mapping, but that even more abstract notions are mapped onto abstract notions within biology terminology.

Summary

Chapter Four reveals the visual scene that is used for each abstract term in genetics, evolution, cell biology and ecology found in the text example. Comprehension of these visual scenes that describe biology terminology by mapping processes, matter and CBI event processes onto functions, structures, localization and destiny may help students better conceptually categorize and remember biology terminology. The four conceptual metaphors that dominate these areas are: ORGANISMS ARE MACHINES, ECOSYSTEMS ARE COMMUNITIES, DNA IS A TEMPLATE, and DESIRED TRAITS ARE VALUABLE.

Within the area of evolution, the majority of the conceptual metaphors focus on processes such as PROCESS IS A FUNCTION while matter is centered on the MATTER IS A STRUCTURE conceptual metaphor. Within cell biology there is a focus on MATTER IS A FUNCTION and MATTER IS A STRUCTURE, while PROCESS IS A FUNCTION dominates the description of the conceptual notions of process. Within ecology, the focus is more heavily on the conceptions of MATTER IS A FUNCTION, MATTER IS A STRUCTURE and PROCESS IS A FUNCTION. Within genetics the majority of the conceptual notions MATTER IS A STRUCTURE and PROCESS IS A STRUCTURE. We can see across the areas of biology that FUNCTION AND STRUCTURE are extremely important in understanding the basic concepts of biology.

The results indicate that the majority of the abstract nouns are in the cell biology area of the biology practice test analyzed. This analysis of common, conceptual metaphors was used to answer the capstone questions *which conceptual metaphors are* *deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?*

Chapter Five will summarize my reflections about my capstone journey on this project. I will discuss the limitations for this type of study as well the promise it may hold for future studies. I will also include suggestions as how this information could be shared with colleagues in a professional development setting in order to instruct English learners in a high school biology classroom.

CHAPTER FIVE: CONCLUSIONS

Introduction

Chapter Five will describe my experience and reflections about my capstone project. This reflection will be focused on my research question: *Which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?* Chapter Five will discuss and explain the difficulties and success that I had in implementing such a challenging topic area. I will also recommend other areas of research based upon my experience with this project. Finally, I will discuss how this project has impacted my teaching strategies and professional practice.

Personal Reflection

As I look back upon the hours of research and reflection I put into this project, I feel a sense of accomplishment for tackling a new area of linguistic research, Cognitive Linguistics, in order to improve my teacher perspective and practice. I thought the study of nominalizations in science would be fairly straightforward. However, as I started the project I felt that comprehension questions regarding vocabulary acquisition were not being addressed thoroughly enough for me to transfer anything tangible to my classroom instruction. Therefore, I strove to find answers to satisfy my expectations of what it took to comprehend new terminology, and that is when I discovered how the field of Cognitive Linguistics brought together many different perspectives, such as philosophy, topology, psychology, and sociology to draw out solutions to describe about how we think about language across the globe. The majority of my research was conducted reading decades of research of various Cognitive Linguistics studies. Each researcher would have their own set of terminology that they used which would require me to do a lot of background research to comprehend their conclusions. As I waded through all the information, I gathered quite an extensive viewpoint about how language is processed and conveyed within different academic speech communities. A lot of linguistic analysis of metaphor is conducted through individual intuition, which left me with some conflicting literature to pull together to make a comprehensive project.

An analysis of the literature led to a solid step-by-step process to deduce the conceptual structure of the biology term. As a novice biology learner myself I felt a sigh of relief to know that there was a structure as how biology terminology was created. Prior to this investigation I did not know that the majority of the terminology in the areas that I researched could be systematically broken down in order to scaffold comprehension. For example, through literature searches and face-to-face discussions with Carla Carr, PhD., a light turned on when I found out that from her experience as a biologist, most terminology is categorized as either a function or a structure. This step set me up conceptually so that I would be prepared to process more details about the term so as to comprehend it. I felt that the strongest link in this investigation was that terms could be conceptually categorized as either a function or a structure. This set the scene for me to explore in depth how the function or structure related to the conceptual metaphor of that biology area. After more reflection and literature searches about the terminology and how they could be conceptually categorized there were still the notions of abstraction left unanswered. How was it that some biology terms were more concrete and others were more abstract? Is it simply a matter of perception, or are there solid answers that everyone can agree upon? This lead to my questioning about identifying the SOURCE DOMAIN and TARGET DOMAIN of the conceptual mapping that was occurring within the term itself. Previously I was able to identify the SOURCE DOMAIN as either being matter or process. The matter category did throw me for a little loop because many terms were categorized as matter but only because they had membership into that group. They were not categorized into the MATTER category only because of a tangible feature, but because of common features or attributes shared by a group. This lead me to review my Cognitive Linguistics literature about Cognitive Grammar processing to more clearly define abstract nouns from a Cognitive Linguistics perspective. Once I had the categories of abstraction defined, I could label the common conceptual metaphors within each term. This lead to a systematic tabulation of data that I could use to compare the frequency of different conceptual metaphors embedded in the biology terminology.

Implications

This investigation may provide insight into conceptual processing of vocabulary that, in turn, may help spur on more research in Cognitive Linguistics that focuses on English Learner classrooms. It is within these classrooms that we have the most readily available language laboratory. With this investigation I have found a pattern to the Tier 3 science vocabulary that I could not have otherwise begun to categorize conceptually. When confronted with a new framework of how to define abstract nouns, knowing where to start is half the battle. By understanding how to initially conceptualize terminology by *structure* or *function* this may help relive a lot of cognitive stress for ELL students of biology. Then it may be possible for students to conceptually categorize new vocabulary because they understand the conceptual mapping of the abstract nouns. They may proceed to analyze new vocabulary because the instructor has identified for them the SOURCE DOMAIN as being either a process, a CBI process, matter or a state and can directly instruct how it is being mapped onto the TARGET DOMAIN of function, structure, localization or destiny. Prior the mapping instruction, it may be necessary to have an introduction to the defining factors of abstract nouns which are part of the MATTER CATEGORY. It may be necessary for students to understand the abstraction that occurs within the definition of words that are categorized as MATTER. It's necessary to understand that the MATTER category is not always defined as such because it is a tangible object, but that it can also be grouped as MATTER because of its purpose/job (FUNCTION), or its projected future (DESTINY). This was shown true with a few terms in this project with CBI as the SOURCE DOMAIN. Even though the number of terms with CBI as the SOURCE DOMAIN represents a small portion of the total number of terms examined, they are terms that may have significant impact on students' basic understanding of essential biology concepts such as *Natural Selection*, *evolution* and *energy*. These are basic concepts that underlie more complex terminology found in biology, especially in the subject area of evolution. Understanding the abstraction that occurs on different levels of the concept creation of the terminology is essential to fully comprehend the complexities within the abstract noun biology terminology. All of this terminology of course would be explained within the topic backdrop of the original conceptual metaphors used to describe the scientific theories of evolution, ecology, cell biology and genetics.

Scaffolding of content concepts is so important to any novice learner to biology but especially important for English Language Learners. When concepts are scaffolded during instruction, it has been my experience that explanations are naturally paired with simplistic language. By pointing out to the students the framework of concepts and the conceptual structure of vocabulary during instruction would give the student an abundance of resources to pull from to comprehend new terminology. Not only showing the concept creation behind the terminology to the students, but also teaching them the strategies to do the same process themselves may help them in the future when struggling with unknown vocabulary in other academic fields of study.

Dissemination of Results

The information from this study will be shared with ESL colleagues at the regional TESOL conference, AMTESOL upon acceptance of my conference submission. I would also would like to share this information within our district during content area planning and professional development. The hope is to ignite other ESL educators and classroom content area teachers to begin research in the area of Cognitive Linguistics to further their understanding of conceptual language development and also to encourage other educators to look at how to scaffold terminology specific to different content areas.

Limitations

Conceptual metaphors are used and created by scientists to describe the conceptual mapping that occurs within an abstract idea. Linguists define conceptual metaphors with a label such as EPISODIC EVENTS ARE OBJECTS, or ECOSYSTEMS ARE COMMUNITIES, to describe the mapping they believe exists in another author's work. What is not known is if every author was aware of the metaphor they were applying to their theory or if it simply was a reaction to the times they lived in. However, Drogosz (2016) concludes that Darwin was expertly aware of his metaphor usage that he applied to his Theory of Natural Selection. Darwin's work and the inventions that came about during the Industrial Revolution created the familiar, physical structure of the machine that would become a metaphorical model used by many to relay abstract ideas in a concrete manner.

Conceptual mappings could be inferred from many different perspectives with each vocabulary term; however, time was of the essence in this project and I deferred to the most basic visual scene that I felt was being described with each abstract noun.

I am an English teacher by trade, with little background in the biological sciences. However, even with my background, I could be responsible for teaching high school students the academic English required to understand this content area. This is the dilemma many ESL teachers face. They are required to help EL students with the content area instruction as well as teaching English language development. In this vein, I do have to put out the disclaimer that I am not in any way a biology expert. In order to correctly categorize biology terminology into specific areas of biology and to begin the conceptual identification of the SOURCE DOMAINS of the biology terminology, Carla Carr, PhD, biology instructor at the University of Mississippi was most gracious in sharing her biology expertise for this project. It became evident from discussions with Dr. Carr, that most biology terms could be defined as either a structure or a process. This information led me to a clear path to identify the TARGET DOMAINS of different biology terminology. Further research into TARGET DOMAINS led to Vandaele's (2002) translation research of biology terminology that shows how she conceptually defines the possible TARGET DOMAINS of biology terms as either being process, structure, localization or destiny.

This project is a reflection of my background knowledge about linguistics being put to use to comprehend biology terminology to answer my capstone research question *which conceptual metaphors are deemed essential knowledge about biology as reflected in the Mississippi standardized high school biology assessment?* I would like to emphasize that regardless of these limitations, after much persistence, I was able to devise a method to use to teach abstract nouns found in biology. I feel this method would allow students better recall of abstract concepts found in biology.

Discussion

During the Chapter Four investigation it became clear to me that I had not yet clearly defined what abstract nouns refer to in this investigation. It also became clear to me when reading Khokhlova's (2013) article that there is an abundance of research that also investigates the basic definition of abstract nouns in different disciplines. Therefore, in this project I would like to say that the grammatical category of abstract nouns is on a continuum of abstraction. This is to say, what may be abstract to one person may not be abstract to another. According to one of the basic tenets of Cognitive Linguistics, comprehension of abstract ideas is contingent upon your previous human experiences with the background knowledge that is required to comprehend the abstract idea (Lakoff & Johnson, 1980b). Therefore, you may be familiar with abstract ideas such as happiness, freedom, community, etc. because you have lived and experienced these concepts your whole life. I believe the same can be said about content area vocabulary. The more familiar you are with abstract ideas found in basic biology concepts, the more adaptable you may be in learning new abstract biology vocabulary.

One of the most important findings of conceptual metaphors in this project is that PROCESS and MATTER are mapped onto most FUNCTION and STRUCTURE concepts embedded in biology terminology. Defining group membership to the abstract noun category became necessary to comprehend the source of abstraction within the nouns. Definition of group membership is more clearly defined by the mapping of PROCESS and MATTER onto the TARGET DOMAIN.

Defining Group Membership of Nouns

According to the CTM directionality of metaphor, in general language metaphor uses abstract sources mapped onto concrete TARGET DOMAINS (Cuadrado and Duran 2013a, p. 63). The noun's SOURCE DOMAIN may be categorized by group membership to matter, process or CBI. Within this membership, categorization of matter became the most problematic. The definition of MATTER came under scrutiny during this investigation because terms that are described as MATTER each have their own membership requirements to the MATTER category. Some are defined as matter because of their visual, identifying aspects, which are later shown as the mapping of MATTER onto STRUCTURE. However, other terms had membership to the MATTER category because their existence is defined by what they so do or what they will become. Thus, MATTER is mapped onto FUNCTION (what they do) and DESTINY (what they will be come). For example*, amino acids* have membership to the matter category because of what it has and what it does. "Any of a large number of compounds found in living cells that contain carbon, oxygen, hydrogen, and nitrogen, and join together to form proteins."[1] Thus the category membership is because of a time element shown in the

[1] http://www.dictionary.com/browse/amino--acids?s=t

words join together and a space element in the word contain. *Amino acids* cannot be *amino acids* unless they contain both of these descriptors. I realized after much reflection that almost anything defined as a noun could belong to a different matter group and it is all relative as to whether one entity belonged to another matter group or not. Therefore, I had to take into account that the matter group has entities with varying embedded requirements in order to belong to the matter group and that this would later be revealed as we uncover the full metaphorical mapping of the term. This process would also reveal to me the degree of abstraction embedded within each noun making it more or less abstract. After defining *matter* with this new perspective I was able to proceed with more confidence of my characterization of the *matter* group membership. After categorizing all the terms in this way it became obvious that MATTER in my research project was pivotal in defining abstraction within nouns. With this project I found that most matter in these areas of biology are defined by their characteristics, which could be based upon behavior or what they possess in order to have group membership with other like objects. For example, *amino acid change* is an abstract process that is mapped onto an abstract function. Or *amino acid* itself is explained by mapping a group membership identification onto an abstract function. These mappings may lead to a lot of confusion because abstraction is used to explain abstraction. Therefore, concrete items in this case are not used to explain abstract notions, which is the opposite objective of a metaphor. I would propose that if a student is not familiar with one abstract idea, such as the category of group membership, the student might not be able to comprehend the term which uses abstraction as a SOURCE DOMAIN.

During this investigation I found an article that helped me tremendously in better defining the TARGET DOMAINS of the conceptual metaphors to categorize cell biology terminology. The article by Sylvie Vandaele (2002) called *Metaphorical Conceptualization in Cell Biology* helped me to conceptually categorize more of these unfamiliar biology terms. Initially I was categorizing terms by whether or not their definitions defined them to exist by the description of their structure or their function. These two categories still left a lot of unanswered questions for me. When I found Vandaele's (2002) article, I found more categories I could use and be confident about how to group them within the MATTER category. Vandaele (2002) explains that the description of the characteristics within an entity in biology can be categorized into four areas: structures, functions, localization and destiny. The *destiny* category opened the door to me to a category that would directly fit with some of my terminology that is physically concrete. That is to say, you can see them under a microscope; however, these entities are described and categorized not by their physical appearance, but by what they become or how they are produced such as *natural selection*, *evolution, ATP, gamete, cancer cells, symptoms, atmospheric nitrogen, pollination, extinction, disease, natural disaster, autosomal recessive condition, and inheritance*. Although these nouns represented only a fraction of the larger sample, because I could conceptually categorize them I felt I had found an answer to their abstraction. The very description that explains their existence is abstract. This leads me to believe that they may be more difficult to comprehend when learning new biology vocabulary.

This understanding of different MATTER membership requirements helped explain how some terms may have more metaphoricity than others. This discovery added to my analysis a manner in which I could the degree of metaphoricity in some terms. This analytical method is paramount in understanding how concrete or abstract a term is. Even though terms are in the MATTER category, their group membership designation (STRUCTURE, FUNCTION, DESTINY, LOCALIZATION) gives a better understanding of the abstract visual scene that the term conveys in its mapping. Understanding how MATTER is mapped onto the TARGET DOMAIN led to a more comprehensive understanding of how matter is defined, whether it be defined by it STRUCTURE, FUNCTION, or DESTINY as shown in the metaphor mapping of SOURCE DOMAINS onto TARGET DOMAINS. Therefore, this identification of varying degrees of metaphoricity in science terminology has been shown to exist by work done by Cuadrado & Durán (2013a). "In science and technology, different metaphorical terms present different degrees of metaphoricity, some of them being highly metaphorical" (Cuadrado & Durán, 2013a, p. 63).

Further Research

Rosch (1978) defines objects as having a *level of abstraction* in The Prototype Theory. She claims that taxonomies are based upon inclusiveness into a category, and the more attributes that have to be included in a category, the higher the level of abstraction is for that category. Therefore, once two elements are combined of like attributes they create a new conceptual category. This is similar to the approach in my study, in which I looked at how elements are combined to determine the degree of abstraction. Rosch (1978) compares the level of abstraction to the creation of the Linnaean taxonomy of animals. "A taxonomy is a system of by which categories are related to one another by means of class inclusion" (Rosch, 1978, p. 5). Therefore, to create a listing of the basic, most common form of elements used, or prototypes, in the level of abstraction of biology terminology would help along the process of scaffolding instruction of the SOURCE or TARGET DOMAINS commonly used in different biology conceptual metaphors found in their taxonomies.

The Prototype Theory and principles of categorization theory (Rosch, 1973,1978) could help determine the concreteness of each biology item in more detail so as to rate in succession which terms may have more concreteness within each entity. This is described by Evans and Green (2006, pp. 28-29 as cited in Cuadrado & Durán, 2013b, p. 3): "Human categories often to appear fuzzy in nature, with some members of a category appearing to be more central and others more peripheral. Moreover, degree of centrality is often a function of the way we interact with a particular category at a given time." Rosch's (1973) theory of radial categories describes prototypes of categories that are central to children's vocabulary and are the most commonly used visual scenes used in everyday interactions (Radden, 2007, pg. 9). These prototype categories, along with the Theory of Iconicity are the underlying, cognitive notions of nominalizations (Zhong, 2006, p. 11). If there were a reference which could possibly list all of the different prototype categories used in western culture, one might be able to make assumptions about which abstract noun biology terminology is either central or on the periphery of the conceptual categories used in the underlying metaphor of the terms.

This type of project may be contingent upon cultural research which could pinpoint what would be the central objects needed for each category. The time required to do this kind of project could last for decades. In addition, I would suggest that this project could be researched further by using the conceptual metaphors I have identified in Step 10 to use to paraphrase the actual definition of the term and compile this information in a reference text for teachers. Paraphrasing is an excellent teacher skill to have to introduce vocabulary to students in a time efficient manner in order to more effectively communicate the framework, or conceptual metaphor, underlying the vocabulary word.

I've learned that comprehension of abstract vocabulary cannot simply happen because you have memorized a definition. Full comprehension carries with it background, conceptual scientific concepts. This research has shown me the importance of teaching the major scientific theories in order to comprehend the full picture of taxonomy for any field. Previously, when I have been able to demonstrate for students a new way of categorizing information, they have found this to be very beneficial. This project has given me a greater appreciation for the creativity involved in the creation of scientific concepts and the language used to describe the abstract theories. Had I not completed this project I might have never known how 'human' science is. Understanding that there is an identifiable progression of abstraction from image schema, to conceptual metaphors, to specific conceptual metaphor within each scientific theory and scientific term made my learning of new vocabulary much more manageable. I suggest the following steps for teachers to take to explain conceptual metaphor creation within biology terminology in effort to create stronger retention and recognition of biology terminology.

I would suggest to teachers that at minimum to use a four step process to explain conceptual metaphor mapping within science terminology. First, I would suggest that teachers explain to students how 'human' science is by pointing out the time period and current scientific and cultural events happening in the world during the scientific discovery. This may help them understand the theorists' viewpoint of how the world works in order to comprehend how science fits in with everyday life. This discussion would allow for teachers' to discus the purpose behind different metaphor strategies used to explain abstract concepts, such as objectification and personification. Next, I would suggest to teachers to show how the metaphor strategy within terms is either linked to or distanced from the original scientific theory. This may gave students a starting point to conceptually categorize terms based upon the area of science, such as evolution, cell theory, genetics or ecology and a basic understanding of how science evolves and changes as new scientific discovers come about which may dispute previous theories. This would also be a time to discuss conceptual metaphors that drive various biology theories such as ECOSYSTEMS ARE COMMUNITIES or ORGANISMS ARE MACHINES. Then, I would suggest that the teachers have a discussion about how science terms could be categorized as matter, processes, or states. A discussion about matter at this time is essential. Students may have a preconceived notion that matter is mostly defined by visual cues such as structure. By discussing in detail with students the different ways in which matter can be defined, such as function, destiny, destiny or structure, may help them understand with more clarity that not all matter is defined by what you can see or touch but that it can also be defined by its role within the scientific theory or what it may become. This instructional process may allow you to segue into the final discussion of common conceptual metaphors and how they could be used to describe conceptual categorization different biology terminology. Prior to teaching this type of perspective of terminology and scientific concepts teachers will need to have background knowledge and experience at conceptually categorizing terms based upon their direct or tangential connection to originating scientific theories.

By finding patterns in the conceptual language used in science I felt more confident that I'm beginning to have tools to confidently teach biology to ELL students. This capstone project allowed me to experience unknown vocabulary similar to the process that my own students undergo. It is with this empathy that I'm motivated to find language patterns so that my students can succeed.

REFERENCES

Ahmad, K. (2006). Metaphors in the languages of science. V.K. Bhatia & M. Gotti, (Eds.) *Explorations in Specialised Genres (Vol. 2).* (pp. 197-220). Bern: Peter Lang.

Behe, M.J. (1996). *Darwin's blackbox: The biochemical challenge to evolution.* New York: Free Press.

Boers, F. (2003). Applied linguistics perspectives on cultural cross-cultural variation in conceptual metaphor, *Metaphor and Symbol,* 18 (4), 231-238.

Boyd, R. (1993). Metaphor and theory change: What is "metaphor" a metaphor for? In A. Ortony (Ed.), *Metaphor and Thought* (pp. 481-532). Cambridge: Cambridge University Press.Retrieved from http://dx.doi.org/10.1017/CBO9781139173865.023

Brookes, D. T. and Etkina, E. (2007). Using conceptual metaphor and functional grammar to explore how language used in physics affects student learning. *Physical Review Special Topics – Physics Education Researcher* 3, 010105 (2007). The American Physical Society. Retrieved from http://journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.3.010105

Chi, M. T.H., (1994). From things to processes: A theory of conceptual change for learning science concepts*, Learning and Instruction, Vol. 4*, 27-43. Pergamon, Elsevier Science Ltd. Retrieved from http://chilab.asu.edu/papers/ChiSlottaLeeuw.pdf

Chi, M. T.H. (1997). Creativity: Shifting across ontological categories flexibly. In T.B. Ward, S.M. Smith, & J. Vaid (Eds.). *Creative thought: An investigation of conceptual structures and processes* (pp.209-234). Washington D.C.: American Psychological Association. Retrieved from http://chilab.asu.edu/papers/Creativity.pdf

Chi, M.T.H., (2013). Two kinds and four sub-types of misconceived knowledge, ways to change it, and the learning outcomes. In Stella Vosniadou (Ed.), *International handbook of research on conceptual change*, (pp. 49-70). New York: Routledge. http://dx.doi.org/10.1017/CBO9781139173865.023

Christie, F. (2007). Letting the secret out: Successful writing in secondary English, *Australian Journal of Language and Literacy*, *30*, (3), 235-247.

Cuadrado Esclapez. G., Duque García, M.M. and Durán Escribano, P. (2007, September). *META-CITEC: a cognitive semantic database of conceptual metaphor in science and technology.* Paper presented at Proceedings of the BAAL Conference 2007. London, UK. Retrieved from http://www.baal.org.uk/proc07/05_georgina_cuadrado_esclapez.pdf

Cuadrado, G., & Durán, P. (2013a). Rocks are human beings: Researching the humanizing metaphor in earth science scientific texts. *Global Journal of Human Social Science Geography, Geo-Sciences, Environmental Disaster Management*, *13* (7), Version 1.0 Year 2013, Global Journals Inc. (USA). Retrieved from http://oa.upm.es/33401/.

Cuadrado, G. and Durán, P. (2013b). Proposal for a semantic hierarchy of terminological metaphors in science and technology, *International Journal of English Linguistics;*

3(4), 55-64. Retreived from http://www.ccsenet.org/journal/index.php/ijel/article/download/29050/17313.

Cuadrado-Esclapez, G., Argüelles-Álvarez, I.,Durán-Escribano, P., Gómez-Ortiz, M.J., Molina-Plaza, S., Pierce- McMahon, J., Robisco-Martín, M.M.,Roldán-Riejos, A., Úbeda-Mansilla, P. (2016). *Diccionario bilingüe de metáforas y metonimias científico-técnicas. ingeniería, arquitectura y ciencias de la actividad física (Español-Inglés / English-Spanish)*, New York New York: Routledge.

Dreyfus, B. (2015.) Applying Conceptual Blending to Model Coordinated Use of Multiple Ontological Metaphors, *International Journal of Science Education*, Volume 37, Issue 5-6, pp. 812-838.

Drogosz, A. (2008). Ontological metaphors in Darwin's The Origin of Species. In Puppel, S.and M. Bogusławska-Tafelska (eds.), *New Pathways in Linguistics*. pp. 93-12. Olsztyn: Instytut Neofilologii. Uniwersytet Warmińsko-Mazurski.

Drogosz, A. (2009). Metaphors of family, tree and struggle in Darwin's The Origin of Species. In Stanislaw Puppel and Marta Boguslawska-Tafelska, (eds.)*, New Pathways in Linguistics* (pp. 109-140). Olsztyn: Instytut Neofilologii. Uniwersytet Warmińsko-Mazurski.

Drogosz, A. (2013). Verbal and pictorial metaphors in the theory of evolution, *PRACE JEZYKOZNAWCZE, ZESZYT, XV/1., WYDAWNICTWO UWM*, 21-30, Retrieved from http://www.uwm.edu.pl/stas/wydawnictwo/Pr.j.zeszyt-1-do-druku%2016.07.pdf.

Drogosz, A. (2016). Darwin's metaphors. A cognitive semantic analysis of the theory of evolution. *Academic Journal of Philology*, Volume 5, pp. 31-45.

Drury, P. (2005). Terminology and specialized translation: the relevance of the diachronic Approach. *LSP and Professional Communication*, *5*, (1), April, 2005.

Evans, V. (2013). Metaphor, lexical concepts and figurative meaning construction, *Journal of Cognitive Semiotics*, *vol. 1-2, (*73-107). Retrieved from *http://pure.au.dk/portal/files/56399444/issue_5.1_2_final.pdf*.

Fang, Z. (2004). Scientific literacy: A systemic functional linguistics perspective. *Science Education*, *89*, 335-347.

Fang, Z., Schleppegrell, M.J., Cox, B. E. (2006). The language demands of science reading in middle school. *International Journal of Science Education 28*, (5), 14, 491-520.

Fehr, C. (2004). Feminism and science: mechanism without reductionism. *NWSA Journal*, *16* (1, spring), 136-156.

Gómez-Moreno, J.M.U. (2011). *Metaphor in specialised language: An English-Spanish comparatives study in marine biology*. (Doctoral thesis, University of Granada, Department of Translation and Interpreting, Grenada, Spain). Retrieved from http://hera.ugr.es/tesisugr/19655095.pdf

Hoang, H. (2014). Metaphor and second language learning: The state of the field. *TESL_EJ*, *18*(2). Retrieved from http://www.teslej.org/wordpress/issues/volume18/ej70/ej70a5/

Harrison, K. (2013). Building resilient communities. *M/C Journal, 16*(5). Retrieved from http://journal.media-culture.org.au/index.php/mcjournal/article/view/716

Hellsten, I. & Nehrlich, B. (2011). Synthetic biology: Building the language of a new science brick by metaphorical brick, *New Genetics and Society, 30* (4), 375-397. doi:10.1080/14636778.2011.592009

Johnson, M. (1987). *The body in the mind: The bodily basis of meaning, imagination, and reason*. Chicago: University of Chicago Press.

Johnson, Mark (ed.) (1981). *Philosophical perspectives on metaphor*. Minneapolis: University of Minnesota Press.

Johnson, M. (2015). Embodied understanding. *Frontiers in Psychology*, *6*, 875. http://doi.org/10.3389/fpsyg.2015.00875

Khokhlova, Natalia (2014). Understanding of abstract nouns in linguistic disciplines. Procedia – Social and Behavioral Sciences, 136 (2014), 8-11. doi: 10.1016/j.sbspro.2014.05.278

Knudsen, S. (2003). Scientific metaphors going public. *Journal of Pragmatics*, *35*, (35), 1247-1263. http://dx.doi.org/10.1016/S0378-2166(02)00187-X

Kövecses, Z. (2002). *Metaphor: A practical introduction.* Oxford: Oxford University Press.

Kuhn, Thomas Samuel (1962). *The structure of scientific revolutions*. Chicago. University of Chicago Press.

Lakoff, G. (1987). *Women, fire and dangerous things*. Chicago: The University of Chicago Press.

Lakoff, G. (1993). The contemporary theory of metaphor. In Andrew Ortony (Ed.) *Metaphor and Thought* (2nd edition), New York. Cambridge University Press.

Lakoff, G. & Johnson, M. (1980a). *Metaphors we live by.* Chicago. University of Chicago Press.

Lakoff, G. & Johnson, M. (1980b). The metaphorical structure of the human conceptual system, *Cognitive Science 4*, 195-208.

Lakoff, G. & Johnson, M. (1999). *Philosophy in the flesh*. New York: Basic Books.

Langacker, R.W. (1987a). *Foundations of cognitive grammar, volume I: Theoretical prerequisites*. Stanford University Press. Stanford, California.

Langacker, R. (1987b). Nouns and verbs. *Language*, *63*(1), 53-94.

Langacker, R.W. (1991). *Foundations of cognitive grammar, volume II: Descriptive application*. Stanford University Press.

Langacker, R.W. (2002). *The cognitive basis of grammar: Concept, image and symbol.* Berlin: Mouton de Gruyter.

Langacker, R.W. (2000). *Grammar and conceptualization*. Berlin and New York: Mouton de Gruyter.

Mallet, J. (1998). Species concepts, In Calow, P. (Ed.) *Encyclopaedia of Ecology and Environmental Management* (pp. 709-711). Blackwell Press.

Merchant, C. (1980). *The death of nature: Women, ecology, and the scientific revolution*. New York, NY: Harper Collins Publishers.

Merchant, C. (1992). *Radical ecology: The search for a livable world*. New York: Routledge.

Nayak, S. (September 13, 2011). Towards a grounded model for ontological metaphors. Paper presented at the Proceedings RANLP Student Research Workshop, Indian

Institute of Technology, Kanpur, India. Retrieved from http://www.aclweb.org/anthology/R11-2018

Pritzker, S. (2003). The role of metaphor in culture, consciousness, and medicine: A preliminary inquiry into the metaphors of depression in Chinese and western medical and common languages. *Clinical Acupuncture and Oriental Medicine*, *4,*(1), 11–28.

Radden, G. and Dirven, R. (2007). *Cognitive English grammar*. Philadelphia.: John Benjamins Publishing Company

Robertson, F. (2013). *Print culture: From steam press to ebook*. New York. Routledge.

Rosch, E. (1973). Natural categories. *Cognitive Psychology* (4), 328-350.

Rosch, E. (1978). Principles of Categorization. In E. Rosch, & B. B. Lloyd (Eds.), *Cognition and Categorization* (pp. 27-48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Schleppegrell, M. J. (2004). *The language of schooling: A functional linguistics perspective*. Mahwah, NJ: Erlbaum.

Sfard, A. (1995) "Reification as the birth of metaphor", *Tijdaschrift voor Didactiek der B-wetenschappen*, 13 (1), 5-25.

Snow, C. (2010). Academic language and the challenge of reading for learning about science. *Science, 328*, 450. DOI: 10.1126/science.1182597

Steen, G.J. (2011). The contemporary theory of metaphor – now new and improved! *Review of Cognitive Linguistics*, *9*, (1), 26-64.

Travers, M.D. (1996). Programming with agents: New metaphors for thinking about computation. (Doctoral dissertation, Massachusetts Institute of Technology, June, 1996). Retrieved from http://xenia.media.mit.edu/~mt/thesis/mt-thesis-2.1.html#fn2

Ureña, J.M. and Tercedor, M. (2011). Situated metaphor in scientific discourse: An English-Spanish contrastive study. *Languages in Contrast*, *11*(2), 216-240. USA: John Benjamins Publishing Company.

Unschuld, P. (1998). *Chinese medicine*. Brookline, MA: Paradigm Publications.

Vandaele, S. (2002). Metaphorical conceptualization in cell Biology. *The Tenth EURALEX International Congress,* Copenhague - Danemark, 13-17 août 2002. Proceedings, vol. II, (p. 649-655). Retrieved from https://papyrus.bib.umontreal.ca/xmlui/bitstream/handle/1866/1462/van02eur.pdf?sequence=1&isAllowed=y

WIDA (2010). The WIDA guiding principles of language development, Retrieved from https://www.wida.us/aboutus/academiclanguage/

Yu, N. (1998). *The contemporary theory of metaphor: A perspective from Chinese*. Philadelphia, PA: John Benjamins Publishing.

Zhong, S. N. (2006). *L2 acquisition of English nominalization by Chinese EFL learners: A cognitive linguistics perspective*. China. Guangdong University of Foreign Studies, National Key Research Center for Linguistics and Applied Research, China.