2010-04-13

Instructional Readers: Teaching Content through Vocabulary

Rachel E. Wood
Brigham Young University - Provo

Instructional Readers: Teaching Content through Vocabulary

Rachel E. Wood

A project submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Arts

Dee Gardner, Chair
Dan P. Dewey
Neil J. Anderson

Department of Linguistics and English Language

Brigham Young University

August 2010

ABSTRACT

Instructional Readers: Teaching Content through Vocabulary

Rachel E. Wood

Department of Linguistics and English Language

Master of Arts

This project resulted in the creation of a prototype for a new book series entitled *Instructional Readers* that will be linguistically engineered to assist English-language learners in acquiring academic and content-based vocabulary in the sciences. The development of the prototype represented a process of trial and error, with decisions firmly grounded in extensive research concerning linguistic features that assist vocabulary growth while reading. The end result, the prototype entitled *Cellular Transport,* reflects the author's best attempt to combine these features. The project write-up details the steps used in writing the prototype to aid in the creation of similar instructional readers in the future.

Keywords: Vocabulary, ESL, Graded Readers, Leveled Readers, Frequency

AKNOWLEDGEMENTS

Without the help and assistance of many parties this project could not have become a reality. Special thanks to my committee chair, Dr. Dee Gardner, for his helpful insights and guidance throughout the writing process. The other two members of my committee, Dr. Neil J. Anderson and Dr. Dan Dewey, also provided valuable feedback. In addition, my husband Ryan deserves special mention for his constant support and unfailing technical know-how. Lastly, thank you to the content experts, Louis Mazzella and Nicholas Pritchett, who reviewed the reader developed for this project.

TABLE OF CONTENTS

ABSTRACT……………………………………………………………………………ii

ACKNOWLEDGEMENTS……………………………………………………………iii

TABLE OF CONTENTS…………………………………………………………………iv

LIST OF TABLES………………………………………………………………………v

CHAPTER ONE: INTRODUCTION…...……………………………………………...1

CHAPTER TWO: PROJECT PHASES...…………………………………………….8

Phase 1: Gathering Electronic Sources……..………………………………….....8

Phase 2: Selecting a Topic…………………………………………………………11

Phase 3: Determining Target Vocabulary………………………………………..12

Phase 4: Creating Linguistically Engineered Text ………………………………14

Phase 5: Creating Supplemental Materials………………………………………21

Phase 6: Reviewing Content...……………………………………………………...24

Phase 7: Designing Layout & Printing……………………………………..…24

CHAPTER THREE: FINAL PRODUCT……………………………………………..26

REFERENCES…………………………………………………………………………34

APPENDIX A: Steps in Creating an *Instructional Reader*………………………….............37

APPENDIX B: Biology Textbooks………...…………………………………………38

APPENDIX C: Frequency List—Types Found in the AWL…………….....……………………39

APPENDIX D: Frequency List—Content Words……………….……………………………42

APPENDIX E: Frequent Multiword Items.......……………………………………………45

APPENDIX F: Biology Teacher Questionnaire……………………………………………46

APPENDIX G: Student Questionnaire………..……………………………………………47

APPENDIX H: *Cellular Transport* Prototype...48

LIST OF TABLES

Table 1: Twelve Biology Textbooks Reviewed……………..……………………………….…..9

Table 2: Readability Scores for One Cellular Transport Chapter……………………………….….10

Table 3: Original Range Percentage for Prototype……………………………….…………...18

Table 4: Adjusted Range Percentage for Prototype.………..………………………………....18

Table 5: Range Percentage for Biology Textbooks…………………….…..……...…………....19

Table 6: *Instructional Readers* Compared to Similar Products.…………………...…………....29

CHAPTER ONE

Introduction

Lexical knowledge is one of the most important aspects of second language acquisition. Wilkins (1972) stated that "while without grammar very little can be conveyed, without vocabulary *nothing* can be conveyed" (p. 111). However, vocabulary is also one of the least explicitly taught skills in ESOL and mainstream content classrooms, as many teachers and researchers believe that vocabulary can be primarily learned implicitly through extensive and meaningful input (Hulstijn, 1988). One method for gaining this input is through reading.

Many secondary school teachers in mainstream classrooms rely on implicit vocabulary learning, and this approach seems to be appropriate for native English-speaking students. Research has shown that the average native-speaking student acquires 2,000–3,000 new words a year, leading to a 40,000-word lexicon by the end of high school (Nagy & Herman, 1987). This approach, however, can prove disastrous for a struggling non-native English speaker. There is a clear distinction between how conversational vocabulary and academic, content-specific vocabulary items are acquired by ELLs. Basic interpersonal communications skills (BICS) are acquired through social interaction (Cummins, 1999). Since this language is mostly developed on the playground with friends, acquired vocabulary tends to be peer-appropriate. The type of extratextual and thematic knowledge that is needed when reading fiction is developed along with BICS. This type of vocabulary takes approximately two years for ELLs to acquire and use proficiently (Cummins, 2000). Cognitive academic language proficiency (CALP), on the other hand, takes ELLs 5–10 years to acquire (Cummins, 2000). Learners receive little input of academic language outside of the classroom. In addition, ELLs in secondary school generally do not have the extratextual or thematic knowledge necessary to start reading texts that require

CALP; they have no basis to begin gleaning meaning of unknown words from context. Because of this, immigrant students are often left far behind native-speaking students (Cummins, 2000).

This problem is compounded in mainstream classes that require highly specialized and technical language, especially in the sciences. Research has shown that ESL secondary school students often struggle in science more than in any other subject, much more than their native English-speaking peers (Case, 2002; McKeon, 1994). These learners must learn complex science content while they are still learning English. Their struggle in science is in large part due to the high frequency of technical language used in secondary school science texts, including words that have one meaning in common use and a specialized meaning in science and words that represent complex concepts. Additionally, there is a lack of language instruction or vocabulary support provided in this area (Solomon & Rhodes, 1995).

Few materials have been developed to assist struggling ELL readers in the content areas, and even fewer incorporate the linguistic components necessary for learners to expand their mental lexicons through reading. Most of the readers available to ESL students often focus on fiction, are simplifications of existing scientific texts, or are original, focused-content readers on scientific topics that use BICS and introduce limited scientific terminology. There are few materials that foster CALP, particularly in the sciences, on the market. Nation and Wang (1999) have called for materials developers to make a distinction between materials meant for BICS and materials meant to foster CALP and for the development of content-specific readers.

In general, there have been a few types of readers made available to assist struggling readers, namely graded readers, leveled readers, simplified texts, and focused-content readers. Graded readers are original texts designed to build on existing lexical knowledge, introducing new vocabulary slowly over time and across many texts. They generally focus on fiction and the language of BICS, ranging between the 300- and 3,000-word vocabulary range (Nation & Wang, 1999). They do provide valuable practice for beginning ELL readers who are acquiring BICS but little practice for readers who need to acquire CALP. They often are not equipped with tools that promote implicit or explicit vocabulary learning. While they do provide simplified vocabulary, they are generally stripped of the syntactic richness that allows readers to make connections and assumptions about the content or about unknown words from context (Yano, Long, & Ross, 1994). The simplified vocabulary that is provided is not repeated enough times within few enough texts to foster significant vocabulary growth at a fast pace. Research shows that learners would have to read one graded reader every week for a year, or read for 50 hours total, in order to encounter individual words enough times for significant vocabulary acquisition (Nation & Wang, 1999). When this extensive reading is done, it is possible for ELLs to gain 150–300 new words per year (Waring & Nation, 2004). While graded readers can provide input to improve reading fluency and for minimal vocabulary growth, this vocabulary growth is insufficient when compared to the 2,000–3,000 words a year learned implicitly by native English speakers. Nation and Wang (1999) conclude that graded readers are not equipped to teach words when they first appear, which leaves them largely inadequate for use in a secondary school situation where ELLs must acquire needed language quickly if they are to keep pace with their native English-speaking peers. More importantly, the small lexical gain an ELL may attain from reading graded readers would most likely add to their BICS, not their CALP.

Another approach to aid struggling readers is leveled readers. Unlike graded readers, these texts offer both fiction and nonfiction varieties. They are authentic texts at various levels of difficulty, generally progressing from more simple to more challenging texts. Different developers rely on different formulas and criteria for leveling texts. Some text progressions are based on readability formulas; others rely on criteria related to multiple aspects such as predictability, formatting, and content; and some rely on letter-sound relationships (Brabham & Villaume, 2002). Leveled texts can also vary in their degree of progression. Some leveled texts estimate grade-level proficiency (e.g. Grade 5), while others progress more slowly at smaller increments (Brabham & Villaume, 2002). For example, some leveled series have as many as 27 levels (LearningA-Z.com, 2010). This allows learners to increase their reading proficiency in smaller steps regardless of their grade level. With their many features and topics, leveled readers can be a valuable tool for developing literacy in the L1; they give elementary school teachers the freedom to provide appropriate texts to students of varying proficiency within the same class (Brabham & Villaume, 2002). As a tool for ELLs in secondary school, however, leveled readers are also lacking. Most leveled readers are only offered for grade levels K–6; they do not provide the content or language required in secondary school settings. Like graded readers, leveled readers rely on existing lexical knowledge and build reading proficiency over time with many texts. Because leveled readers aim to provide texts with vocabulary already known by the learner at each level, their primary focus is building reading fluency, not vocabulary acquisition. However, ELLs struggling in mainstream classrooms may require a tool that can help them achieve grade-level proficiency and vocabulary in a relatively short time frame.

Another type of material available to ELLs includes simplifications of existing texts and topics. These texts use simple synonyms and simplified syntax with the aim of making the content easier to comprehend. Ironically, studies have shown that elaboration (adding words) is often more effective in aiding ELLs' comprehension (Oh, 2001). Simplifications often delete valuable redundancies or additional information deemed superfluous in an attempt to make reading easier, but these simplifications are often detrimental to readers' comprehension. The greater amount of syntactic detail in elaborated, or unmodified, texts provide more clues for learners to infer meaning (Yano, et al., 1994). While it has also been suggested that lexical simplification of texts should be considered in its own right (Gardner & Hansen, 2007), simplification may also have the downside of not exposing ELLs to new terms vital to learning content in English.

A final type of text that is gaining more prevalence on the market is focused-content readers. These are readers written specifically for ELLs, and they focus on academic content such as science, history, and math. These texts are valuable resources that can assist ELLs in comprehending difficult concepts. While little research has been done using these texts, an overview of available focused-content readers on scientific topics revealed both strengths and limitations to these types of readers as well. For example, these readers generally contain simplified prose on topics relevant to secondary school classrooms that may be easier for ELLs to comprehend. On the other hand, these readers often lack linguistic elements that may further assist reading comprehension and vocabulary growth. A more in-depth discussion of existing focused-content readers will be provided later in this paper. The aim of this project, therefore, is to expand the idea of focused-content readers to include linguistic components that assist reading comprehension and academic and content-specific vocabulary acquisition.

Of the four text approaches discussed, none provides a full range of features or content necessary to promote academic or content-specific vocabulary growth in ELLs. There is still a gap to be filled. A new book series entitled *Instructional Readers*, which is at the heart of the current project, is being developed in response to this gap and to Nation and Wang's (1999) call for content-specific materials meant to foster CALP. *Instructional Readers* is a book series linguistically engineered to foster ELLs' academic vocabulary growth in different content areas, specifically the sciences, at the secondary school level. This series attempts to bridge the gap between the social language the students have and the academic language they must achieve. The books bridge this gap through the many linguistic features incorporated in their creation that support academic vocabulary growth and reading comprehension. This unique combination of linguistic features is not evident in readers currently on the market.

The target audience for *Instructional Readers* is secondary school ESL students, or ELLs, and any ESOL student working toward eventual admission to an English-speaking university. Because these readers focus on content-based and academic language, this project assumes that these learners have already been exposed to some English texts and have obtained basic interpersonal communications skills, including a basic command of the most frequent 2,000 English words from West's (1953) General Service List (GSL).

Each book in the series will eventually cover a small aspect of biology, physics, chemistry, or environmental science. Topics may include cellular transport, photosynthesis, ecosystems, and much more. Each topic will be carefully chosen by surveying national academic standards and by reviewing mainstream textbooks. This will ensure that each topic in the series will have ecological value in secondary school science classes. For this MA project, a prototype for a biology reader that focuses on cellular transport has been created.

The following phases detail the developmental process of the series prototype *Cellular Transport*. This represents an exploration of creating both the process and the criteria for the prototype and series, a process based both on substantial research and trial and error. A comparison of the prototype against existing biology texts and similar ESL materials is then included, followed by qualitative feedback from experienced secondary school science teachers, an ESL content teacher, and current ELLs concerning the efficacy of the book. Finally, a succinct table is provided that summarizes the steps and criteria that can be followed in creating a similar product (see Appendix A).

CHAPTER TWO

Project Phases

The following phases detail the steps taken to create the series' prototype *Cellular Transport.* These steps are summarized in a table in Appendix A, which may be used to create similar instructional readers.

Phase 1: Gathering Electronic Sources

Finding Texts

In order to have a broad sampling of the language used in academic texts, eight textbooks containing the topic of cellular transport were collected at the target grade levels (9–12). Originally, twelve texts were obtained; however, after reviewing their language, four texts were not used because they were either deemed too advanced for a secondary school text or because multiple texts were written by the same author (see Table 1). The eight biology textbooks that were analyzed were written for and marketed to secondary schools. They claim to be appropriate for grades 9–12, since different schools teach biology at different grade levels.

The eight texts analyzed for this project were produced by four different publishers and represent the work of 26 different authors. These texts were selected because they are currently produced by the leading education publishers in the country (see Appendix B). This ensures that standard science, or biology, topics are found in each textbook and will, therefore, be found in most secondary school biology classrooms. The chosen textbooks were also written by different authors. Authors tend to use the same type of language between texts (Hoover, 2003). In addition, these authors often copy content directly from chapters in one textbook for use in another. Multiple texts by the same author, therefore, were not ideal for analyzing vocabulary across a content area due to the lack of natural variance in the language. Using texts from multiple authors accounted for variance in the language, but it also allowed for identification of vocabulary used consistently between texts and authors in the content area. By extension, this language represents the most valuable language the students could learn in this topic area.

Table 1: Twelve Biology Textbooks Reviewed

Bailey, D., Enger, E. & Ross, F. (2009). *Concepts in Biology, 13th Edition.* New York, NY: McGraw-Hill Higher Education.
Berg, L. R., Martin, D. W. & Solomon, E. P. (2008). *Biology, 8th Edition.* Belmont, CA: Brooks Cole.
BSCS. (2006). *Biology: An Ecological Approach.* Dubuque, IA: Kendal/Hunt Publishing Company.
Campbell, N. A., Dickey, J. L., Reece J. B., Simon, E. J. & Taylor M. R. (2009). *Biology: Concepts and Connections, 6th Edition.* New York, NY: Prentice Hall.
DeSalle, R. & Heithaus, M. R. (2008). *Biology.* Austin, TX: Holt, Rinehart and Winston.
Evers, C., Starr, C., Starr, L. & Taggart, R. (2009). *Biology: The Unity and Diversity of Life, 12th Edition.* Belmont, CA: Brooks Cole.
Hertz, P. E., McMillan, B., Russell, P. J., Starr, C. & Wolfe, S. L. (2008). *Biology: The Dynamic Science.* Belmont, CA: Brooks Cole.
Hopson, J. L. & Postlethwait, J. H. (2009). *Biology.* Austin, TX: Holt, Rinehart and Winston.
Johnson, G., Losos, J., Mason, K., Raven, P. & Singer, S. (2008). *Biology, 8th Edition.* New York, NY: McGraw-Hill Higher Education.
Levine, J. & Miller, K. (2007). *Prentice Hall Biology.* New York: NY: Prentice Hall.
Nowicki, S. (2008). *Biology.* Tornoto, Canada: McDougal Littell.
Starr, C. (2008). *Biology: Concepts and Applications, 7th Edition.* Belmont, CA: Brooks Cole.

Highlighted texts were not used.

The eight texts were written in a highly academic register. The readability of one chapter on cellular transport from one of the eight biology textbooks was calculated to get an idea of how difficult the text may be for ELLs in secondary schools to comprehend. Only one chapter was used to determine readability because analysis of word frequency, which will be discussed later, revealed that the eight texts were comparable in word usage and frequency and, therefore, would yield similar readability scores. Readability scores indicate how easy or difficult a text is, and they assign a grade level where the given text may be appropriate for native English-speaking learners (Child, 2009). According to a variety of readability scores, the average readability of the cellular transport chapter was 12.16 (see Table 1). A grade level score of 12.16 would be difficult for many native English-speaking students, and especially problematic for ELLs.

Table 2: Readability Scores for One Cellular Transport Chapter

Flesch-Kincaid Grade Level	11.10
Gunning-Fog Score	13.70
Coleman-Liau Index	14.80
SMOG Index	10.50
Automated Readability Index	10.70
Average Grade Level	**12.16**

(addedbytes.com/code/readability-score/)

The books ranged between 900 and 1,200 pages and 25 to 30 chapters, with each chapter containing approximately 30 pages, 9,500–15,000 tokens (running words), and 1,500–2,500 different types (different words). Each chapter covered a different topic in biology, such as cell structure, photosynthesis, matter and energy, and ecosystems.

Creating Electronic Files

Both physical and electronic texts were used. Physical texts were obtained from public schools in Utah and New Jersey and from the Harold B. Lee Library at Brigham Young University and scanned into .txt format using OmniPage. Electronic texts were purchased from iChapters.com when possible..

As a side note, the electronic texts did not provide any advantage over scanning physical texts, and in some ways they were more inconvenient, as they could only be viewed with a special program called Oracle IRM that had to be downloaded with the text. This program did not allow the user to convert the files into PDF or text files. The only solution to this was printing the desired chapter, scanning the paper copy into OmniPage, and creating a text file in that program.

Phase 2: Selecting a Topic

There was a large amount of overlap between Phases 1 and 2. A first step in selecting the topic for this project's prototype was to examine national and state standards for education in the sciences. This proved to be highly inefficient. Although the U.S. Department of Education (1997) stated that "all states and schools will have challenging and clear standards of achievement and accountability for all children, and effective strategies for reaching those standards" (p. 1), many standards at the state level were either incomplete at the time of this research or too general.

A more efficient process of selecting a topic was examining the collected biology textbooks. Mainstream textbooks from the leading education publishers all covered the same topics, almost in the same order. Topics were only considered for the prototype if they were covered in each of the eight mainstream biology texts to ensure that ELLs in most secondary schools would encounter that topic. The original topic chosen for this project was "cells."

Once the topic was selected, the text files on that topic were analyzed to see if the scope of the topic was appropriate. The files were run through Paul Nation's Range program (Nation, 2007). This program counted the different words (types) and word repetitions (tokens) found in each text and separated the vocabulary into words found in the General Service List of English words (GSL), the Academic Word List (AWL), and words not found on either list (content words). These results were pasted into an Excel spreadsheet to be analyzed. The AWL words and the content words were the focus of this project because it was assumed that the ELLs using the reader have acquired BICS and, therefore, the words in the first two base lists of the GSL. However, words from the GSL with specialized content meanings were also identified. This process will be discussed in greater detail later. In the main, the words not found on any list represented the content words in the texts. Because of the size of the texts being analyzed, words in these two lists were considered important if they appeared in five of the eight texts and appeared at least 20 times overall (see Appendices C & D). These had the potential to become target words for the new reader. While these guidelines assisted the process of selecting target words, there was some subjectivity in the words chosen. Factors such as the words' importance to creating meaning, their even distribution between texts, and the ease with which they could be defined were also taken into account.

This analysis process with the chapters on the general topic of "cells" resulted in 101 important words, or types, from the AWL and 229 important content words. This was too many target words for the scope of a reader of approximately 15–20 pages, requiring further paring down of the chosen topic. This process led to the selection of the subtopic "cellular transport" for the prototype reader. The analysis process with the chapters on cellular transport produced more manageable results, with 17 important words from the AWL and 35 important content words not found on any of the high frequency lists, and representing key concepts of the topic.

Phase 3: Determining Target Vocabulary

As mentioned previously, the target vocabulary words from the AWL and content word list were selected to be featured in the prototype reader based on their frequency in the eight biology textbooks. However, frequency was not the only factor in selecting target vocabulary.

The cumulative percentage was calculated for the words on both lists based on their overall frequency. The word "cell," for example, occurred 573 times within the eight texts, and of the more than 750 different content words, "cell" accounted for 13 percent of the occurrences of these words in the texts. In fact, the top 18 words on the list comprised just over 50 percent of the occurrences of such words based on cumulative frequency. With the AWL, only 15 words (out of 277) comprised just over 50 percent of the total occurrences of AWL words in the texts. Therefore, these few content and academic words were deemed the most valuable for ELLs to acquire to comprehend a chapter on cellular transport. Thus, it became a goal to incorporate at least 50 percent of the words (based on frequency) from these two lists as target vocabulary in the reader, including different words beyond this percentage if the topic required and if space allowed.

Another consideration was multiword items. The word “cell” was a high-frequency word, but it was found both alone and in nominal compounds such as “cell wall,” “cell membrane,” and “red blood cell.” The most effective way to find these compounds was to run the original texts through the kfNgram program (Fletcher, 2007), which identified chunks of two or more words based on the specifications entered into the program (see Appendix E). The resulting list of multiword items was then analyzed to determine which were the most frequent and essential to comprehending the text. These items each had their own specialized meanings that would not be clear from knowing the meaning of the individual words comprising the items. Thus, these high-frequency compounds were treated in the reader as target vocabulary with their own meanings.

Although words from the GSL, which is comprised of two 1,000-word lists, were generally not used as target words, it was important to review the words in that list to determine whether any of them had a specialized meaning that might be pertinent to the content area. For example, the word “solution” appeared in base list two of the GSL. “Solution” does have a specialized meaning in the context of cellular transport; it signifies a liquid that has been mixed with a solid, as opposed to its more common usage, “an answer to a problem.” ELLs must understand this specialized meaning to comprehend the text. “Solution” was also a high frequency word on base list two. For these reasons, it was considered as a target word in the reader.

Finally, word families were also compiled to verify whether frequency rankings were influenced by word family repetitions, or tokens, with word family being operationalized as a base form with its inflectional and transparent derivational family members. Examples of word families from the content word list included “cell,” “cells,” and “cellular,” and “diffuse” and “diffusion.” The Range program compiled a word family list for the AWL words automatically, and word families for the content words were determined manually in Excel using an alphabetized listing of words. After analyzing these word families, it was concluded that they did not greatly influence word frequency rankings. For the most part, the high frequency word families correlated with the individual high frequency words, or types, and this process did not result in changes to the target words included in the reader.

Phase 4: Creating Linguistically Engineered Text

Incorporating Linguistic Knowledge

The text of *Cellular Transport* is completely unique, not a simplification of original texts. One of the main focuses of writing the text was to make target vocabulary more salient and easier to understand and to acquire. The first consideration in obtaining this goal was to provide contexts that aid guessing word meaning from context. Beck, KcKeown, & McCaslin (1983) define four types of contexts on a cline of usefulness to readers when guessing meaning of unknown vocabulary:

1. Misdirective contexts
2. Nondirective contexts
3. General contexts

4. Directive contexts

Misdirective contexts can actually direct readers to incorrect meanings of unknown words and are almost never beneficial for incidental vocabulary learning. Nondirective contexts are neutral in directing readers to meaning—they essentially give no clues to the meaning of unknown words. General contexts provide enough clues for readers to be able to place an unknown word in a general category, but not enough to come to a conclusive meaning. Finally, directive contexts contain clues around an unknown word that point readers directly to the word's correct meaning (Beck et al., 1983). Directive contexts are the most useful for determining meaning of unknown words within natural prose. However, there is a fifth type of context useful for determining meaning of unknown words—pedagogical contexts. Pedagogical contexts are similar to directive contexts; the difference is that, while directive contexts occur naturally in writing, pedagogical contexts are constructed with an instructional aim in mind (Beck, et al., 1983; Gardner, 2007).

Since pedagogical contexts are specifically written with clues to assist vocabulary acquisition and to point to a word's specialized meaning, this type of context was written surrounding each content-based target word. This occurred the first time each target word was introduced in the reader. An example of this feature within the reader occurs around the target word "cell":

Cells *are the smallest working units of life. All living things are made of cells.*

Here the word "cell" is essentially followed by a definition and additional information that points to the word's meaning. This feature makes it more likely that students will understand the meaning of a target word the first time it is read (Beck et al., 1983; Gardner, 2007). In addition, target words were bolded the first time they appeared in the text in order to make them more salient to the learner.

Target words from the AWL, on the other hand, were not purposefully embedded in pedagogical contexts. These words are not often found in text that points to their meaning, and providing their definitions in context can disrupt the flow of the text and create unnatural contexts. Vocabulary from the AWL, such as “function” and “occur,” can be found across genres, and it was assumed that this vocabulary will naturally be encountered by learners more often than content-based vocabulary. Therefore, these target words were bolded the first time they appeared in the reader, and they were defined in the reader’s glossary, but they were not presented within pedagogical contexts with the exception of a few instances where simple definitions did not impede the flow of the text.

Another feature that assists learners in noticing and learning target vocabulary is repeating the words multiple times throughout the text. Waring and Nation (2004) define two levels of vocabulary knowledge. The first level of lexical knowledge, the form-meaning relationship, is the ability to connect a word’s spelling with its definition. The second level is attaining all additional knowledge necessary to have full command of a word. Both levels of lexical knowledge require repeated exposure to words in context over time (Waring & Takaki, 2003). According to research, target words must be repeated throughout each text at least 6–10 times, or more, to provide students with multiple exposures to each word; this repetition helps students notice and acquire the words (Jenkins, Stein, & Wysocki, 1984; Saragi, Nation, & Meister, 1978). Reading these words in different contexts within a short time period offers learners better opportunities to garner word meaning and usage. Unlike graded readers, where learners have to read a book every week to encounter vocabulary enough times to acquire new words, *Instructional Readers* incorporate each target word at least six times within one text—enough times to foster much faster vocabulary growth.

In order for learners to be able to guess the meaning of unknown words from context, regardless of the type of contexts the words are found in, learners must already have a certain level of existing vocabulary knowledge. Research has shown that 95–98 percent word knowledge of any given text is vital for reading comprehension (Carver, 1994; Laufer, 1989 & 1992; Liu & Nation, 1985; Nation, 2001). To encourage readers to guess the meaning of target words from context, and to help them comprehend the text as a whole, the goal of this project was that at any given time in the reader, 95–98 percent of the words could be assumed known and only 2–5 percent would be unknown target words. The words assumed known were derived from the 2,000 most frequent words in the GSL, the more basic language that ELLs in public schools are generally able to acquire first.

Because target words must be repeated at least six times in the text, the goal of reaching 95–98 percent words known proved challenging, and some assumptions were made. Based on the research that claims that 6–10 repetitions of a word is enough for a learner to know a word, it was assumed that after a word was repeated six times within the reader, it became known, and new target words could be introduced. Target words continued to be used beyond 6–10 times whenever possible after they were assumed known. This system of gradually adding new target words results in a reader that becomes relatively more lexically dense as the text progresses, but allows the learner to build on newly acquired topic vocabulary, a process that potentially could form a bridge to more difficult biology textbooks. This process created problems when attempting to calculate the percentage of known versus unknown words in the reader. When the text was run through the Range program, the program counted each instance of a target word as an unknown word. This produced a high instance of unknown words because target words were repeated so frequently within a short text.

To adjust this calculation, it was necessary to manually calculate the percentage of words known by tallying the number of times a target word was considered an unknown word versus a known word. Thus, a target word that appeared up to six times was considered unknown, and the word was considered known for all of the instances beyond six. The number of times the word was considered known was then added to the words assumed known from the GSL, and the percentage was recalculated. The difference was substantial. Before the original calculation was adjusted, the Range program indicated that 27.87 (9.82 percent AWL and 18.05 percent content words) percent of the total words in the reader were assumed unknown, or from the AWL and content lists (see Table 2). Once adjustments were made, however, it was revealed that only 9.72 (4.34 percent AWL and 5.38 percent content words) percent of the words in the reader were unknown (see Table 3). Another weakness in calculating percentages using Range included the program's inability to count the multiword items that were deemed important target vocabulary.

Table 3: Original Range Percentages for Prototype

Word List	Tokens	%	Types	%
General High Frequency (GSL)	1447	72.12	230	83.03
Academic High Frequency (AWL)	197	9.82	23	8.3
Content	362	18.05	24	8.66
Total	20620		277	

Table 4: Adjusted Range Percentages for Prototype

Word List	Tokens	%	Types	%
General High Frequency (GSL)	1447	72.12	230	83.03
Academic High Frequency (AWL)	**87**	**4.34**	23	8.3
Content	**108**	**5.38**	24	8.66
Assumed Known	**369**	**18.39**		
Total	20620		277	

These numbers were not ideal compared to the original goal of obtaining 95–98 percent words known. However, they were far superior to the coverage found in a standard secondary school biology text. Results from the Range program indicated that the average words assumed unknown between the eight biology texts analyzed was 29.86 (8.50 percent AWL and 21.36 percent content words) percent (see Table 4), a seemingly impossible reading task for most ELLs without substantial assistance.

Table 5: Range Percentages for Biology Textbooks

Word List	Tokens	%	Types	%
General High Frequency (GSL)	2360	70.14	1086	51.1
Academic High Frequency (AWL)	1752	8.5	274	12.89
Content	4405	21.36	265	36
Total	8517		2125	

Moreover, the reader is intended to be somewhat challenging. Lukens (2003) states that authors of simplified nonfiction often condescend to students by “oversimplifying, thinking of the readers as dear little things, or guarding their ears from the whole truth” (p. 290). *Instructional Readers*, on the other hand, offer an age- and subject-appropriate approach to complex science topics through challenging, yet potentially more attainable, language.

Writing & Revising

The process for writing the body of the reader was largely a top-down process. During the writing process, the original biology texts were referenced to ensure that the content was correct and that target vocabulary was used around other appropriate target vocabulary. Target words were used as many times as possible, surrounded only by words assumed known, before a new target word was introduced. The first time each target word was used, it was used in a sentence that provided a pedagogical context. All relevant information pertaining to the target word was included at this point.

Once a rough draft was complete, the text was revised. The text was run through the Range program. This counted the number of times each target word appeared in the text. If a word was not used at least six times, more text was written to incorporate that word in appropriate contexts. Results from the Range program also revealed whether any non-target words were used that were not found on the GSL. Any non-target, unknown words were then replaced with words found on the GSL. This improved the percentage of assumed known words in the text and increased readability. If the percentage of known words was too low, it was considered whether any target words were repeated too often and could be replaced with a known word or whether there were too many target words in general.

While making these considerations, some target words were discarded in order to improve repetition and the number of different words found in the text. Frequency in the original biology texts was considered, and the deleted target words represented the least frequent words that had been chosen for the book. Some of these terms included “structure” and “cell wall.” Another term, “ion,” was also deleted despite its high frequency because it was determined, after reviewing the original biology texts, that this term was mainly used in examples and not in explaining the actual processes of cellular transport. This term was also too cumbersome in that it did not fit well in the context of the topic and that defining the term required unknown vocabulary not included as target vocabulary. These revisions improved some of the percentages calculated in the Range program. For example, the reader originally contained 303 different words; after the revisions, it contained 277 different words, an even smaller vocabulary load for ELLs. After each revision, the text was run through the Range program again to determine whether more revisions were needed.

Phase 5: Creating Supplemental Materials

While most of the supporting research for this project promotes focus on meaning over form to support implicit learning, other research does support incorporating integrated skills and explicit teaching to enhance acquisition and to solidify new vocabulary knowledge (Elley & Mangubhai, 1981; Zimmerman, 1997). This project assumed that learners will use this book in conjunction with a teacher, tutor, or group of students. With this in mind, a generalized teacher's guide was provided in the back of the book to assist teachers and tutors in planning effective lessons based on the reader. The guide stresses the importance of frontloading vocabulary and accessing schema or developing background knowledge to assist learners in comprehending the content as they encounter target words in the text (Nation & Wang, 1999; Schmitt, 2000). All of the other features found in the reader are unique and may also be incorporated in a teacher's or tutor's lesson plan. These features provide additional vocabulary learning assistance and compensate for not reaching 95–98 percent words assumed known within the prototype's text.

Starting Points were also provided for teachers and students. This feature appears at the beginning of each section; it connects common experiences with the content to be learned. The following is a sample Starting Point from the reader:

> *Have you ever used a strainer to separate water from pasta? Why does the pasta stay in the strainer while the water moves easily through the strainer's holes? Like a strainer, the outside of a cell allows some things to move through it while keeping other things from moving through.*

Here learners are able to access a common experience and use it as a metaphor for the process they will read about. This helps to access background knowledge and allows learners to add new knowledge to what they already know.

The inside front cover of the book provides a list of target vocabulary that learners will encounter in the text. This also gives students the opportunity to preview vocabulary before they read it in the text. The inside front cover also contains vocabulary learning strategies that learners can incorporate into their learning experience to help them acquire target vocabulary faster. These strategies include saying the word out loud, using the context for clues about the target word's meaning, using a glossary or dictionary, keeping a word log, and making flash cards. Teaching vocabulary learning strategies is recommended in the teacher's guide. Graves (1987) states that "regardless of how much instruction we do in schools, students will actually do most of their learning independently. It therefore makes sense to encourage students to adopt personal plans to expand their vocabularies over time" (p. 177). Another goal of this series, therefore, moves beyond meeting learners' immediate vocabulary needs; it also aims to train students to become independent vocabulary learners.

In addition, discussion questions and activities at the end of each section in the reader are designed to help learners solidify the content they have learned and to productively use the target vocabulary. Gill (2009) stresses the importance of incorporating interactive features, such as discussions and activities, to assist learning through reading. The questions and activities in the reader were designed to elicit responses that use the target vocabulary. Following the section on passive transport, one discussion question asks:

> *What is the concentration gradient? How does the concentration gradient affect what happens during all three types of passive transport?*

This discussion question elicits a large amount of target vocabulary from the section. To produce an adequate response, learners must discuss the concentration gradient, osmosis, diffusion, facilitated diffusion, areas of high and low concentration, and more. The discussion questions are also key in determining whether a learner has comprehended the text and in assessing learners' progress and needs.

The activities provide opportunities for learners to use the target language in all skill areas—reading, writing, listening, and speaking. These activities reinforce both content and vocabulary. The activity following the passive transport section in the reader states:

> *Get a clear glass of water and some food coloring. Place a drop of food coloring in the water. Describe what happens using words you learned in this section.*

This example allows learners to experience diffusion firsthand and to interact with each other while using the new vocabulary. These activities may be expanded to incorporate more skills, such as writing a summary of the process, and additional activities may be created by the teacher or tutor using the reader. Discussion questions and activities provide opportunities for both implicit and explicit learning as learners practice their new words (Beck et al., 1983). These features may allow learners to gain more command of the target words by using them in appropriate contexts (Waring & Nation, 2004).

A glossary can also be found in the back of the book. Gill (2009) affirms that the leading non-fiction readers on the market demonstrate factual accuracy through features such as glossaries. The glossary provides yet another context for target words that learners may reference. It gives the specialized meaning of each word. Most of the definitions used in the glossary were taken or derived from the *Longman Dictionary of Contemporary English* online (http://www.ldoceonline.com/). These definitions were found to be most useful because of their clarity and simplicity; they were written using Longman's own list of 2,000 common English words. Although this list does not entirely match the GSL, these definitions were determined sufficient for the scope of this project to reduce the time it would take to create unique definitions. Definitions for target words or phrases not found at this source were revisions and simplifications of definitions found in the original biology texts.

Finally, images that portray target vocabulary were used throughout the text. These images were taken from the public domain or were used under fair use law. Carter (2000) stated that “books with carefully designed illustrations that partner with the text contribute to [students’] thinking.…Illustrations introduce core concepts necessary for understanding a topic and serve as integral portions of each book” (p. 707). Thus, the images used in the reader are directly related to the adjacent text. Captions beneath the images solidify information found in the text, repeat target vocabulary, and give learners a visual representation of what they are reading about, supporting conceptual and vocabulary development.

Phase 6: Reviewing Content

Before the reader was taken to press, it was reviewed by content experts. A content expert was defined as someone, usually a professor or teacher, who has studied and researched the topics in the reader. Gill (2009) noted that the leading non-fiction readers on the market showed evidence of consulting with experts on the given subject. The content expert ensured that the information in the reader was accurate. This was essential since the author of the reader was not an expert in the content area, despite having read eight or more chapters on the subject, and this process gave credibility to the work. Two biology teachers from North Hunterdon High School in Annandale, New Jersey, Louis Mazzella and Nicholas Prichett, acted as content experts for the prototype. Their feedback affirmed that the information in the reader was factually sound.

Phase 7: Designing Layout and Printing

The reader was designed in InDesign. Compared to QuarkXPress, InDesign provides many more functions and design capabilities and is the industry standard for layout design. The layout of the reader is just as important for comprehension and learning as the linguistic aspects of the text (Gill, 2009). Each of the reader's features is presented in a logical order throughout the book. Vocabulary is previewed on the first page, a table of contents directs the learner to appropriate topics, *Starting Points* access background knowledge before a section starts, images are provided adjacent to relevant topics, and there is a review at the end of each section. Each feature in the reader is pertinent to where the learner is in the reader and to leading the learner through a logical and pedagogically sound progression of learning. In addition, the colors, images, layout, and typefaces all contribute to a reader "designed to engage today's visually oriented learners" (Moss, 2003, p. 12).

The reader was also carefully edited and proofread, and, finally, sent to press. The InDesign file was collected for output and saved as a PDF. When taken to press, an 80lb paper weight and white color were selected, along with binding and trim options. The PDF was taken to the press at least two weeks before the final printed copy was needed, giving the project creator time to check proofs and ensure that the final product looked as intended.

A summary of the above phases and procedures is succinctly outlined in Appendix A, which could serve as a guide to develop future readers of this nature.

CHAPTER THREE

Final Product

The final product was a 9" x 6" booklet containing 11 pages of text and 22 pages total, including the cover and other features. The small size of the reader was also important to the overall product. A small reader is far less intimidating than the thick biology texts students receive in secondary schools. The small size and length of the reader may be motivating for ELLs. In order to gain a substantial amount of vocabulary from context, learners must posses a high amount of intrinsic motivation. Nation and Wang (1999) argue that vocabulary knowledge is only one of many important factors that affect reading and learning from reading. One of the other important factors includes the learner's interest in the book being read (Nation & Wang, 1999). The size and design of the reader may add to learners' interest in the book and topic. The short book represents a doable task, one learners can begin with an end in sight. Completing the readings and activities associated with the readers can leave struggling learners with an important sense of accomplishment and motivation to continue learning a subject that was previously inaccessible to them. Overall, these bite-sized readers may reduce the affective load often created when ELLs attempt to negotiate a traditional biology text.

Instructional Readers Compared to Traditional Biology Texts

As discussed previously, the eight biology textbooks analyzed for this project were long, lexically dense texts with 9,500–15,000 running words and 1,500–2,500 different words in each chapter. Comparatively, the *Cellular Transport* reader contained only 11 pages of content-based text, half that of a single chapter in a standard biology textbook. While the reader's text does contain 2,006 running words, there are only 277 different words, or types—a far more manageable vocabulary load for learners trying to acquire vocabulary. This number also demonstrates how often the target vocabulary is repeated. Although this is a more manageable text for ELLs, it is recognized that much detail is lost in exchange for a more readable text. Learners will not learn every aspect of the concepts and processes presented in these readers. Traditional biology textbooks do have an advantage in this area; they provide more robust information on the given topics. Therefore, these readers are proposed as transitional tools that can lead to the comprehension of mainstream texts. As target vocabulary builds upon itself in the reader, the reader becomes denser and more similar to a traditional biology text. This progression may help ELLs transition to reading mainstream texts.

There are few linguistic elements found in traditional biology texts that assist comprehension or vocabulary development. Only a few words are previewed at the beginning of each chapter. Key vocabulary is usually bolded within the text, but parenthetical definitions or other types of aides such as pedagogical contexts are only rarely provided. Helpful contexts may be more accurately described as directive contexts, as vocabulary teaching is not the goal of these textbooks; the goal is to teach science concepts. These bolded words do not necessarily reflect the most frequent or useful words for comprehending the text and are, thus, less important for learners to know. The textbooks are lexically dense, and important vocabulary is surrounded by more difficult vocabulary. Based on observation, unknown vocabulary is generally not surrounded by vocabulary that is assumed known.

Some linguistic elements that are helpful in these biology texts include glossaries and word repetition. English-only glossaries are provided at the end of each textbook, which can be very helpful to learners, assuming learners can comprehend the provided definitions. In addition, some words are repeated throughout the given chapters. This is evident in the high frequency words identified in the Range program. The repetition can give learners valuable exposure to key words, providing opportunities to notice and acquire these words. However, word repetition cannot be considered in its own right; the presence of helpful contexts is key to garnering meaning from context.

In contrast, the many linguistic elements found in *Instructional Readers* may make reading comprehension and vocabulary acquisition easier for learners. Target words were chosen based on a frequency count of words in eight biology textbooks. The words targeted in the series are the most important for students to know in a mainstream classroom. To make it easier for readers to guess the meaning of target words from context, a high percentage of the words are assumed known, and, although the original goal was to have only 2–5 percent unknown target words at any given time to help students to comprehend the subject matter of the texts (Carver, 1994; Hu & Nation, 2000), 9.72 percent are unknown target words. This percentage of unknown words is an improvement from the 29.86 percent unknown words in the biology textbooks. In addition, target words are repeated throughout each text at least six times to provide students with multiple exposures to each word, and supplementary vocabulary learning tools have been added to close additional gaps; the repetition may help students to notice and acquire the words (Saragi et al., 1978). Finally, target words are surrounded by pedagogical contexts specifically written to point to each word's meaning (Beck et al., 1983; Gardner, 2007). This feature makes it more likely that students will understand the meaning of a target word the first time they read it.

Instructional Readers Compared to Similar Products

A number of publishers currently provide content-based materials for ELLs. After a review of these products, it is clear that these materials are valuable resources, and a number of them do incorporate helpful features, but none appear to provide the many linguistic features or

Table 6: *Instructional Readers Compared to Similar Products*

	Vocab Based on Frequency/ Real Texts	Uses Pedagogical Contexts	Repeats Target Vocab	Frontloads Vocab	Activities	Promotes Vocab Learning Strategies	Appropriate Length	Appropriate Topics
Instructional Readers	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contemporary “Science Series”	N/A	Yes	Somewhat	No	Yes	No	Yes	No
Heinemann Raintree “Freestyle Express”	No	No	No	No	No	No	No	Yes
Heinemann Raintree “Sci-Hi”	Somewhat	No	No	No	No	No	Yes	Yes
Heinle “Gateway to Science”	No	Yes	No	No	Somewhat	Somewhat	No	Somewhat
Millmark Education “ConceptLinks”	Somewhat	Somewhat	No	Yes	Yes	Yes	No	Somewhat
The Rosen Publishing Group “Rosen Classroom Books & Materials”	N/A	No	No	No	Yes	No	Yes	No

learning aids that *Instructional Readers* provide in one package. Table 5 outlines which features can be found in products currently available by publishers compared to *Instructional Readers*.

Initial Reactions of Teachers

Two secondary school biology teachers from North Hunterdon High School in Annandale, New Jersey, served as content experts. These teachers, Louis Mazzella and Nicholas Prichett, checked for factual accuracy and provided their initial reactions to the *Cellular Transport* prototype. Louis Mazzella is director of the science department at the school, teaching biology and chemistry, and Nicholas Pritchett teaches biology and AP environmental science. Although the teachers were made aware of linguistic features in the text, this was not their area of expertise, and their comments were directly related to content and layout (see Appendix F for complete questionnaire). When asked whether the text seemed easier than a traditional biology textbook, both teachers responded that the text did seem easier. Pritchett wrote that it seemed like a “text for a low-level bio class.” Mazzella also added that the “comparisons are useful and the [pictures] do aid in understanding target words.” Overall, both teachers stated that they would recommend the text to help ELLs learn science concepts and vocabulary and to get them up to grade level. Prichett stated, “I would recommend [this book] due to the fact that the text does not assume there is prior knowledge. The examples are clear and often paired with a diagram. The vocabulary is clearly displayed as well. The hard part is actually getting the students to look at a textbook, and this seems more appealing” (L. Mazzella & N. Prichett, personal communication, January 19, 2010).

Initial Reactions of Students

The *Cellular Transport* prototype was used for action research during two days that the project developer was teaching her own advanced ESL life sciences class. The class consisted of eight adult students and lasted 65 minutes. Six students spoke Spanish as a first language, one spoke Portuguese, and one spoke Japanese. Planning lessons around the reader was almost effortless, as all the necessary components or ideas of a lesson were found within the reader. Each lesson followed the basic layout and features in the reader. Vocabulary was previewed, and vocabulary strategies were discussed and implemented; students were instructed to maintain a vocabulary log while reading. Background knowledge was accessed or developed using the *Starting Points.* Through the class discussion, it became clear that the majority of the class had no prior knowledge of this topic. The activities and discussion questions were used after students read each section. Initially, the teacher intended to complete the book over two days; however, this was not adequate time to complete the entire reader. Three days would be optimal to cover all sections and to allow for adequate discussion and practice.

The reader was well received by students. After using the reader for two days, the students requested to use the reader for a third day. They asked whether there were more topics in the series and wanted to use *Instructional Readers* over their current texts. One student stated that the *Cellular Transport* reader was "not boring like our books."

The students also filled out a brief questionnaire to provide feedback on the reader (see Appendix G for complete questionnaire). When asked whether the overall design of the reader looked like a book they would want to read to learn an academic subject, students unanimously responded "yes." One student added that "the color and the pictures help to catch our attention." Most students also agreed that the pictures were helpful in understanding the concepts and words in the text, with only one student responding more hesitantly, "I guess so." Students also enjoyed the activities and discussion questions. One student commented that they provided a "good opportunity to try what we've just learned." Students were also asked about the clarity of the writing and whether the context was helpful when learning meanings of target words. Most agreed that the text was clear and that it was easier to learn new words. One student stated that he "could understand almost everything." Another gave valuable criticism, stating that the glossary was confusing because the glossary definitions were different from in the text. This was a valid concern. Future materials developers may want to consider creating a glossary with unique definitions that match the lexis with the rest of the text. For the purpose of this project, however, definitions taken from other sources saved time and were viewed as providing yet another context for the target words; therefore, the variance in the text and glossary was deemed acceptable.

Finally, students were asked whether they liked the reader for learning academic topics and vocabulary. All the students in the class responded that they enjoyed the reader. Most stated that the text was clear and easy to understand. Others commented that they were able to learn words quickly. One student wrote that "it made it easier to understand the vocabulary and the content. Good and simple ways to explain topics." Other students responded that the pictures and examples within the text were also helpful.

Based on observation, the classes using the reader were very successful. Students were engaged both with the text and with each other. Compared to previous classes during the semester that used other materials and texts, the students used more target vocabulary in their discussions while using the prototype than during any other class period where target vocabulary was introduced.

Conclusion

In conclusion, *Instructional Readers* has the potential to fill a well defined gap in the ESOL materials market. The series' unique combination of linguistic features, coupled with relevant science topics, aims to meet the immediate needs of struggling ELLs in mainstream science classrooms and can serve as a transitional tool from the social language many students already have to the content-specific language they must acquire to read mainstream science textbooks.

While the *Cellular Transport* prototype received positive feedback from both teachers and students, more quantitative research needs to be done to determine the overall effectiveness of the prototype and linguistic features utilized in the series. Future research should aim to determine how much vocabulary can be gained by using these readers and at what rate. Research should also examine how use of these readers influences reading comprehension of traditional science textbooks and overall performance and grades in mainstream science classrooms.

REFERENCES

Beck, I. L., McKeown, G. M., & McCaslin, E. S. (1983). Vocabulary development: All contexts are not created equal. *The Elementary School Journal, 83,* 177–181.

Brabham, E. G. & Villaume, S. K. (2002). Leveled text: The good news and the bad news. *The Reading Teacher, 55*, 438–441.

Carter, B. (2000). A universe of information: The future of nonfiction. *The Horn Book*, *76*, 697–707.

Carver, R. P. (1994). Percentage of unknown words in text as a function of the relative difficulty of the text: Implications for instruction. *Journal of Reading Behavior, 26,* 413–437.

Case, R. (2002). The intersection of language, education and content: Science instruction for ESL students. *The Clearing House, 76*(2), 71–74.

Child, D. (2009). Added Bytes: Check Test Readability [Software]. Available from addedbytes.com/code/readability-score

Cummins, J. (1999). BICS and CALP: Clarifying the distinction. (Opinion Papers Ed. 438551). (pp. 1–7): EDRS.

Cummins, J. (2000). *Language, power and pedagogy: Bilingual children in the crossfire.* Tonawanda, NY: Cambrian Printers Ltd.

Elley, W. B. & Mangubhai, F. (1981). The long-term effects of a book flood on children's language growth. *Directions, 7,* 15–24.

Fletcher, W. H. (2007, December 4). *kfNgram information & help.* Retrieved October 26, 2009, from http://www.kwicfinder.com/kfNgram/kfNgramHelp.html

Gardner, D. (2007). Children's immediate understanding of vocabulary: Contexts and dictionary definitions. *Reading Psychology, 28,* 331–373.

Gardner, D. & Hansen, E. C. (2007). Effects of lexical simplification during unaided reading of English informational texts. *TESL Reporter, 40,* 27–59.

Gill, S. R. (2009). What teachers need to know about the "new" nonfiction. *The Reading Teacher, 63,* 260-267.

Graves, M. F. (1987). The roles of instruction in fostering vocabulary development. In M. G. McKeown & M. E. Curtis (Eds.) *The nature of vocabulary acquisition* (pp. 165–184). Hillsdale, NJ: Erlbaum.

Hoover, D. L. (2003). Another perspective on vocabulary richness. *Computers and the Humanities, 37*, 151–178.

Hu, M. & Nation, P. (2000). Vocabulary density and reading comprehension. *Reading in a Foreign Language, 23*, 403–430.

Hulstijn, J. H. (1988). Experiments with semi-artificial input in second language acquisition research. *Language Learning and Learner Language, 8*, 207–223.

Jenkins, J. R., Stein, M. L., & Wysocki, K. (1984). Learning vocabulary through reading. *America Educational Research Journal, 21*, 767–787.

Laufer, B. (1989). What percentage of text-lexis is essential for comprehension? In C. Lauren & M. Nordman (eds.) *Special language: From humans thinking to thinking machines,* Clevedon, Avon: Multicultural Matters.

Laufer, B. (1992). How much lexis is necessary for reading comprehension? In P. Arnaud & H. Bejoint, *Vocabulary and applied linguistics* (pp. 126–132). London: Palgrave Macmillan.

LearningA-Z.com, (2010, January 24). *Hundreds of printable leveled readers to meet the reading needs of all your K–6 students.* Retrieved from ReadingA-Z.com website: http://www.readinga-z.com/guided-reading/guided-reading.php

Liu N. & Nation, P. (1985). Factors affecting guessing vocabulary in context. *RELC Journal, 16*(1), 33–42.

Lukens, R. J. (2003). *A critical handbook of children's literature* (7th ed.). Boston: Allyn & Bacon.

McKeon, D. (1994). Language, culture and schooling. In Genesee F. (Ed.) *Educating second language children: The whole child, the whole curriculum, the whole community* (pp. 15–32). New York: Cambridge University Press.

Moss, B. (2003). *Exploring the literature of fact: Children's nonfiction trade books in the elementary classroom*. New York: Guilford.

Nagy, W. E. & Herman, P. A. (1987). Breadth and depth of vocabulary knowledge: Implications for acquisition and instruction. In M. G. McKeown & M. E. Curtis (Eds.) *The Nature of Vocabulary Acquisition* (pp. 19–35). Hillsdale, NJ: Erlbaum,.

Nation, P. (2001). *Learning vocabulary in another language.* Cambridge: Cambridge University Press.

Nation, P. (2007). Range Program with GSL/AWL List [Software]. Available from http://www.victoria.ac.nz/lals/staff/paul-nation.aspx

Nation, P. & Wang, K. (1999). Graded readers and vocabulary. *Reading in a Foreign Language, 12,* 355–380.

Oh, S. (2001). Two types of input modification and EFL reading comprehension: Simplifications versus elaboration. *TESOL Quarterly, 35*, 69–96.

Saragi, T., Nation, P., & Meister, G. F. (1978). Vocabulary learning and reading. *System, 6*, 72–78.

Schmitt, N. (2000). *Vocabulary in language teaching.* New York: Cambridge University Press.

Solomon, J. & Rhodes, N. (1995). *Conceptualizing academic language,* Santa Cruz, CA: University of California, National Center for Research on Cultural Diversity and Second Language Learning.

U.S. Department of Education (1997, July 28). *The seven priorities of the U.S. Department of Education.* Retrieved from http://www2.ed.gov/updates/7priorities/index.html

Waring, R. & Nation, P. (2004). Second language reading and incidental vocabulary learning. *Angles on the English-speaking World, 4,* 97–110.

Waring, R. & Takaki, M. (2003). At what rate do learners learn and retain new vocabulary from reading a graded reader? *Reading in a Foreign Language, 4,* 130–163.

West, M. (1953). *A general service list of English words.* London: Longman, Green.

Wilkins, D. A. (1972). *Linguistics in language teaching.* London: Edward Arnold (Publishers) Ltd.

Yano, Y., Long, M., & Ross, S. (1994). The effects of simplified and elaborated texts on foreign language reading comprehension. *Language Learning, 44,*189–219.

Zimmerman, C. B. (1997). Do reading and interactive vocabulary instruction make a difference? An empirical study. *TESOL Quarterly, 31*, 121–140.

Appendix A: Steps in Creating an *Instructional Reader*

Creating *Instructional Readers*	
Phase 1: *Gathering Electronic Sources*	• Gather eight or more mainstream science textbooks. • Text should represent various authors. • Create .txt files of selected chapters.
Phase 2: *Selecting a Topic*	• Select a topic found in all gathered textbooks. • Run the .txt files of the selected chapters through Range. • Analyze the number of significant high frequency words. • Words are significant if they appear in over half the texts and at least 20 times overall. • If there are too many significant words, select a sub-topic.
Phase 3: *Determining Target Vocabulary*	• Import word lists from Range into Excel. • Sort results of each list by frequency and determine cumulative frequency. • Important high frequency words in Base List Three (AWL) and Types Not Found in Any List may become target vocabulary. • Use 50% of the significant words based on cumulative frequency. • Determine important multiword items using the kfNgram program. • Review the GSL for words with specialized meanings.
Phase 4: *Creating Linguistically Engineered Text*	• Surround target words from the Types Not Found list with pedagogical contexts the first time they appear. • Provide pedagogical contexts for words from the AWL if it does not impede the flow of the text. • Repeat target vocabulary at least six times throughout the text, and as many times as possible before introducing new vocabulary. • Aim for 95–98 percent vocabulary assumed known from the GSL. • Calculate percentage of words known in Range, adjusting for target vocabulary repeated more than six times. • Revise text until a satisfactory percentage of words assumed known is achieved.
Phase 5: *Creating Supplemental Materials*	• Include a teachers' guide that give suggestions on how to use the reader while teaching. • Starting Points before each section should access learners' background knowledge and tie into the topic. • Preview target vocabulary using lists and vocabulary strategies. • Discussion questions and activities should elicit target vocabulary. • Include a glossary using either unique definitions or definitions from the *Longman Dictionary of Contemporary English*.
Phase 6: *Reviewing Content*	• Ask content experts to review the reader for factual accuracy.
Phase 7: *Designing Layout & Printing*	• Design a colorful, visually appealing layout using InDesign. • A table of contents and other aids give organization to the reader. • Edit and proofread.

Appendix B: Biology Textbooks

Bailey, D., Enger, E. & Ross, F. (2009). *Concepts in Biology, 13th Edition.* New York, NY: McGraw-Hill Higher Education.

Berg, L. R., Martin, D. W. & Solomon, E. P. (2008). *Biology, 8th Edition.* Belmont, CA: Brooks Cole.

BSCS. (2006). *Biology: An Ecological Approach.* Dubuque, IA: Kendal/Hunt Publishing Company.

Campbell, N. A., Dickey, J. L., Reece J. B., Simon, E. J. & Taylor M. R. (2009). *Biology: Concepts and Connections, 6th Edition.* New York, NY: Prentice Hall.

DeSalle, R. & Heithaus, M. R. (2008). *Biology.* Austin, TX: Holt, Rinehart and Winston.

Hertz, P. E., McMillan, B., Russell, P. J., Starr, C. & Wolfe, S. L. (2008). *Biology: The Dynamic Science.* Belmont, CA: Brooks Cole.

Johnson, G., Losos, J., Mason, K., Raven, P. & Singer, S. (2008). *Biology, 8th Edition.* New York, NY: McGraw-Hill Higher Education.

Levine, J. & Miller, K. (2007). *Prentice Hall Biology.* New York: NY: Prentice Hall.

Appendix C: Frequency List—Types Found in the AWL

TYPES Found in the AWL	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cum Freq	Cumulative Frequency%
CONCENTRATION*	8	267	39	26	15	36	32	48	44	27	267	15.23972603
TRANSPORT*	8	205	9	9	15	26	34	47	45	20	472	26.94063927
ENERGY*	8	92	17	8	7	11	10	21	14	4	564	32.19178082
PROCESS*	7	55	10	8	10	2	9	8	8	0	619	35.33105023
FACILITATED*	7	51	4	5	6	6	7	4	19	0	670	38.24200913
AREA*	7	43	2	6	0	5	7	7	10	6	713	40.69634703
ENVIRONMENT*	6	40	7	1	0	7	4	0	20	1	753	42.97945205
PASSIVE*	7	40	2	0	5	5	4	7	13	4	793	45.26255708
REQUIRE*	7	28	3	4	0	3	5	6	5	2	821	46.86073059
CONCENTRATED*	7	27	3	9	2	3	0	1	7	2	848	48.40182648
CHANNEL*	5	24	0	4	4	10	4	0	2	0	872	49.7716895
CHAPTER	7	24	2	4	0	2	3	7	5	1	896	51.14155251
CHANNELS*	5	21	0	4	3	2	0	2	10	0	917	52.34018265
SPECIFIC*	6	20	6	2	1	4	0	0	6	1	937	53.48173516
CONCEPTS	6	18	5	2	1	0	3	5	2	0	955	54.50913242
FUNCTION*	7	18	3	3	1	1	3	4	3	0	973	55.53652968
STRUCTURE	6	18	2	7	1	1	3	4	0	0	991	56.56392694
RELEASED*	5	17	2	0	0	4	0	2	8	1	1008	57.53424658
SELECTIVELY*	7	17	6	4	1	1	3	1	1	0	1025	58.50456621
SECTION	5	16	0	2	0	3	8	1	2	0	1041	59.41780822
OCCURS*	5	14	5	0	1	3	3	0	2	0	1055	60.21689498
REGION	4	14	0	1	0	0	2	7	0	4	1069	61.01598174
REGIONS	3	14	1	0	11	2	0	0	0	0	1083	61.81506849
AREAS*	6	13	2	2	0	0	2	2	2	3	1096	62.55707763
EXTERNAL	1	12	0	0	0	0	0	0	12	0	1108	63.24200913
INPUT	5	12	3	1	0	0	5	2	1	0	1120	63.92694064
RELEASE	4	11	0	0	0	3	2	2	4	0	1131	64.55479452
REQUIRES*	7	11	2	2	1	1	2	0	2	1	1142	65.1826484
CONSTANTLY	6	10	5	1	1	0	1	0	1	1	1152	65.75342466
NORMAL	3	10	4	0	0	0	4	0	2	0	1162	66.32420091
TRANSPORTED	7	10	2	1	0	2	2	1	1	1	1172	66.89497717
MAINTAIN	5	9	1	0	0	1	4	2	1	0	1181	67.4086758
PROCESSES	7	9	0	1	1	2	1	1	1	2	1190	67.92237443
INVOLVED	3	8	2	0	0	0	0	0	4	2	1198	68.37899543
OCCUR	5	8	3	1	0	0	2	0	1	1	1206	68.83561644
SIMILAR	4	8	1	0	0	0	1	3	3	0	1214	69.29223744
TRANSPORTS	3	8	1	0	0	2	0	0	5	0	1222	69.74885845
CHEMICAL	4	7	2	1	0	0	0	3	1	0	1229	70.14840183
CONSTANT	4	7	2	0	0	0	0	3	1	1	1236	70.54794521
CONTRAST	4	7	1	0	0	1	4	0	1	0	1243	70.94748858
DYNAMIC	3	7	2	0	0	0	3	2	0	0	1250	71.34703196
INTERNAL	3	7	3	2	0	0	2	0	0	0	1257	71.74657534
PORTION	4	7	3	1	0	0	2	0	1	0	1264	72.14611872
RANDOM	4	7	0	0	1	0	3	1	2	0	1271	72.5456621
REVERSE	3	7	0	0	0	0	2	0	4	1	1278	72.94520548

TYPES Found in the AWL	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cum Freq	Cumulative Frequency%
CONCEPT	3	6	1	3	0	0	0	2	0	0	1290	73.63013699
EVENTUALLY	3	6	0	1	0	0	0	1	4	0	1296	73.97260274
RELEASES	3	6	0	0	0	3	0	1	2	0	1302	74.31506849
RIGID	5	6	1	0	0	2	1	1	0	1	1308	74.65753425
ROLE	3	6	0	0	0	0	1	4	1	0	1314	75
VOLUME	4	6	0	3	0	1	1	1	0	0	1320	75.34246575
ASSESSMENT	3	5	0	2	0	0	1	2	0	0	1325	75.62785388
CREATES	3	5	2	0	0	0	2	0	1	0	1330	75.91324201
DATA	3	5	0	1	0	2	0	2	0	0	1335	76.19863014
DESIGN	2	5	0	2	0	0	0	3	0	0	1340	76.48401826
EDITION	1	5	5	0	0	0	0	0	0	0	1345	76.76940639
EXPANDING	5	5	0	1	1	1	0	1	1	0	1350	77.05479452
FUNCTIONS	4	5	0	1	0	1	1	0	2	0	1355	77.34018265
ILLUSTRATED	3	5	0	0	1	0	3	0	1	0	1360	77.62557078
ILLUSTRATES	4	5	1	0	0	0	2	0	1	1	1365	77.9109589
PERCENTAGE	1	5	5	0	0	0	0	0	0	0	1370	78.19634703
PRIOR	1	5	5	0	0	0	0	0	0	0	1375	78.48173516
PROHIBITED	1	5	5	0	0	0	0	0	0	0	1380	78.76712329
PUBLISHER	1	5	5	0	0	0	0	0	0	0	1385	79.05251142
RANDOMLY	4	5	0	1	0	1	1	0	2	0	1390	79.33789954
TRANSMITTED	1	5	5	0	0	0	0	0	0	0	1395	79.62328767
VIOLATION	1	5	5	0	0	0	0	0	0	0	1400	79.9086758
CHEMICALS	3	4	0	0	0	0	0	2	1	1	1404	80.1369863
CONTACT	2	4	0	2	2	0	0	0	0	0	1408	80.3652968
ELEMENTS	1	4	0	0	0	0	0	0	0	4	1412	80.59360731
IDENTIFY	3	4	0	1	0	1	0	2	0	0	1416	80.82191781
MAINTAINS	3	4	1	0	0	0	2	0	1	0	1420	81.05022831
METHOD	2	4	2	0	0	0	2	0	0	0	1424	81.27853881
METHODS	3	4	1	0	0	1	0	0	0	2	1428	81.50684932
OVERALL	3	4	1	0	0	0	1	2	0	0	1432	81.73515982
PREDICTING	2	4	0	2	0	2	0	0	0	0	1436	81.96347032
PROCEDURE	4	4	0	0	0	1	1	1	1	0	1440	82.19178082
REGULATE	4	4	1	1	0	1	1	0	0	0	1444	82.42009132
REQUIRED	3	4	2	0	0	1	1	0	0	0	1448	82.64840183
SIMILARLY	2	4	2	0	0	0	2	0	0	0	1452	82.87671233
SURVIVE	3	4	2	0	1	0	0	1	0	0	1456	83.10502283
TOPIC	2	4	0	0	0	1	0	0	3	0	1460	83.33333333
ANALYSIS	3	3	0	0	0	1	1	0	1	0	1463	83.50456621
ANALYZE	2	3	0	0	0	0	1	2	0	0	1466	83.67579909
ANALYZING	3	3	0	1	0	0	0	1	1	0	1469	83.84703196
ASSIST	1	3	0	0	0	0	0	0	3	0	1472	84.01826484
CONCLUDE	2	3	0	0	0	0	1	2	0	0	1475	84.18949772
CONTRACT	1	3	0	0	0	0	0	0	3	0	1478	84.36073059
COUPLED	1	3	0	0	0	0	3	0	0	0	1481	84.53196347
CYCLE	1	3	0	0	0	0	0	0	3	0	1484	84.70319635
DESIGNING	3	3	0	1	0	1	0	1	0	0	1487	84.87442922
ESTABLISHED	1	3	0	0	0	0	0	0	3	0	1490	85.0456621
EVALUATING	2	3	0	0	0	2	0	0	1	0	1493	85.21689498
EXPOSED	2	3	0	0	0	0	1	0	2	0	1496	85.38812785

TYPES Found in the AWL	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cum Freq	Cumulative Frequency%
ILLUSTRATION	2	3	0	2	0	0	1	0	0	0	1502	85.73059361
INITIALLY	2	3	0	0	0	0	0	1	2	0	1505	85.90182648
INTERACT	2	3	0	0	0	2	1	0	0	0	1508	86.07305936
INTERACTIVE	1	3	0	0	0	0	3	0	0	0	1511	86.24429224
INVOLVES	1	3	0	0	0	0	0	0	3	0	1514	86.41552511
LOCATED	2	3	0	0	1	0	0	0	2	0	1517	86.58675799
NORMALLY	2	3	0	0	0	0	1	0	2	0	1520	86.75799087
PERCENT	2	3	1	0	0	0	0	0	2	0	1523	86.92922374
POSITIVELY	3	3	1	0	0	0	0	1	1	0	1526	87.10045662
PREDICT	3	3	0	0	0	1	1	1	0	0	1529	87.2716895
REGULATING	2	3	1	0	0	0	2	0	0	0	1532	87.44292237
RELEASING	1	3	0	0	0	3	0	0	0	0	1535	87.61415525
REMOVAL	3	3	0	1	0	1	0	0	1	0	1538	87.78538813
REMOVE	2	3	0	0	0	2	0	0	1	0	1541	87.956621
SITE	3	3	1	1	0	1	0	0	0	0	1544	88.12785388
ACADEMIC	2	2	0	0	0	1	1	0	0	0	1546	88.24200913
ACCUMULATE	2	2	0	0	0	0	0	0	1	1	1548	88.35616438
AFFECTED	2	2	1	0	0	1	0	0	0	0	1550	88.47031963
ATTACHED	1	2	0	2	0	0	0	0	0	0	1552	88.58447489
COLLAPSE	2	2	1	1	0	0	0	0	0	0	1554	88.69863014
COMPOUND	2	2	1	0	0	0	1	0	0	0	1556	88.81278539
CONSTANTS	1	2	0	0	0	0	0	2	0	0	1558	88.92694064
CONTRACTING	2	2	0	1	0	0	0	0	1	0	1560	89.04109589
CORE	1	2	0	2	0	0	0	0	0	0	1562	89.15525114
DISPOSABLE	2	2	0	0	0	0	0	1	1	0	1564	89.26940639
DISTRIBUTED	2	2	0	0	1	0	0	0	0	1	1566	89.38356164
ENABLES	2	2	0	0	0	0	0	1	0	1	1568	89.49771689
ENVIRONMENTS	2	2	0	0	0	0	0	1	1	0	1570	89.61187215
EXPAND	1	2	0	0	0	0	0	2	0	0	1572	89.7260274
EXPORT	2	2	0	0	0	1	0	1	0	0	1574	89.84018265
FACILITATE	2	2	0	1	0	0	0	1	0	0	1576	89.9543379
HYPOTHESES	2	2	0	1	0	1	0	0	0	0	1578	90.06849315
HYPOTHESIS	1	2	0	2	0	0	0	0	0	0	1580	90.1826484
INDIVIDUAL	1	2	0	2	0	0	0	0	0	0	1582	90.29680365
INITIAL	2	2	0	0	0	0	1	1	0	0	1584	90.4109589
INVESTIGATION	1	2	0	0	0	0	0	2	0	0	1586	90.52511416
LABEL	2	2	0	0	0	1	0	1	0	0	1588	90.63926941
LINKS	2	2	0	1	0	0	0	0	1	0	1590	90.75342466
LOCATION	1	2	0	0	0	0	0	2	0	0	1592	90.86757991
MAINTAINING	1	2	0	0	0	0	2	0	0	0	1594	90.98173516
MECHANISM	2	2	0	1	0	0	0	0	0	1	1596	91.09589041
MECHANISMS	2	2	1	0	0	0	0	0	1	0	1598	91.21004566
MEDICAL	2	2	1	0	0	0	0	1	0	0	1600	91.32420091
NEGATIVE	1	2	0	0	0	0	0	0	2	0	1602	91.43835616
OCCURRED	1	2	0	0	0	2	0	0	0	0	1604	91.55251142
POSITIVE	2	2	1	0	0	0	0	0	1	0	1606	91.66666667
REACTIONS	1	2	2	0	0	0	0	0	0	0	1608	91.78082192

***Indicates types used as target vocabulary within reader.**

Appendix D: Frequency List—Content Words

TYPES Not Found in Any List	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cumulative Frequency	Cumulative Frequency%
CELL*	8	573	55	73	32	98	78	89	99	49	573	13.00794552
MEMBRANE*	8	317	52	54	19	39	41	38	59	15	890	20.20431328
CELLS*	8	223	60	23	22	17	32	15	44	10	1113	25.26674234
MOLECULES*	8	219	65	29	7	16	10	39	42	11	1332	30.23836549
DIFFUSION*	8	186	32	21	15	16	30	19	44	9	1518	34.46083995
OSMOSIS*	8	102	19	10	8	16	16	8	22	3	1620	36.77639047
IONS	8	94	8	5	3	23	15	9	30	1	1714	38.91032917
PROTEINS*	8	90	4	7	3	22	9	24	16	5	1804	40.95346198
PROTEIN*	8	85	6	8	5	13	13	4	33	3	1889	42.8830874
CARRIER	4	68	8	0	0	17	7	0	36	0	1957	44.42678774
GRADIENT*	6	64	12	0	0	13	5	17	7	10	2021	45.87968218
DIFFUSE*	8	63	4	6	5	10	7	12	14	5	2084	47.30987514
HYPOTONIC*	6	51	3	5	0	7	7	14	15	0	2135	48.4676504
ENDOCYTOSIS*	7	49	8	3	3	4	6	12	13	0	2184	49.5800227
MOLECULE*	8	49	7	3	1	3	7	6	20	2	2233	50.69239501
HYPERTONIC*	7	47	3	7	1	3	7	14	12	0	2280	51.75936436
ISOTONIC*	7	45	4	5	1	4	7	16	8	0	2325	52.78093076
EXOCYTOSIS*	7	43	4	2	1	5	7	10	14	0	2368	53.75709421
PLASMA	2	43	14	0	0	0	29	0	0	0	2411	54.73325766
MEMBRANES*	6	35	7	12	4	0	0	1	8	3	2446	55.52780931
SODIUM	7	33	2	2	1	15	9	2	2	0	2479	56.276958
VESICLE*	4	29	0	0	0	7	0	12	9	1	2508	56.93530079
BILAYER*	6	28	0	10	2	9	2	1	4	0	2536	57.57094211
CYTOSOL	2	28	0	0	0	1	0	0	27	0	2564	58.20658343
DISSOLVED	8	28	11	4	2	2	3	4	1	1	2592	58.84222474
EQUILIBRIUM*	6	28	2	6	0	4	4	2	10	0	2620	59.47786606
SOLUTE	4	28	0	3	0	5	9	0	11	0	2648	60.11350738
GLUCOSE	7	26	2	6	3	1	0	2	11	1	2674	60.70374574
POTASSIUM	8	25	2	2	1	9	6	2	2	1	2699	61.27128263
PERMEABLE*	7	24	8	6	3	2	3	1	1	0	2723	61.81611805
VESICLES*	3	24	0	0	0	9	0	7	8	0	2747	62.36095346
LIPID*	5	23	0	10	3	8	0	1	1	0	2770	62.8830874
ORGANISMS	7	23	6	3	3	1	2	1	7	0	2793	63.40522134
OXYGEN	5	22	12	1	0	4	0	4	1	0	2815	63.9046538
CONCENTRATIONS	7	21	3	3	4	1	4	0	4	2	2836	64.38138479
DIFFUSES	6	21	4	0	2	3	0	2	5	5	2857	64.85811578
ION	5	21	1	0	1	6	1	0	12	0	2878	65.33484677
NA	3	21	0	0	0	3	6	0	12	0	2899	65.81157775
VACUOLE	6	20	8	4	1	0	3	1	3	0	2919	66.26560726
SODIUM-POTASSIUM	5	18	0	1	0	3	1	1	12	0	2937	66.67423383
SOLUTES	6	18	0	1	0	3	1	4	8	1	2955	67.08286039
SURROUNDINGS	3	18	15	1	0	0	0	0	0	2	2973	67.49148695
ATP	5	17	0	0	0	4	2	3	6	2	2990	67.87741203
CELLULAR	2	17	2	0	0	0	15	0	0	0	3007	68.26333712
PHAGOCYTOSIS	5	16	3	2	1	0	0	4	6	0	3023	68.62656073
CYTOPLASM	6	15	1	4	1	5	1	0	0	3	3038	68.96708286

TYPES Not Found in Any List	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cumulative Frequency	Cumulative Frequency%
II	4	14	4	7	0	1	2	0	0	0	3067	69.62542565
COM	4	13	5	1	0	2	5	0	0	0	3080	69.92054484
OSMOTIC	4	13	2	7	3	0	1	0	0	0	3093	70.21566402
PHOSPHATE	3	13	0	0	0	5	1	0	7	0	3106	70.5107832
FLUID	4	12	0	0	0	3	0	6	2	1	3118	70.78320091
FUSE	4	12	1	0	0	5	0	2	4	0	3130	71.05561862
SOLVENT	3	12	0	0	0	2	5	0	5	0	3142	71.32803632
BEAKER	2	11	0	0	0	0	0	1	10	0	3153	71.57775255
CONTRACTILE	5	11	1	2	1	2	0	0	5	0	3164	71.82746879
EXPEND	4	11	5	0	1	0	0	1	4	0	3175	72.07718502
LIPIDS	4	11	0	3	2	0	0	1	5	0	3186	72.32690125
BACTERIA	6	10	2	1	2	1	0	1	3	0	3196	72.553916
DILUTE	5	10	1	3	2	1	0	0	3	0	3206	72.78093076
FUSES	4	10	2	1	0	0	0	5	2	0	3216	73.00794552
NERVE	3	10	1	0	0	0	0	8	1	0	3226	73.23496027
VACUOLES	4	10	1	2	0	2	0	0	5	0	3236	73.46197503
CARBON	5	9	4	1	0	2	0	1	1	0	3245	73.66628831
COURSESMART	1	9	9	0	0	0	0	0	0	0	3254	73.87060159
DIOXIDE	5	9	4	1	0	2	0	1	1	0	3263	74.07491487
ENZYMES	3	9	3	0	0	0	0	4	2	0	3272	74.27922815
GRAPE	2	9	0	0	0	8	0	0	1	0	3281	74.48354143
VOCABULARY	4	9	0	0	0	1	2	4	2	0	3290	74.68785471
WWW	3	9	5	1	0	0	0	0	3	0	3299	74.89216799
BIOLOGY	3	8	5	1	0	0	0	2	0	0	3307	75.0737798
DYE	2	8	0	0	3	0	0	5	0	0	3315	75.2553916
LYSOSOMES	3	8	5	0	0	1	0	0	2	0	3323	75.43700341
MAGNIFICATION	3	8	0	0	2	0	5	1	0	0	3331	75.61861521
SHRINKS	4	8	3	0	0	2	2	0	0	1	3339	75.80022701
X	3	8	0	0	2	0	5	0	1	0	3347	75.98183882
H2O	3	7	0	0	0	1	0	0	4	2	3354	76.14074915
KINETIC	2	7	4	0	0	0	0	0	3	0	3361	76.29965948
ML	2	7	0	0	0	0	0	1	6	0	3368	76.45856981
PHOSPHOLIPID	4	7	1	0	0	0	2	1	3	0	3375	76.61748014
RECALL	5	7	1	1	0	1	3	0	1	0	3382	76.77639047
SALTS	5	7	1	2	1	0	0	1	0	2	3389	76.93530079
SHRINK	5	7	2	1	0	0	1	0	2	1	3396	77.09421112
ATPASE	1	6	0	0	0	0	6	0	0	0	3402	77.23041998
JAR	1	6	0	0	0	6	0	0	0	0	3408	77.36662883
NONPOLAR	3	6	0	0	0	4	0	1	1	0	3414	77.50283768
POUCH	2	6	0	0	0	2	0	0	4	0	3420	77.63904654
ANIMATION	2	5	0	2	0	0	3	0	0	0	3425	77.75255392
BIOLOGICAL	2	5	0	4	1	0	0	0	0	0	3430	77.86606129
BREAKDOWN	3	5	1	0	0	0	2	2	0	0	3435	77.97956867
DISSOLVE	4	5	1	0	1	1	0	0	2	0	3440	78.09307605
FRESHWATER	2	5	3	0	0	0	0	0	2	0	3445	78.20658343
GREEK	3	5	0	1	0	0	3	0	1	0	3450	78.32009081
HTTP	1	5	5	0	0	0	0	0	0	0	3455	78.43359818
IMAGEPAG	1	5	5	0	0	0	0	0	0	0	3460	78.54710556
ONION	2	5	0	0	0	0	4	0	1	0	3465	78.66061294
ORG	3	5	0	0	0	1	0	1	3	0	3470	78.77412032

TYPES Not Found in Any List	RANGE	FREQ	F1	F2	F3	F4	F5	F6	F7	F8	Cumulative Frequency	Cumulative Frequency%
PINOCYTOSIS	2	5	1	0	0	0	0	0	4	0	3480	79.00113507
PM	1	5	5	0	0	0	0	0	0	0	3485	79.11464245
PROSECUTED	1	5	5	0	0	0	0	0	0	0	3490	79.22814983
SAC	3	5	3	0	0	0	0	0	1	1	3495	79.34165721
SHRIVEL	3	5	0	0	0	0	2	2	1	0	3500	79.45516459
SOLUBLE	3	5	0	0	1	1	0	0	3	0	3505	79.56867196
VIOLATORS	1	5	5	0	0	0	0	0	0	0	3510	79.68217934
XMLID	1	5	5	0	0	0	0	0	0	0	3515	79.79568672
AMMONIA	1	4	4	0	0	0	0	0	0	0	3519	79.88649262
CM	2	4	0	0	0	0	0	2	2	0	3523	79.97729852
CO	3	4	2	0	0	0	1	0	0	1	3527	80.06810443
COOKIES	1	4	0	0	0	0	4	0	0	0	3531	80.15891033
DIALYSIS	1	4	0	0	0	0	0	0	4	0	3535	80.24971623
ENGULF	3	4	2	1	0	0	0	1	0	0	3539	80.34052213
ENGULFING	2	4	3	0	0	0	0	1	0	0	3543	80.43132804
EXIT	1	4	0	0	0	0	0	4	0	0	3547	80.52213394
FLUIDS	3	4	0	2	0	0	0	1	1	0	3551	80.61293984
GRADIENTS	2	4	0	0	0	3	0	0	1	0	3555	80.70374574
HORMONES	3	4	0	0	0	1	1	2	0	0	3559	80.79455165
HYPER-	4	4	0	0	0	1	1	1	1	0	3563	80.88535755
HYPO-	4	4	0	0	0	1	1	1	1	0	3567	80.97616345
HYPO-TONIC	4	4	1	0	1	0	1	0	1	0	3571	81.06696935
INTERIOR	2	4	0	1	0	0	0	0	3	0	3575	81.15777526
LAB	4	4	0	0	0	1	1	1	1	0	3579	81.24858116
NAL	3	4	0	0	0	1	2	0	1	0	3583	81.33938706
PLASTIC	1	4	0	0	0	0	0	4	0	0	3587	81.43019296
PORES	2	4	0	0	0	1	0	0	3	0	3591	81.52099886
RACHEL	1	4	4	0	0	0	0	0	0	0	3595	81.61180477
SCILINKS	2	4	0	0	0	0	0	1	3	0	3599	81.70261067
TUBING	1	4	0	0	0	0	0	0	4	0	3603	81.79341657
UNICELLULAR	2	4	0	0	0	1	0	0	3	0	3607	81.88422247
CL-	2	3	0	0	0	1	0	0	2	0	3610	81.9523269
COLLIDE	3	3	0	1	0	0	1	1	0	0	3613	82.02043133
COLOR-ENHANCED	1	3	0	0	0	0	3	0	0	0	3616	82.08853575
COMPARTMENT	1	3	0	3	0	0	0	0	0	0	3619	82.15664018
CONTINUALLY	2	3	0	0	0	0	1	2	0	0	3622	82.22474461
CUBE	1	3	0	0	0	0	0	0	3	0	3625	82.29284904
CYTOLYSIS	1	3	0	0	0	0	0	0	3	0	3628	82.36095346
DEHYDRATED	2	3	2	0	0	0	0	1	0	0	3631	82.42905789
DIGESTED	2	3	2	0	0	0	0	0	1	0	3634	82.49716232
ENGULFED	2	3	2	0	0	0	1	0	0	0	3637	82.56526674
EXPEL	3	3	0	0	1	0	1	0	0	1	3640	82.63337117
GOLGI	3	3	1	0	0	1	0	0	1	0	3643	82.7014756
IMPULSE	1	3	0	0	0	0	0	3	0	0	3646	82.76958002
ISO-	3	3	0	0	0	0	1	1	1	0	3649	82.83768445
KIDNEYS	2	3	2	0	0	1	0	0	0	0	3652	82.90578888
LETTUCE	1	3	3	0	0	0	0	0	0	0	3655	82.9738933
LITERALLY	2	3	0	0	2	0	0	1	0	0	3658	83.04199773
LM	2	3	0	0	0	0	2	0	1	0	3661	83.11010216

***Indicates types used as target vocabulary within reader.**

Appendix E: Frequent Multiword Items

2 Word Phrases	Freq	3 Word Phrases	Freq	4 Word Phrases	Freq
Active transport*	53	Across the membrane	21	A higher concentration of	9
Animal cells	9	Cell membrane pumps	4	Across a/the cell membrane	23
Carrier protein(s)*	54	Cell water diffuses	4	Across the plasma membrane	9
Cell membrane(s)*	73	Compare and contrast	3	Against a concentration difference	3
Cell structure	4	Concentration of molecules	3	Against the concentration gradient	8
Cell transport	10	Concentration of solute	3	Area of high/lower concentration	10
Cell wall(s)	12	Diffusion and osmosis	4	Concentration of dissolved particles	4
Concentration gradient*	35	Endocytosis and exocytosis	5	Diffuse through the cell	7
Diffuse across	12	Equilibrium is established	4	Diffuse through transport proteins	9
Diffuse through	13	Inside the cell	27	Hypotonic, isotonic, or hypertonic	6
Dilute solution	3	Into the cell	31	Molecules across a membrane	4
Dissolved particles	4	Movement of molecules	7	Out of the cell	30
External environment	5	Movement of water	9	Pass through the membrane	18
Facilitated diffusion*	36	Must expend energy	5	Region of higher concentration	5
High(er) concentration*	28	Outside the cell	35	Region of lower concentration	5
Hypertonic solution*	9	Red blood cells	4	Through the cell membrane	4
Hypotonic solution*	8	Selectively permeable membrane*	9	Through the lipid bilayer	5
Ion channels	12	Soluble in lipids	4	Through the plasma membrane	8
Low(er) concentration*	24	Through the cell	3	Up a concentration gradient	8
Molecules diffuse	7	Through the membrane	10	Use energy to move	7
Transport proteins*	11				

Appendix F: Biology Teacher Questionnaire

Overview

This is a prototype for a new book series I have developed called *Instructional Readers*. They are linguistically engineered texts aimed at teaching content-specific vocabulary and topics to ESL and other struggling readers. Linguistic features are based on research that shows which features assist vocabulary development while reading. A few of these features include making the target words salient (bold), repeating target words throughout a single text, providing helpful contexts that point to the meaning of the words, and (most importantly) all words that are not target words are from the 2,000 most frequent/common English word list. You will notice that the text begins at a basic level, and the difficulty increases as target vocabulary is reused and more vocabulary is introduced. Please let me know if you have any questions about the purpose of the book or its features.

Questions

1. Does the text seem easier (but not too easy) than a standard high school biology text?

2. Is it easier to understand the meanings of target words from their context than in a standard high school biology text?

3. Would the Starting Points, Activity, and Discuss sections be helpful in teaching a lesson to a struggling (ESL) student?

4. Are there any factual errors or glaring omissions?

5. Would you recommend this type of book be used to help bring ESL (or other struggling readers) up to grade level? Why or why not?

Appendix G: Student Questionnaire

Cellular Transport Book – Opinion

Do not write your name on the paper. Answer the questions as honestly as possible. Feel free to explain your answers.

1. Think about the book's design. Does it look like a book you would want to read to learn an academic subject?

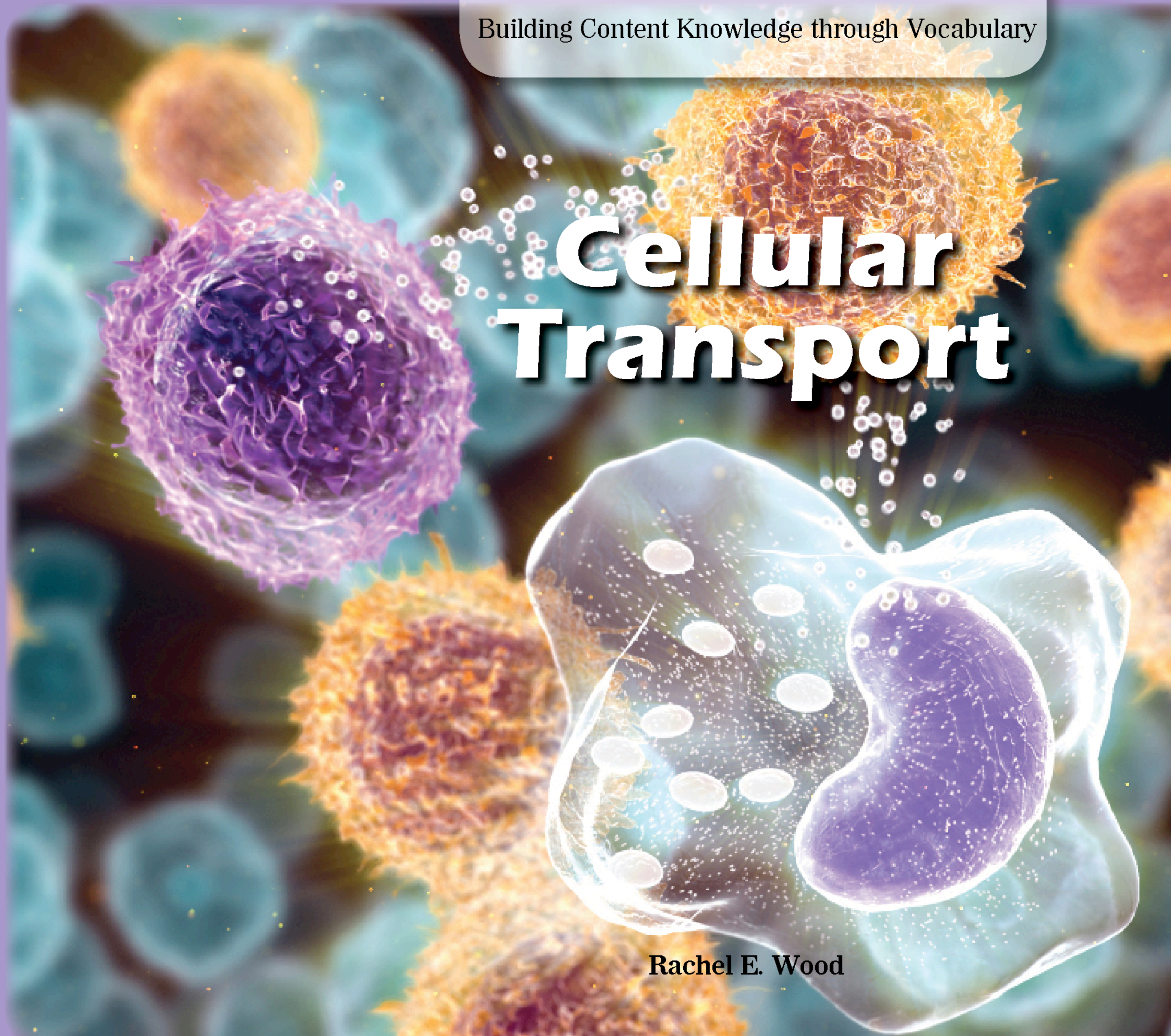
2. Did the pictures help you to understand important words and ideas?

3. Did the activities and discussion questions help you to understand the content and to use new words?

4. Was the writing in the book clear and easy to understand?

5. Did the context help you to learn the meanings of new words?

6. Overall, did you like this book for learning academic topics and vocabulary? Why or why not?



Instructional Readers

Building Content Knowledge through Vocabulary

Cellular Transport

Rachel E. Wood

Instructional Readers:
Biology Series

What Do I Need to Know?

Important Words

Look at these words. Have you ever seen any of them before? What do you already know that might help you? Find these words as you read.

Content Words

- Active Transport
- Cell
- Cell Membrane
- Cellular Transport
- Concentration Gradient
- Diffuse
- Diffusion
- Endocytosis
- Equilibrium
- Exocytosis
- Facilitated Diffusion
- Hypertonic Solution
- Hypotonic Solution
- Isotonic Solution
- Lipid Bilayer
- Molecule
- Osmosis
- Passive Transport
- Permeable
- Protein
- Protein Channel
- Selectively Permeable
- Solution
- Transport Proteins
- Vesicle

Academic Words

- Area
- Concentration
- Energy
- Environment
- Function
- Occur
- Process
- Release
- Require
- Specific

Become an Independent Learner

As you read, use some of the strategies below when you see a word you do not know. If one strategy does not help you, try another one. Using many strategies can help you learn more vocabulary faster.

- *Say the word out loud.*
- *Use the context.*
- *Use the glossary.*
- *Use a dictionary.*
- *Keep a word log.*
- *Make flash cards.*

Cellular Transport

Table of Contents

Section 1: The Cell Membrane 4
Section 2: Passive Transport 7
Section 3: Active Transport 13
Glossary 17
Teacher's Guide 21

Instructional Readers: Biology Series

Starting Point

Have you ever used a strainer to separate water from pasta? Why does the pasta stay in the strainer while the water moves easily through the strainer's holes? Like a strainer, the cell membrane allows some things to move through it while keeping other things from moving through.

The Cell Membrane

Cells are the smallest working units of life. All living things are made of cells. Each cell is surrounded by a **cell membrane**. The cell membrane protects the cell and allows some substances to flow in and out of the cell. This means that the cell membrane is **permeable** to some substances. If something is permeable, substances can freely pass through it. The cell membrane is permeable if a substance can pass through it. If a substance cannot pass through the cell membrane, the cell membrane is not permeable. Since all cell membranes allow some substances to pass through and not others, they are often called **selectively permeable**.

The cell membrane is made of many different **molecules**. Molecules are very small parts of a cell or a substance. Molecules are so small that they cannot be seen by the human eye. Molecules can be part of a liquid, solid, or gas. Different molecules have different **functions**. In a cell, the **lipid bilayer** is a protective cover of molecules that forms most of the cell membrane. The molecules that make the lipid bilayer are so close together that the lipid bilayer is able to prevent many outside substances from entering the cell. This protects the cell, and it is part of what makes the cell membrane selectively permeable. The lipid bilayer also makes the cell membrane strong and elastic.

Proteins are another type of molecule that can be found in the cell membrane. There are many different types of proteins. Proteins can have many different functions within the cell membrane. Some proteins help to strengthen and protect the cell membrane. Other proteins help to move substances in and out of the cell through the cell membrane.

The cell membrane helps the cell to stay alive by bringing in materials that the cell needs to live and by **releasing**, or getting rid of, waste that the cell does not need. When substances travel through the cell membrane it is called **cellular transport**. There are two types of cellular transport. The first type of cellular transport is called **passive transport**.

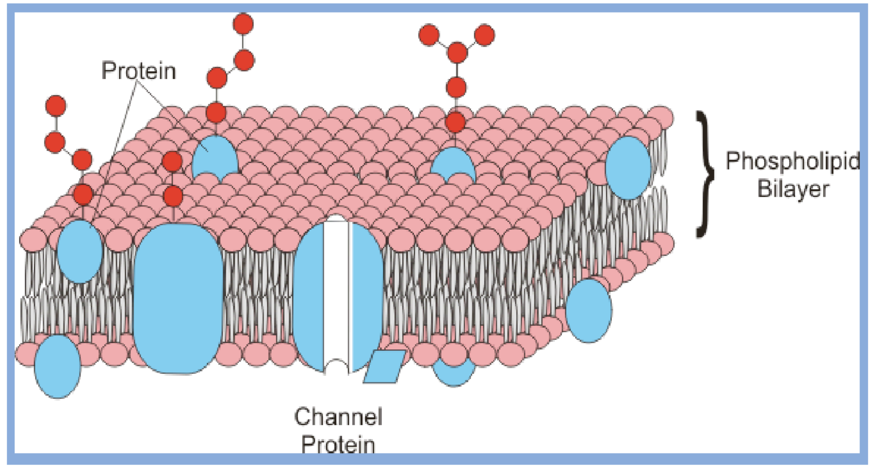


Image 1: The Cell Membrane *The cell membrane is made of many different molecules that form the lipid bilayer, proteins, and other parts of the cell.*

Passive transport happens when molecules can pass through the cell membrane without any help from parts of the cell. The second type of cellular transport is called **active transport**. Active transport happens when parts of the cell need to work to help molecules move through the cell membrane.

Review

- All cells have a cell membrane.
- All cell membranes are selectively permeable. They only allow some substances through and not others.
- Cell membranes are made of many different molecules that have many different functions.
- Cellular transport happens when substances move through the cell membrane. There are two types of cellular transport: passive transport and active transport.

Activity

Look at Image 1: The Cell Membrane. Try to find the parts of the cell membrane that are described in this section. Describe how each part functions.

Discuss

1. *Why is it important for cells to have a cell membrane? How does it protect the cell?*
2. *What does it mean for a cell membrane to be selectively permeable? Why is it important for a cell membrane to be selectively permeable?*
3. *Name two things that are made of molecules in the cell membrane. How do these two things function?*

Starting Point

Have you ever driven through a tunnel? How did the tunnel help you to get where you were going? Did it help you to drive through a mountain or a river? One type of passive transport–facilitated diffusion–works like a tunnel. There are proteins that make a kind of tunnel that some molecules can move through.

Passive Transport

Passive transport happens when a cell does not need to use any **energy** for a substance to be able to pass through the cell membrane. This means that the substance moves itself through the cell membrane. The cell does not need to do any work, or use energy, to move the substances during passive transport. There are three types of passive transport. **Diffusion** is the first type of passive transport. Diffusion happens when the molecules of a substance spread through a liquid or gas. **Facilitated diffusion** is the second type of passive transport. Facilitated diffusion happens when certain molecules move through the cell membrane with the help of proteins. **Osmosis** is the third type of passive transport. Osmosis happens when water moves through the cell membrane.

Diffusion

Diffusion is the first type of passive transport. Diffusion is a **process** where the molecules of a substance spread through a liquid or gas. You can see diffusion happening when you place a drop of yellow food coloring in a glass of water. As the molecules from the yellow food coloring spread through the water, the entire glass of water turns yellow. This is diffusion.

During diffusion, molecules move from an **area** of high **concentration** to an area of low concentration. When a substance has a high

Image 2: Diffusion *Molecules diffuse from an area of high concentration to an area of low concentration.*

concentration, there are more molecules of that substance in one area than in another. For example, the yellow food coloring has a very high concentration of yellow food coloring molecules. When it is placed in the glass of water, the molecules in the yellow food coloring spread through the water because the water has a low concentration of yellow food coloring molecules.

In a cell, substances that easily **diffuse**, or spread, through the lipid bilayer of the cell membrane go through the process of diffusion. During diffusion, molecules move in or out of the cell from an area of high concentration to an area of low concentration. For example, if there is a high concentration of water outside the cell and a low concentration of water inside the cell, water molecules will diffuse from the outside of the cell to the inside. This can also **occur**, or happen, in the opposite direction. If the area of high concentration is inside the cell, then the molecules will diffuse out of the cell to the area of low concentration. This is called moving along the **concentration gradient**. The concentration gradient is the concentration of molecules at different points in a substance. Since molecules of **specific** substances can simply follow the concentration gradient from areas of high concentration to areas of low concentration, the cell does not have to use any energy for diffusion to work.

Facilitated Diffusion

Facilitated diffusion is the second type of passive transport. There are molecules of some substances that cannot pass through the lipid bilayer, but they can still pass through the cell membrane. Instead of moving through the lipid bilayer, these molecules move through **protein channels** that are part of the cell membrane. Protein channels help specific molecules to move through the cell membrane. There are many different kinds of protein channels. Each type of protein channel allows only one type of molecule to pass through it. For example, some protein channels allow only sugars to move through the cell membrane. When molecules move through the cell membrane with the help of protein channels, it is called facilitated diffusion.

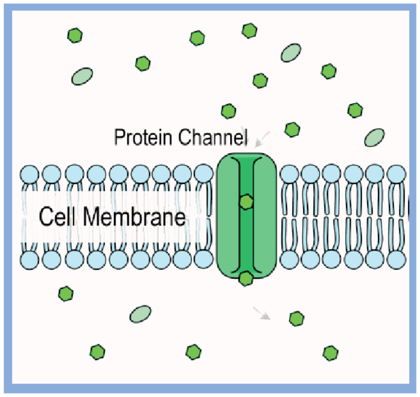


Image 3: Protein Channel *Protein channels move specific molecules through the cell membrane.*

Facilitated diffusion is like diffusion in one important way. During facilitated diffusion, molecules move through the cell membrane from an area of high concentration to an area of low concentration. Since the molecules can move along the concentration gradient, the cell does not use any energy for facilitated diffusion to occur.

Osmosis

Osmosis is the third type of passive transport. Osmosis occurs when water molecules diffuse through a selectively permeable cell membrane. Only water can go through the process of osmosis. Like diffusion, water molecules pass through the cell membrane from an area of high concentration to an area of low concentration during osmosis. The purpose of osmosis is to reach **equilibrium**. Equilibrium is a balance between two areas. In a cell, equilibrium means that the concentration of specific molecules is equal inside and outside the cell.

For example, if a cell is placed in a **solution** of sugar and water, the water molecules inside the cell will move from the area of high concentration to the area of low concentration. If there is a higher concentration of water inside the cell, the water will move out of the cell. If there is a higher concentration of water in the sugar solution, the water will move into the cell and cause the cell to swell. Since the cell membrane is permeable to water molecules but not permeable to sugar molecules, only the water molecules move through the cell membrane until equilibrium is reached on both sides of the cell membrane. This is the process of osmosis.

During osmosis, water moves through a selectively permeable membrane because there are different concentration levels of a solution on either side. If the cell is placed in a **hypertonic solution**, the solution outside the cell has a lower concentration of water than inside the cell. This hypertonic solution will cause water to diffuse out of the cell. As a result, the cell will get smaller. Sometimes hypertonic solutions can cause a cell to lose so much water that it dies. But if the cell is placed in a **hypotonic solution**, the solution outside the cell has a higher concentration of water than inside the cell. This hypotonic solution will cause water to

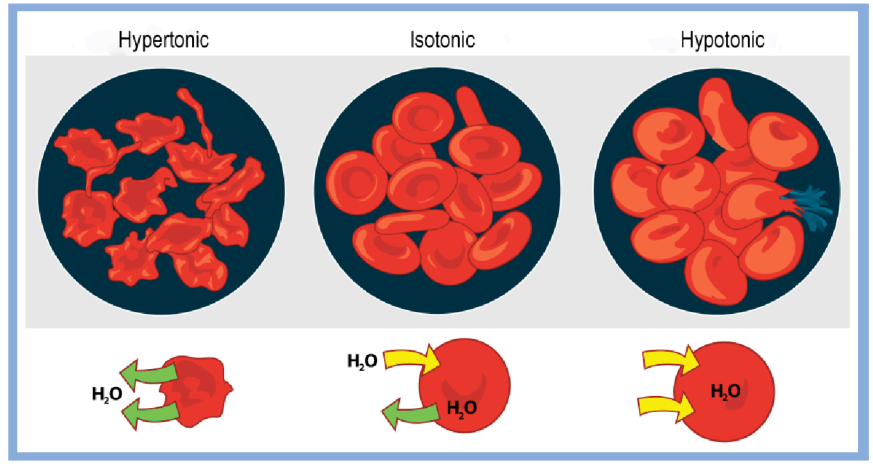


Image 4: Hypertonic, Isotonic, and Hypotonic Solutions *A hypertonic solution causes water to diffuse out of a cell. An isotonic solution does not cause osmosis because there is equilibrium. A hypotonic solution causes water to diffuse into the cell.*

diffuse into the cell. As a result, the cell will swell. Sometimes hypotonic solutions can cause a cell to swell so much that it bursts. However, many cells can protect themselves when they are in hypertonic or hypotonic solutions. Also, if a cell is placed in an **isotonic solution**, the water concentration is equal inside and outside the cell. An isotonic solution will not cause any change in the cell because there is equilibrium. When there is equilibrium, osmosis does not occur.

Review

- Passive transport happens when molecules can move through the cell membrane without the cell using energy. There are three types of passive transport: diffusion, facilitated diffusion, and osmosis.
- During all three types of passive transport, molecules move from areas of high concentration to areas of low concentration.
- Diffusion happens when molecules from any substance spread through a liquid or gas.
- Facilitated diffusion happens when specific molecules move through the cell membrane with the help of protein channels.
- Osmosis can only occur with water.
- In a hypertonic solution, water will diffuse out of the cell.
- In a hypotonic solution, water will diffuse into the cell.
- In an isotonic solution, there is equilibrium, so water will not move in or out of the cell.

Activity

Get a clear glass of water and some food coloring. Place a drop of food coloring in the water. Describe what happens using words you learned in this section.

Discuss

1. *What is the concentration gradient? How does the concentration gradient affect what happens during all three types of passive transport?*
2. *What is facilitated diffusion? What is the most important part of the cell that helps during this process? How does it work?*
3. *Name the three types of concentrated solutions and describe how they affect osmosis and equilibrium.*

Starting Point

Have you ever seen or used an old pump that pumps water? Find a picture of an old pump on the Internet. How does it work? One type of active transport uses special proteins that move materials through the cell membrane like a pump.

Active Transport

Active transport occurs when parts of the cell need to work to help molecules move through the cell membrane. This **requires** the cell to use energy. During active transport, molecules can move from areas of low concentration to areas of high concentration. The molecules move against the concentration gradient. This is the opposite of what occurs during passive transport. Active transport can move food and small or large molecules through the cell membrane.

Active transport works in two ways. First, active transport of small molecules requires the help of **transport proteins** that are part of the cell membrane. Transport proteins function like a pump to move molecules through the cell membrane from an area of low concentration to an area of high concentration. The sides of the transport

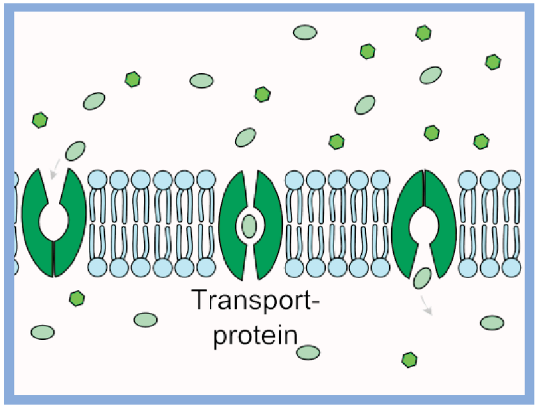


Image 5: Transport Proteins Transport Proteins push specific molecules through the cell membrane from an area of low concentration to an area of high concentration.

proteins move and push the molecules through the cell membrane and **release** them on the other side. The transport proteins need to use energy so they can function against the forces of diffusion; they require energy to move molecules against the concentration gradient.

The second type of active transport occurs when pockets move large amounts of materials through the cell membrane. Parts of the cell membrane fold around large molecules, food, or even entire cells and form a pocket. These pockets are called **vesicles**. The vesicle then breaks off from the outside of the cell membrane and transports the materials

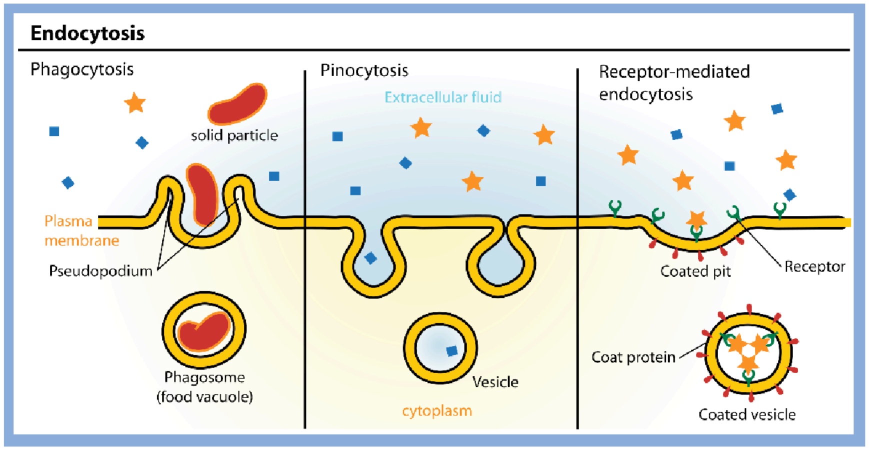


***Image 6*: Endocytosis** *Vesicles form around cells, molecules, and food from the cell's environment and carry them into the cell.*

to the other side of the membrane where the material is released. The vesicle then opens and becomes part of the cell membrane again. This process can occur in both directions. When these vesicles transport materials into the cell it is called **endocytosis**. Endocytosis only brings specific substances into the cell. Endocytosis is the process cells use to get food or other important materials from their **environment**. When the vesicles transport materials out of the cell it is called **exocytosis**.

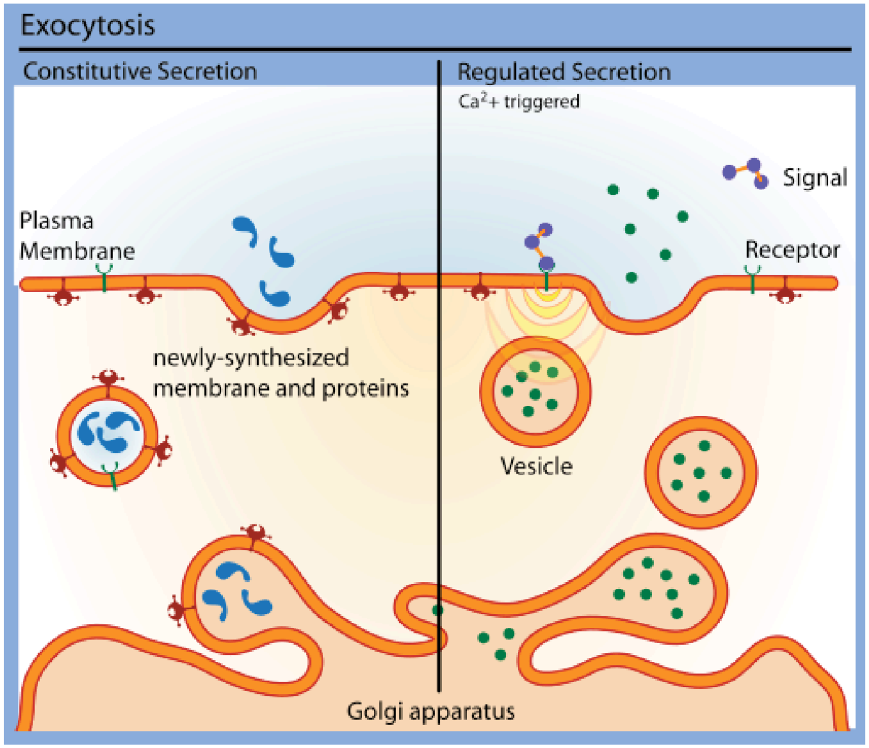


***Image 7*: Exocytosis** *Vesicles form around waste and other materials that the cell does not need to carry it out of the cell.*

Exocytosis only moves specific substances out of the cell. Exocytosis is the process cells use to release waste or materials that the cell does not need. Exocytosis releases these materials into the environment outside the cell. Both endocytosis and exocytosis use energy so they can function against the forces of diffusion.

Review

- Active transport requires the cell to use energy so that substances can be moved from areas of low concentration to areas of high concentration.
- One type of active transport requires the use of transport proteins. Transport proteins move specific molecules in and out of the cell.
- The second type of active transport requires the use of vesicles. Vesicles are pockets that bring in certain materials from the cell's environment (endocytosis). Vesicles can also carry waste out of the cell (exocytosis).

Activity

Look at Image 5: Transport Proteins. Describe what is happening in the picture. Name the parts of the cell membrane that are not labeled in the picture.

Discuss

1. In what ways is active transport different from passive transport?
2. What is a vesicle? How is it formed? What happens to a vesicle after it releases the material it was carrying?
3. What is the difference between endocytosis and exocytosis? How is the cell's environment important in these processes?

Glossary

Content Words

Active Transport	movement of a substance through a cell membrane against the concentration gradient; requires the use of energy
Cell	the smallest part of a living thing that can exist independently
Cell Membrane	the biological membrane that separates the inside of a cell from the outside environment
Cellular Transport	the movement of substances through the cell membrane
Concentration Gradient	the changing concentration level of a substance over a distance
Diffuse	to spread through something
Diffusion	the movement of a substance from an area of high concentration to an area of low concentration
Endocytosis	the process by which the cell membrane of a cell folds inwards to ingest material
Equilibrium	a state of rest or balance due to the equal action of opposing forces
Exocytosis	the process by which the cell membrane of a cell folds to releases material

Facilitated Diffusion — a form of passive transport facilitated by transport proteins

Hypertonic Solution — a solution that has a lower concentration of water and a higher concentration of another substance than another solution, such as the inside of a cell

Hypotonic Solution — a solution that has a higher concentration of water and a lower concentration of another substance than another solution, such as the inside of a cell

Isotonic Solution — a solution that has an equal concentration of water compared to another solution, such as the inside of a cell

Lipid Bilayer — a thin cover made of two layers of lipid molecules that surrounds a cell

Molecule — the smallest unit into which any substance can be divided without losing its own chemical nature, usually consisting of two or more atoms

Osmosis — the gradual process of liquid passing through a membrane

Passive Transport — the movement of a substance through a cell membrane without the cell using energy

Permeable — allows water, gas, molecules, etc. to pass through it

Protein — molecules found in a cell that perform specific functions

Protein Channel — helps specific molecules to move through the cell membrane during facilitated diffusion

Selectively Permeable — allows some water, gas, molecules, etc. to pass through it, but not others

Solution — a liquid in which a solid or gas has been mixed

Transport Proteins — helps some molecules to move through the cell membrane by acting like a pump; requires the use of energy

Vesicle — helps some molecules and other substances to move through the cell membrane by forming a pocket around the substance and carrying it to the other side; requires the use of energy

Academic Words

Area any amount of space or surface; part

Concentration a large amount of something in a particular place; the amount of a substance contained in a liquid

Energy the ability that something has to work or move

Environment the total of surrounding things, conditions, or influences; surroundings

Function to work in the correct or intended way

Occur to happen

Process a series of actions that are done in order to achieve a particular result

Release to let a substance flow out; to let go

Require to need something

Specific one particular thing, person, or group

Teacher's Guide

The purpose of this book is to help English-language learners in mainstream classrooms to keep pace with their native English-speaking counterparts. With this in mind, the following are suggested guidelines for how to use this material. It is not meant to be worked through from beginning to end if the need is not there. Use portions that meet the immediate needs of your learners.

Before You Read

- Review the vocabulary learning strategies outlined on the first page. Model how to use them.
- Access students' background knowledge. What do they already know that might help them understand these words and concepts? The Starting Points may be useful in this area.
- Preview the target vocabulary. Have students look at the word list. Which words do they know? What do they think some of the unknown words might mean? Define unknown words before students begin reading. Use visuals and other aids when possible.

As You Read

- Practice the vocabulary learning strategies together and individually.
- Discuss short sections of the reading to ensure comprehension and understanding of the target words.

After You Read

- Discuss the topics in the reading. Elicit responses where the students must use the target vocabulary. Use the Activity and Discuss sections at the end of each section.
- Visit ScienceVocabulary.com for worksheets and more practice in all the skill areas.