Spring 4-30-2023

Building on Strengths: Empowering Struggling High School Readers Using Key Strategies

Jennifer Druggan
wrtgteacher@yahoo.com

Spring 4-30-2023

Building on Strengths: Empowering Struggling High School Readers Using Key Strategies

Jennifer Druggan

Building on Strengths: Empowering Struggling High School Readers Using Key Strategies

Jennifer N. Druggan, B.A., M.A.E.

Otterbein University

April 6, 2023

Table of Contents

VITA

Teaching Experience

2019-Present	Instructional Literacy Coach Allen D. Nease High School St. Johns County School District Ponte Vedra Beach, Florida
2009-2019	Tenth Grade English Language Arts Teacher $(HS)^2$ Academy Reynoldsburg City Schools Reynoldsburg, Ohio
2003-2009	Seventh Grade Writing Teacher Baldwin Road Middle School Reynoldsburg City Schools Reynoldsburg, Ohio

Education

2023	Master of Arts in Education Curriculum and Instruction: Concentration Reading Otterbein University Westerville, Ohio
2003	Bachelor of Arts Integrated Language Arts 7-12 Ohio Dominican University Columbus, Ohio

Building on Strengths: Empowering Struggling High School Readers Using Key Strategies

Abstract

The curriculum presented is for struggling high school readers so that they can use mastery experiences with two high yield reading strategies – self-questioning and summarizing – to improve their reading comprehension, which will build self-efficacy and help them to develop a growth mindset. The question that drove this research is what is the best way to meet the academic needs of a diverse student population in a remedial reading class in a way that helps them to build their literacy toolbox and develop a respect for and maybe even a love of lifelong learning? The curriculum is built upon current research of the Active View of Reading Model in conjunction with best practices in reading comprehension strategies and tools to build self-efficacy and a growth mindset. The unit plan outlines how to use a variety of graphic organizers to help students organize and comprehend short stories, videos, novels, textbooks, and non-fiction resources that can be found in an Environmental Science classroom as well as ways to utilize self-questioning and summarizing to increase students' comprehension. It also incorporates Fisher and Frey's Gradual Release Model and collaborative conversations to help students increase self-efficacy.

Keywords: high school, remedial reading, Environmental Science, graphic organizers, self- questioning, summarizing, self-efficacy, growth mindset

Chapter 1: Introduction

The topic of career and college readiness has been driving educational reform from the state level as they work to create new standards and benchmarks to companies that are creating curriculum and assessment tools that are being used in classrooms daily (Mokher et

al., 2010). It has become clear that students lack readiness for success whether it be in the workforce or college. As reported in "Are They Really Ready to Work", 80.9% of high school graduates have deficient skills in written communication and 38.4% in reading comprehension (Casner-Lotto et al., 2006). More recently, data from the 2019 National Assessment of Educational Progress (NAEP) report shows just how significantly the situation has devolved. According to the 2019 NAEP report, 35% of 4th graders, 34% of 8th graders, and 37% of 12th graders are performing the proficiency level set by NAEP.

Many educators struggle with this reality as they feel that they are doing everything that they can to prepare students in the classroom, but they cannot make up for years of disengagement, social isolation, and limited motivation (Donalson & Halsey, 2020). Even those students who are working in class need to practice their reading and comprehension strategies outside of school to close the achievement gap, but that is not happening. "Over half of students report reading literary texts outside of school once or twice a year or less" (NAEP report cards – home, 2019).

To help close the achievement gap, high school students are frequently placed in remedial reading courses (Donalson & Halsey, 2022). While this seems like a productive strategy, these placements bring with them some negative consequences. Greathouse (2018), a leading educator and researcher explains, "As an unintended consequence, students within remedial reading courses have a limited opportunity to accelerate both academically and personally" (p. 220). Moreover, students are often forced to replace elective courses that they love with remedial reading courses, leaving them feeling stigmatized and unmotivated (Donalson & Halsey, 2020). Unfortunately, students need these skills, and there is often no time

in a standard English classroom, yet these skills must be taught. The purpose of the remedial reading class is best described by Fisher, Hattie, and Frey (2016). They explain that "Learning demands that students be able to apply – transfer – their knowledge, skills, and strategies to new tasks and situations" (p. 19). According to current research, this is not happening because even if students find success in the remedial reading class, they still find themselves feeling frustrated when attempting to access complex texts. "Current instructional approaches experienced in many remedial reading courses may be successful at providing remediation, but failing to offer students opportunities to accelerate within these contexts holds the potential for remedial students to remain at-risk beyond the remedial classroom" (Greathouse, 2018, p. 220). Positively, researchers have found development of self-efficacy to be a key component of students' success in remedial reading classes. (Greathouse, 2018). "Success in reading tasks provides the experiential-based evidence students need to build higher levels of self-efficacy" (Donalson & Halsey, 2020, p. 196). Given these observations, creating an effective remedial reading class is challenging but essential.

All high school students, even those with superior reading comprehension skills, regularly interact with high level, low interest texts on district, state, and national tests, and they must rely on the strategies in their reading toolbox to comprehend, answer questions, and write about the texts. Students need a set of strategies that they can employ under various circumstances to ensure through comprehension. An effective remedial reading class helps students gain the necessary reading skills that they need to be successful in all of their classes as well as in life. Greathouse (2018) says it best when he explains, "We must look to not only challenge our students in their learning, but find ways to engage, motivate, and allow for

creativity within our classrooms in our effort to move them forward in their thinking and well-being" (p. 223). While it is true that students need to find success in school, it is their ability to transfer that knowledge to real life situations is what should be at the heart of the remedial reading curriculum. As Penny Kittle (2013) so profoundly states, "Reading is oxygen for a student's future success" (p. 63). Therefore, what is the best way to meet the academic needs of a diverse student population in a remedial reading class in a way that helps them to build their literacy toolbox and develop a respect for and maybe even a love of lifelong learning?

This very question drives my professional life. As the Instructional Literacy Coach at a highly ranked high school in a highly ranked county in Florida, I am charged with answering this seemingly rhetorical question. The school system and the school have a long history of high rigor and academic excellence. The community is affluent, and for most families, the expectation is that students attend a four-year college upon graduation from high school. These circumstances compound the profound impact of academic failure on students who struggle with reading. My capstone project is born out of my passion for supporting those students. Our classes are full of students who find themselves in remedial reading classes year after year, but they never leave the class because their reading levels do not increase enough to merit the change.

Our district has programs (Rewards and Wilson) in place to address the decoding, fluency, and automaticity challenges that these students face, but that has not been enough to help them make the necessary growth. Despite finding success in the classroom, students are unable to find success on the state tests that allow them to move out of the remedial reading class and into the elective of their choice, so our students need a curriculum that is designed to

help struggling high school readers to master and utilize two high impact reading strategies – self-questioning and summarizing – which will assist them in increasing their reading comprehension of both literary and informational texts (Dole et al., 1991; Fisher et al., 2016; Kamil, 2008; Pressley, 2002; Pressley & Afflerbach, 1995; Torgensen et al., 2007). Adding these strategies to their toolbox and utilizing them regularly to achieve mini-mastery experiences will likely build self-efficacy and help them develop a growth mindset. (Donalson & Halsey, 2020; Dweck, 2006; Ortlieb & Schatz, 2020; Pressley 2002). This level of knowledge coupled with empowerment will get them out of the remedial reading class and on with learning and life.

Chapter 2: Literature Review

Evolution of the Science of Reading

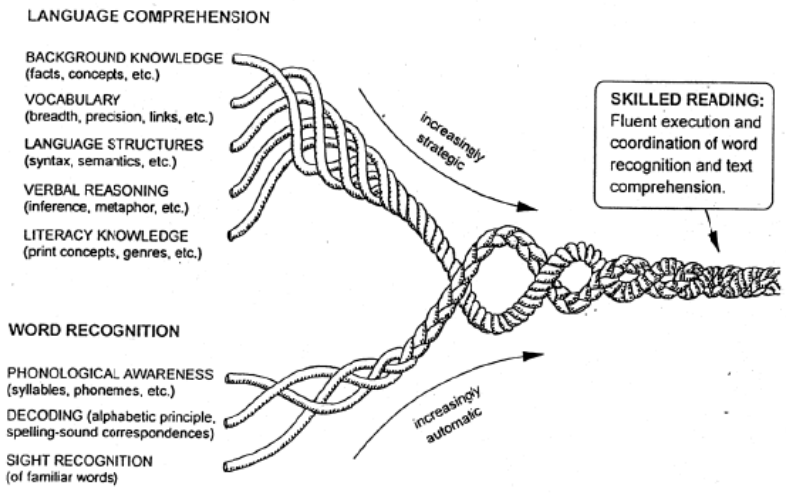
Over recent years, the understanding of how one reads and what makes one an effective reader has evolved. Gough & Tunmer (1986) offered what they believe to be the foundational belief:

> The simplest view of the relation between decoding and reading which anyone has ever seriously entertained is this: Reading equals the product of decoding and comprehension, or *R = D* x *C,* where each variable ranges from *0* (nullity) to *1* (perfection). We trust it is clear that by comprehension we mean, not reading comprehension, but rather *linguistic* comprehension, that is, the process by which given lexical (i.e., word) information, sentences and discourses are interpreted (p. 6).

This theory highly influenced reading curriculum then, and it continues to influence in some states even now. In the early 1990s, Scarborough began her interpretation of the simple view of reading and published an infographic with her interpretation of the formula.

Figure 1

Scarborough's Rope



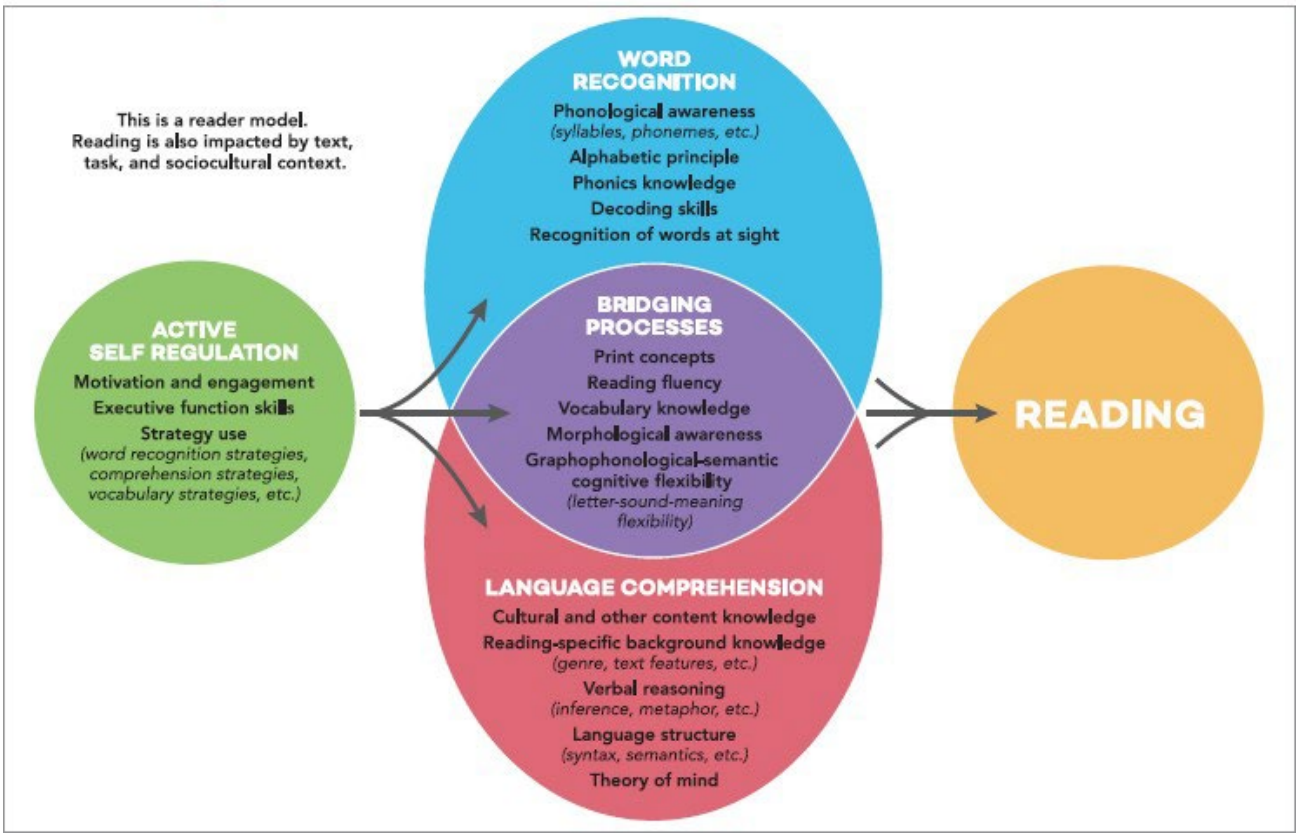
Note: According to Scarborough, this figure represents the many strands that are woven together in skilled reading. It, along with Gough & Tunmer's Simple View of Reading (SVR), has provided the foundation for curriculum since its publication in 2001.

Shortly after the publication of Scaborough's Rope, researchers began addressing the fact that it provided a limited perspective on skilled reading. "In summary, comprehension depends on letter- and word-level processes. That is only the beginning of the story of skilled comprehension, however" (Pressley, 2002, p. 294). It became clear that while Scarborough's conclusions were true, there were skills involved in reading comprehension that were not address by this theory. This is further confirmed when Biancarosa said, "Even excellent basic reading instruction in the primary grades does not guarantee that a student will successfully make the shift to these higher-level literacy demands" (2012, p. 22). In 2021, Duke and Cartwright offered an updated infographic that added components of reading that they

believed were missing from the SVR model. They called it the Active View of Reading Model.

Figure 2

The Active View of Reading Model



Note: This model builds on the work of Gough & Tunmer as well as Scarborough to include current research findings (Duke & Cartwright, 2021).

In their 2021 article, they added to the previous SVR model based upon current research. There findings were as follows:

> (1) Reading difficulties have a number of causes, not all of which fall under decoding and/or listening comprehension as posited in the simple view; (2) rather than influencing reading solely independently, as conceived in the simple view, decoding and listening comprehension (or in terms more commonly used in reference to the simple

> view today, word recognition and language comprehension) overlap in important ways; and (3) there are many contributors to reading not named in the simple view, such as active, self-regulatory processes, that play a substantial role
>
> in reading. We point to research showing that instruction aligned with these advances can improve students' reading (Duke & Cartwright, 2021, p. S25).

As previously mentioned, the students at our school either come with the decoding and listening comprehension skills necessary to access grade level texts, or they are receiving instruction to help them close the gap; however, they are lacking in the active, self-regulatory process skills that allow them to move past the words to sentence and paragraph comprehension.

Self-Regulatory Process Skills/Reading Comprehension Strategies

In this context, self-regulatory process skills refer to reading comprehension strategies. As time with high school students is limited and there is intense pressure for them to increase their reading levels at a rapid rate, it is imperative to isolate the reading comprehension strategies that have the highest impact. In 1991, Dole et al. synthesized research on reading comprehension and identified five key comprehension strategies: drawing importance, summarizing information, drawing inferences, generating questions, and monitoring comprehension. Pressley revised Dole et al.'s list to include predicting, questioning, imagining, clarifying, and summarizing as strategies that metacognitively sophisticated readers do to attain high levels of comprehension (2002). "We can say that it appears that asking and answering questions, summarizing, and using graphic organizers are particularly powerful strategies. But even with these strategies we cannot say which ones are the best or better than others for

which students and for which classrooms" (Kamil, 2008, p. 18). Although some of their suggestions vary, self- questioning and summarizing were consistently identified as necessary reading comprehension strategies.

John Hattie, educational researcher, is known for his meta-analyses of instructional practices as well as the work that was built upon that data. To quantify his findings, he developed a statistical formula for evaluating the impact of instructional strategies (Fisher et al., 2016). This is known as an effect size. "The effect size – it represents the magnitude of the impact that a given approach has" strategies (Fisher et al., 2016, pp. 6). Although there are instructional strategies that have a negative or low effect size (ranging from -0.20 – 0.18), those which range from 0.40 – 1.20 are within the zone of desired effects (Fisher et al., 2016, 10). In their book *Visible Learning for Literacy Impact: Grades K-12,* Fisher et al. identify high impact strategies for accelerating student literacy based upon the data from Fisher's meta- analyses. There are over one hundred strategies listed in the book, but the highest impact strategies pertaining specifically to reading instruction are in the range of 0.48 – 0.79 effect size (Fisher et al., 2016).

Of the strategies presented by researchers, the two that consistently appear every list also have an effect size that has potential to considerable accelerate student learning. According to the Corwin Visible Learning Meta^{x} website, self-questioning has an effect size of 0.59 ("Self-Verbalization/Self- Questioning", 2021) and outlining and summarizing has an effect size of 0.71 ("Outlining and Summarizing", 2021).

Self-Questioning

"It is our obligation to renew our students' curiosity and guide them toward inquiry"

(Tovani, 2000, p. 93). Many people find this statement to be true, but it is infrequently applied to reading. Text is often seen as something to "get through" rather than something to interact with. If students do not interact with the text, then they will struggle to make meaning of it. "If children are meaning makers and bring their own understanding to text, they must formulate questions in response to their puzzles, uncertainties, and interest so their interpretation of the text can grow" (Wilson, 2002, 75). This presents the idea that engagement and motivation can be boosted by having students generate questions as they read.

Initially, research focused on the value of self-questioning and the benefits on student learning. In the mid-1980s, self-questioning was a key component of a teaching method called reciprocal teaching. In their study, Palinscar and Brown concluded that "Training resulted in reliable transfer to laboratory tasks differed in surface features from the training and assessment tasks- summarizing, predicting questions, and detecting incongruities all improved" (1984, p.167). What they called predicting questions was a form of formulating questions based upon the text. When students did this, they were more focused on the main idea of the text, and they were continually checking their understanding (Palinscar & Brown, 1984). The benefit to having student engage in reciprocal teaching is that it is collaborative in nature. It affords students the opportunity to engage in critical thinking through questioning with a community to help deepen the meaning of the text. Tovani devoted a chapter to self-questioning. In it, she highlights the benefits of strategy: inferring, clear up confusion, clarifying, interacting with text, and motivating themselves (Tovani, 2000). Other benefits included more student engagement, more self-monitoring of comprehension, and more independent learning (Fisher et al., 2016; Joseph et al., 2016; Rouse-Billman & Alber-Morgan, 2019).

From there, researchers began to focus on methods for best implementing questioning in the classroom. As with any teaching strategy, modeling, chunking, guided practice, and feedback were most frequently addressed (Fisher et al., 2016; Joseph et al., 2016; Kamil, 2008). A literature review by Joseph et al. provided the most comprehensive ideas on how to implement self-questioning in the classroom. They introduce three tools for helping students develop questions: RAP (Read, Ask, Put), QAR (Question, Answer, Relationships), and TWA (Think Before Reading, While Reading, and After Reading) (Joseph et al., 2016). Each of these equally effective methods is a way of chunking the reading process so that students can generate appropriate questions about a given text. They go on to explain how self-generating questions allowed students to more accurately retell main ideas, recall details, and answer various types of questions (Joseph et al., 2016). More recently, Brown & Pyle, present the SQSR (Self- Questioning Strategy Routine) and a self-questioning guide. Essentially, they take best practices for questioning and create a comprehensive strategy for teaching it in a content area class (Brown & Pyle, 2021, p. 446).

The existing research provides adequate evidence that this strategy is beneficial for struggling readers. It also provides a framework within which a curriculum can be built.

Summarizing

Summarizing is another research-based active process skill that supports increasing reading comprehension. According to Watson et al., “Summarization, the ability to tell what the text is about in a concise manner, helps students to concentrate on the major points of a text and compact the information to better comprehend and remember what they read” (2012, p. 85). Based upon meta-analysis of research on summarizing, Marzano et al. identify summarizing

as an effective for increasing reading comprehension (2001). This sentiment is echoed by several researchers, and they offer ideas for implementing summarizing in their books (Burke, 2000; Marzano et al., 2001). Tovani, who does not address summarizing as a comprehension strategy unique to itself, makes it an important component in her proposed double-entry diaries (2000). More recently, Wormeli & Stafford challenged, "summarization is one of the most underutilized teaching techniques we have today, and yet it yields some of the greatest leaps in comprehension and long-term retention of information. It's worth restructuring our lessons to provide summarization experiences" (2019, p. 2).

Research shows that summarizing is a proven strategy that also transfers to later in life. In his book, *Reading Reminders: Tools, Tips, and Techniques,* Burke takes it a step further when he explains that summarizing is a skill that is necessary for success after high school and college (2000). Helping students to understand the relevance and application of a skill to their lives is crucial for student engagement, and Allington's conclusion helps identify those ways in which people summarize on a daily basis. "Literate people summarize informational texts routinely in their conversations. They summarize weather reports, news articles, stock market information, and editorials. In each case, they select certain features and delete ignore other features of the texts read" (Allington, 2013, 122).

Summarizing is a complex task, and by learning to master it, students grow in a variety of areas. "To do so, students must possess multiple skills, including knowledge of text structure, the ability to find the main idea of a text, and to summarize what they read" (Watson et al., 2012, p. 82). To effectively instruct students on summarizing it is important to recognize several key points identified by Marzano et al. They made three generalizations about summarizing:

> 1) to effectively summarize, students must delete some information, substitute some information, and keep some information; 2) to effectively delete, substitute, and keep information, students must analyze at a fairly deep level; 3) Being aware of the explicit structure of information is an aid to summarizing information (Marzano, 2001, pp. 30-32).

Once teachers understand these components of summarizing, they are better able to helps students learn the process and value of the strategy.

The research also focuses on best practices for teaching summarizing. One method, known as The Five Cs of Summarizing, was presented by McEwan. "The five Cs are *comprehend, chunk, compact,*

conceptualize, and *connect*…when taught using the I Do It, We Do It Lesson Plan, give students a systematic way to approach the summarizing of a long article, a full-length book, or a chapter in the textbook" (2007, p. 38). Her book also provides a series of instructional aids that walk students through her summarizing process. Wormeli and Stafford offer 60 summarizing activities for any subject in their book, *Summarization in Any Subject: 60 Innovative, Tech-Infused Strategies for Deeper Student Learning* (2019). These activities allow students to summarize in creative ways that go beyond outlines, web maps, and paragraphs.

There is no question about the value of learning to effectively summarize due to the complexity of the task. "When students construct written summaries of texts, discussions, and concepts, they engage in an immediate review process that allows them to notice their own level of understanding and receive timely and actionable feedback" (Fisher et al., 2016, p. 57). In addition to the intellectual challenge as well as the opportunity for teachers and students to

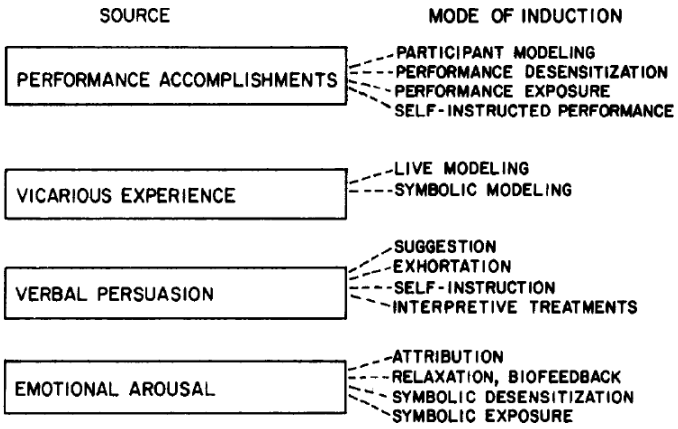
communicate about the summary, the process yields impressive results. “Interventions targeted at improving students’ reading comprehension reported that middle and high school struggling readers, in general, performed better at immediate posttest and follow- up on measures of summarizing text and identifying the main idea compared with answering multiple- choice questions” Daniel et al., 2021, pp. 180-181). Stevens et al.’s research confirms the conclusions made by Daniel et al., “In sum, this review supports summarizing and main idea intervention as an effective practice for improving struggling readers’ reading comprehension” (Stevens et al., 2019, p. 146). Self-questioning and summarizing are valuable strategies for students to know and use. However, they are a means to a bigger influence. When struggling readers embrace the fact that they can learn, despite years of failure, they build self-efficacy which leads to a growth mindset.

Self-Efficacy

Self-efficacy, or the belief that one can accomplish a given task, is an essential quality for successful learners to possess (Bandura, 1977; Fisher et al. 2016; Kittle, 2013; Ortlieb & Schatz, 2020; Tovani, 2000). Bandura’s seminal work on self-efficacy illuminates the power of one’s belief in oneself. His research on how people build their sense of self-efficacy through four types of experiences can be implemented directly in the classroom (1977).

Figure 3

Bandura’s Efficacy Expectations



Note: Bandura categorizes sources of information that lead to self-efficacy into four groups: performance accomplishments (referred to in this paper as mastery experiences), vicarious experiences, verbal persuasion, and emotional arousal. (Bandura, 1977, 195).

All four sources identified by Bandura play a role in helping struggling, high school readers build self-efficacy. Two of them, verbal persuasion and emotional arousal, have a profound psychological impact. Strategically addressing the psychological components that inhibit self-efficacy lays a foundation that maximizes the impact of the experiential sources.

Given that high schoolers who still find themselves struggling to access and comprehend texts, it is important that they are routinely encouraged and reminded that they can learn and grow (Bandura, 1977). This verbal persuasion plants the seeds of thought that, despite their struggle, they can still find success. “Although social persuasion alone may have definite limitations as a means of creating an enduring sense of personal efficacy, it can contribute to the successes achieved through corrective performance” (Bandura, 1977, p. 198). Likewise, it is essential to recognize that these struggling students have experienced years of failure when it comes to reading tasks; this results in feelings of inadequacy and fear (Bandura, 1977). When students meet new challenges with a sense of fear, they can further limit their success.

"Because high arousal usually debilitates performance, individuals are more likely to expect success when they are not beset by aversive arousal than if they are tense and viscerally agitated" (Bandura, 1977, p. 198). Emotional arousal can also provide positive momentum to struggling, high school readers. "In addition to diminishing proneness to aversive arousal, such approaches also teach effective coping skills by demonstrating proficient ways of handling threatening situations" (Bandura, 1977, p. 198). Explicit attention to verbal persuasion and emotional arousal helps teachers to create a safe space where student can take risks and build what Bandura calls performance experiences; these are more recently labeled as mastery experiences and will be referred to as such throughout this paper.

The other two sources of self-efficacy are experiential in nature. First, students' repeated success on challenging tasks allows them to build confidence and transferrable skills. Even partial mastery experiences have a profound effect on struggling readers (Bandura, 1977). As students begin to develop more confidence though mastery experiences, failure has less of an impact. "After strong efficacy expectations are developed through repeated success, the negative impact of occasional failures is likely to be reduced" (Bandura, 1977, p. 195). In fact, not only do occasional failures have less of an impact on students, but those previously detrimental experiences also become valuable to the student as they can use them to build coping strategies (Bandura, 1977). Experiencing mastery experiences is not the only way for students to build self-efficacy, they can also learn from the experiences of others. "Seeing others perform threatening activities without adverse consequences can generate expectations in observers that they too will improve if they intensify and persist in their efforts" (Bandura, 1977, p. 197).

In their research on self-efficacy in reading, Ortlieb and Schatz explain that "Using models, experiences, and feedback emulates the gradual release of responsibility that is needed to develop and maintain students' self-efficacy" (Ortlieb & Schatz, 2020, p. 746). This perspective takes Bandura's theoretical elements and relates them to a classroom practice: vicarious experience with teacher and peer modeling, performance accomplishments with mastery experiences, verbal persuasion with calibrated feedback, and physiological and affective states (emotional arousal) with student agency (2020).

A study by Solheim concluded, "The level of self-efficacy affects how much students understand of the texts they read but probably also the degree to which they are able to demonstrate what they have actually understood" (Solheim, 2011, p. 22). This perspective was also expressed by Ortlieb and Schatz. Their research showed that "As students develop increased levels of self-efficacy, a diverse array of literacy skills also improve, demonstrating the connection between the affective and cognitive domains" (Ortlieb & Schatz, 2020, 736).

In their meta-analysis of research on the impact of interventions on reading self-efficacy, Unrau et al. deducted that Bandura's theory can be used to guide instruction (2018). They concluded that there was adequate evidence to support implementing self-efficacy interventions in the curriculum and that the efficacy rate was directly correlated to the number of sources utilize as well as the quality of those sources (Unrau, 2018). "For example, attending to the quality with which strategies are modeled for students, providing vicarious experiences for them, offering persuasive feedback, and encouraging attention to readers' emotional and physiological states while reading could contribute to more potent motivational and performance outcomes" (Unrau, 2018, p. 199).

Growth Mindset

It is the research on self-efficacy upon which the concept of mindset is built. The commonly held understanding of mindset is that there are two mindsets: fixed and growth, and most people, however, fall somewhere on a mindset spectrum between the two (Dweck, 2006). Their place on the spectrum varies greatly depending upon the task, the person's emotional state, and many other factors (Dweck, 2016).

Interestingly, it is all learners (both teachers and students) who battle to understand and control their mindsets as they navigate through the growth process when striving for positive learning outcomes (Bandura, 1977; Dweck, 2016). In her book, Dweck mentions an experiment completed by Wood and Bandura in 1989. Their observation that, "construing ability as an acquirable skill fostered a highly resilient sense of personal efficacy" (Wood & Bandura, 1989, p. 412). This is the foundation upon which growth mindset in the classroom is built.

Dweck goes on to explain that people with a growth mindset work to build learning rather than expect it to be imparted on them (Dweck, 2006). If students and educators alike can embrace that "your basic qualities are things you can cultivate through your efforts, your strategies, and help from others. Although people may differ in every which way – in their initial talents and aptitudes, interests, or temperaments – everyone can change and grow through application and experience" (Dweck, 2006, p. 7) learning is limitless.

In her book *I Read It, but I Don't Get It - Comprehension Strategies for Adolescent Readers* (2000), Tovani builds on this idea as she presents a method for instruction based upon empowerment through growth mindset (2000). She advocates for teachers and students to embrace and develop the perspective that not only do all students want to read, but they can

with the right support. Like Tovani who emphasizes the importance of teachers having a growth mindset, Fisher, Frey, and Hattie (2016) direct educators to engage in collaborative conversations with colleagues to identify areas of understanding as well as areas of misconception so that teachers and learners can build upon their successes and address areas of growth. Additionally, they outline ways in which self-efficacy positively influences learners.

Kittle's work, *Book Love: Developing Depth, Stamina, and Passion in Adolescent Readers* (2013), is, in part, designed to explain why educators need to approach reading instruction with a new emphasis, helping students understand that reading is a key that opens the door to a whole new world of learning which makes growth mindset crucial to literacy development.

This information provides a foundation for a new pedagogical approach to supporting all readers, especially those who are struggling. While learning and utilizing summarizing and self-questioning, students will experience mini-mastery experiences that will boost self-efficacy and help them to develop a growth mindset that will serve them in school and beyond.

Chapter 3: Theoretical Framework

Teachers of struggling adolescent readers face a unique set of challenges as they attempt to help their students access and comprehend increasingly challenging texts. The process of reading and understanding sophisticated text that is at or above grade level becomes exponentially more difficult with students who have a history of struggling with reading comprehension (Biancarosa, 2012). They come to class with years of failed reading experiences which have changed their perception of who they are as people as well as learners (Donalson & Halsey, 2020). When these students reach high school, they are given high level, informational texts that are designed to provide them with the necessary knowledge to move to the next

level of learning mastery or provide them with information necessary to pass an assessment (Biancarosa, 2012). This process leaves them feeling defeated and frustrated. When they experience these emotions, they shut down and withdraw from the learning process (Beers, 1998). Thus, when educators work to build students' self-efficacy through a variety of learning experiences, they help them increase their reading comprehension and foster a growth mindset.

Self-Efficacy Theory

Bandura's theory of self-efficacy is based upon the premise that "psychological procedures, whatever their form, serve as a means of creating and strengthening expectations of personal efficacy" (1977). The findings presented in his article "Self-Efficacy: Toward a Unifying Theory of Behavioral Change" provide specific paths for helping struggling, high school readers to find success and growth even when they expect failure to be the result of trying to learn.

First, students need to be in an environment in which they can witness their peers experiencing not only success but exhibiting resilience when they struggle. "Seeing others perform threatening activities without adverse consequences can generate expectations in observers that they too will improve if they intensify and persist in their efforts" (Bandura, 1977, p. 197). This can be done through regular, collaborative learning experiences in which students are grappling together on a challenge or celebrating each other's successes. In a similar way, students can build confidence through scaffolded lessons. By chunking skills and gradually releasing tasks to individually learners, they are more inclined to stay engaged in the learning process (Ortlieb et al., 2020).

Struggling readers also need to experience trying and succeeding at challenging tasks. “While challenges are part of learning development, educators are positioned to provide scaffolds to empower learners to confront their academic difficulties” (Ortlieb et al., 2020, p. 741). Many struggling readers have the ability to complete simple reading comprehension tasks with material that is below grade level but completing these does not increase their level of self-efficacy. “Students’ perceptions of themselves as leas able readers and writers are reinforced when they are given literacy tasks that are less involved or less challenging than those assigned to their peers” (Colvin & Schlosser, 1997, p. 279). This is not easy for educators as they must be carefully created, but they are essential for student development.

> Independent performance can enhance efficacy expectations in several ways: (a) It creates additional exposure to former threats, which provides participants with further evidence that they are no longer adversely aroused by what they previously feared. Reduced emotional arousal confirms increased coping capabilities. (b) Self-directed mastery provides opportunities to perfect coping skills, which lessen personal vulnerabilities to stress. (c) Independent performance, if well executed, produces success experiences, which further reinforce expectations of self-competency. (Bandura, 1977, p. 202)

Providing struggling students with verbal persuasion is another way to encourage their success. “…people who are socially persuaded that they possess the capabilities to master difficult situations and are provided with provisional aids for effective action are likely to mobilize greater effort than those who receive on the performance aids” (Bandura, 1977, p. 198). Struggling readers need to take risks to grow and find success. They also need to

recognize the skills and strategies good readers use when they face challenging texts. Providing students with verbal persuasion and opportunities to be reflective allows them to strategize skills and strategies that they can employ as they strive for independence; it is this use of metacognition that will help them to tackle texts of all complexities. “Engaging in feedback loops positions students to engage in metacognition, for it is when students are metacognitive about strategy usage reading comprehension is regulated and developed” Ortlieb et al., 2020, 745).

Finally, taking steps to reduce emotional arousal through modeling and providing scaffolding for materials and skill will support growth of students’ self-efficacy. Building self-efficacy is not enough to get struggling readers on the path to success. They need to also recognize that they are embarking on a

journey that will be full of challenges and times when they do not believe that they can accomplish a task. They need something to be able to rely on (a growth mindset along with effective reading strategies) in those moments that may take them back to when they did not believe that they could improve their reading comprehension.

Growth Mindset Theory

Building a growth mindset about reading and learning will help students to understand that failure is an inevitable and necessary part of the learning process. After years of failure, students can disengage from the learning process. The goal for remedial reading teachers is to combat that natural tendency. “It’s common for students to turn off to school and adopt an air of indifference, but we make a mistake if we think any student stops caring” (Dweck, 2006, p. 204). Many teachers assume that students are lazy or do not care about learning when in fact,

they may just be lacking the reading strategies and self-efficacy to complete the assigned task. By creating a safe space where the focus becomes learning rather than being correct, students feel empowered and "remain in charge of their learning" (Dweck, 2006, p. 81).

By supporting students in an environment in which they are free to take risks, they will be able to overcome the perception that they are a bad reader, a bad student, or uneducable. Additionally, when their skills are challenged with high level texts, they are not debilitated if they struggle or fail to comprehend. "They don't believe in permanent inferiority. And if they are behind – well, then they'll work harder, seek help, and try to catch up" (Dweck, 2006, p.77).

In order for students to achieve this level of independence and drive, teachers must provide them with the tools to achieve higher standards. Ideally, they will reach a point where they do not want to stop trying because all experiences even those that end in failure lead to learning and growth. The goal of this curriculum is to integrate graphic organizers for two high impact reading comprehension strategies – self- questioning and summarizing – into the remedial reading classroom so that those who struggle with reading comprehension have tools that they can use to access any text. As students are already receiving reading instruction for literary texts through their English classes, the texts will be pulled from the Environmental Science curriculum. Unless struggling readers are highly engaged in a topic, they need to be motivated to invest their time and energy into reading to combat their pattern of failure over the years. Through this process, they can strengthen the necessary skills to build mastery reading comprehension experiences thereby increasing their level of self-efficacy. As students develop a strong sense of self- efficacy, they will form a growth mindset that will propel their academic risk-taking and thus their learning. It is through this process that students will develop

transferable skills, and they will have the confidence and willingness to try when they experience challenging reading tasks in school and in life.

Active View of Reading Model

Building on the foundational research of Scarborough and Gough and Tunmer, Duke and Cartwright introduced a new, more comprehensive explanation of what is really required for people to achieve full comprehension when reading. According to their research, the reading process begins with active self-regulatory processing skills which include motivation and engagement, executive functioning skills, and strategy use (Duke & Cartwright, 2021). This perspective was different because Scarborough's previous model was limited to language comprehension and word recognition. Since the publication of Scarborough's findings, it has been the foundation for remedial reading curriculum. This is problematic because the absence of other key components necessary for full comprehension meant that some students were still lacking in these areas, and they were not receiving instruction in their deficit areas. It is no wonder that they were unable to acquire the necessary skills which were essential for the expected growth. "In fact, comprehension strategy use has been shown to predict reading ability even beyond word recognition and language comprehension" (Duke & Cartwright, 2021, p. S32).

Self-Regulatory Processing Skills

Duke and Cartwright offer a few examples of comprehension strategies including word recognition, comprehension, and vocabulary. However, there are many more strategies that good readers employ as they read. John Hattie's meta-analyses offer insight into the comprehension strategies with the highest effect size, meaning they fall in the zone of optimal

effect. Two strategies that have both a high effect size are self-questioning and summarizing (Fisher et al., 2016). Self-questioning allows students engage in a personal way with texts identifying both what they find interesting as well as what they find challenging. By providing students with the opportunity to both ask and answer questions, they become actively engaged in the process of reading for a purpose (Tovani, 2000; Wilson, 2002). It is also a unique method for students to show that their comprehension level of a text. The process of learning to summarizing is a valuable transfer skill as students need to learn how hone in on key ideas and details, think deeply on a particular topic, and organize information in a clear and concise manner (Marzano, 2001). In a world in which people are inundated with information, much of which is questionable, students need these skills to filter through it to become informed members of society. Additionally, the process of summarizing increases students' understanding of the texts but also their retention of what they learned. (Wormeli & Stafford, 2019). This is crucial for students who are struggling with reading.

There are several goals for placing students in an intensive reading class. The main overarching goal is to help students independently make meaning of any text. "Readers need to construct their own meaning. In order to this, they need to apply reading strategies – consciously at first, but eventually it becomes automatic" (Tovani, 2000). Ideally, this seemingly lengthy process should happen quickly – within one school year – so that students are able to attain the necessary skills that will allow them to access content materials in their other classes. This will also allow them to get back into the elective classes that they want. As students learn at their own pace, the timeline for each individual student will vary. So, the goal becomes to plant seeds – seeds that will grow in other classes and in other settings. In order to achieve this

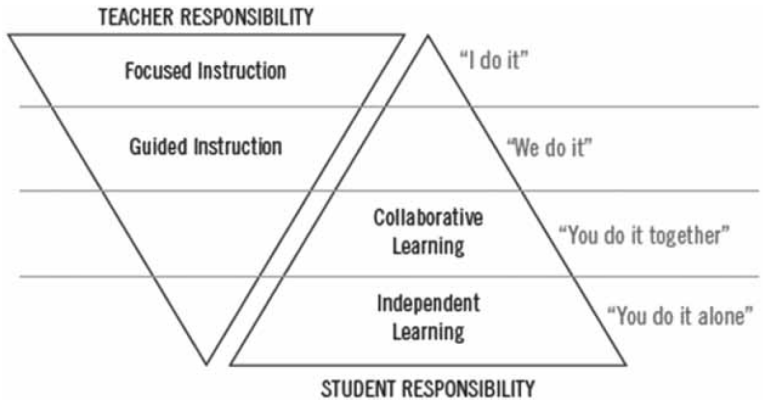
goal, the lessons need to be carefully crafted to ensure maximum growth. The following lessons contain certain key components that are imbedded into the lessons. Research and experience have proven that they are essential to helping students increase their reading comprehension.

Fisher et al. (2016) presents several key components of a well-crafted lesson which should be implemented in each class. First, students should be taught key study skills, namely notetaking and annotating which will allow them to actively interact with new information. Additionally, repeated reading and cooperative learning provide students with important opportunities to revisit texts and synthesize their understand of the text. Finally, providing students with feedback that is timely, specific, understandable, and actionable gives them the guidance necessary framework within which they can form their own understanding.

In 1983, Pearson and Gallagher presented a new perspective on teaching known as the Gradual Release of Responsibility Model (GRR). It was born out of the observation that teachers were presenting material and then having students practice without incorporating guided practice into the lesson. Based upon newer research, the practice has evolved based upon newer research and been refined. In 2014, Fisher and Frey presented a new model. In their model, what is emphasized is who is doing the work, with work responsibility gauged by the relative amount of space allocated to teachers and students in I Do, We Do, and You Do zones. One other significant variation from the original model is the addition of the Collaboration (You do together) Zone, which lies in between the Teacher/ Student collaboration in the Guided Instruction Phase and the Independent Practice phase. (Pearson & Gallagher, 2019, p.14).

Figure 4

Fisher and Frey's Gradual Release of Responsibility Model



Note: Using Pearson and Gallagher's Gradual Release of Responsibility Model, Fisher and Frey applied new research findings to create an updated model with specific classroom implications. (Fisher & Frey, 2014).

As the research suggests, this method is highly effective when used with struggling, adolescent readers due to the inclusion of modeling, guided practice, and collaboration with both the teacher and fellow students.

As one reads, they must take the information presented and make sense of it. "Access tools are specific materials and strategies that help students organize and synthesize their thoughts as they read" (Tovani, 2000, p. 20). While researchers provide many tools that they believe are most helpful to students when trying to comprehend challenging texts, there is one that is regularly suggested, graphic organizers (Edmonds et al., 2009; Hall et al., 2013; Joseph et al., 2016; Kamil, 2008; Praveen & Rajan, 2013; Torgensen et al., 2017; Watson et al., 2012). They have become integrated in most secondary classrooms in one way or another, but they are not always explicitly taught nor are students taught how to decide which graphic organizer is appropriate for which context. One study completed by Hall et al. found that, "organizers can help students to compare and contrast, establish cause and effect, sequence events, and order

concepts according to hierarchical importance" (2013, p. 51). They are recommended as a foundational component of effectively self-questioning and summarizing (Kamil, 2008; Torgensen et al., 2017).

It is not enough to present what should be done in the remedial classroom. In fact, much of what is determined to be effective through research is already being done by many remedial reading teachers. The real value of this conversation lies in the how these ideas should be implemented. Once meaning and purposeful activities and assessments have been created, teachers can focus on how the concepts are taught and how feedback can be used to guide learning and instruction. When done effectively, students accumulate mastery experiences in self-questioning and summarizing that help them increase comprehension; this builds self-efficacy and leads to a growth mindset.

Chapter 4: Curriculum

The unit was designed to provided students opportunities to practice and learn how to use self- questioning and summarizing to comprehend texts real-world texts and resources. The hope is that they will develop skills that they can transfer to other classes as well as to real-world reading experiences.

Therefore, it is important that students practice with texts and resources that are relevant to their learning and life. The resources chosen can be found in an Environmental Science classroom. While researchers like Pugalee have written entire books on content area literacy in math and science, limited research exists about implementation of content area literacy in the remedial reading classroom (2014). Allington also recommends what he calls for content area mastery support (2016). This curriculum is designed to do just that. Each activity is paired with

a relevant resource to help students extract information that helps them better understand the answer to the essential question: What impact do humans have on the environment? Throughout the lesson, students will work both collaboratively and individually to increase mini-mastery experiences as well as self-efficacy. A particular emphasis is also placed on utilizing feedback that helps promote a growth mindset in students.

There are several intentional curriculum decisions that were made so that students can have mini-mastery experiences to build self-efficacy and foster a growth mindset. First, the content is scaffolded and ranges from texts that are below grade level with the lesson culminating in a text that is above grade level. According to ARbookfinder.com, the first text is *The Giving* Tree is written at a 560 Lexile. *The Lorax*, which is said to be a 3.1 Lexile is more challenging for high school students due to the use of non-sense words, so it is placed after *The Giving Tree*. The textbook, while there is not a printed Lexile level, is often challenging for the 9th grade students who utilize it at our school. The articles are of varying rigor to allow the opportunity for additional scaffolding in the middle of the unit. The final text, *Silent Spring,* is considered an 11.5 Lexile level. Scaffolded texts allow for more performance accomplishments during which students build knowledge and skills so that they can have mini-mastery experiences and build their self-efficacy.

Additionally, each activity is designed using Fisher and Frey's Gradual Release of Responsibility model. If an activity is being done for the first time, the teacher will model the skill and/or thinking necessary using a small chunk of the content. This could be the first few lines of a poem, the first minute of a video, or the first few paragraphs of a story. Initially, exemplars of products are also provided so that the expectations are clear allowing the

emphasis of the feedback to rest on comprehension rather than on task completion accurately completing the task. These vicarious experiences will also help student achieve mini-mastery experiences more quickly.

Finally, careful attention was paid to infuse collaboration throughout the unit. This provides students with vicarious experiences as they see their partners and group members find success. Additionally, students are taught and are expected to utilize respectful discussion stems. This encourages consistent verbal persuasion and emotional arousal even when the teacher is busy. Sharing out and celebrating students' successes is also crucial as it reinforces all four sources of self-efficacy.

Daily and unit lessons are a true labor of love. They are carefully crafted over years; they evolve with experience, trial and error, blood, sweat, and tears. What works seamlessly with one set of students will cause chaos with another. What will feel like a warm comfy sweater to one teacher will feel like an albatross on the back of another. The following set of lessons that can be utilized in part or as a whole, but ideally, they will spark new ideas that will open up conversation with colleagues. They will inspire teachers to think outside of the proverbial box of reading instruction and lead to new and creative ways to help empower students to be builders of understanding and seekers of knowledge through attainable, transfer skills: self-questioning and summarizing. The unit is as follows:

Reading to Learn: Human Impact on Land

Florida Standards for Environmental Science

SC.912.L. 17.12: Discuss the political, social, and environmental consequences of sustainable use of land.

SC.912.L.17.14: Assess the need for adequate waste management strategies.

SC.912.L.17.16: Discuss the large-scale environmental impacts resulting from human activity including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

Florida Standards for Reading

ELA.9.R.2.2: Evaluate the support an author uses to develop the central idea(s) throughout a text.

ELA.9.R.3.2: Paraphrase content from grade-level texts.

ELA.9.V.1.3: Apply knowledge of context clues, figurative language, word relationships, reference materials, and/or background knowledge to determine the connotative and denotative meaning of words and phrases, appropriate to grade level.

ELA.K12.EE.1.1: Cite evidence to explain and justify reasoning.

ELA.K12.EE.3.1: Make inferences to support comprehension.

ELA.K12.EE.4.1: Use appropriate collaborative techniques and active listening skills when engaging in discussions in a variety of situations.

Learning Objective

I can use questioning strategies to learn, from a variety of sources, the impact that humans can have on the land, and I can summarize what I have learned.

Summative

Students strategically place hexagons that they have created throughout the unit to show relationships between key words that they deem to be important. They will then select five of the most significant relationships and explain the relationships and why they are important.

Teaching Tools

- Appointment Times (Appendix A)
- Collaboration Stems: based on ideas from (Heick, 2022) (Appendix B)
- Cornell Notes (Appendix C)
- Discussion Stems: based on ideas from (Staake, 2022) (Appendix D)
- Four Types of Questions (Appendix E)
- Hexagon Thinking Directions: based on ideas from (Gosner, 2020) (Appendix F)
- Hexagon Thinking Summative: based on ideas from (Gosner, 2020) (Appendix G)
- Jigsaw Graphic Organizer (Appendix H)
- Mind Mapping Textbooks (Appendix I)
- Showing My Thinking: based on ideas from (Mulvahill, 2019) (Appendix J)
- Venn Diagram (Appendix K)
- Word Sort (Appendix L)

Resources

Videos:

Cutts, S. (2012). YouTube. Retrieved March 26, 2023, from

https://www.youtube.com/watch?v=WfGMYdalClU&t=50s.

Children's Books:

Seuss. (1971). *The lorax*. Random House. (Appendix M)

Silverstein, S. (1964). *The giving tree*. Harper & Row. (Appendix N)

Textbook:

Heithaus, M. R., & Arms, K. (2013). Chapter 14: Land. In *Environmental science* (pp. 354–377). essay, Houghton Mifflin Harcourt. (Appendix O)

Heithaus, M. R., & Arms, K. (2013). Chapter 15: Food and agriculture. In *Environmental science* (pp. 378–407). essay, Houghton Mifflin Harcourt. (Appendix P)

Fiction:

Steinbeck, J. (2014). Chapter One. In *The grapes of wrath* (pp. 3–7). essay, Viking. (Appendix Q)

Informational:

Carson, R. (2002). Chapter 2. In *Silent spring* (pp. 3–7). essay, A Mariner Books. (Appendix R)

Donley, N., & Gunstone, T. (2021, June 1). Pesticides are killing the organisms that keep our soils healthy. *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/pesticides-are-killing-the-worlds-soils/ (Appendix S)

Flesher, J. (2020, February 6). Factory farms provide abundant food, but environment suffers. *PBS*. Retrieved March 26, 2023, from https://www.pbs.org/newshour/economy/factory-farms-provide- abundant-food-but-environment-suffers (Appendix T)

How fertilizers harm earth more than help your lawn. (2009, July 20). *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/how-fertilizers-harm-earth/ (Appendix U)

Kennedy, M., & Cassetty, S. (2022, October 24). Pros and cons of gmos: An evidence-based comparison of genetically modified foods. *Insider*. Retrieved March 26, 2023, from https://www.insider.com/guides/health/diet-nutrition/gmo-pros-and-cons (Appendix V)

Activities

Activity	Content Resource	Teaching Tools	Approx. Time
1.	Metacognition about Questions	Discussion Stems	20 Minutes
2.	*The Giving Tree* by Shel Silverstein	Ways to Show Thinking	20 Minutes
3.	See Activity #2	Four Types of Questions, Collaboration Stems	40 Minutes
4.	See Activity #2	Hexagonal Thinking Directions	10 Minutes
5.	"Man"	Four Types of Questions, Collaboration Stems, Hexagonal Thinking Directions	20 Minutes
6.	*The Giving Tree* by Shel Silverstein and "Man"	Venn Diagram	20 Minutes
7.	See Activity #6	Whiteboards	20 Minutes
8.	*The Lorax* by Dr. Seuss	Four Types of Questions, Collaboration Stems, Hexagonal Thinking Directions	60 Minutes
9.	Chapter 14 of *Environmental Science*	Cornell Notes	30 Minutes
10.	See Activity #9	Four Types of Questions, Collaboration Stems	20 Minutes
11.	See Activity #9	Hexagonal Thinking Directions	20 Minutes
12.	Chapter One from *The Grapes of Wrath*	Word Sort	20 Minutes
13.	See Activity #12	Four Types of Questions, Collaboration Stems	30 Minutes
14.	See Activity #12	Hexagonal Thinking Directions	15 Minutes
15.	Chapter 15 of *Environmental Science*	Mind Mapping Textbooks, Collaboration Stems	50 Minutes
16.	See Activity #15	Four Types of Questions, Collaboration Stems	15 Minutes
17.	See Activity #15	Hexagonal Thinking Directions	20 Minutes
18.	• "How Fertilizers Harm Earth More Than Help Your Lawn" • "Pesticides are Killing the Organisms that Keep Our Soils Healthy" • "Genetically Modified Foods" • "Factory Farms Provide Abundant Food, but Environmental Suffers"	Jigsaw Graphic Organizer	Part 1: 20 Minutes Part 2: 30 Minutes
19.	• See Activity #18	Hexagonal Thinking Directions	20 Minutes
20.	from *Silent Spring*	Ways to Show Thinking, Four Types of Questions, Hexagonal Thinking Directions, Collaboration Stems, and Venn Diagram, Cornell Notes, or Mind Mapping	90 Minutes

Activity	Content Resource	Teaching Tools	Approx. Time
21.	All Unit Resources	Hexagonal Thinking Project	90 Minutes

Materials

- Composition Notebook for collecting ideas, notes, and practice work.
- Post it notes for interacting with resources.
- Various colored pens and highlighters for interacting with resources.
- Teaching Tools (Appendices A-L)
- Content Materials (Appendices M-V)

Reading to Learn: What Impact do Humans Have on the Environment?

Jennifer Druggan

Lesson Overview

For the next few weeks, we will be learning about the impact that humans have on the environment.

We will use several different graphic organizers to help us organize and comprehend the new material.

Through this process, we will develop and refine our self-questioning and summarizing skills using different types of resources.

Our goal is to learn new ways to organize information to help us learn and acquire new knowledge.

Florida Standards for Environmental Science

SC.912.L. 17.2

- Discuss the political, social, and environmental consequences of sustainable use of land.

SC.912.L.17.14:

- Assess the need for adequate waste management strategies.

SC.912.L.17.16:

- Discuss the large-scale environmental impacts resulting from human activity including waste spills, oil spills, runoff, greenhouse gases, ozone depletion, and surface and groundwater pollution.

Florida B.E.S.T. Standards for Reading

Evaluate	ELA.9.R.2.2: Evaluate the support an author uses to develop the central idea(s) throughout a text.
Paraphrase	ELA.9.R.3.2: Paraphrase content from grade-level texts.
Apply	ELA.9.V.1.3: Apply knowledge of context clues, figurative language, word relationships, reference materials, and/or background knowledge to determine the connotative and denotative meaning of words and phrases, appropriate to grade level.
Cite	ELA.K12.EE.1.1: Cite evidence to explain and justify reasoning.
Make	ELA.K12.EE.3.1: Make inferences to support comprehension.
Use	ELA.K12.EE.4.1: Use appropriate collaborative techniques and active listening skills when engaging in discussions in a variety of situations.

Unit Overview

Essential Question: What impact do humans have on the environment?

Formatives: annotations of texts, graphic organizers that students use to organize their understanding of the texts, hexagons for individual texts.

Summative: Hexagonal Thinking Project

Activity #1: Overview

Tasks:

- They will read two statements about questions and reflect on them in their composition notebook.
- They will discuss their ideas with others to process through their thoughts and to understand the ideas of others.

Description:

- Student begin with quiet, independent work in which they are introduced to the concept of self-questioning.
- They will practice exploring challenging ideas.
- They transition to collaborative conversations for understanding using a pre-completed Appointment Times document (see the Teaching Tools section).

Self-Questioning

In your composition notebook, explain why you agree or disagree with the following statements:

1. Asking a question is a sign of understanding, not ignorance; it requires both knowledge and then–critically–the ability to see what else you're missing.
2. Questions are more important than answers because they reflect both understanding and curiosity in equal portions.

Discussion

- Now that you have prepared your thoughts, you will discuss your ideas with a partner.
- You will use the sentence stems from your sheet to help make sure that your discussion is productive.
- Please glue this into your composition notebook as we will continue to use it to guide our discussions.

26 Sentence Stems For Higher-Level Discussion In The Classroom

Clarifying

Could you give me your thesis?

Is it your position that...

To be clear, you're saying that...

I'm confused when you say Z, Can you elaborate?

Paraphrasing

Put another way, you're saying...

So you're saying that...

Is it fair to say that you believe...

I hear you saying that...

Agreeing

I agree with Y because...

Z's point about X was important because...

The evidence for Z is overwhelming when you consider that...

X and I are coming from the same position.

Despite disagreeing about Y, I agree with Z that...

Disagreeing

I see it differently because...

The evidence I've seen suggests something different.

Some of that is fact, but some of it is opinion as well.

I agree that Y, but we also have to consider that...

We see Z differently.

Building On

Y mentioned that...

Yes--and furthermore...

The author's claim that Z is interesting because...

Adding to what X said,...

If we change Xs position just a little, we can see that...

Summarizing

Overall, what I'm trying to say is...

My whole point in one sentence is...

More than anything else, I believe that...

TeachThought. Learn better

(Heick, 2022)

Discussion

Talk with your 9:00 partner about your response to the first statement. Be prepared to share with the class.

Talk with your 12:00 partner about your response to the second statement. Be prepared to share with the class.

Activity #2: Overview

Task:

- Read and annotate *The Giving Tree* with an emphasis on how the author portrays human impact the environment (see the Content Materials section).
- Begin to build their reading toolbox by gluing their annotated work into their composition notebook.

Description:

- This is a children's book which is easily accessible to students in the remedial reading classroom. This affords students the opportunity to practice the close reading skills.
- Student can also begin to activate prior knowledge and build background knowledge
- They will utilize the Showing My Thinking document (see the Teaching Tools section).

Interacting with Texts

1. Begin by interacting with the text, *The Giving Tree* by Shel Silverstein, using the Showing My Thinking symbols. Remember, we will be gluing this into your notebook so be neat.
2. When you are done, pull out your independent reading book and begin reading.

Showing My Thinking Chart

Before you begin reading, number each paragraph (even if they are small). As you read, place the symbols to show your thinking. (You should have approximately one symbol for every 4-5 sentences.) For each symbol, write a brief note in the margin so that you remember what you were thinking. (*These are crucial because you will use these notes later.*)

1 2 3	Number each paragraph (big and small)
	This is the main idea.
	This word is new to me.
	This is an important idea or example.
?	I don't understand why…
	This makes sense to me because…
!	This is shocking because…
+	This is true because…
—	I disagree because…
CS	I can relate to this because…
CW	This reminds me of…
CT	I've seen this before when…

Activity #3: Overview

Tasks:

- As a whole class, we will learn about the Four Types of Questions (see Teaching Tools section).
- Individually or collaboratively depending upon the situation presented, they will work to generate their own questions.
- They will practice answering other's questions.
- They will give each other feedback on the questions that they created using the Collaboration Stems (see Teaching Tools Section).

Description:

- These activities are designed to help student practice challenging skills with an accessible text.
- They are also designed to give students the opportunity to learn how to work cooperatively in a respectful and productive way.
- They are facilitated as a whole group to build classroom expectations.

Types of Questions: Team Learning

Right There

These are literal questions whose answers can be found in the text. Often the words used in the question are the same words found in the text.

My Right There Questions:

1. Who are the two main characters in the story?
2. Why does the boy come to see the tree initially?

Your Task:

1. Individually, create a Right There question and write it on your copy of the text.
2. Trade questions with your shoulder partner and answer each other's questions.

Use your Collaboration Stems to take a Reflection Break

Here is a copy of the Collaboration Stems.

Please glue them in your composition notebook.

Focus on giving warm feedback.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Types of Questions: Team Learning

Think and Search

These ask readers to collect information from more than one part of the text and put it together to answer the question.

My Think and Search Questions:

1. What is similar about the way the boy reacts each time he comes to see the tree?
2. What are the things that the boy needs throughout the story?

Your Task:

1. Individually, create a Think and Search question.
2. Trade questions with your across partner and answer each other's questions.

Use your Collaboration Stems to take a Reflection Break

Now, ask a question.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Types of Questions: Team Learning

Author and You

These questions are based on information found in the text but ask the reader to relate the question to their own experience. You must read the text in order to answer the question.

My Author and You Questions:

1. Tell about a time when you felt like the tree.
2. Do you think that the boy changed? Explain your answer.

Your Task:

1. Individually, create an Author and You question.
2. Trade questions with your diagonal partner and answer each other's questions.

Use your Collaboration Stems to take a Reflection Break

Give cool feedback to help make individual time more effective.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Types of Questions: Team Learning

On My Own

These questions do not require the students to have read the passage. Readers rely on their background or prior knowledge to answer the question.

My On My Own Questions:

1. What do you think causes people to be selfish? Explain your answer.
2. Is it okay to give someone everything that you have? Explain your answer.

Your Task:

1. Individually, create an On My Own question.
2. Trade questions with your diagonal partner and answer each other's questions.

Use your Collaboration Stems to take a Reflection Break

Choose the type of feedback that you think is most appropriate.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Activity #4: Overview

Tasks:

- On the front side of a 5x5 hexagon, students will generate a scientific key word(s) for the resource that they explored.
- On the back side of the hexagon, they will write a quote with an in-text citation from a text or a summary from a video as well as an explanation of how the key word(s) relate to the essential question: What impact do human have on the Environment?

Description:

- The hexagons are at the heart of this unit. Students will create one or more hexagons for each content resource that we read. At the end of the unit, students will strategically organize their hexagons based upon their relationships to each other. For the summative, they will identify six significant connections and explain how they relate to the essential question: What impact do human have on the Environment?

Connecting Ideas

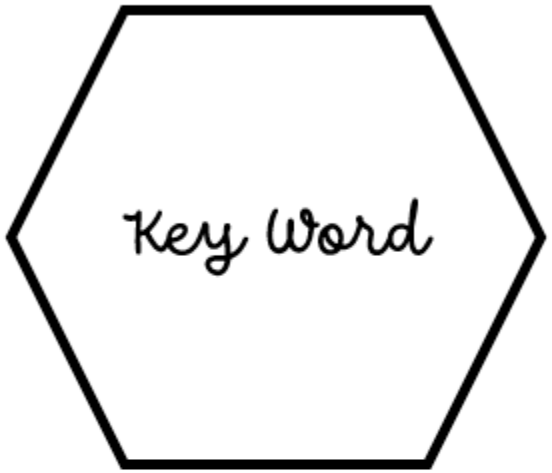
For each source we use, we will create one or more hexagons to summarize what we have learned that helps us answer our essential question: What impact do humans have on the environment? When we finish exploring the topic, we will work to determine how all of these ideas work together.

Make one hexagon for *The Giving Tree*.

Hexagonal Thinking Directions

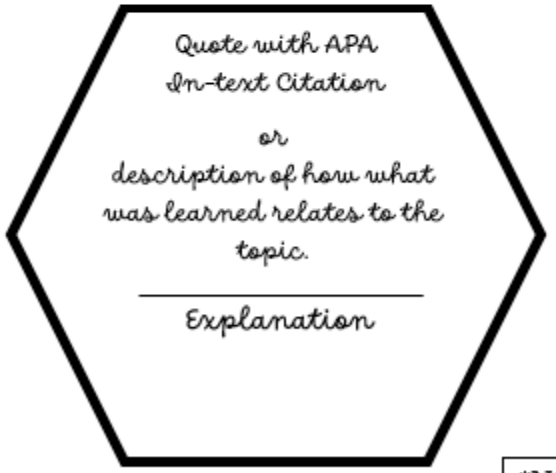
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Explaining and Connecting

- All of the components of the hexagon are important because they all need to work together to tell what you just learned that answers the question: What impact do humans have on the environment?
- The only way to make sure that all three parts are connected is if your explanation sentence tells your key word(s), tells how it was explained in your text, and tells how it all relates to the essential.
- Give me your best critiques for the sample on the next slide.

Sample Hexagon for *The Giving Tree*

Parasitism

"'I wish I could give you something…but I have nothing left'" (Silverstein, 1964, p. 55).

At this point in the story, the boy has grown into an old man. He returns to see the tree, but the tree has nothing to offer because the boy has taken all his fruit, branches, and even the trunk. This is representative of the parasitic relationship humans have with the land.

Activity #5: Overview

Tasks:

- Students will watch a short video depicting the impact man has on the environment.
- After watching the video, they will generate one of each type of question for the video that they watched.
- We will share out questions as a class to generate discussion.
- They will then create a hexagon for this source.

Description:

- At the high school level, teachers often use videos to present content. The material comes quickly and students benefit from the practice of watching videos and extracting important information.
- They will continue to practice learning collaboratively.
- Finally, they will continue to build knowledge to help them answer the essential question.

What questions can we ask about this video?

In your composition notebook, write at least one of each type of question.

We will share out as a class to see what we know.

Connecting Ideas

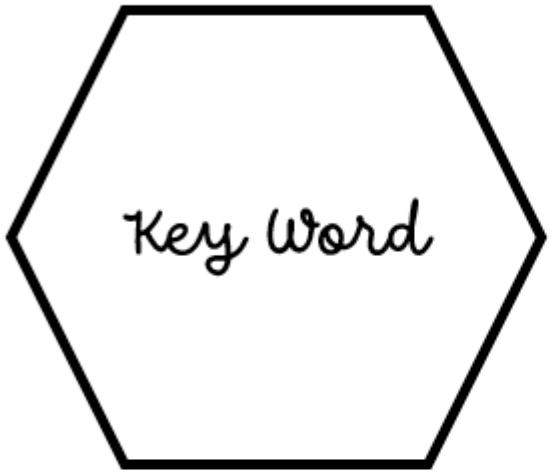
For each source we use, we will create one or more hexagons to summarize what we have learned. When we finish exploring the topic, we will work to determine how all of these ideas work together.

Make one hexagon for *Man*.

Hexagonal Thinking Directions

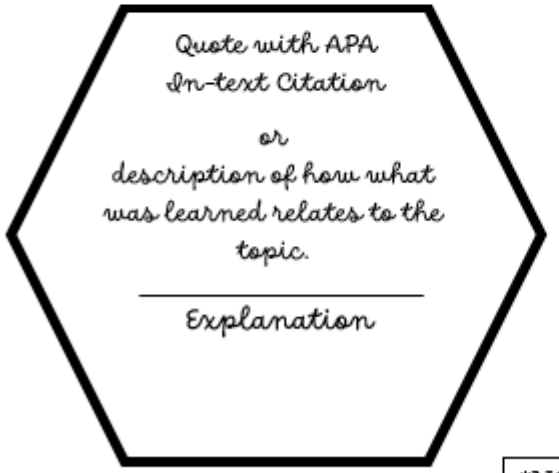
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Sample Hexagon for “Man”

Destruction

The video shows a man encountering various forms of nature and using it but killing it in the process.

It is showing all the ways in which humans selfishly take what they want from the environment and destroy it in the process. Specifically, man joyously turns trees into paper and builds cities and factories where forests once were.

Activity #6: Overview

Tasks:

- Students will create a Venn Diagram identifying three similarities and three differences between two resources.
- They will then share their thoughts.

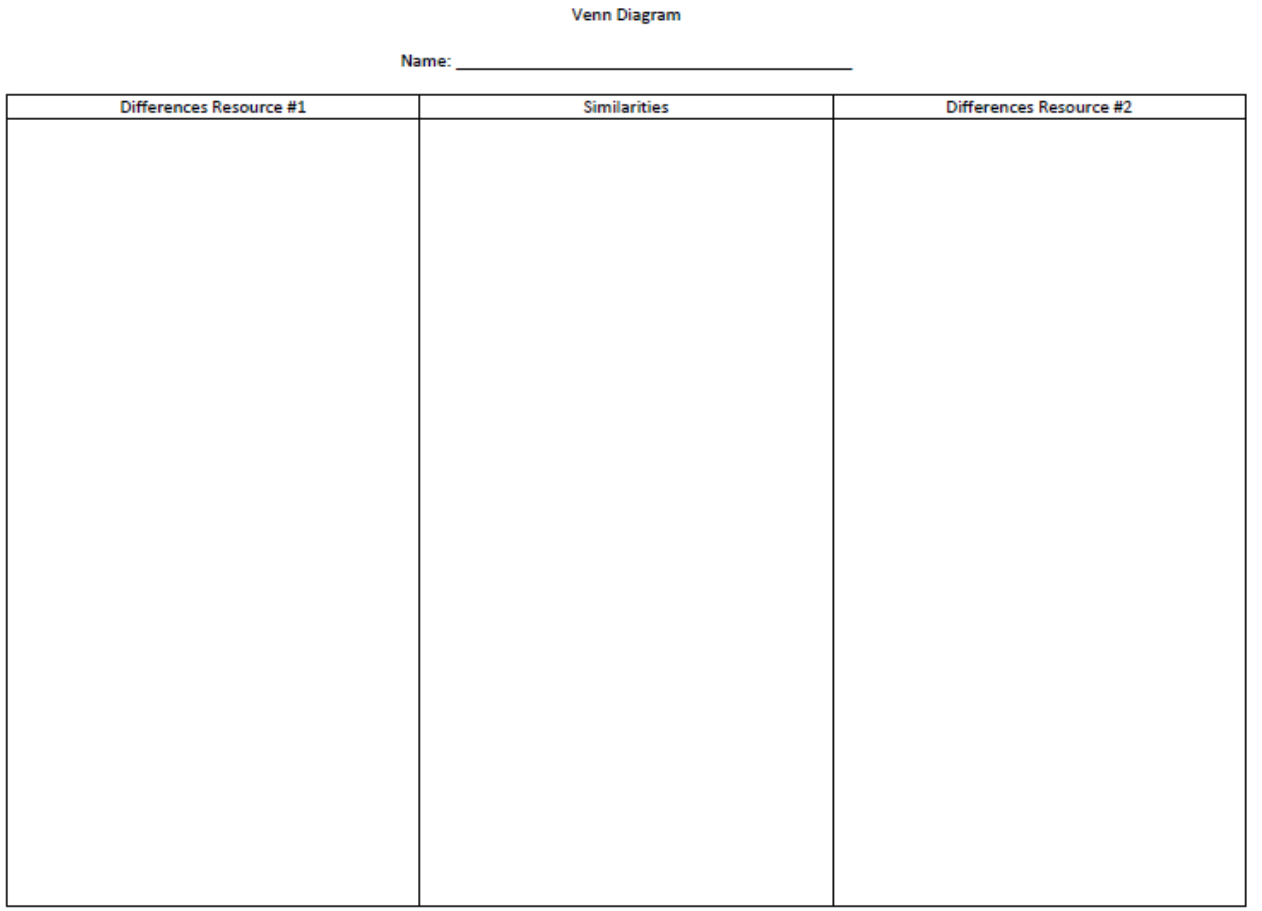
Description:

- They will be comparing the similarities and differences between the content presented in *The Giving Tree* and "Man".
- In addition, they will also look at the presentation of the material. This way they can begin to distinguish the formal presentation versus informal presentation of content.

Making Connections

In your composition notebook, create a Venn Diagram with three similarities and the differences that you see between *The Giving Tree* by Shel Silverstein and "Man" by Steve Cutts.

Be prepared to share your ideas with the class.



Venn Diagram

Name: _____

Differences Resource #1	Similarities	Differences Resource #2

Activity #7: Overview

Tasks:

- Students will read one of their questions to the class.
- The rest of the class will answer the question using their whiteboards.
- I will observe answers to check for understanding and identify misconceptions for clarifying and reteaching.

Description:

- This allows students to take ownership of their learning and build a collaborative classroom culture.
- It also gives me the time to gauge each student's level of understanding as well as any misconceptions that they may have so that I can address them right away.

Check for Understanding

- Today, you get to be the teacher!
- One at a time, you will ask the class one of your questions of your choosing. (Try to vary the types of questions that you are asking.
- Your classmates will individually answer the question on their whiteboard.
- I will be taking notes to see what we understand and what we need to cover again.

Activity #8: Overview

Tasks:

- Students will read and annotate Dr. Suess's *The Lorax* using the Ways to Show my Thinking chart.
- They will continue to practice generating questions.
- They will also create two new hexagons for their final project.

Description:

- Although students are doing the same activities that they performed with *The Giving Tree,* this task is more complex due to the more complex text. The nonsense words in *The Lorax* help students to practice persisting when challenged.
- They are also continuing to gain knowledge that helps them answer the essential question.

Interacting with Texts

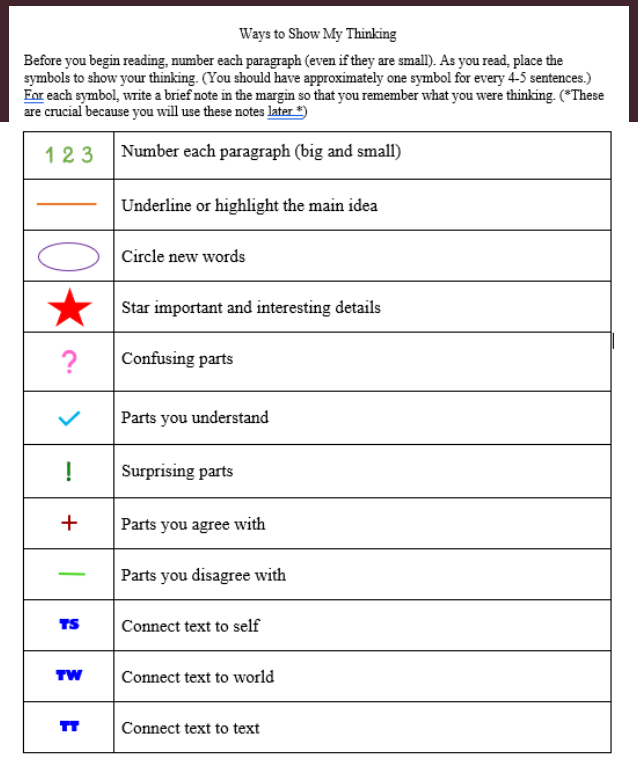
1. Begin by interacting with the text, *The Lorax by Dr. Seuss*, using the Showing My Thinking symbols. Remember, we will be gluing this into your notebook so be neat.
2. This is a longer text, and it is also more challenging because of the nonsense words. It is written is a sort of code, so work to crack it.
3. Let's read the first page together to help each other make sense of the text and strategize how to show our thinking.
4. Write a one sentence summary explaining what we learned on the first page.

Ways to Show My Thinking

Before you begin reading, number each paragraph (even if they are small). As you read, place the symbols to show your thinking. (You should have approximately one symbol for every 4-5 sentences.) For each symbol, write a brief note in the margin so that you remember what you were thinking. (*These are crucial because you will use these notes later *)

1 2 3	Number each paragraph (big and small)
	Underline or highlight the main idea
	Circle new words
	Star important and interesting details
?	Confusing parts
	Parts you understand
!	Surprising parts
+	Parts you agree with
—	Parts you disagree with
TS	Connect text to self
TW	Connect text to world
TT	Connect text to text

Interacting with Texts



Ways to Show My Thinking

Before you begin reading, number each paragraph (even if they are small). As you read, place the symbols to show your thinking. (You should have approximately one symbol for every 4-5 sentences.) For each symbol, write a brief note in the margin so that you remember what you were thinking. (*These are crucial because you will use these notes later.*)

1 2 3	Number each paragraph (big and small)
——	Underline or highlight the main idea
⬭	Circle new words
★	Star important and interesting details
?	Confusing parts
✓	Parts you understand
!	Surprising parts
+	Parts you agree with
—	Parts you disagree with
TS	Connect text to self
TW	Connect text to world
TT	Connect text to text

1. You have developed some strategies for cracking the code, so now you can work with your 6:00 partner to read the rest of the text.
2. Show your thinking as you go.
3. When you are done, pull out your independent reading book and begin reading.
4. We will have a discussion when everyone is finished.

Types of Questions: Partner Learning

Right There

These are literal questions whose answers can be found in the text. Often the words used in the question are the same words found in the text.

Task:

1. With your 12:00 partner, generate **four Right There** questions for The Lorax.
2. Now, trade questions with another group and see if you can answer each other's questions correctly.

Types of Questions: Partner Learning

Think and Search

These ask readers to collect information from more than one part of the text and put it together to answer the question.

Task:

1. With your 3:00 partner, generate **three Think and Search** questions for The Lorax.
2. Now, trade questions with another group and see if you can answer each other's questions correctly.

Use your Collaboration Stems to take a Reflection Break

Choose the type of feedback that you think is most appropriate.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Types of Questions: Partner Learning

Author and You

These questions are based on information found in the text but ask the reader to relate the question to their own experience. You must read the text in order to answer the question.

Task:

1. With your 6:00 partner, generate **two Author and You** questions for The Lorax.
2. Now, trade questions with another group and see if you can answer each other's questions correctly.

Types of Questions: Partner Learning

On My Own

These questions do not require the students to have read the passage. Readers rely on their background or prior knowledge to answer the question.

Task:

1. With your 9:00 partner, generate **one On My Own** questions for The Lorax.
2. Now, trade questions with another group and see if you can answer each other's questions correctly.

Use your Collaboration Stems to take a Reflection Break

Choose the type of feedback that you think is most appropriate.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Connecting Ideas

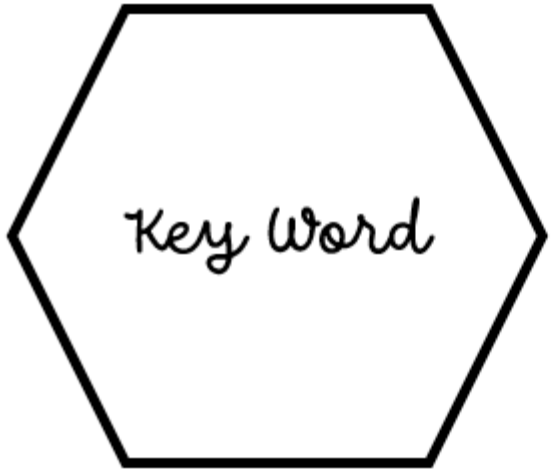
Look back at the hexagon that you already made.

Make two hexagons for *The Lorax* *summarizing the new information that you have learned that help us answer our essential question: What impact do human have on the environment? Be sure to use new key words too as we are building our vocabulary!*

Hexagonal Thinking Directions

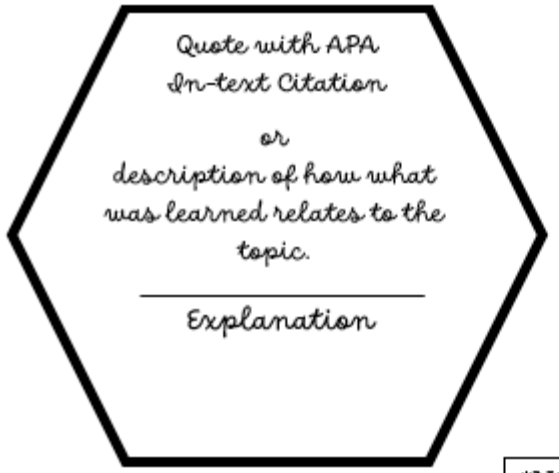
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Sample Hexagon for *The Lorax*

Short-sighted

"'Look, Lorax,' I said. 'There's no cause for alarm. I just chopped one tree. I am doing no harm'" (Dr. Seuss, 1971, p. 28)

Humans often fail to see the impact of one decision that they make. They justify their choices that negatively impact the earth by saying that they just did it once. Typically, it does not stop at once, but even if it did, one time done by several people has a profound impact.

Activity #9: Overview

Tasks:

- Students will preview and chunk a chapter out of the Environmental Science textbook.
- We will create Cornell Notes for the chapter using the gradual release model.

Description:

- Most high school textbooks are written at or above grade level and the chapters are lengthy, so students need practice learning how to access the text.
- As Cornell Notes are a new skill for most struggling students, we will begin creating them as a whole class. They will practice in pairs, and finally, they will complete them independently.

Cornell Notes

A tool for isolating the MOST important information.

- You need much of the information presented in chapter 14 of *Environmental Science*, but we need to determine what is most important because we cannot remember everything.
- To help us, we will be taking notes using a strategy called Cornell Notes.
- With your shoulder partner read the first section “How We Use Land” on pages 355-357.

Cornell Notes

A tool for isolating the MOST important information.

- Now, in the left-hand column labeled Key Ideas, write the first sub-heading Land Use and Land Cover. What color are the words?
- Then, read that section and write down three or four of the most important details that you read. Both you and your shoulder partner can write down the same information for this section.
- Let's share out as a class what we decided were the most important details. Please add any details that you missed.

Cornell Notes

Chapter: _____

Name: _____

Key Ideas	Details

Cornell Notes

A tool for isolating the MOST important information.

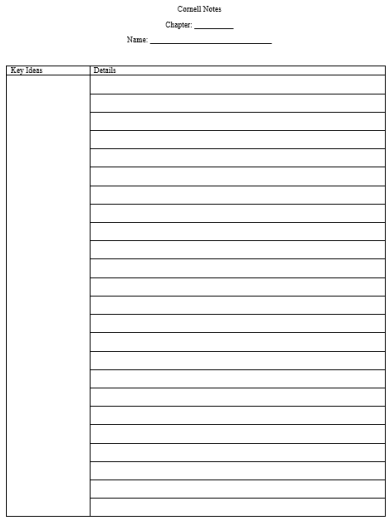
What should we write down for our next key idea?

Given the length of the section, how many details should we have?

Please read the next two sections with your shoulder partner and write down your detail(s).

Cornell Notes

A tool for isolating the MOST important information.


Cornell Notes

Chapter: _____

Name: _____

Key Ideas	Details

Let's preview the next section.

1. How many key ideas will you have?
2. What can you do with the words that are in orange?
3. Do we want to make all of the words in orange key ideas as well?

With your 12:00 partner, read section two and fill out the Cornell Notes sheet.

Cornell Notes

A tool for isolating the MOST important information.

- Now that you have some practice, read section three and complete the Cornell Notes independently.
- Don’t worry. You will have a chance to review your key ideas with someone when everyone has finished.

Activity #10: Overview

Tasks:

- With their shoulder partner, students will create an Author and You question for the entire chapter. They need to come up with four points that they would like to see in the correct answer.
- They will join another partnership and answer each others question.
- Back with just their shoulder partner, they will have a reflection break using the Collaboration Stems about how they can make their question more effective or what made it effective.

Description:

- As students get better with generating their own questions, they will focus on the most challenging type of question: Author and You.
- They will work with classmates to test the efficacy of their question based upon the answers that they receive.
- They will then strategize how they could have written a more effective question or what made it effective.

Refining Your Questions

- Since you are beginning to master the art of question writing, create an Author and You question for all of Chapter 14 with your shoulder partner.
- Create a bulleted list of the information that you think should be included in a complete answer.
- Join another partnership, trade questions, and answer the new one on their paper.
- Look over the other partnerships answer and give them collaborative feedback about their answers.
- Finally, get with your shoulder partner to evaluate the effectiveness of your question. Use the Collaboration Stems to guide you. Write what you did well and what you would change on the paper and turn it in.

Use your Collaboration Stems to take a Reflection Break

Choose the type of feedback that you think is most appropriate.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Activity #11: Overview

Tasks:

- Look at the hexagons that you have created so far.
- Create one hexagon for each of the four sections of the chapter. As we get more detailed information, create new key words that help us to further answer the question: What impact do humans have on the environment?

Description:

- Students are beginning to acquire a good deal of information. They must now get creative as to what they put on their hexagons to ensure that they get a full picture of human impact on the environment.
- I will frame it by saying, pretend that you need to teach a friend about this topic. Make sure that you include everything that they need to know.

Connecting Ideas

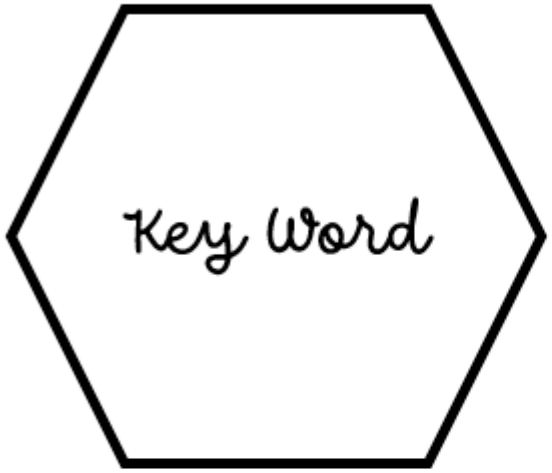
Make a new hexagon for each section of Chapter 14 for a total of four.

Keep those new ideas coming!

Hexagonal Thinking Directions

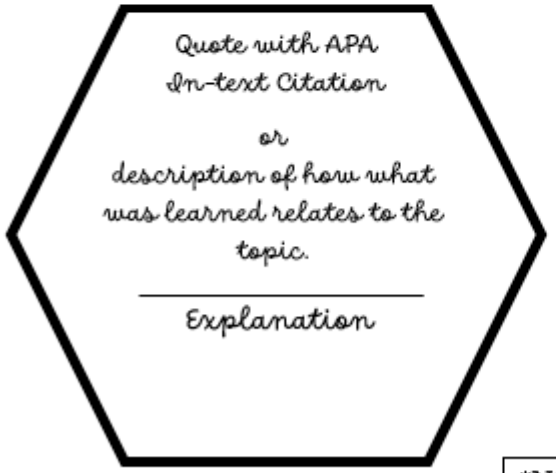
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Activity #12: Overview

Tasks:

- In their composition notebooks, students will write/draw what they think land looks like when humans negatively impact it.
- Then, I will then read aloud the first two paragraphs from chapter one of *The Grapes of Wrath* looking specifically for words that describe what it looked like during the dustbowl. They will annotate.
- As a class, we will sort the key words into three categories: verbs, colors, and other adjectives.

Description:

- The task of accessing the content will be gradually released to students. The text is at a lower reading level as it is a different type of text, but it is rich with information about the impact of human impact on the environment.
- The word sort will help student visualize what the land really looks like. This is important because their summarizing activity is to draw in as much detail as possible what was described in the chapter.

from *The Grapes of Wrath* by John Steinbeck

- Review: Take a look at the hexagons that you have created so far. What key words have you identified?
- In your composition notebook, write down what you think land looks like when it has been negatively impacted by humans.
- Let's explore one author's description.
- You should have a copy of chapter one of The Grapes of Wrath as well as a pen and a highlighter.

Reading with Purpose: Team Learning

- I am going to read the first two paragraphs of the chapter aloud. While you are listening, please highlight or underline words that the author uses to paint a picture of the land.
- Let's sort the words that you underlined. Here are the categories:

Verbs	Colors	Other Adjectives

Activity #13: Overview

Tasks:

- With their 9:00 partner, they will read and annotate the next six paragraphs annotating for powerful verbs, colors, and descriptive adjectives that paint a picture of the scene.
- When completed, they will generate a On My Own Question with their partner.
- They will join another partnership and trade and answer questions as before.
- Finally, they will reflect on the efficacy of their question.

Description:

- They are continuing to practice the strategies that have been previously introduced in hopes that they will find some that become natural to them.
- The collaborative component is important because it further supports comprehension and engagement.

Reading with Purpose: Partner Learning

- With your shoulder partner, read and annotate the next six paragraphs by identifying words that create a picture of the land and create one of each type of question. Reference your notes in your composition notebook if you need a refresher.
- Join another partnership and discuss your questions and possible answers.
- I want to discuss the most challenging questions that are presented, so work to challenge us.

Activity #14: Overview

Tasks:

- Independently, students will finish reading and annotating chapter one of *The Grapes of Wrath* annotating for verbs, colors, and other adjectives that describe the setting.
- On a plain, white piece of paper, they will then draw a detailed, color image of what was described in the chapter.
- Finally, they will create two new hexagons using the excerpt from the novel.

Description:

- I will circulate while students read independently to check for comprehension and to look at the work they have done so far.
- I will also emphasize that they use descriptive words for their hexagon key words as that is what Steinbeck does really well in this text.

Reading with Purpose: Individual Learning

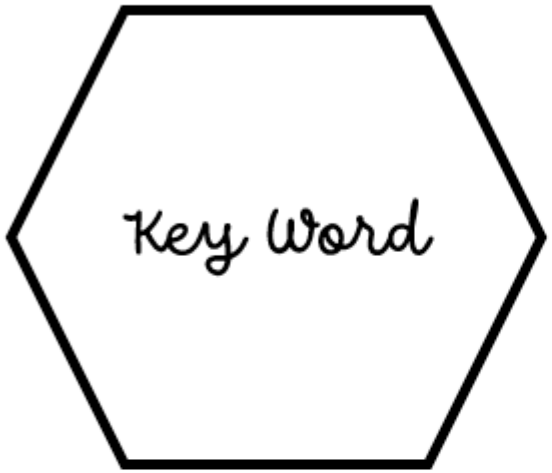
- Finish reading and annotating the chapter on your own. Focus on the way the author describes how the environment impacts the people who live there.
- When you finish reading, use the colored pencils to draw a picture of what the author describes. Be sure to include people and animals in your landscape. You are creating a visual summary, so include lots of good details.

Connecting Ideas

Make up to 2 new hexagons for chapter one. Remember to be creative with your key word choice. We are building our vocabulary.

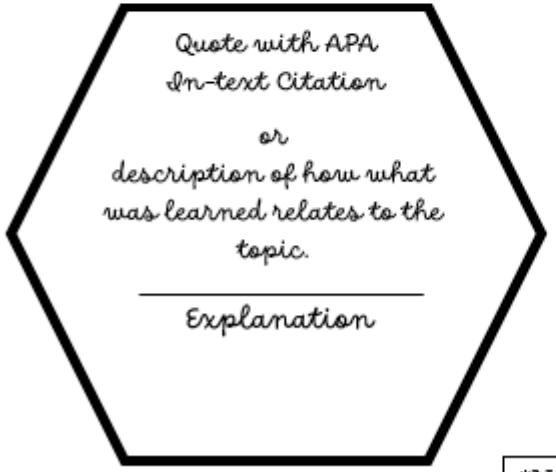
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Activity #15: Overview

Tasks:

- Students will read and annotate chapter 15 of *Environmental Science*.
- They will use a new strategy, mind mapping, so we will do that using the gradual release model.
- Initially, we will focus on chunking the text and identifying key information.

Description:

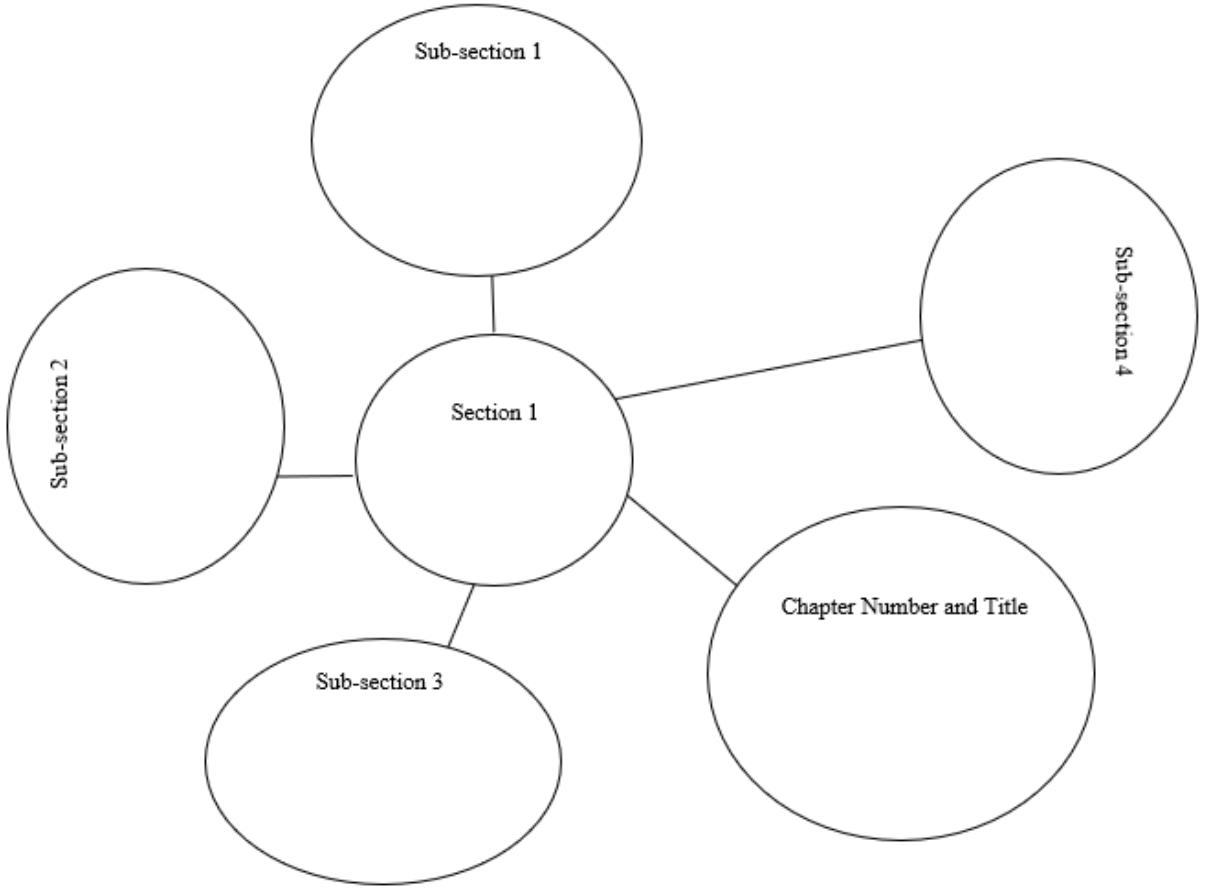
- In addition to this chapter being written above grade level, it is long and full of non-essential information.

Mind Mapping – Team Learning

Another tool for isolating the MOST important information.

Chapter 15 is not well organized, so we need to take control of how we read it. Begin with a large piece of plain white paper and draw the bubble you see here in the middle of the page.

1. What should we place in the In the circle titled Chapter Number and Title?
2. What is section 1 called? Place that in bubble titled Section 1. You can add a few words to explain the section, but the goals is to summarize and only include the most important information.

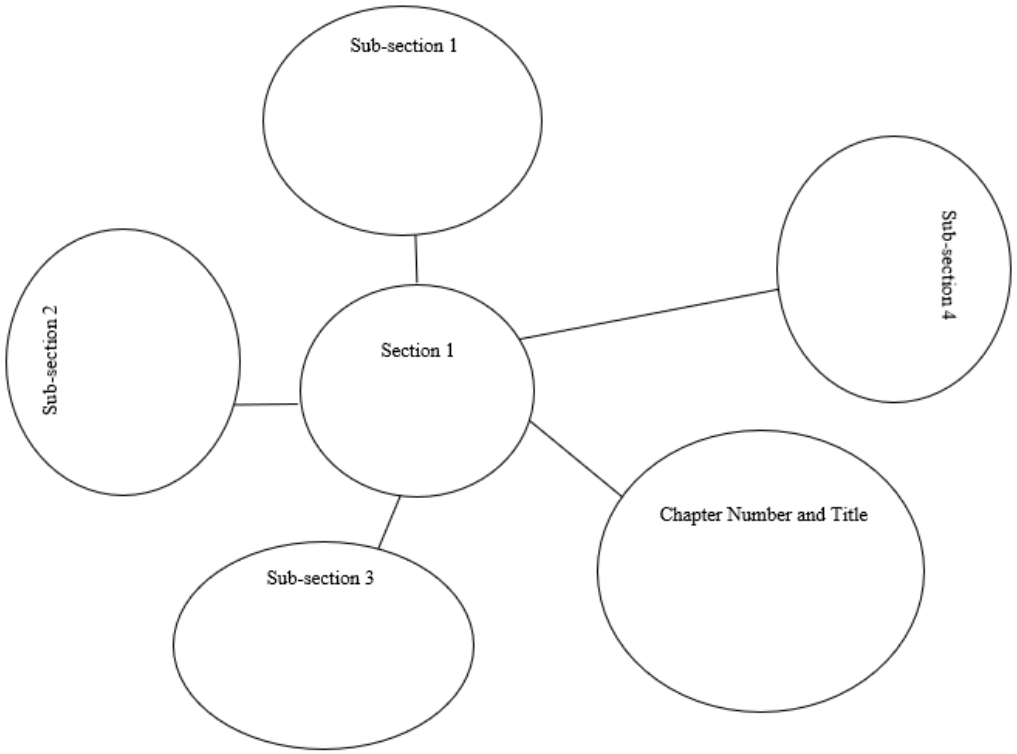


Note: This tool may be tricky for you because not all brains work in the same way. It's okay because we try hard things. You may not want to use it again, but you may like it.

Mind Mapping – Team Learning

Another tool for isolating the MOST important information.

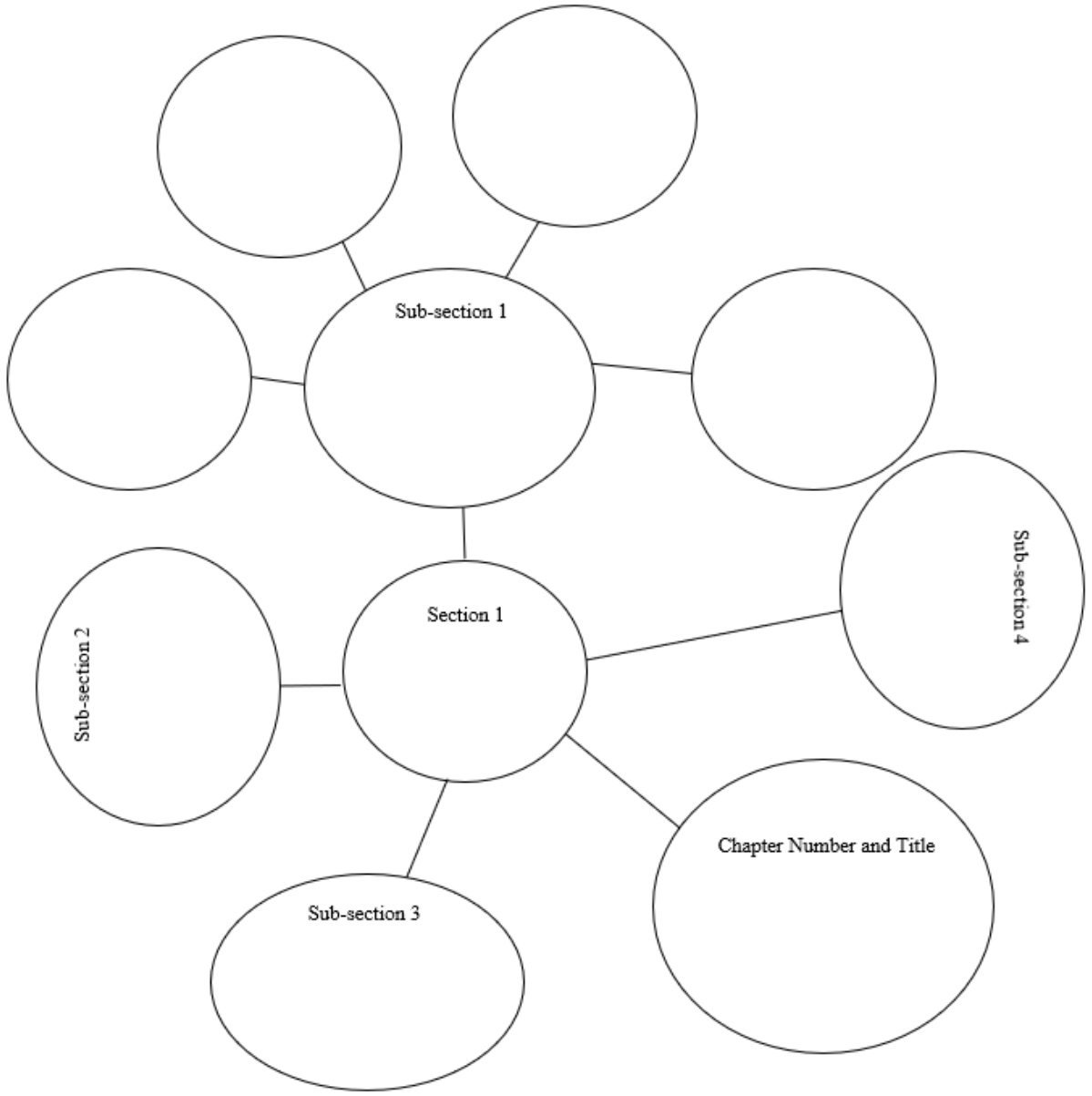
1. What should go in the oval labeled Sub-section 1?
2. Where do we put the details from the chapter so that we can study all of the most important information?



Mind Mapping – Partner Learning

Another tool for isolating the MOST important information.

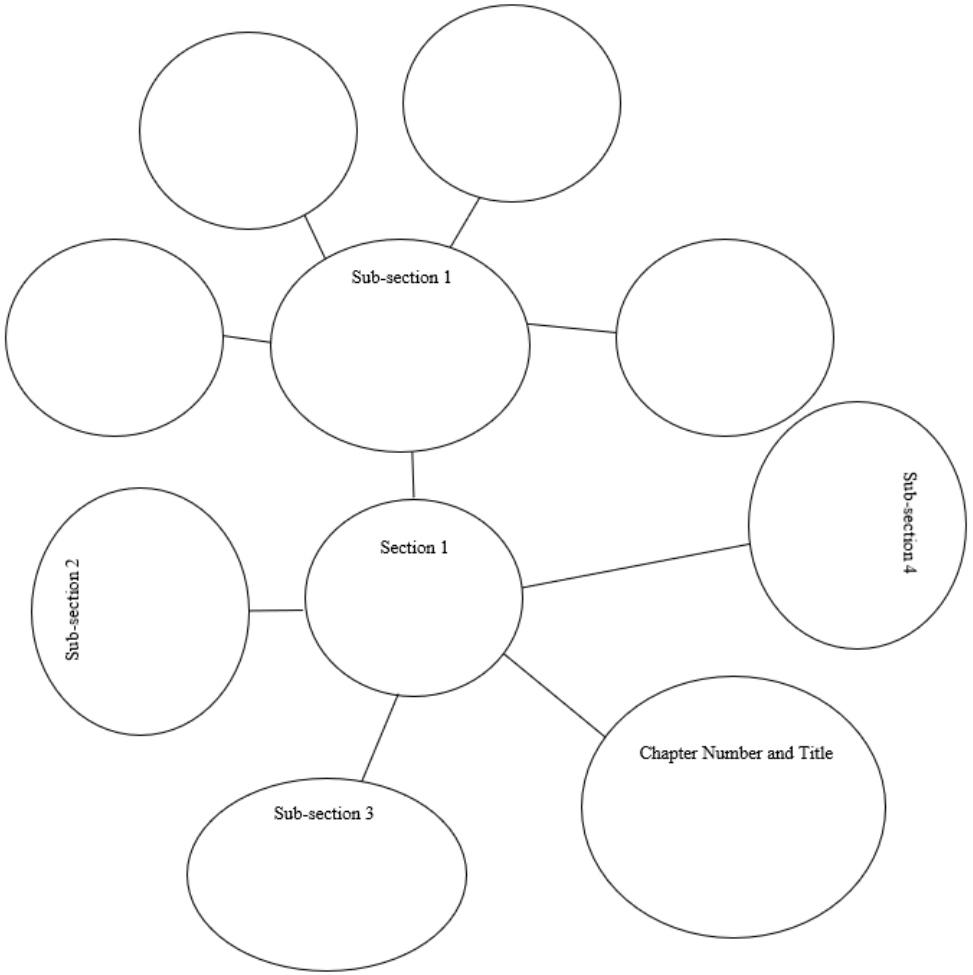
1. Because all four paragraphs in the section have important information, we will add four bubbles off of Sub-section 1.
2. With your shoulder partner, read the four paragraphs and write a sentence summarizing each paragraph.
3. Be prepared to share out with the class.



Mind Mapping – Partner Learning

Another tool for isolating the MOST important information.

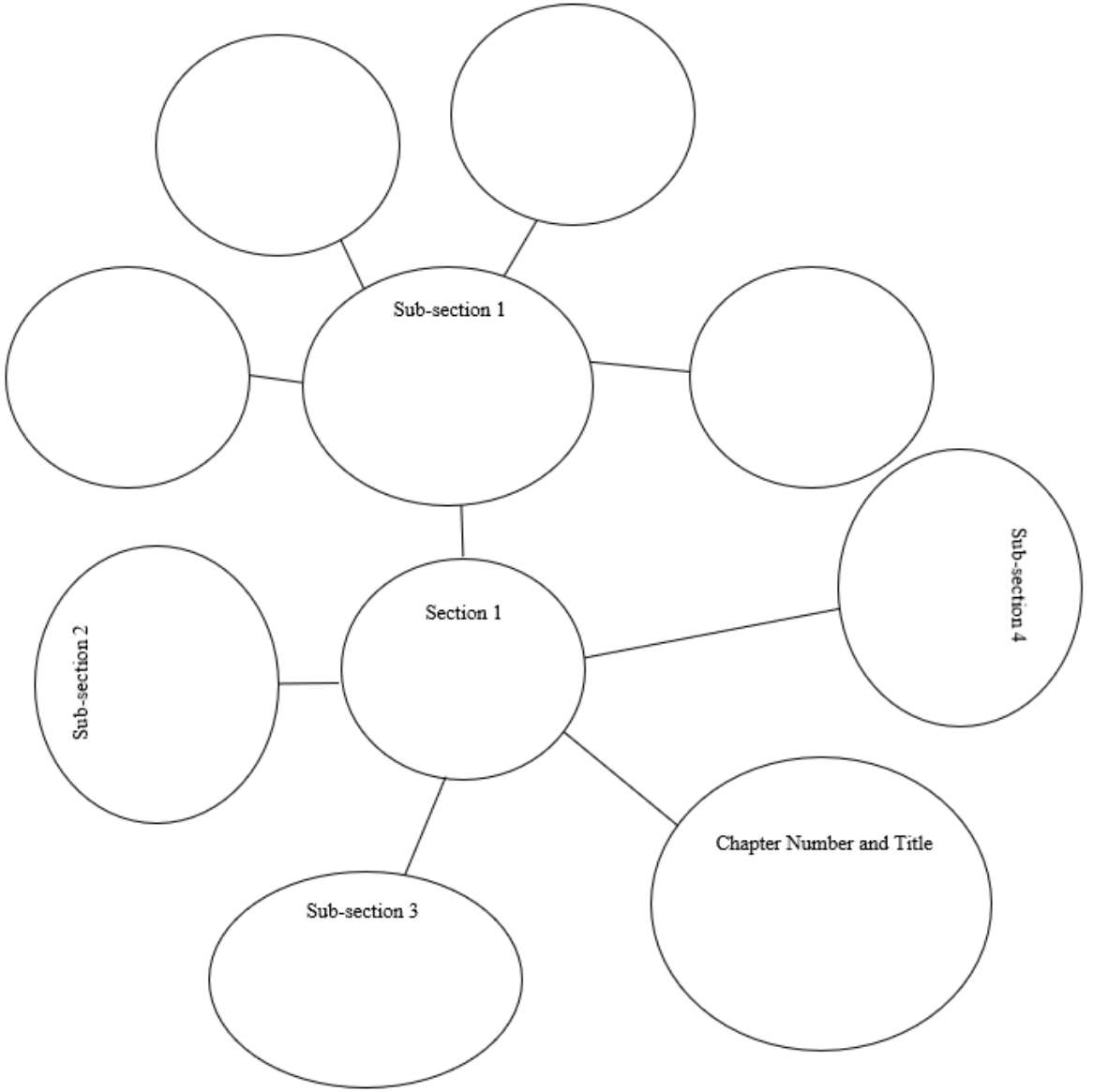
1. What should we label Sub-section 2?
2. Preview the section. How many bubbles do we want off of Sub-section 2?
3. With your shoulder partner, read this sub-section and add two details.



Mind Mapping

Another tool for isolating the MOST important information.

1. Now, complete sub-sections 3 and 4.
2. You did it! Your persisted through.
3. Join a partnership and examine both of your mind maps and see where you agree and where you disagree.
4. Let's work together as a class to see what information we definitely want on our mind maps.



Mind Mapping – Partner Learning

- Now the fun really starts!
- The second section is challenging because there are 13 sub-sections. I told you that this was going to be fun!
- Work with your 9:00 partner to divide and conquer. Decide who will read which section and how many details you want to include for each sub-section. Preview the material and sketch out a plan in your composition notebook before you begin so that you are working smarter not harder.

Mind Mapping – Independent Learning

- Now that you are getting good at this, you will work on your own.
- Preview the third section. How many sub-headings do you want to draw?
- Read the third section and complete the mind map with the most essential information.
- You will have an opportunity to briefly share out with your shoulder partner, but this is the version that I will grade, so be sure to ask me questions if you have them. Otherwise, you are working silently.

Use your Collaboration Stems to take a Reflection Break

Choose the type of feedback that you think is most appropriate.

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Activity #16: Overview

Tasks:

- With their 12:00 partner, students will create an Author and You or an On My Own question for the entire chapter. They need to come up with four points that they would like to see in the correct answer.
- They will join another partnership and answer each others question.
- Back with just their shoulder partner, they will have a reflection break using the Collaboration Stems about how they can make their question more effective or what made it effective.

Description:

- Now that students have mastered the types of questions, they can choose what works for them.
- They will work with classmates to test the efficacy of their question based upon the answers that they receive.
- They will then strategize how they could have written a more effective question or what made it effective.

Questioning

- With your 12:00 partner, create an Author and You or an On My Own question that you believes help capture all of the key information from the chapter. Remember to have four points they need to include in their answer.
- Now, join another partnership to answer each other's questions. Share you answers and discuss them.
- Come back and have a quick collaborative conversation with your partner.

Use your Collaboration Stems to

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Choose the type of feedback that you think is most appropriate.

Activity #17: Overview

Tasks:

- Look at the hexagons that you have created so far.
- Create one hexagon for each section of the chapter. As we get more detailed information, create new key words that help us to further answer the question: What impact do humans have on the environment?

Description:

- Students are beginning to acquire a good deal of information. They must now get creative as to what they put on their hexagons to ensure that they get a full picture of human impact on the environment.
- I will frame it by saying, pretend that you need to teach a friend about this topic. Make sure that you include everything that they need to know.

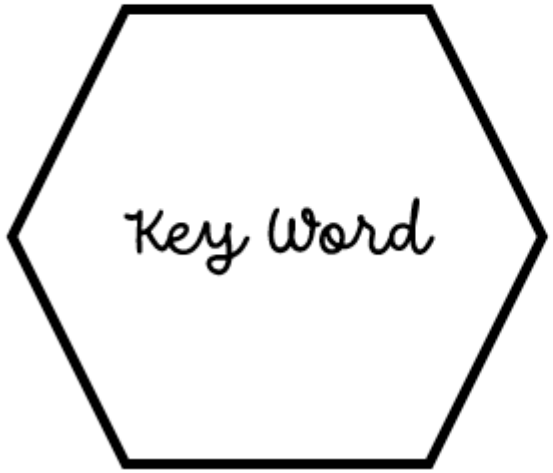
Connecting Ideas

Make a new hexagon for each section of Chapter 15. *You are pushing through. We are almost there!*

Hexagonal Thinking Directions

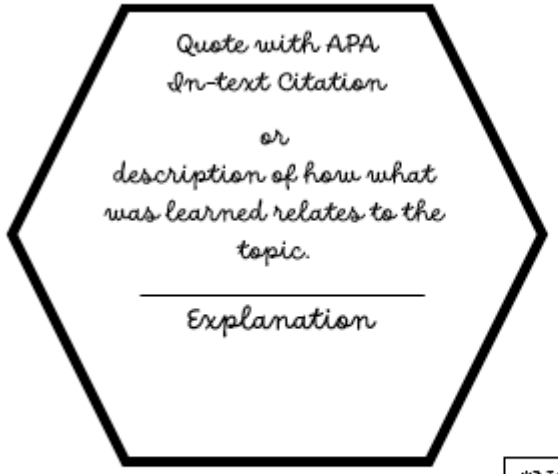
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Activity #18: Overview

Tasks:

- Students will begin in homogeneous groups to read and annotate a text which is at their reading level. The topics are fertilizers, pesticides, genetically modified foods, and factory farms.
- They will then go to heterogeneous groups of 4 in which they learn about a new topic.

(Teacher Directions follow)

Description:

- This jigsaw activity is designed to create collaborative learning while allowing every member of the class to be an expert at something.
- They will also learn fairly quickly about four important environmental impacts.

Jigsaw Activity – Teacher Directions

1. Divide students into 4 homogenous groups using reading data. This is their Learning Group.
2. Assign each group a text.
   A. Level 1 – “How Fertilizers Harm Earth More Than Help Your Lawn”
   B. Level 2 – “Pesticides are Killing the Organisms that Keep Our Soils Healthy”
   C. Level 3 – “Genetically Modified Foods”
   D. Level 4 – “Factory Farms Provide Abundant Food, but Environmental Suffers”

Jigsaw Activity – Learning Groups

Overview: Today, you will be learning about one of four topics. Once you have fully prepared, you will go to a different group and teach them what you have learned. Then, they will teach you what they learned.

1. In your small group, read the article and annotate it using the Showing My Thinking Chart. You can do this individually or as a group, but everyone needs a fully annotated article.
2. Complete the Learning Group Side of the Graphic Organizer. (Appendix I)
    A. Section 1: Write the title of the Article. Then, Chunk the article into 4 parts and write down at least 5 key ideas for each part. You can divide up the work and each of you can summarize a different section, but you need to be prepared enough to be able to teach it.
    B. Section 2: As a group, generate one of each type of question for the article.
    C. Section 3: As a group, answer each of your questions.
3. Have students take a moment to highlight the most important information that they want to share with their teaching group member.

Jigsaw Activity – Teacher Directions

1. Now, divide students into 4 heterogenous groups.
2. You should have one at least one representative from each of the learning groups so that all of your topics are covered.
3. When they begin presenting, the group members who are listening need to take notes in the table on the back of the paper.
4. Let them know that they will complete a formative “quiz” using Plickers, so they need to make sure that they do a thorough job teaching their topic and taking notes when they are the student.

Jigsaw Activity – Teaching Groups

Overview: Now, you will teach your topic and learn about the other three topics.

1. Listen carefully to the presenter and take notes in the table on the back of the paper.
2. You will be able to use these notes at the end of the period when we do a check for understanding quiz so ask clarifying questions if you have them.

Activity #19: Overview

Tasks:

- Look at the hexagons that you have created so far.
- Create one hexagon for each article. As we get more detailed information, create new key words that help us to further answer the question: What impact do humans have on the environment?

Description:

- Students are beginning to acquire a good deal of information. They must now get creative as to what they put on their hexagons to ensure that they get a full picture of human impact on the environment.
- I will frame it by saying, pretend that you need to teach a friend about this topic. Make sure that you include everything that they need to know.

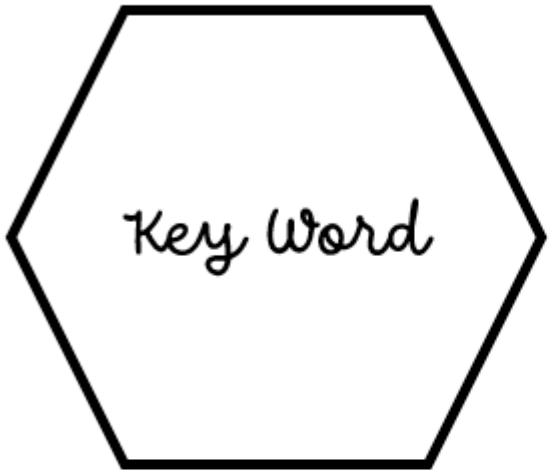
Connecting

Make a new hexagon for each section of Chapter 15. *You are pushing through. We are almost there!*

Hexagonal Thinking Directions

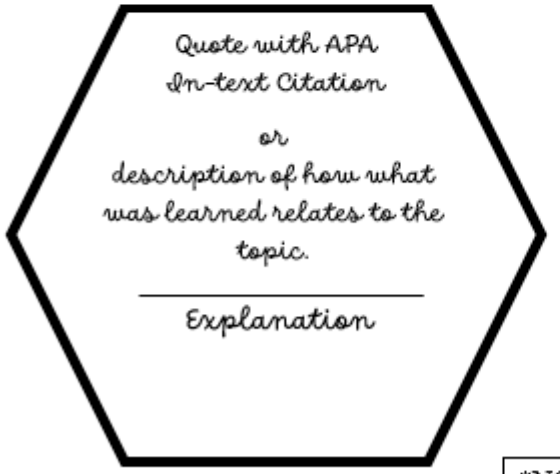
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



On side 1, write a key word or phrase that describes what you learned from the text.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.

Activity #20: Overview

Tasks:

- Students will begin by reading and annotating the text using the Ways to Show Thinking chart.
- They will choose one of the tools that we have used so far: Venn Diagram, Mind Map, or Cornell Notes to organize the information that they think is most important.
- Then, they will generate one of each type of question.
- Finally, they will create one hexagon for the text.

Description:

- This culminating activity is highly rigorous and challenging.
- The purpose is to help students understand that, while they may not understand everything, they will understand some things. They have the skills to access even sophisticated texts.
- Once everyone has completed the task, I will give students feedback, and we will review their work and understanding.

Silent Spring

- You should feel very proud as you have worked really hard, and you have come to our last text for the unit. Today, you are going to read an excerpt from Rachel Carson's, *Silent Spring*. Carson was a Marine Biologist and conservationist who work is considered important to the conservation movement.
- This is a challenging text, but you are ready. We are not reading to understand every word; we are reading to lift out important information that helps us answer our essential question: What impact do humans have on the environment?
- You will do the following tasks independently.

Comprehending

- Begin by reading and annotating the text using your Ways to Show Thinking chart.
- Choose one of the tools that we have used so far: Venn Diagram, Mind Map, or Cornell Notes to organize the information that you think is most important.
- Generate one of each type of question.
- Create one hexagon for the text.

Activity Overview

Tasks:

- Students will take their 19 hexagons from the unit and strategically place them based upon relationships between the terms.
- Label 6 places where important connections occur and explain their relationship with respect to the essential question: What impact do human have on the environment?

Description:

The goal is for students to show how their thinking has expanded and evolved regarding human impact on the environment.

This process helps students to reflect on how much they learned by actively reading and interacting with the resources.

This helps students add to their toolbox as well as to their self-efficacy.

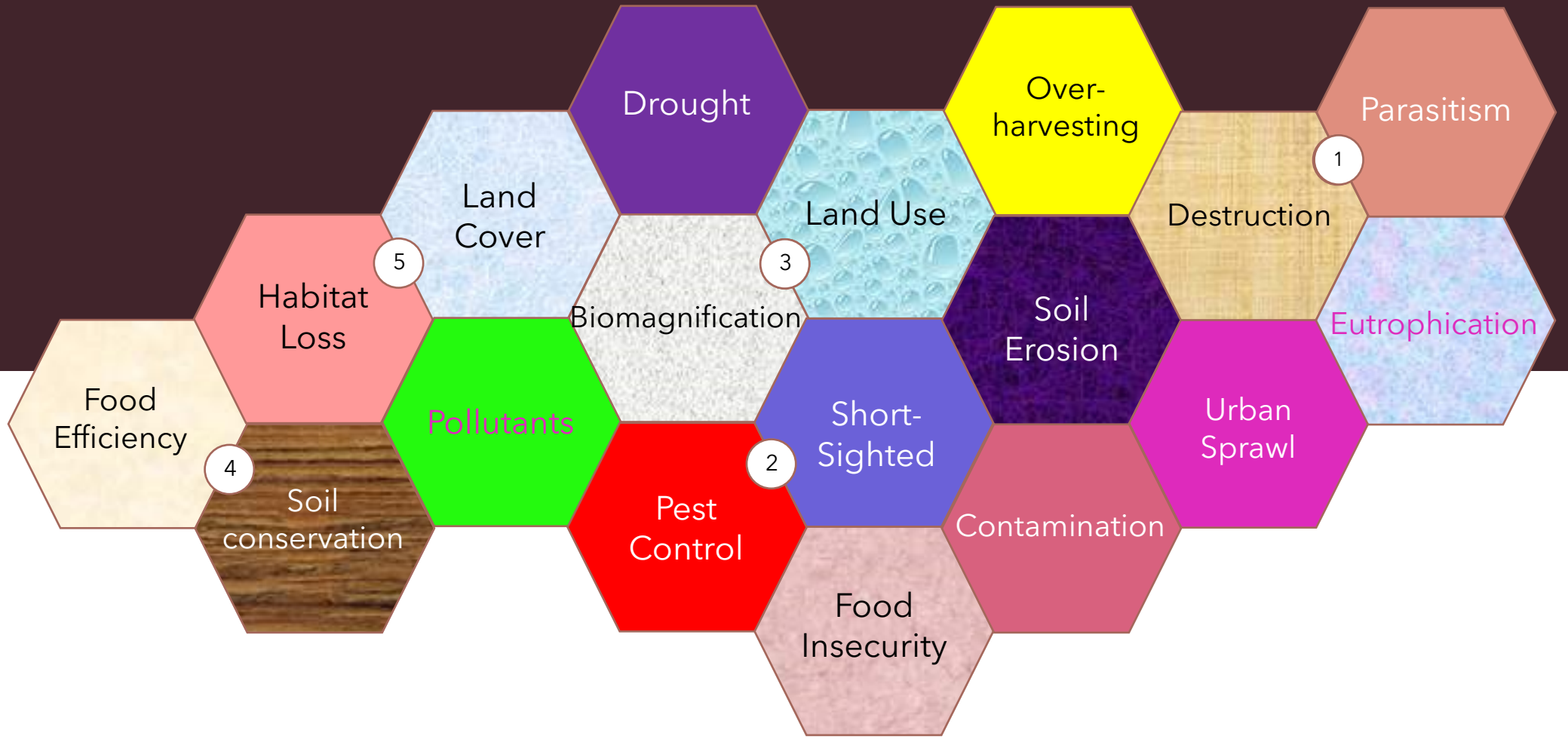
Hexagonal Thinking Summative Project

Hexagonal Thinking Summative Project

1. Strategically place your hexagons based upon how your key words relate to each other and tape them down on the poster board. Make sure that they are positioned so that they can be read easily. *There is no wrong answer unless you cannot explain the relationship between the key words.*
2. Pick **six** connections that are most significant to understanding human impact on land and mark them using an arrow. Write one complete paragraph explaining each of the connections. You should have a total of six paragraphs. Glue the paragraphs to the back of the poster board.
3. Use the rubric to revise your work to ensure that it completely reflects your learning.

Hexagon Thinking Summative Project

Hexagon Thinking Summative Project



Hexagon Thinking Summative Project

Side 2 Sample

The video shows a man encountering various forms of nature and using it but killing it in the process.

It is showing all the ways in which humans selfishly take what they want from the environment and destroy it in the process. Specifically, man joyously turns trees into paper and builds cities and factories where forests once were.

Side 2 Destruction

1

"'I wish I could give you something…but I have nothing left'" (Silverstein, 1964, p. 55).

At this point in the story, the boy has grown into an old man. He returns to see the tree, but the tree has nothing to offer because the boy has taken all his fruit, branches, and even the trunk. This is representative of the parasitic relationship humans have with the land.

Side 2 Parasitism

Explain Your Connections Example

1. Parasitism and Destruction: Parasitism is when one organism lives off another which dies as a result. It is the ultimate form of destruction. This is what humans are doing when they take advantage of natural resources like the boy did in *The Giving Tree* and Once-ler in *The Lorax*.

Rubric

Criteria	20	16	14	12	10
Quotes with in-text citation	Meaningful quotes or facts are chosen to support the key terms, and the in-text citations are error free.	Appropriate quotes or facts are presented to support the key terms, and the in-text citations have few errors.	Adequate quotes or facts are presented to support the key terms, and the in-text citations have multiple errors.	An attempted is made to provided quotes or facts that support the key terms with in-text citations.	Rework is needed.
Explanation	Insightful explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	Appropriate explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	Limited explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	An attempt is made to explain the significance of the quotes or information and how they relate to the topic.	Rework is needed.
Connection	Insightful connections are made between the key terms with a elaborate explanations of how they relate to the topic.	Appropriate connections are made between the key terms with clear explanations of how they relate to the topic.	Limited connections are made between the key terms with minimal explanations of how they relate to the topic.	An attempt is made to connect the key terms and an attempt is made to explain how they relate to the topic.	Rework is needed.
Presentation	The hexagons are legible and neat, and they are assembled artfully with six clearly identified connections between key terms.			The hexagons lack legibility and neatness, and/or an attempt is made to identify six connections between key terms.	Rework is needed.

Teaching Tools

- Appointment Times (Appendix A)
- Collaboration Stems (Appendix B)
- Cornell Notes (Appendix C)
- Discussion Stems (Appendix D)
- Four Types of Questions (Appendix E)
- Hexagon Thinking Directions (Appendix F)
- Hexagon Thinking Summative Project Rubric (Appendix G)
- Jigsaw Graphic Organizer (Appendix H)
- Mind Mapping Textbooks (Appendix I)
- Ways to Show My Thinking (Appendix J)
- Venn Diagram (Appendix K)
- Word Sort (Appendix L)

Sentence Stems to Foster a Growth Mindset

1. I noticed how hard you worked on that.
2. Let's solve that problem together.
3. You can do hard things.
4. What did you learn?
5. Thanks for your effort on that task.
6. You're on the right track.
7. What went well?
8. I believe in you.
9. …yet.
10. It's okay to make mistakes.

1. Great use of resources.
2. I admire your patience.
3. How dies it feel to be so close to reaching your goal?
4. I like your determination.
5. Think about where you were _____ ago and look at you now.
6. Let's reflect on what you did.
7. What could you improve?
8. I noticed … Can you help me understand what is happening?
9. Interesting…I wonder if…/have you considered…
10. I hadn't thought of that. Can you explain more?

Content Materials

Videos:

Cutts, S. (2012). YouTube. Retrieved March 26, 2023, from https://www.youtube.com/watch?v=WfGMYdalClU&t=50s.

Children's Books:

Seuss. (1971). *The lorax*. Random House. (Appendix M)

Silverstein, S. (1964). *The giving tree*. Harper & Row. (Appendix N)

Textbook:

Heithaus, M. R., & Arms, K. (2013). Chapter 14: Land. In *Environmental science* (pp. 354–377). essay, Houghton Mifflin Harcourt. (Appendix O)

Heithaus, M. R., & Arms, K. (2013). Chapter 15: Food and Agriculture. In *Environmental science* (pp. 378–407). essay, Houghton Mifflin Harcourt. (Appendix P)

Fiction:

Steinbeck, J. (2014). Chapter One. In *The grapes of wrath* (pp. 3–7). essay, Viking. (Appendix Q)

Content Materials

Informational:

Carson, R. (2002). Chapter 2. In *Silent spring* (pp. 3–7). essay, A Mariner Books. (Appendix R)

Donley, N., & Gunstone, T. (2021, June 1). Pesticides are killing the organisms that keep our soils healthy. *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/pesticides-are-killing-the-worlds-soils/ (Appendix S)

Flesher, J. (2020, February 6). Factory farms provide abundant food, but environment suffers. *PBS*. Retrieved March 26, 2023, from https://www.pbs.org/newshour/economy/factory-farms-provide-abundant-food-but-environment-suffers (Appendix T)

How fertilizers harm earth more than help your lawn. (2009, July 20). *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/how-fertilizers-harm-earth/ (Appendix U)

Kennedy, M., & Cassetty, S. (2022, October 24). Pros and cons of gmos: An evidence-based comparison of genetically modified foods. *Insider*. Retrieved March 26, 2023, from https://www.insider.com/guides/health/diet-nutrition/gmo-pros-and-cons (Appendix V)

Chapter 5: Conclusion

High school students who struggle with reading often present themselves as being lazy, disrespectful, angry, and disruptive. However, these behaviors may be a defense resulting from being worn down by years of failed efforts. They are the students who need the most patience, attention, and practice, but they are the most challenging to engage and instruct. Thus, teachers need a solid curriculum based on empirical research and a large toolbox of strategies that will help them to reach these students. The success or failure of these students sets the course for their futures. On one side, their success allows them to start their life as an adult with some necessary reading skills and the belief that they can learn which is proven by receiving their coveted high school diploma. On the other side, failure means that their adult life begins feeling as though they are unable to read and learn. Students lack confidence after struggling with reading for 12 years can transfer out into their experiences out in the world following graduation. Ultimately, this curriculum is designed to ignite the creativity in teachers who are faced with the overwhelming yet deeply rewarding challenge of changing the course of the lives of struggling high school readers.

Foundationally, this curriculum is built on the active self-regulation component of Duke and Cartwright's Active View of Reading Model. First, the activities were created to increase motivation and engagement. They also provide students will regular opportunities to learn and practice a variety of comprehension and content organization strategies. Included in the curriculum are a variety of materials that are content based, specifically Environmental Science and include fiction and non-fiction texts as well as an informational video. They were carefully chosen and organized to be scaffolded to help increase students' opportunities of mini-mastery

experiences. The activities presented utilize Fisher and Frey's Gradual Release of Responsibility model so that students are clear about the tasks so that they can focus on the learning. This also allows teachers to focus their attention and feedback on students' progress with reading comprehension. It also offers collaborative and independent learning activities that help students to practice and have mini-mastery experiences that will help them build reading comprehension and self-efficacy with goal of developing a growth mindset. A variety of graphic organizers are also included to help students organize and make sense of texts. Based upon the research by Fisher & Frey (2014), learning self-questioning and summarizing strategies have a profound effect on students' ability to comprehend texts and build self-efficacy. While the lessons can be used in part or as a while, they are really designed to spark creativity and conversation about what struggling high school readers need and how we can best support them on their learning journey.

The challenge in creating a meaningful curriculum is making it accessible to both reading and content area teachers. If these skills are only practiced in the remedial reading classroom, students miss seeing how the skills that they are learning are not easily transferable but also incredibly useful in all areas of their lives. Additionally, content area teachers sometimes lack the confidence to embark on this reading journey. So, the curriculum is presented for a remedial reading teacher to use in a remedial reading classroom, but the skills and tools could be taught and practiced in any classroom in which content is presented in a written form.

There are several steps that need to be accomplished next. First, careful attention needs to be given to ensuring that the texts and resources are reflective of the content being taught. Once resources with the appropriate content are chosen, careful attention needs to be paid to

the reading levels of the materials. They should be carefully scaffolded so that students can build mastery experiences. They should begin at the student's reading level, then into the student's zone of proximal development, and finally, at grade level or above. Once these steps are in place, the curriculum needs to be tested to determine whether focusing instruction and intentional practice on self-questioning and summarizing to tackle grade level, content area texts create mastery experiences and help increase comprehension and self-efficacy which will boost a growth mindset so that students feel empowered to learn.

References

Accelerated Reader Bookfinder. Accelerated Reader Bookfinder US - Welcome. (2021). Retrieved April 2, 2023, from https://www.arbookfind.com/

Allington, R. L. (2013). What really matters when working with struggling readers. *The Reading Teacher*, *66*(7), 520–530. https://doi.org/10.1002/TRTR.1154

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215. https://doi.org/10.1037/0033-295x.84.2.191

Beers, K. (1998). Choosing not to read: Understanding why some middle schoolers just say no. In Beers, K. (Eds.), *Into Focus: Understanding and Creating Middle School Readers* (pp.37-64). Norwood, Massachusetts: Christopher-Gordon Publishers, Inc.

Biancarosa, G. (2012). Adolescent literacy: More than remediation. *Educational Leadership*, *69*(6), 22–27.

Bloom, B. S. (1985). *Developing talent in young people*. New York, Ballantine.

Brown, S. A., & Pyle, N. (2021). Self-questioning strategy routine to enhance reading comprehension among secondary students. *TEACHING Exceptional Children*, *53*(6), 441–449.

Burke, J. (2000). *Reading reminders : tools, tips, and techniques*. Boynton/Cook Publishers.

Casner-Lotto, J., Barrington, L., & Partnership for 21st Century Skills. (2006). Are they really ready to work? Employers' perspectives on the basic knowledge and applied skills of new entrants to the 21st century U.S. workforce. In *Partnership for 21st Century Skills*. Partnership for 21st Century Skills.

Carson, R. (2002). Chapter 2. In *Silent spring* (pp. 3–7). essay, A Mariner Books.

Colvin, C., & Schlosser, L. K. (1997). Developing academic confidence to build literacy: What teachers can do. *Journal of Adolescent & Adult Literacy*, *41*(4), 272–281.

Cutt, S. (2012). *YouTube*. Retrieved March 26, 2023, from https://www.youtube.com/watch?v=WfGMYdalClU&t=50s.

Daniel, J., Capin, P., & Steinle, P. (2021). A synthesis of the sustainability of remedial reading intervention effects for struggling adolescent readers. *Journal of Learning Disabilities*, *54*(3), 170–186.

Dole, J. A., Duffy, G. G., Roehler, L. R., & Pearson, P. D. (1991). Moving from the old to the new: Research on reading comprehension instruction. *Review of Educational Research*, *61*(2), 239–264.

Donalson, K., & Halsey, P. (2020). Adolescent readers' perceptions of remedial reading classes: A case study. *Reading Improvement*, *57*(4), 187–196.

Donley, N., & Gunstone, T. (2021, June 1). Pesticides are killing the organisms that keep our soils healthy. *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/pesticides-are-killing-the-worlds-soils/

Duke, N. K., & Cartwright, K. B. (2021). The science of reading progresses: Communicating advances beyond the simple view of reading. *Reading Research Quarterly*, *56*(1), S25–S44. https://doi.org/10.1002/rrq.411

Dweck, C. S. (2016). *Mindset: The New Psychology of Success*. Ballantine Books.

Edmonds, M. S., Vaughn, S., Wexler, J., Reutebuch, C., Cable, A., Tackett, K. K., & Schnakenberg, J. W. (2009). A synthesis of reading interventions and effects on reading comprehension outcomes for older struggling readers. *REVIEW OF EDUCATIONAL RESEARCH*, *79*(1),

262–300. https://doi.org/10.3102/0034654308325998

Fisher, D., & N. Frey, N. (2014). Better learning through structured teaching: A framework for the gradual release of responsibility (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Fisher, D., Frey, N., & Hattie, J. (2016). *Visible learning for literacy, grades K-12: Implementing the practices that work best to accelerate student learning*. Corwin/A SAGE Company.

Flesher, J. (2020, February 6). Factory farms provide abundant food, but environment suffers. *PBS*. Retrieved March 26, 2023, from https://www.pbs.org/newshour/economy/factory-farms-provide-abundant-food-but-environment-suffers

Gonser, S. (2020, October 16). *Using 'hexagonal thinking' to deepen classroom conversations*. Edutopia. Retrieved April 1, 2023, from https://www.edutopia.org/article/using-hexagonal-thinking-deepen-classroom-conversations

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education, 7*(1), 6–10. https://doi.org/10.1177/074193258600700104

Greathouse, P. A. (2018). Effects of a positive youth development approach to literacy through young adult literature in the secondary remedial reading class: an action research study. *Educational Action Research*, *26*(2), 220–238. https://doi.org/10.1080/09650792.2017.1307127

Hall, C., Kent, S. C., McCulley, L., Davis, A., & Wanzek, J. (2013). A new look at mnemonics and graphic organizers in the secondary social studies classroom. *Teaching Exceptional Children*, *46*(1), 47–55. https://doi.org/10.1177/004005991304600106

Heick, T. (2022). *26 sentence stems for higher-level conversation in the classroom*. TeachThought. Retrieved March 26, 2023, from https://www.teachthought.com/critical-thinking/sentence-stems/

Heithaus, M. R., & Arms, K. (2013). Chapter 14: Land. In *Environmental science* (pp. 354–377). essay, Houghton Mifflin Harcourt.

Heithaus, M. R., & Arms, K. (2013). Chapter 15: Food and agriculture. In *Environmental science* (pp. 378–407). essay, Houghton Mifflin Harcourt.

How fertilizers harm earth more than help your lawn. (2009, July 20). *Scientific American*. Retrieved March 26, 2023, from https://www.scientificamerican.com/article/how-fertilizers-harm-earth/

Joseph, L. M., Alber-Morgan, S., Cullen, J., & Rouse, C. (2016). The effects of self-questioning on reading comprehension: A Literature Review. *Reading & Writing Quarterly*, *32*(2), 152–173.

Kamil, M. L. (2008). *Improving adolescent literacy. [electronic resource]: effective classroom and intervention practices*. National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences.

Kennedy, M., & Cassetty, S. (2022, October 24). Pros and cons of gmos: An evidence-based comparison of genetically modified foods. *Insider*. Retrieved March 26, 2023, from https://www.insider.com/guides/health/diet-nutrition/gmo-pros-and-cons

Kittle, P. (2013). *Book love: Developing depth, stamina, and passion in adolescent readers*. Heinemann. Mokher, C. G., Barnett, E., Leeds, D. M., & Harris, J. C. (2019). Re-Envisioning College Readiness Reforms: Florida's Statewide Initiative and Promising

Practices in Other

Marzano, R. J., Pickering, D., & Pollock, J. E. (2001). *Classroom instruction that works: research-based strategies for increasing student achievement*. Association for Supervision and Curriculum Development.

Mokher, C. G., Barnett, E., Leeds, D. M., & Harris, J. C. (2019). Re-envisioning college readiness reforms: Florida's statewide initiative and promising practices in other states. *Change*, *51*(2), 14–23. https://doi.org/10.1080/00091383.2019.1569968

McEwan, E. K. (2007). *40 ways to support struggling readers in content classrooms, Grades 6-12*. Corwin.

Mulvahill, E. (2019, February 5). *23 close reading anchor charts that will help your students dig deep*. We Are Teachers. Retrieved April 1, 2023, from https://www.weareteachers.com/close-reading-anchor-charts/

National Assessment of Educational Progress. (2019). *NAEP report cards - home*. The Nation's Report Card. Retrieved June 19, 2022, from https://www.nationsreportcard.gov/

Ortlieb, E., & Schatz, S. (2020). Student's self-efficacy in reading – Connecting theory to practice. *Reading Psychology*, *41*(7), 735–751. https://doi.org/10.1080/02702711.2020.1783146

Outlining and summarizing. Corwin Visible Learning plus. (2021, August). Retrieved February 5, 2023, from https://www.visiblelearningmetax.com/influences/view/outlining_and_summarizing

Palincsar, A. S., & Brown, A. L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*(2), 117–175.

Pearson, P. D., & Gallagher, M. C. (1983). *The Instruction of Reading Comprehension. Technical Report No. 297*.

Potash, B. (2021, November 18). *What is hexagonal thinking? plus, 13 examples to inspire you*. We Are Teachers. Retrieved March 26, 2023, from https://www.weareteachers.com/hexagonal-thinking/

Praveen, S. D., & Rajan, P. (2013). Using graphic organizers to improve reading comprehension skills for the middle school ESL students. *English Language Teaching*, *6*(2), 155–170.

Pressley, M. (2002). Metacognition and self-regulated comprehension. In A.E. Farstrup & S.J. Samuels (Eds.), What research says about reading instruction (3rd ed., pp. 291– 309). Newark, DE: International Reading Association.

Pressley, M., & Afflerbach, P. (1995). *Verbal protocols of reading : the nature of constructively responsive reading*. Lawrence Erlbaum Associates.

Pugalee, D.K. (2014). *Effective content reading strategies to develop mathematical and scientific literacy: Supporting the common core state standards and the next generation science standards*. Rowman & Littlefield Publishers.

Rouse-Billman, C., & Alber-Morgan, S. (2019). Teaching self-questioning using systematic prompt fading: Effects on fourth graders' reading comprehension. *Preventing School Failure*, *63*(4), 352–358. https://doi.org/10.1080/1045988X.2019.1619508

Scarborough, H. S. (2001). Connecting early language and literacy to later reading (dis)abilities: Evidence, theory, and practice. In S. Neuman & D. Dickinson (Eds.), Handbook for research in early literacy. New York: Guilford Press.

Self-verbalization / self questioning. Corwin Visible Learning plus. (2021, August). Retrieved February 5, 2023, from https://www.visiblelearningmetax.com/influences/view/self-verbalization~self_questioning

Seuss. (1971). *The lorax*. Random House.

Silverstein, S. (1964). *The giving tree*. Harper & Row.

Solheim, O. (2011). The impact of reading self-efficacy and task value on reading comprehension scores in different item formats. *Reading Psychology*, *32*(1), 1–27. https://doi.org/10.1080/02702710903256601

Staake, J. (2022, December 9). *How to use sentence stems (plus 60+ examples for every subject)*. We Are Teachers. Retrieved April 1, 2023, from https://www.weareteachers.com/sentence-stems/

Steinbeck, J. (2014). Chapter One. In *The grapes of wrath* (pp. 3–7). essay, Viking.

Steinbeck, J. (2014). Chapter Five. In *The grapes of wrath* (pp. 42–53). essay, Viking.

Stevens, E. A., Park, S., & Vaughn, S. (2019). A review of summarizing and main idea interventions for struggling readers in grades 3 through 12: 1978-2016. *Remedial and Special Education*, *40*(3), 131–149.

Torgesen, J. K., Houston, D. D., Rissman, L. M., Decker, S. M., Roberts, G., Vaughn, S., Wexler, J., Francis, D. J., Rivera, M. O., & Lesaux, N. (2017). Academic literacy instruction for adolescents: A guidance document from the Center on Instruction. In *Center on Instruction*. Center on Instruction.

Tovani, C. (2000). *I read it, but I don't get it - comprehension strategies for adolescent readers*. Stenhouse Publishers.

Unrau, N. J., Rueda, R., Son, E., Polanin, J. R., Lundeen, R. J., & Muraszewski, A. K. (2018). Can reading self-efficacy be modified? A meta-analysis of the impact of interventions on reading self-efficacy. *Review of Educational Research*, *88*(2), 167–204.

Watson, S. M. R., Gable, R. A., Gear, S. B., & Hughes, K. C. (2012). Evidence-based strategies for improving the reading comprehension of secondary students: Implications for students with learning disabilities. *Learning Disabilities Research & Practice (Wiley-Blackwell)*, *27*(2), 79–89. https://doi.org/10.1111/j.1540-5826.2012.00353.x

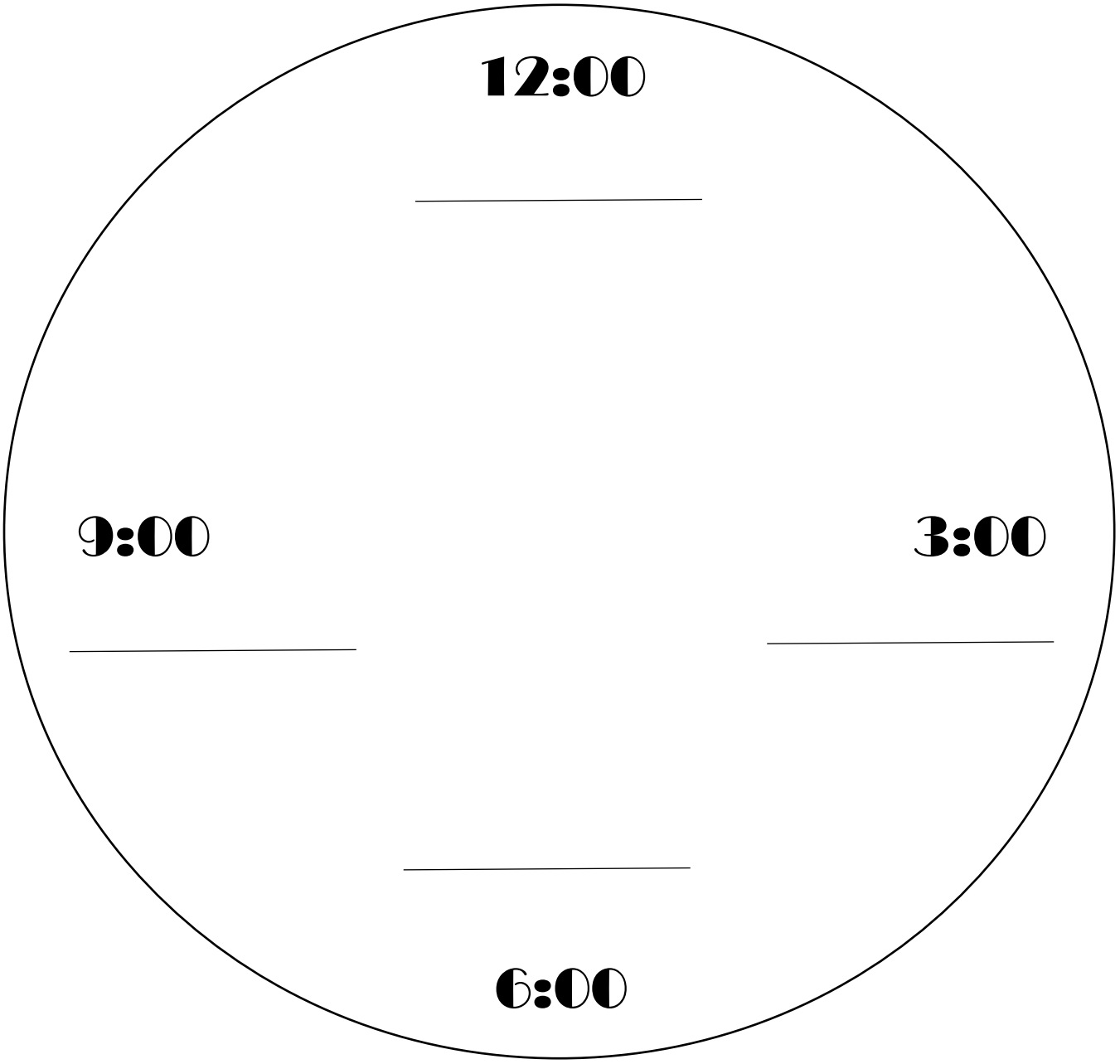
Wilson, L. (2002). *Reading to live: How to teach reading for today's world*. Heinemann.

Wood, R., & Bandura, A. (1989). Impact of conceptions of ability on self-regulatory mechanisms and complex decision making. *Journal of Personality & Social Psychology*, *56*(3), 407–415. https://doi.org/10.1037/0022-3514.56.3.407

Wormeli, R. & Stafford, D. (2019). *Summarization in Any Subject: 60 Innovative, Tech-Infused Strategies for Deeper Student Learning: Vol. 2nd edition*. ASCD.

Appendix A

Appointment Times



Appendix B

Collaboration Stems

Warm Feedback	Questions	Cool Feedback
• I like how/the way you… • I like the part when/where… • I was impressed with… because… • I thought…was well done because… • One thing you did really well was… • The most outstanding aspect of your work was… • You make a good point about… • Your work shows… • Your observation/work made me think about… • •	• One question I still have is…? • Did you consider…? • What do you think about…? • Could you have…? • I wonder…? • Can you explain…in a different way? • What else can you do to…? • What did you mean by…? • What is another…? • What would happen if…? • How would…change…? • If you used…how would that…? • •	• Another way to …is… • I was thinking… • Maybe you could try… • One idea that you could develop more is… • Remember to… • You might want to consider/think about/try… • I was confused by… • More information here might… • Your thinking isn't clear when… • Adding more evidence would help to… • •

Appendix C

Cornell Notes

Chapter: ___________

Name: ___________________________________

Key Ideas	Details

Key Ideas	Details

Appendix D

Discussion Stems

Clarifying
Could you give me your thesis in one sentence?
Is it your position that…
To be clear, you're saying that…
I'm confused when you say Z, Can you elaborate?

Paraphrasing
Put another way, you're saying…
So you're saying that…
Is it fair to say that you believe…
I hear you saying that…

Agreeing
I agree with Y because…
Z's point about X was important because…
The evidence for Z is overwhelming when you consider that…
X and I are coming from the same position.
Despite disagreeing about Y, I agree with Z that…

Disagreeing
I see it differently because…
The evidence I've seen suggests something different.
Some of that is fact, but some of it is opinion as well.
I agree that Y, but we also have to consider that…
We see Z differently because...

Building On
Y mentioned that…
Yes–and furthermore…
The author's claim that Z is interesting because…
Adding to what X said,…
If we change Xs position just a little, we can see that…

Summarizing
Overall, what I'm trying to say is…
My whole point in one sentence is…
More than anything else, I believe that…

https://www.teachthought.com/critical-thinking/sentence-stems/

(Heick, 2022)

Right There

Definition:

These are literal questions whose answers can be found in the text. Often the words used in the question are the same words found in the text.

Examples:

Who are the two main characters in the story?
Why did the frogs go extinct?
Where did the idea come from?

THINK AND SEARCH

Definition:

These ask readers to collect information from more than one part of the text and put it together to answer the question.

Examples:

What are the major causes of malnutrition?
How does the setting change throughout the story?
What is different about the weather in the two different areas?

Author and You

Definition:

These questions are based on information found in the text but ask the reader to relate the question to their own experience. You must read the text in order to answer the question.

Examples:

Tell about a time you felt like the main character?
How would you solve the issue presented in the chapter?
What do you think is the most significant challenge?

On My Own

Definition:

These questions do not require the students to have read the passage. Readers rely on their background or prior knowledge to answer the question.

Examples:

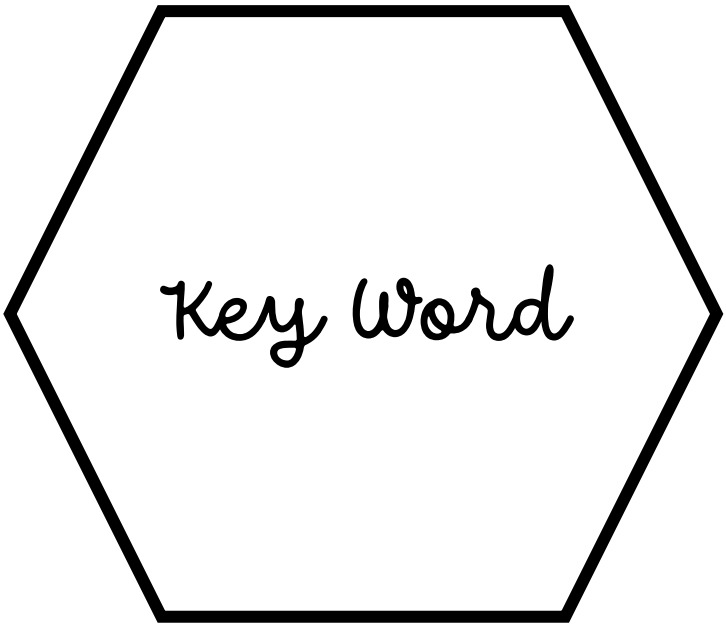
Can teenagers change the world?
What is the most important natural resource?
Which non-renewable resource could humans do without?

Appendix F

Hexagonal Thinking Directions

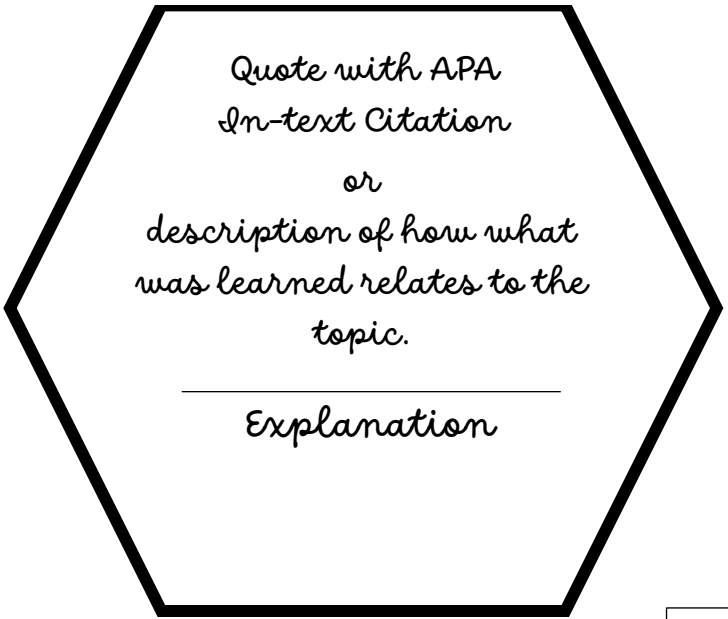
For each text you will create one or more (five inch) hexagons that contain information about human impact on the environment.

Side 1



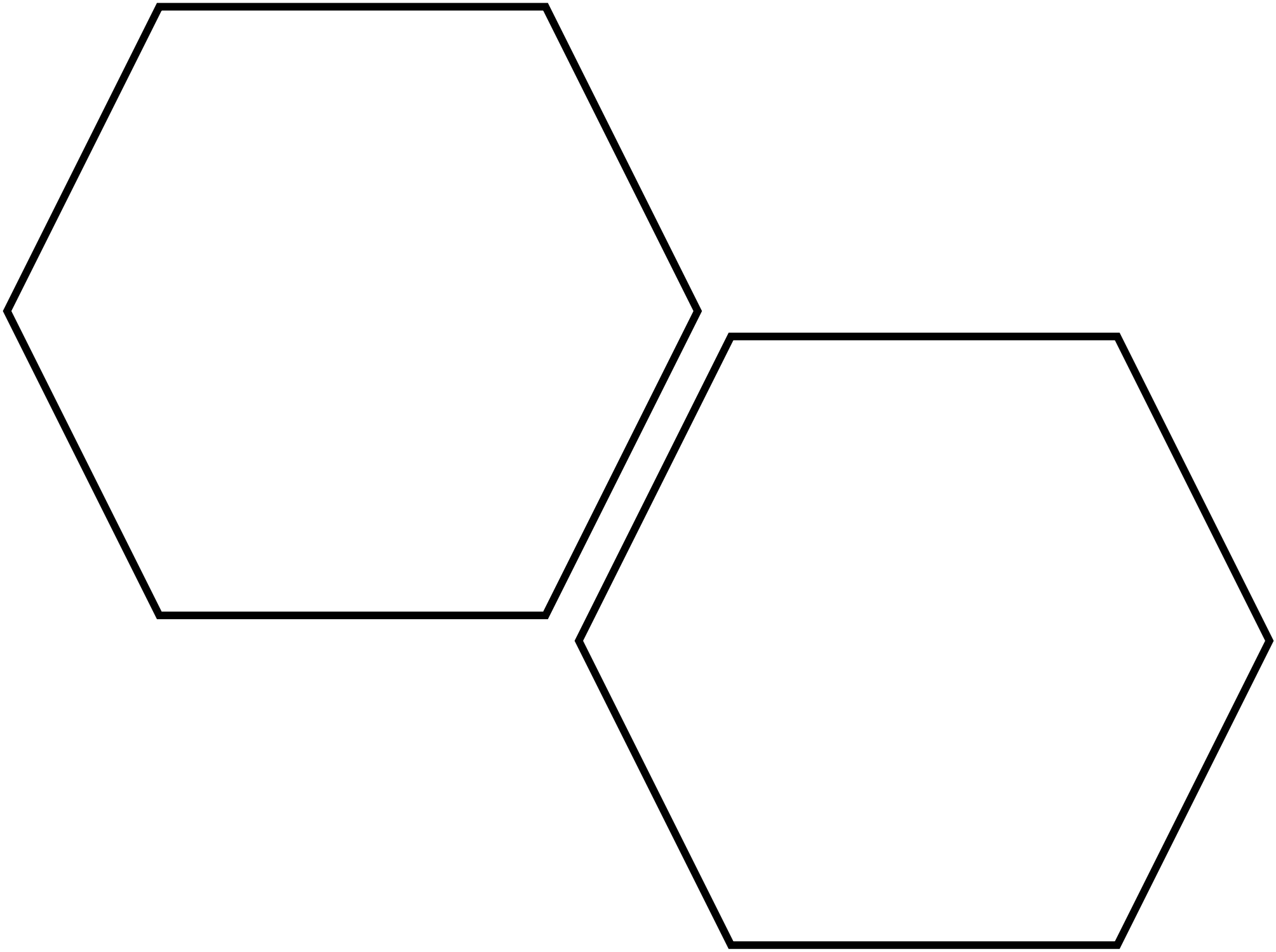
On side 1, write a key word or phrase that describes what you learned from the resource.

Side 2



On side 2, explain your key word and how the word relates to human impact on land. If you are using a written text, you also need to write a quote with the in-text citation in APA format.

*NOTE: It is important that these are done well and neatly as we will be using them in the summative project. More details will follow about this.



Appendix G

Rubric

Criteria	20	16	14	12	10
Quotes with in-text citation	Meaningful quotes or facts are chosen to support the key terms, and the in-text citations are error free.	Appropriate quotes or facts are presented to support the key terms, and the in-text citations have few errors.	Adequate quotes or facts are presented to support the key terms, and the in-text citations have multiple errors.	An attempted is made to provided quotes or facts that support the key terms with in-text citations.	Rework is needed.
Explanation	Insightful explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	Appropriate explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	Limited explanations are provided to explain the significance of the quotes or information and how they relate to the topic.	An attempt is made to explain the significance of the quotes or information and how they relate to the topic.	Rework is needed.
Connection	Insightful connections are made between the key terms with a elaborate explanations of how they relate to the topic.	Appropriate connections are made between the key terms with clear explanations of how they relate to the topic.	Limited connections are made between the key terms with minimal explanations of how they relate to the topic.	An attempt is made to connect the key terms and an attempt is made to explain how they relate to the topic.	Rework is needed.
Presentation	The hexagons are legible and neat, and they are assembled artfully with six clearly identified connections between key terms.			The hexagons lack legibility and neatness, and/or an attempt is made to identify six connections between key terms.	Rework is needed.

Total Points Earned: _____

Appendix H

Jigsaw Graphic Organizer

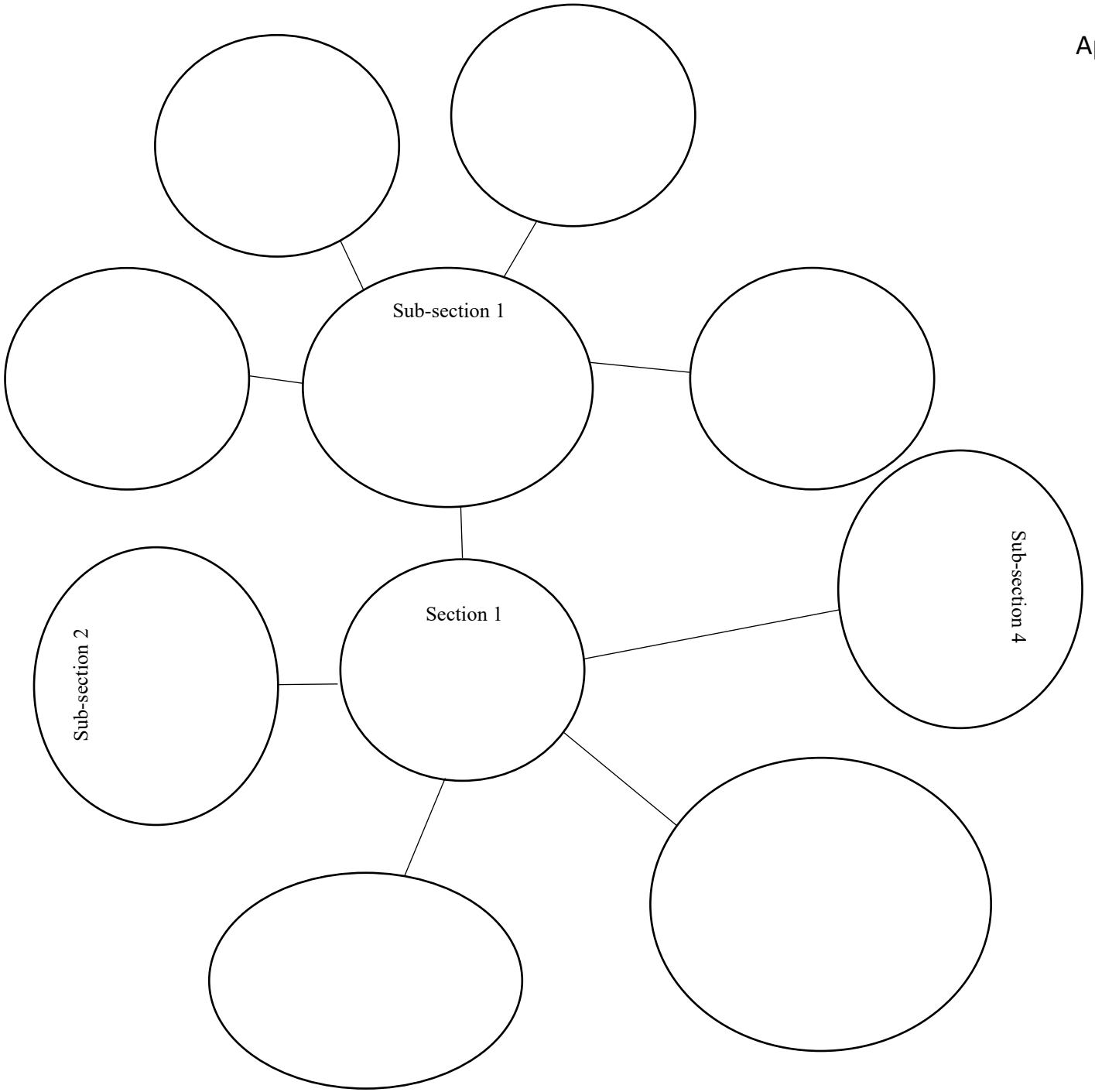
Learning Group Members: _____

Article Title & Key Ideas	Key Ideas	Questions – Create One of Each	Answers
Section 1:	Section 3:	Right There:	Right There:
		Think and Search:	Think and Search:
Section 2:	Section 4:	Author and You:	Author and You:
		On My Own:	On My Own:

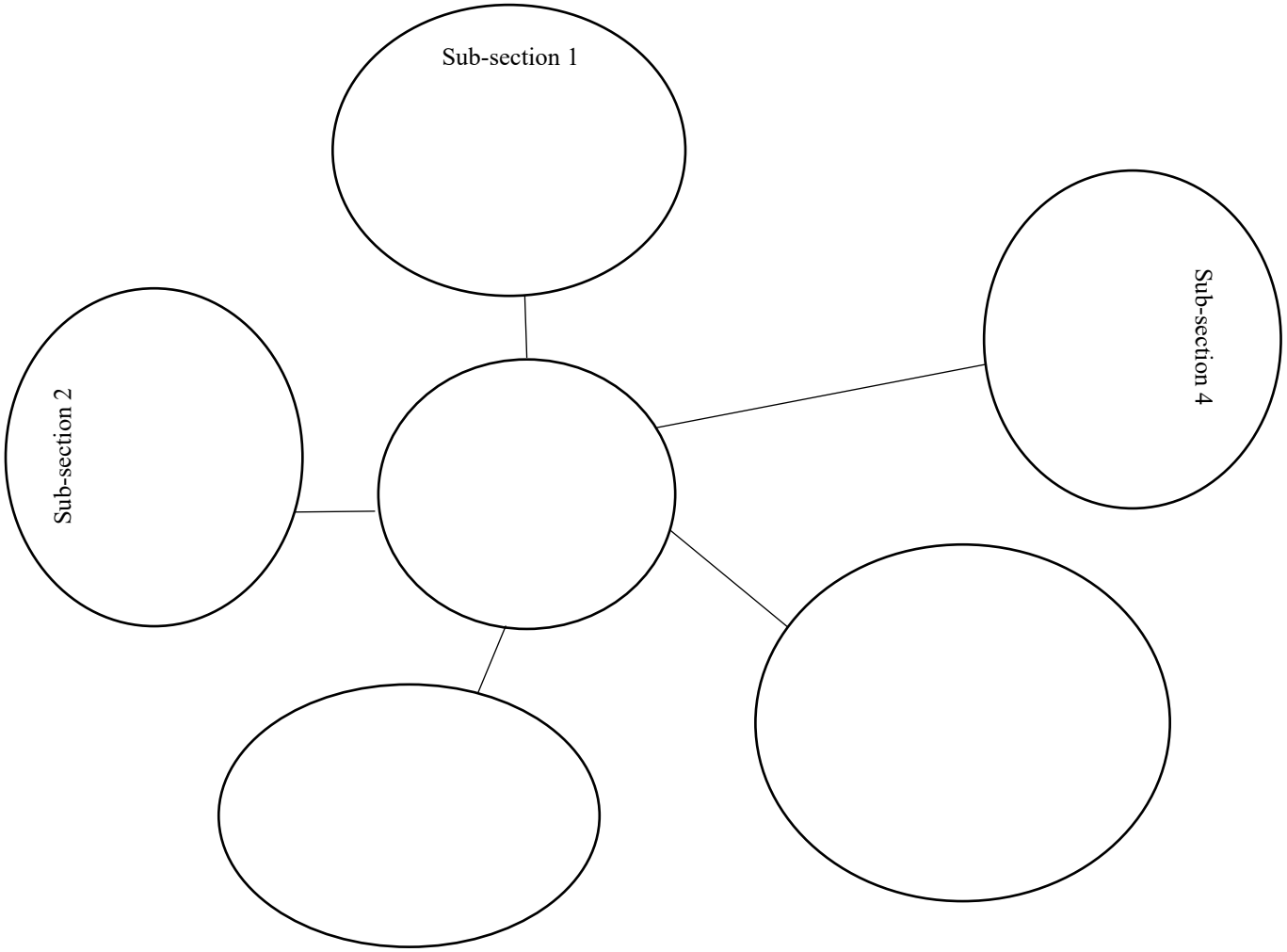
Appendix H Teaching Group Members: _____

Fertilizers	GMOs
Factory Farms	Pesticides

Appendix I



Appendix I



Appendix J

Ways to Show My Thinking Chart

Before you begin reading, number each paragraph (even if they are small). As you read, place the symbols to show your thinking. (You should have approximately one symbol for every 4-5 sentences.) For each symbol, write a brief note in the margin so that you remember what you were thinking. (*These are crucial because you will use these notes later.*)

1 2 3	Number each paragraph (big and small)
	This is the main idea.
	This word is new to me.
	This is an important idea or example.
?	I don't understand why…
	This makes sense to me because…
!	This is shocking because…
+	This is true because…
	I disagree because…
CS	I can relate to this because…
CW	This reminds me of…
CT	I've see this before when…

Appendix K

Venn Diagram

Name: _____

Differences Resource #1	Similarities	Differences Resource #2

Appendix L

Word Sort

Name: _____

Verbs	Colors	Other Adjectives

Appendix M

The Lorax

By Dr. Seuss

UNLESS someone like you cares a whole awful lot,
nothing is going to get better.

It's not.

At the far end of town where the Grickle-grass grows and the wind smells slow-and-sour when it blows and no birds ever sing excepting old crows... is the Street of the Lifted Lorax.

And deep in the Grickle-grass, some people say, if you look deep enough you can still see, today, where the Lorax once stood just as long as it could before somebody lifted the Lorax away.

What was the Lorax? And why was it there? And why was it lifted and taken somewhere from the far end of town where the Grickle-grass grows? The old Once-ler still lives here.

Ask him, he knows.

You won't see the Once-ler. Don't knock at his door. He stays in his Lerkim on top of his store. He lurks in his Lerkim, cold under the roof, where he makes his own clothes out of miff-muffered moof. And on special dank midnights in August, he peeks out of the shutters and sometimes he speaks and tells how the Lorax was lifted away. He'll tell you, perhaps... if you're willing to pay.

On the end of a rope he lets down a tin pail and you have to toss in fifteen cents and a nail and the shell of a great-great-great- grandfather snail.

Then he pulls up the pail, makes a most careful count to see if you've paid him the proper amount. Then he hides what you paid him away in his Snuvv, his secret strange hole in his gruvvulous glove. Then he grunts. I will call you by Whisper-ma-Phone, for the secrets I tell you are for your ears alone.

SLUPP! Down slupps the Whisper-ma-Phone to your ear and the old Once-ler's whispers are not very clear, since they have to come down through a snergelly hose, and he sounds as if he had smallish bees up his nose. Now I'll tell you, he says, with his teeth sounding gray, how the Lorax got lifted and taken away... It all started way back... such a long, long time back...

Way back in the days when the grass was still green and the pond was still wet and the clouds were still clean, and the song of the Swomee-Swans rang out in space... one morning, I came to this glorious place. And I first saw the trees! The Truffula Trees! The bright-colored tufts of the Truffula Trees! Mile after mile in the fresh morning breeze.

And under the trees, I saw Brown Bar-ba-loots frisking about in their Bar-ba-loot suits as the played in the shade and ate Truffula Fruits. From the rippulous pond came the comfortable sound of the Humming-Fish humming while splashing around.

But those trees! Those trees! Those Truffula Trees! All my life I'd been searching for trees such as these. The touch of their tufts was much softer than silk. And they had the sweet smell of fresh butterfly milk.

I felt a great leaping of joy in my heart. I knew just what I'd do! I unloaded my cart. In no time at all, I had built a small shop. Then I chopped down a Truffula Tree with one chop. And with great skillful skill and with great speedy speed, I took the soft tuft. And I knitted a Thneed!

The instant I'd finished I heard a ga-Zump! I looked. I saw something pop out of the stump of the tree I'd chopped down. It was sort of a man. Describe him...That's hard. I don't know if I can. He was shortish, and oldish, and brownish and mossy. And he spoke with a voice that was sharpish and bossy.

Mister! He said with a sawdusty sneeze, I am the Lorax. I speak for the trees. I speak for the trees, for the trees have no tongues. And I'm asking you, sir, at the top of my lungs-- he was very upset as he shouted and puffed-- What's that THING you've made out of my Truffula tuft?

Look, Lorax, I said. There's no cause for alarm. I chopped just one tree. I am doing no harm. I'm being quite useful. This thing is a Thneed. A Thneed's a Fine-Something-That-All-People-Need! It's a shirt. It's a sock. It's a glove. It's a hat. But it has other uses. Yes, far beyond that. You can use it for carpets. For pillows! For sheets! Or curtains! Or covers for bicycle seats! The Lorax said, Sir! You are crazy with greed. There is no one on earth who would buy that fool Thneed!

But the very next minute I proved he was wrong. For, just at that minute, a chap came along, and he thought that the Thneed I had knitted was great. He happily bought it for three ninety-eight. I laughed at the Lorax, You poor stupid guy! You never can tell what some people will buy.

I repeat, cried the Lorax, I speak for the trees!

I'm busy, I told him. Shut up, if you please. I rushed 'cross the room, and in no time at all, built a radiophone. I put in a quick call. I called all my brothers and uncles and aunts and I said, listen here! Here's a wonderful chance for the whole Once-ler Family to get mighty rich! Get over here fast! Take the road to North Nitch. Turn left at Weehawken. Sharp right at South Stitch.

And, in no time at all, in the factory I built, the whole Once-ler Family was working full tilt. We were all knitting Thneed's just as busy as bees, to the sound of the chopping of Truffula Trees.

Then... Oh! Baby! Oh! How my business did grow! Now, chopping one tree at a time was too slow. So I quickly invented my Super-Axe-Hacker, which whacked off four Truffula Trees at one smacker. We were making Thneed's four times as fast as before! And that Lorax?... He didn't show up any more.

But the next week he knocked on my new office door. He snapped! I'm the Lorax who speaks for the trees, which you seem to be chopping as fast as you please. But I'm also in charge of the Brown Bar-ba-loots, who played in the shade in their Bar-ba-loot suits and happily lived, eating Truffula Fruits. NOW...thanks to your hacking my trees to the ground, there's not enough Truffula Fruit to go 'round.

And my poor Bar-ba-loots are all getting the crummies because they have gas, and no food, in their tummies! They loved living here. But I can't let them stay. They'll have to find food. And I hope that they may. Good luck, boys, he cried. And he sent them away.

I, the Once-ler, felt sad as I watched them all go. BUT... business is business! And business must grow regardless of crummies in tummies, you know.

I meant no harm. I most truly did not. But I had to grow bigger. So bigger I got. I biggered my factory. I biggered my roads. I biggered my wagons. I biggered the loads of the Thneed's I shipped out. I was shipping them forth to the South! To the East! To the West! To the North! I went right on biggering...selling more Thneed's. And I biggered my money, which everyone needs.

Then again he came back! I was fixing some pipes when that old nuisance Lorax came back with more gripes. I am the Lorax, he coughed and he whiffed. He sneezed and he snuffled. He snarggled. He sniffed. Once-ler! He cried with a cruffulous croak. Once-ler! You're making such smogulous smoke!

My poor Swomee-Swans...why, they can't sing a note! No one can sing who has smog in his throat. And so, said the Lorax, --please pardon my cough-- they cannot live here. So I'm sending them off. Where will they go? I don't hopefully know. They may have to fly for a month...or a year... To escape from the smog you've smogged-up around here.

What's more, snapped the Lorax. (His dander was up.) Let me say a few words about Gluppity-Glupp. Your machinery chugs on, day and night without stop making Gluppity-Glupp. Also Schloppity-Schlopp. And what do you do with this leftover goo? I'll show you. You dirty old Once-ler man, you!

You're glumping the pond where the Humming-Fish hummed! No more can they hum, for their gills are all gummed. So I'm sending them off. Oh, their future is dreary. They'll walk on their fins and get woefully weary in search of some water that isn't so smeary.

And then I got mad. I got terribly mad. I yelled at the Lorax, Now listen here, Dad! All you do is yap-yap and say, Bad! Bad! Bad! Bad! Well, I have my rights, sir, and I'm telling you I intend to go on doing just what I do! And, for your information, you Lorax, I'm figgering on biggering and Biggering and BIGGERING and **BIGGERING!!** Turning MORE Truffula Trees into Thneed's which everyone, EVERYONE, **EVERYONE** needs!

And at that very moment, we heard a loud whack! From outside in the fields came a sickening smack of an axe on a tree. Then we heard the tree fall. The very last Truffula Tree of them all! No more trees. No more Thneed's. No more work to be done. So, in no time, my uncles and aunts, every one, all waved my good-bye. They jumped into my cars and drove away under the smoke-smuggered stars.

Now all that was left beneath the bad-smelling sky was my big empty factory... the Lorax... and I.

The Lorax said nothing. Just gave me a glance... just gave me a very sad, sad backward glance... as he lifted himself by the seat of his pants. And I'll never forget the grim look on his face when he hoisted himself and took leave of this place, through a hole in the smog, without leaving a trace. And all that the Lorax left here in this mess was a small pile of rocks, with one word... **UNLESS**.

Whatever that meant, well, I just couldn't guess.

That was long, long ago. But each day since that day I've sat here and worried and worried away. Through the years, while my buildings have fallen apart, I've worried about it with all of my heart.

But now, says the Once-ler, Now that you're here, the word of the Lorax seems perfectly clear. UNLESS someone like you cares a whole awful lot, nothing is going to get better. It's not.

SO... Catch! Calls the Once-ler. He lets something fall. It's a Truffula Seed. It's the last one of all! You're in charge of the last of the Truffula Seeds. And Truffula Trees are what everyone needs. Plant a new Truffula. Treat it with care. Give it clean water. And feed it fresh air. Grow a forest. Protect it from axes that hack. Then the Lorax and all of his friends may come back.

Appendix N

The Giving Tree By Shel Silverstein

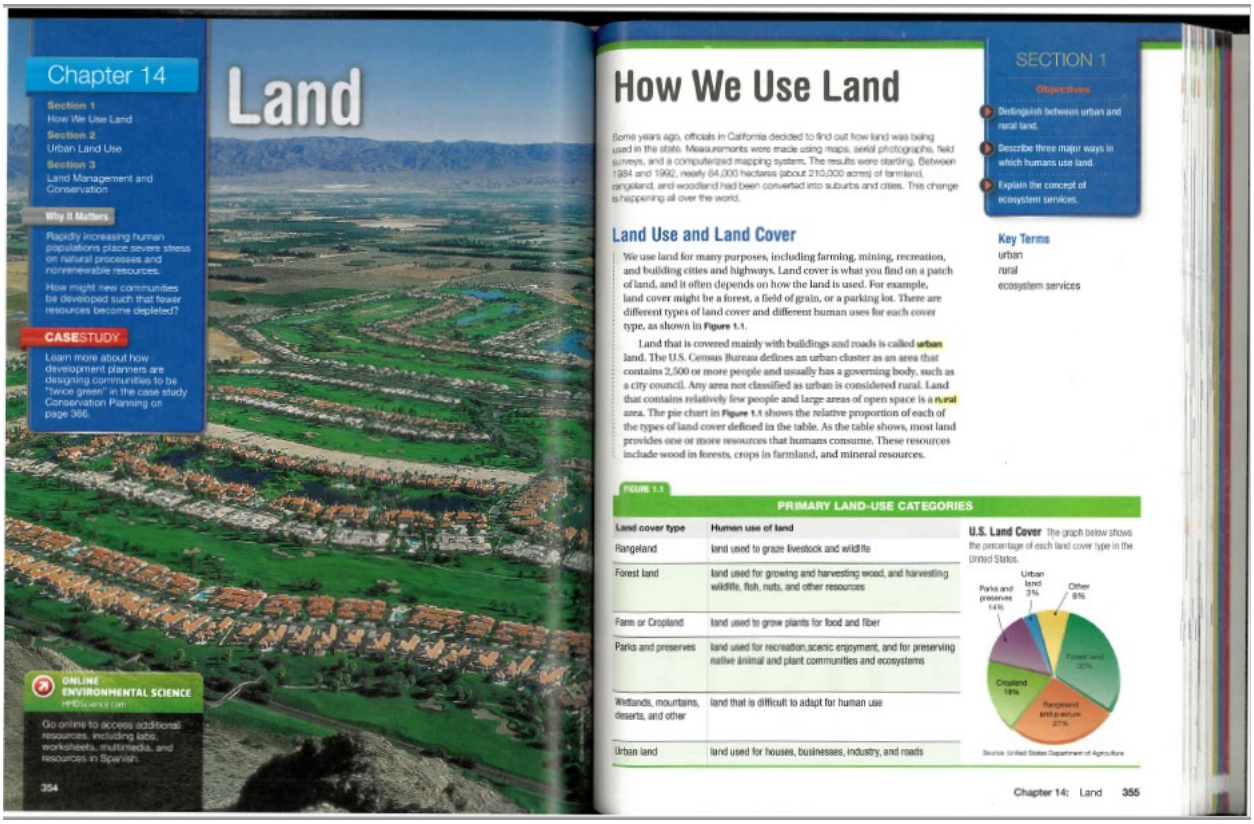
Once there was a tree....
and she loved a little boy.
And everyday the boy would come
and he would gather her leaves
and make them into crowns
and play king of the forest.
He would climb up her trunk
and swing from her branches
and eat apples.
And they would play hide-and-go-seek.
And when he was tired,
he would sleep in her shade.
And the boy loved the tree....
very much.
And the tree was happy.
But time went by.
And the boy grew older.
And the tree was often alone.
Then one day the boy came to the tree
and the tree said, "Come, Boy, come and
climb up my trunk and swing from my
branches and eat apples and play in my
shade and be happy."
"I am too big to climb and play" said
the boy.
"I want to buy things and have fun.
I want some money?"
"I'm sorry," said the tree, "but I
have no money.
I have only leaves and apples.
Take my apples, Boy, and sell them in
the city. Then you will have money and
you will be happy."

And so the boy climbed up the
tree and gathered her apples
and carried them away.
And the tree was happy.
But the boy stayed away for a long time....
and the tree was sad.
And then one day the boy came back
and the tree shook with joy
and she said, "Come, Boy, climb up my trunk
and swing from my branches and be happy."
"I am too busy to climb trees," said the boy.
"I want a house to keep me warm," he said.
"I want a wife and I want children,
and so I need a house.
Can you give me a house ?"
" I have no house," said the tree.
"The forest is my house,
but you may cut off
my branches and build a

house. Then you will be happy."
And so the boy cut off her branches
and carried them away
to build his house.
And the tree was happy.
But the boy stayed away for a long time.
And when he came back,
the tree was so happy
she could hardly speak.
"Come, Boy," she whispered,
"come and play."
"I am too old and sad to play,"
said the boy.
"I want a boat that will
take me far away from here.
Can you give me a boat?"
"Cut down my trunk
and make a boat," said the tree.
"Then you can sail away...
and be happy."
And so the boy cut down her trunk
and made a boat and sailed away.
And the tree was happy
... but not really.

And after a long time
the boy came back again.
"I am sorry, Boy,"
said the tree," but I have nothing
left to give you -
My apples are gone."
"My teeth are too weak
for apples," said the boy.
"My branches are gone,"
said the tree. " You
cannot swing on them - "
"I am too old to swing
on branches," said the boy.
"My trunk is gone, " said the tree.
"You cannot climb - "
"I am too tired to climb" said the boy.
"I am sorry," sighed the tree.
"I wish that I could give you something....
but I have nothing left.
I am just an old stump.
I am sorry...."
"I don't need very much now," said the boy.
"just a quiet place to sit and rest.
I am very tired."
"Well," said the tree, straightening
herself up as much as she could,
"well, an old stump is good for sitting and resting
Come, Boy, sit down. Sit down and rest."
And the boy did.
And the tree was happy.

Appendix O



Chapter 14

Land

Section 1 How We Use Land
Section 2 Urban Land Use
Section 3 Land Management and Conservation

Why It Matters

Rapidly increasing human populations place severe stress on natural processes and nonrenewable resources.

How might new communities be developed such that fewer resources become depleted?

CASESTUDY

Learn more about how development planners are designing communities to be "twice green" in the case study Conservation Planning on page 366.

ONLINE ENVIRONMENTAL SCIENCE

Go online to access additional resources, including labs, worksheets, multimedia, and resources in Spanish.

354

How We Use Land

Some years ago, officials in California decided to find out how land was being used in the state. Measurements were made using maps, aerial photographs, field surveys, and a computerized mapping system. The results were startling. Between 1984 and 1992, nearly 84,000 hectares (about 210,000 acres) of farmland, rangeland, and woodland had been converted into suburbs and cities. This change is happening all over the world.

SECTION 1

Objectives

- Distinguish between urban and rural land.
- Describe three major ways in which humans use land.
- Explain the concept of ecosystem services.

Key Terms
urban
rural
ecosystem services

Land Use and Land Cover

We use land for many purposes, including farming, mining, recreation, and building cities and highways. Land cover is what you find on a patch of land, and it often depends on how the land is used. For example, land cover might be a forest, a field of grain, or a parking lot. There are different types of land cover and different human uses for each cover type, as shown in Figure 1.1.

Land that is covered mainly with buildings and roads is called **urban** land. The U.S. Census Bureau defines an urban cluster as an area that contains 2,500 or more people and usually has a governing body, such as a city council. Any area not classified as urban is considered rural. Land that contains relatively few people and large areas of open space is a **rural** area. The pie chart in Figure 1.1 shows the relative proportion of each of the types of land cover defined in the table. As the table shows, most land provides one or more resources that humans consume. These resources include wood in forests, crops in farmland, and mineral resources.

FIGURE 1.1

PRIMARY LAND-USE CATEGORIES

Land cover type	Human use of land
Rangeland	land used to graze livestock and wildlife
Forest land	land used for growing and harvesting wood, and harvesting wildlife, fish, nuts, and other resources
Farm or Cropland	land used to grow plants for food and fiber
Parks and preserves	land used for recreation, scenic enjoyment, and for preserving native animal and plant communities and ecosystems
Wetlands, mountains, deserts, and other	land that is difficult to adapt for human use
Urban land	land used for houses, businesses, industry, and roads

U.S. Land Cover The graph below shows the percentage of each land cover type in the United States.

Source: United States Department of Agriculture

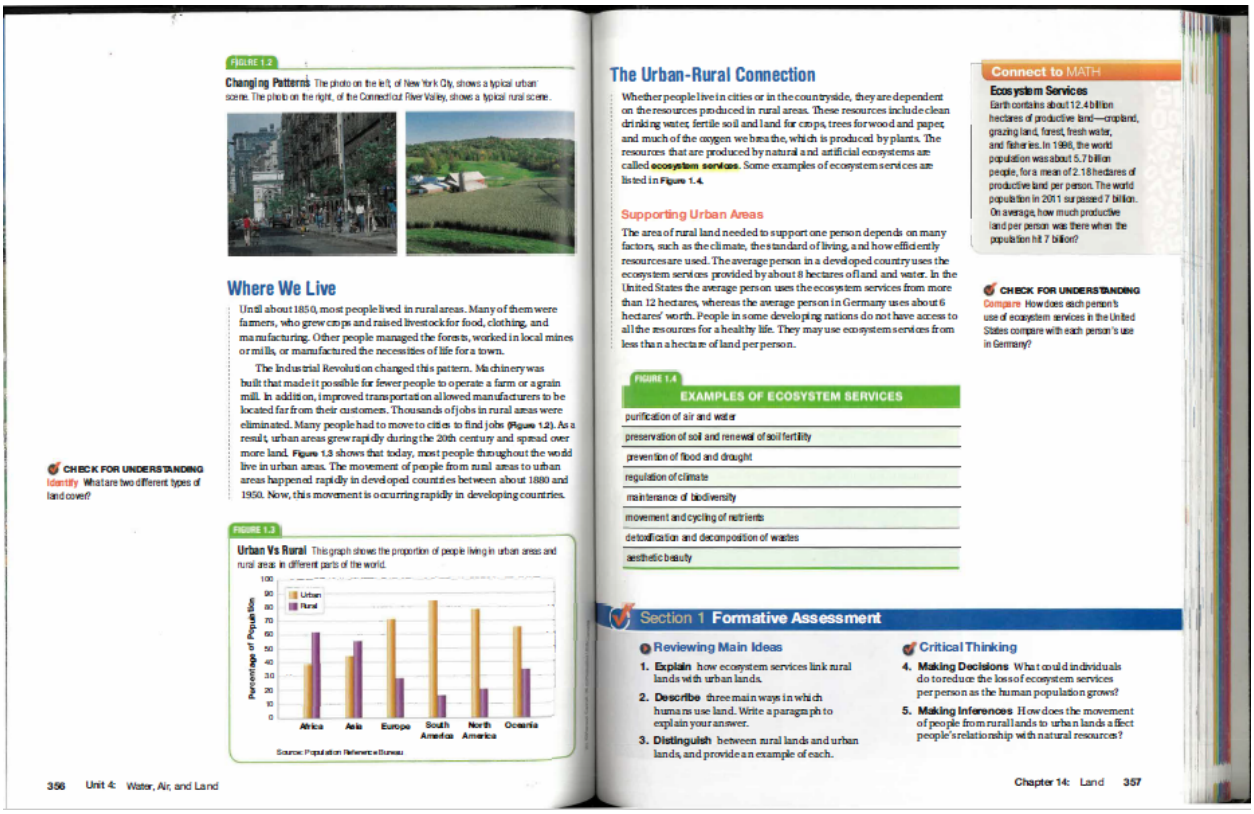


FIGURE 1.2

Changing Patterns The photo on the left, of New York City, shows a typical urban scene. The photo on the right, of the Connecticut River Valley, shows a typical rural scene.

Where We Live

Until about 1850, most people lived in rural areas. Many of them were farmers, who grew crops and raised livestock for food, clothing, and manufacturing. Other people managed the forests, worked in local mines or mills, or manufactured the necessities of life for a town.

The Industrial Revolution changed this pattern. Machinery was built that made it possible for fewer people to operate a farm or a grain mill. In addition, improved transportation allowed manufacturers to be located far from their customers. Thousands of jobs in rural areas were eliminated. Many people had to move to cities to find jobs (Figure 1.2). As a result, urban areas grew rapidly during the 20th century and spread over more land. Figure 1.3 shows that today, most people throughout the world live in urban areas. The movement of people from rural areas to urban areas happened rapidly in developed countries between about 1880 and 1950. Now, this movement is occurring rapidly in developing countries.

CHECK FOR UNDERSTANDING
Identify What are two different types of land cover?

FIGURE 1.3

Urban Vs Rural This graph shows the proportion of people living in urban areas and rural areas in different parts of the world.

Source: Population Reference Bureau

The Urban-Rural Connection

Whether people live in cities or in the countryside, they are dependent on the resources produced in rural areas. These resources include clean drinking water, fertile soil and land for crops, trees for wood and paper, and much of the oxygen we breathe, which is produced by plants. The resources that are produced by natural and artificial ecosystems are called **ecosystem services**. Some examples of ecosystem services are listed in Figure 1.4.

Supporting Urban Areas

The area of rural land needed to support one person depends on many factors, such as the climate, the standard of living, and how efficiently resources are used. The average person in a developed country uses the ecosystem services provided by about 8 hectares of land and water. In the United States the average person uses the ecosystem services from more than 12 hectares, whereas the average person in Germany uses about 6 hectares' worth. People in some developing nations do not have access to all the resources for a healthy life. They may use ecosystem services from less than a hectare of land per person.

FIGURE 1.4

EXAMPLES OF ECOSYSTEM SERVICES

purification of air and water
preservation of soil and renewal of soil fertility
prevention of flood and drought
regulation of climate
maintenance of biodiversity
movement and cycling of nutrients
detoxification and decomposition of wastes
aesthetic beauty

Connect to MATH

Ecosystem Services
Earth contains about 12.4 billion hectares of productive land—cropland, grazing land, forest, fresh water, and fisheries. In 1998, the world population was about 5.7 billion people, for a mean of 2.18 hectares of productive land per person. The world population in 2011 surpassed 7 billion. On average, how much productive land per person was there when the population hit 7 billion?

CHECK FOR UNDERSTANDING
Compare How does each person's use of ecosystem services in the United States compare with each person's use in Germany?

Section 1 Formative Assessment

Reviewing Main Ideas

1. **Explain** how ecosystem services link rural lands with urban lands.
2. **Describe** three main ways in which humans use land. Write a paragraph to explain your answer.
3. **Distinguish** between rural lands and urban lands, and provide an example of each.

Critical Thinking

4. **Making Decisions** What could individuals do to reduce the loss of ecosystem services per person as the human population grows?
5. **Making Inferences** How does the movement of people from rural lands to urban lands affect people's relationship with natural resources?

SECTION 2

Objectives

- Describe the urban crisis, and explain what people are doing to deal with it.
- Explain how urban sprawl affects the environment.
- Explain how open spaces provide urban areas with environmental benefits.
- Explain the heat-island effect.
- Describe how people use a geographic information system as a tool for land-use planning.

Key Terms

urbanization
infrastructure
urban sprawl
heat island
land-use planning
geographic information system (GIS)

Urban Land Use

Historically, communities grew around good sources of water for drinking, agriculture, and transportation. Now, people tend to live where they can find the things that they need and want, such as jobs, schools, and recreational areas. For most people today, this means living in an urban area.

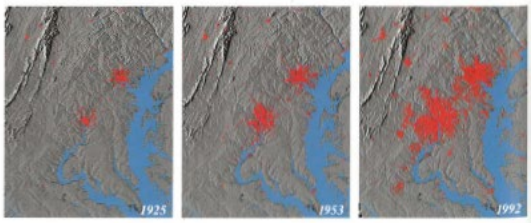
Urbanization

The movement of people from rural areas to cities is known as **urbanization.** People usually leave rural areas for more plentiful and better paying jobs in towns and cities. In developed countries, urbanization slowed in the second half of the 20th century. In 1960, 70 percent of the U.S. population was classified as urban. By 2011, this percentage had increased to slightly more than 79 percent. As urban populations have grown, many small towns have grown together and formed larger urban areas. The U.S. Census Bureau calls these complexes metropolitan areas. Some examples are Denver-Boulder in Colorado and Boston-Worcester-Lawrence in Massachusetts. **Figure 2.1** shows the expansion of the Washington, D.C.–Baltimore metropolitan area over the years. These maps were created using data from the U.S. Census Bureau.

Urban areas that have grown slowly or are carefully planned can be pleasant places to live. Roads and public transportation in these areas have been built to handle the growth, so that traffic flows freely. Buildings, roads, and parking lots are mixed in with green spaces and recreational areas. These green spaces may provide these urban areas with much needed ecosystem services such as moderation of temperature, infiltration of rainwater runoff, and aesthetic value.

FIGURE 2.1

Urbanization The Washington, D.C.–Baltimore area has grown larger and more densely populated over the years. Red areas indicate urban development.



The Urban Crisis

When urban areas grow rapidly, they often run into trouble. A rapidly growing population can overwhelm the infrastructure and lead to traffic jams, substandard housing, and polluted air and water. **Infrastructure** is all of the things that a society builds for public use. Infrastructure includes roads, sewers, railroads, bridges, canals, fire and police stations, schools, libraries, hospitals, water mains, and power lines. When more people live in a city than its infrastructure can support, the living conditions deteriorate. This growth problem has become so widespread throughout the world that the term *urban crisis* was coined to describe the problem. **Figure 2.2** shows an example of urban crisis in Hong Kong. The hillside is covered with substandard housing in an area that lacks the necessary infrastructure for people to live in healthy conditions.

Urban Sprawl

Rapid expansion of a city into the countryside around the city is called **urban sprawl.** Much of this expansion results from building suburbs or housing and associated commercial buildings on the boundary of a larger town. People living in the suburbs generally commute to work in the city by car. Many of these suburbs are built on land that was previously used for food production, as shown in **Figure 2.3.** In 2000, more Americans lived in suburbs than in cities and the countryside combined. Each year suburbs spread over another 1 million hectares (2.5 million acres) of land in the United States.

FIGURE 2.2

Urban Growth Rapid urban growth has led to substandard housing on the hillsides above Hong Kong.

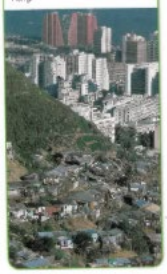


FIGURE 2.3

Urban Sprawl This photograph shows suburban development spreading out around farmland.

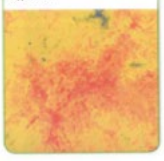
FIELDSTUDY
Go to Appendix B to find the field study **Land Use Planning.**

FIGURE 2.4

Marginal Lands The search for ocean views lead people to build these homes on the California coastline, which is giving way as a result of erosion.

FIGURE 2.5

Heat Islands The urban heat island over Atlanta is shown in this computer-enhanced satellite image. Areas with higher temperatures appear red.



CHECK FOR UNDERSTANDING
Explain How do heat islands affect local rainfall?

Development on Marginal Lands

Many cities were first built where there was little room for expansion. As the cities grew, suburbs were often built on *marginal land*—land that is poorly suited for building. For example, Los Angeles and Mexico City are built in basins. These cities have expanded up into the surrounding mountains where the slopes are prone to landslides. The houses shown in **Figure 2.4** were built on land that is unsuitable for development because of the natural process of erosion along the coastline. Structures built on marginal land can become difficult or impossible to repair and can be expensive to insure.

Other Impacts of Urbanization

Environmental conditions in a city are different from those of the surrounding countryside. Cities both generate and trap more heat. Roads and buildings absorb more heat than vegetation does. They also retain heat longer. The increased temperature in a city is called a **heat island.** Atlanta, Georgia, is an example of a city that has a significant heat island, as shown in **Figure 2.5.**

Heat islands can affect local weather patterns. Hot air rises over a city, cooling as it rises, and eventually produces rain clouds. In Atlanta and many other cities, increased rainfall is a side effect of the heat island. The heat-island effect may be moderated by planting trees for shade and by installing rooftops that reflect rather than retain heat.

Urban Planning

Land-use planning is determining in advance how land will be used—where the best locations are for houses, businesses, and factories to be built, where land will be protected for recreation, and where infrastructure like sewers and electrical lines should be placed.

Making land-use plans is complex and often controversial. Federal, state, and local governments require developers to prepare detailed reports assessing the environmental impact of many projects. Developers, city governments, local businesses, and citizens often disagree about land-use plans. Projects that affect large or environmentally sensitive areas are often studied carefully and subject to heated debate.

Technological Tools

One important technological tool for land-use planning involves using a geographic information system.

A **geographic information system (GIS)** is a computerized system for storing, manipulating, and viewing geographic data. GIS software allows a user to enter different types of data about an area, such as the location of sewer lines, roads, and parks, and then create maps. **Figure 2.6** shows several images of Seattle, Washington, created from GIS data. Each image corresponds to a different combination of information. GIS allows users to display layers of information about an area and to overlay these layers, like overhead transparencies, on top of one another. It is used for environmental projects such as understanding habitat requirements of species, patterns of pollutant spread, and so on.

Connect to HISTORY

Ancient Urban Planning
People have practiced urban planning for thousands of years. The ancient Mexican city of Teotihuacan was a marvel of urban planning. The city had a grid plan oriented to 15 degrees, 25 minutes east of true north. It had two central avenues that divided the city into four quadrants. About 2,000 homes and apartment compounds lined the main avenue, which also had a channel running under it that gathered rainwater. Teotihuacan had all this—before 750 BC.

FIGURE 2.6

GIS Imaging The images below are of Seattle, Washington. Each image represents a different GIS layer, each with specific information.

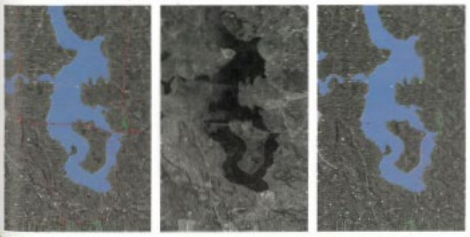


FIGURE 2.7

Mass Transit The BART transit system in California's San Francisco Bay Area moves thousands of people a day with much less environmental impact than if the people drove their own cars.

Transportation

Most cities in the United States are difficult to travel in without a car. Many U.S. cities were constructed after the invention of the automobile. In addition, availability of land was not a limiting issue, so many American cities sprawl over large areas. By contrast, most cities in Europe were built before cars, have narrow roads, and are compact.

In many cities, *mass transit systems* have been constructed to get people where they want to go. Mass transit systems, such as the one shown in **Figure 2.7**, use buses and trains to move many people at one time. Mass transit systems save energy, reduce highway congestion, reduce air pollution, and limit the loss of land to roadways and parking lots. Where the construction of mass transit systems is not reasonable, carpooling is an important alternative.

Open Space

Open space is land that is set aside for agriculture or scenic and recreational enjoyment. Open spaces within urban areas include parks, public gardens, and bicycle and hiking trails. Open spaces left in their natural condition are often called *greenbelts*. These greenbelts provide important ecological services.

Open spaces have numerous environmental benefits and provide valuable functions. The plants in open spaces absorb carbon dioxide, produce oxygen, and filter out pollutants from air and water. Plants even help keep a city cooler in the summer. Open spaces used for agriculture provide food resources. Some open spaces, especially those with vegetation, also reduce drainage problems by absorbing more of the rainwater runoff from building roofs, asphalt, and concrete. This ecological service results in less flooding after a heavy rain. Open spaces provide urban dwellers with much-needed places for exercise and relaxation.

CHECK FOR UNDERSTANDING
Describe What are three benefits that are provided by open spaces in urban areas?

Section 2 Formative Assessment

Reviewing Main Ideas

1. **Describe** the term *urban crisis*, and explain how people are addressing it.
2. **Explain** how urban areas create heat islands.
3. **Explain** how open spaces provide environmental benefits to urban areas.
4. **Describe** how GIS can be used as a land-use planning tool.

Critical Thinking

5. **Identifying Relationships** Write a short paragraph in which you describe the benefits of using a geographic information system for land-use planning.
6. **Making Decisions** Describe the environmental implications of urban sprawl.

Land Management and Conservation

SECTION 3

Objectives

- Explain the benefits of preserving farmland.
- Describe two ways that rangeland can be managed sustainably.
- Describe the environmental effects of deforestation.
- Explain the function of parks and of wilderness areas.

Key Terms
overgrazing
deforestation
reforestation
wilderness

As the human population grows, the resources of more rural land are needed to support the population. The main categories of rural land are farmland, rangeland, forest land, national and state parks, and wilderness. Throughout our history, we have sometimes managed these lands sustainably so that they will provide resources indefinitely. We have also sometimes reduced their productivity by overusing or polluting them. The condition of rural land is important because of the ecological services that it provides. These services are especially important for the urban areas that rely on the productivity of rural land.

Farmlands

Farmland, such as that shown in **Figure 3.1**, is land that is used to grow crops. The United States contains more than 100 million hectares of prime farmland. However, in some places, urban development threatens some of the most productive farmland. Examples of places where farmland is threatened are southern California, parts of North Carolina's Piedmont region, and the Twin Cities area of Minnesota. In 1996, the U.S. government established a national Farmland Protection Program to help state, county, and local governments protect farmland in danger of being paved over or otherwise developed. The program was renewed in 2008.

FIGURE 3.1

Threatened Farmlands This farmland next to the suburbs of Mililani, Hawaii, is used to grow a variety of crops.

ECOFACT

Soil
Nothing can grow without soil. Soil used for agriculture should be sustainably managed. If not, then nutrients can be depleted or soil becomes so compacted that roots can't grow properly. Erosion can occur and healthy topsoil eroded away.

Rangelands

Land that supports different vegetation types like grasslands, shrublands, and deserts and that is not used for farming or timber production is called *rangeland*. Rangelands can be arid, like rangelands in the desert Southwest, or relatively wet, like the rangelands of Florida. The most common human use of rangeland is for the grazing of livestock, as shown in **Figure 3.2**. The most common livestock are cattle, sheep, and goats, which are valued for their meat, milk, wool, and hides. Native wildlife species also graze these lands. Like farmland, rangeland is essential for maintaining the world's food supply. World population growth may require a 40 percent increase in the food production of rangeland from 1977 to 2030.

Problems on the Range

Some rangelands in the United States have become degraded by poor land management strategies. Most damage to rangeland comes from **overgrazing**, or allowing more animals to graze in an area than the range can support. When animals overgraze, too many of the plants are eaten, and the land can become degraded. Overgrazing often results in changes in the plant community. Less desirable plant species may invade the area and replace more desirable plant species. In severe cases, all the vegetation is eaten. Once the plants are gone, there is nothing to keep the soil from eroding.

CHECK FOR UNDERSTANDING
Explain How does rangeland become degraded?

FIGURE 3.2

Rangelands The photo below shows productive rangeland in the western United States.

Maintaining the Range

Much of the rangeland in the United States is public land managed by the federal government, which leases the rangeland to ranchers. Much of it is degraded. The Public Rangelands Improvement Act of 1978 was enacted to reverse this trend and improve land management practices.

Sustaining the productivity of rangeland generally means limiting herds to sizes that do not degrade the land. Rangeland may also be left unused for periods of time so that the vegetation can recover. Improving rangeland that has been degraded by overgrazing often includes methods such as killing invasive plants, planting native vegetation, and fencing areas to let them recover to the state they were in before they were overgrazed. Ranchers help control grazing by providing several small water sources so that livestock do not overgraze the vegetation around a single water source.

FIGURE 3.3

Harvesting Trees Methods for harvesting trees include clear-cutting (left) and selective cutting (right).

Forest Lands

Trees are harvested to provide products we use everyday, such as paper, furniture, and lumber and plywood for homes. In addition to wood and paper, we value forest products such as maple syrup and turpentine. There are many ecosystem services provided by forests; however, one of the most important is the removal of CO_2 from the air. This is known as *carbon sequestration*.

Harvesting Trees

People use enormous amounts of wood. The worldwide average is 1,800 cm^3 of wood used per person each day. However, on average, each person in the United States uses about 3.5 times this amount. This is the equivalent of each person in the United States cutting down a tree that is 30 m tall every year. About 1.5 billion people in developing countries depend on firewood as their main source of fuel.

The timber industry classifies forest lands into three categories—virgin forest, which is forest that has never been cut; native forest, which is forest that is planted and managed; and tree farms, which are areas where trees are planted in rows and harvested like other crops. The two most widely used methods of harvesting trees are clear-cutting and selective cutting. These methods are shown in **Figure 3.3**. *Clear-cutting* is the process of removing all or most of the trees from an area of land. In some instances, a few "seed trees" or snags are left behind to help regrow the area or provide wildlife habitat. Standard clear-cutting can dramatically change or destroy established wildlife habitat and in some cases, cause soil erosion. Wood that is not commercially viable may be cut, but left behind to decay. The main alternative is selective cutting, which is usually practiced on smaller areas owned by individuals. *Selective cutting* is the process of cutting and removing only certain trees, leaving the rest. Selective cutting is more expensive than clear-cutting, but selective cutting is usually less destructive and can improve the health of the forest.

QUICKLAB

Measuring Soil Depth and Compaction

Procedure

1. Find a plot of undisturbed soil in a forest, meadow, park, or other undisturbed area near your school.
2. Press a 1 m wooden dowel down into the undisturbed soil as far as it will go. Measure (in centimeters) how deep the dowel went into the soil. Record the measurement, along with your observations on how soft the soil was and how easy it was to press the meterstick into the soil. Repeat this five times in the same plot of undisturbed soil.
3. Pour 1 L of water onto the undisturbed soil. Use a stopwatch to record how long it takes for the soil to fully absorb the water.
4. Repeat this procedure at a plot of disturbed soil in a path, dirt road, or other area where the soil is bare and vegetation has been cleared or trampled.

Analysis

1. How did the soil depth and hardness in the plot of undisturbed soil differ from that in the plot of disturbed soil?
2. Which plot absorbed water faster?

ECOFACT

Burning Trees and CO_2

When trees are cut and burned, they release carbon dioxide. From 1850 to 1990, deforestation released more than 100 billion metric tons of carbon dioxide into the atmosphere worldwide. Some scientists think this additional CO_2 is contributing to an increase in average global temperatures.

Deforestation

The clearing of trees from an area without replacing them is called **deforestation**. Most countries become severely deforested as populations expand and the demand for forest products increases. Forests are cleared to convert the land into farmland, or to make space for roads, homes, factories, and office buildings.

Deforestation reduces wildlife habitat, but it has other impacts, too. For example, without tree roots or a cover crop to hold the soil in place, soil is easily washed or blown into the valley below. In New York, forests on hillsides were cleared and plowed for farmland during the 19th century, and as much as 90 percent of the soil eroded. During the Great Depression, of the 1930s, hundreds of farmers in the area went bankrupt. The state bought many of the abandoned farms and let the forests regenerate. Today, many of the hillsides are covered with state forest, which is used for recreation.

The rate of deforestation is especially high in tropical rain forests, where the soil is relatively thin. Unless farming is done sustainably, clearing only small areas that will naturally regenerate, farmers must clear more forest every few years when the soil nutrients are used up. Whether forests are cleared for farming or wood, or commercial ranches or plantations, if trees are not replanted, natural resources are steadily depleted.

Reforestation

Clear-cut forest can be replanted or allowed to regrow naturally. **Reforestation** is the process by which trees are planted to re-establish trees that have been cut down in a forest land. In some places in the U.S., steep hillsides were deforested for farming or development and then abandoned when farming became less economical. The cost of deforestation, which caused soil erosion, landslides, and flooding, was too high. So forest has now been allowed to regenerate or has been replanted.

The area of east Texas known as the Big Thicket was heavily logged in the early 1900s. During the Depression, the federal government bought the land from timber companies in order to help them stay in business. Afterward the government kept the land and , in 1974, made it into the first National Preserve in the national park system.

Globally, more than 90 percent of timber comes from forests that are not sustainably managed, however, some governments require reforestation after timber has been harvested from public land. Many governments are currently working to improve reforestation efforts and promote less destructive logging methods, as seen in **Figure 3.4**. A number of private organizations have also established tree-planting programs.

FIGURE 3.4

Reforestation Tree seedlings have been planted to reforest this hillside as part of a reforestation project in the Fiji Islands.

CASESTUDY

Conservation Planning

Undeveloped land is often sold to developers who have plans to build homes, or commercial properties, in that space. As more land is developed, green spaces can disappear – but now some urban planners are reversing this trend, trying to preserve ponds, forests, and grasslands as much as possible. These planners hope not only to conserve animal habitats and native plants, but also to improve the quality of life for people who do not want to live and work in a totally manmade landscape.

Traditionally, subdivision planners lay out streets for a development first, divide the remaining land into house lots of relatively equal size and shape, and then set aside certain lots to be used as public space. Conservation planning reverses this process, setting aside as much as 80 percent of a development to be common, or shared, green space, while putting new homes on much smaller lots. Planners like Randall Arendt pioneered the conservationist approach to planning. Arendt first goes out and physically walks around the space, finding out everything that he can about it. "If you don't like ticks or chiggers and are afraid of snakes," he warns student planners, "you need to get a different job." Arendt sketches the areas that will be protected natural habitat first, concentrating on preserving old growth forests, areas around rivers and streams, natural slopes and ridges in the land, arable land, and land that forms an important habitat for native plants and animals. After setting aside land to be protected, Arendt chooses locations for houses. Then he "connects the dots" to plan streets and walking trails, making sure streets curve around the natural lay of the land.

Colored candles are used on top of land sketches to see how housing might be configured.

Arendt typically takes planners out to walk around a site and make sketches. Later, they sit down and add details to their sketches. Arendt gives out handfuls of colored candles for planners to move around on top of their sketches to see how they might configure housing.

Many environmentalists are calling the work of conservation planners-like Arendt "twice green," meaning the planning is environmentally green and financially prudent. Home buyers will pay more for smaller homes in conservation subdivisions, because the homes are in a more beautiful area and have yards that are more private. Preserving natural features means grading less land and moving less dirt, which saves developers money. In one Texas development, Arendt's plans saved developers approximately $250,000 – or 83% of the original planned grading costs. Conservation planning also saves money by not using traditional cement stormwater drainage and underground sewers, which are expensive to install. Instead of a fast flowing drainage system, planners reduce runoff by using rain gardens to hold stormwater as long as possible, letting stormwater gradually trickle first into fields, then wetlands, and then run off into rivers, ponds and streams.

This diagram shows how green planning helps protect natural resources, while offering attractive and valuable building sites for development.

Critical Thinking

1. **Applying Ideas** Designer Andrea Tyson, a conservation planner from Naples, Florida, calls Arendt's approach "capitalism mated with conservation." Explain why you think she would use this term.
2. **Expressing Viewpoints** Some communities are enacting laws that require a certain percentage of land in new developments to be conserved. Do you think this is a good idea? Why or why not?

FIGURE 3.5

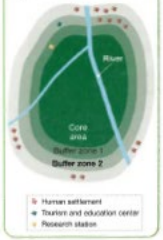
U.S. National Parks National parks in the United States are concentrated in the West.

CHECK FOR UNDERSTANDING

Describe What are three uses of public lands in the United States?

FIGURE 3.6

Biosphere Reserves Biosphere reserves are places where human populations and wildlife live side by side.



Parks and Preserves

In the 1870s, a group of explorers brought news to Congress of a magnificent expanse of land in Wyoming and Montana. The explorers expressed their concern that the land would be damaged by the development that had changed the northeastern United States. Congress agreed to protect the land, and the first national park—Yellowstone—was created. Today, the United States has about 50 national parks, as shown in **Figure 3.5**.

Public lands in the United States have many purposes. Most public lands are not as protected as the national parks are. Some public lands are leased to private companies for logging, mining, and ranching. Other public lands are maintained for hunting and fishing, as wildlife refuges, or for protecting endangered species.

International efforts include the United Nations' *Man and the Biosphere* Program. This program has set up several hundred preserves throughout the world since 1976. These preserves are called biosphere reserves and are unusual in that they include people in the management plan of the reserves, as shown in **Figure 3.6**.

Wilderness

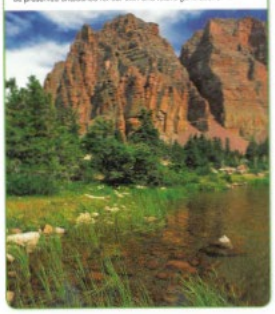
The U.S. Wilderness Act, which was passed in 1964, designated certain lands as wilderness areas. **Wilderness** is an area in which the land and the ecosystems it supports are protected from all exploitation. So far, 474 regions covering almost 13 million hectares (32 million acres) have been designated as wilderness in the United States. **Figure 3.7** shows an example of a wilderness area. Wilderness areas are open to hiking, fishing, boating (without motors), and camping. Building roads or structures and using motorized equipment are not allowed in these areas.

Benefits of Protected Areas

Without protected areas and preserves around the world, many more species would be extinct and valuable ecosystem services lost. In a crowded world, these protected areas often provide the only place where unspoiled forests, deserts, or prairies remain. Without these areas, the plants and animals that can survive only in these ecosystems would disappear. These protected areas also provide recreation for people, and serve as outdoor classrooms and research laboratories where people can learn more about the natural world.

FIGURE 3.7

Protected Wilderness In the United States, wilderness areas, such as the High Uintas Wilderness area shown here, are supposed to be preserved untouched for our own and future generations.



Threats to Protected Areas

Around the world, more people visit national parks and wilderness areas each year and leave their mark on the land. The same litter and traffic jams that have plagued our cities now plague many of our national parks. Rangelands, mining and logging sites, oil and gas drilling operations, factories, power plants, and urban areas are often close enough to the parks to affect their health. In addition, preserved areas are as affected by climate change and by air and water pollution as the rest of the world.

Private Conservation Efforts

Nongovernmental organizations and individuals also help protect natural and agricultural lands. Conservation organizations maintain preserves and individuals and communities, especially in tropical areas, protect local ecosystems to promote ecotourism. By 2011, over 1700 private land trusts protected more than 37 million acres of land in the U.S.

Section 3 Formative Assessment

Reviewing Main Ideas

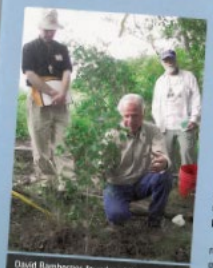
1. **Explain** what reforestation is and why it is important.
2. **List** and explain two methods of managing rangelands sustainably.
3. **Describe** the function of parks and of wilderness.
4. **Describe** the environmental effects of deforestation.

Critical Thinking

5. **Recognizing Relationships** Read the first paragraph under the head "Threats to Protected Areas." Why do you suppose that some of our nation's national parks and wilderness areas are degraded?
6. **Recognizing Relationships** What are the benefits of preserving farmland?

Making a Difference

Restoring The Range



David Bamberger, founder of the Bamberger Ranch Preserve.

When Ohioan J. David Bamberger first moved to San Antonio, Texas as a vacuum cleaner sales representative, he was charmed by the dry, grass-covered rangeland of the Texas Hill Country. But much of the land was degraded. It had been overgrazed by cattle and was left with thin soil and dried-up creeks.

Bamberger became intrigued by the idea of restoring some of the range to its original beauty. He was inspired by a book his mother gave him called Pleasant Valley, by Louis Bromfield. Long before it was popular, Bromfield had theories about how degraded habitats could be restored and how they could then be managed in a sustainable manner. Bamberger was intrigued by the idea of putting Bromfield's theories into action.

The Bamberger Ranch

In 1969, David Bamberger bought his first plot of land near Johnson City. Since then, David and Margaret Bamberger have expanded the ranch to nearly 2,300 hectares (5,500 acres). It is one of the largest habitat restoration projects in Texas, and shows the beauty of this area before it was damaged by human activities.

In its natural state, the ranch should have been grassland, with woody shrubs only near creeks. Instead, it had become overgrown with juniper shrubs and trees (often called cedar, *Juniperus ashei*, which can grow in poor soil and choke out other plants.

Bamberger read everything he could find on the degradation and restoration of rangeland. He found that two main things destroy the range: overgrazing and the suppression of wildfires. Overgrazing causes soil erosion. The lack of fires permits the growth of shrubs that shade out grasses and wildflowers.

The Bambergers set to work to restore the property. They cleared most of the junipers, which left more water in the soil. They planted native trees, wildflowers, and grasses, and they controlled the grazing.

ECOZine at HMDScience.com — Go online for the latest environmental science news and updates on all EcoZine articles.

Grazing is necessary for healthy grassland. The American prairies were home to huge herds of bison (buffalo), which cropped the grass and fertilized the soil with their droppings. The Bambergers combined the grazing they needed with the preservation of an endangered species. San Antonio Zoo asked the Bambergers if they could help preserve the endangered scimitar horned oryx, an antelope with thin, curved horns that is native to North Africa. Only a few small herds of this species remained, and the zoo feared that the oryx were becoming inbred, with too little genetic diversity. The Bambergers agreed, and the ranch is now home to a large herd of oryx.

The Effects of Restoration

The change in the ranch since Bamberger first bought it is most obvious at the fence line bordering the ranch. Beyond the fence there is a small forest of junipers and little other vegetation. On Bamberger's side, the main plants are grasses and wildflowers, with shrubs and trees in canyons and gullies beside the creeks. When the Bambergers first arrived, they counted only 48 species of birds on the ranch. Now, there are more than 219 species because plant diversity on the ranch has increased. In the early days, deer on the ranch weighed only about 20 kg. Now they weigh about 40 kg, thanks to the improved grazing.

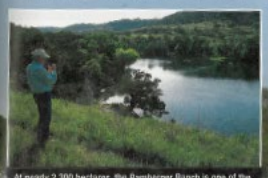
In addition to deer and oryx, cattle and goats live on the ranch. Some of these are used for experiments on the effects of domestic animals on rangeland. Students and faculty from nearby universities are studying this question by using exclosures. These are fences that keep large animals out of an area. The vegetation inside an exclosure is invariably taller than that outside because grazing animals are excluded. But in addition, the plant mix inside the exclosure is different from that outside. This is because grazing mammals eat only a few nutritious species and leave the others.

The Distribution of Water

One important change in the ranch under the Bambergers' management has been the change in water distribution. Water is very important in rangeland, which naturally gets little rainfall. Many of the creeks dry up between rainy periods, but water remains in the soil and underground. Grasses have spreading root systems that absorb water from a wide area. Poor management changes this balance by allowing junipers to take over the land. A juniper can take up 10 L of water a day from the soil, leaving too little for nearby grasses and wildflowers to survive. Then, when it rains heavily, the junipers cannot absorb all the water and it runs off the land. With no grass roots to hold the soil in place, the soil erodes into the creeks. When the Bambergers arrived at the ranch, it was degraded rangeland. They drilled wells 150 meters deep (500 ft) and did not reach the water table. Now, with the restoration of grassland, soil erosion has been reduced and much more water remains in the soil. Creeks and lakes contain water for most of the year, and a dry spell is not a disaster. The water in the creeks and lakes is clear and full of fish, instead of muddy because it is full of soil.

Sustainability

The Bamberger Ranch is a working ranch, raising and selling livestock, but it is also home to dozens of other projects. Bamberger consultants advise others who are interested in managing rangeland in a sustainable fashion. Volunteers help by building and repairing nature trails and performing all kinds of maintenance work. The ranch hosts research on grasslands and range management, conferences on habitat restoration, and educational workshops.

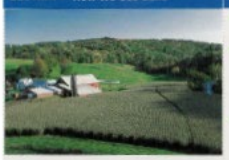


At nearly 2,300 hectares, the Bamberger Ranch is one of the largest habitat restoration projects in Texas. This is a photo of a portion of the Bamberger Ranch used for sustainable ranching.

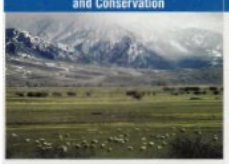
What Do You Think?

Habitat restoration shows us what the land was like before the settlers arrived. It also shows us how much the land has changed under human management. Can you think of any habitat in your area that could be restored? How would you go about trying to restore it? What do you think it would look like after restoration?

CHAPTER 14 Summary

SECTION 1 How We Use Land	OBJECTIVES	KEY TERMS
	• Land is covered with forest, cropland, pastures, roads, and towns. • Urban areas are mostly covered with houses, roads, businesses, and industrial and municipal structures. Rural areas have less dense human populations and include forest land, cropland, rangeland, and other land cover types. • Urban areas need very large areas of rural ecosystems to supply them with water, food, wood, and other ecosystem services.	urban rural ecosystem services

SECTION 2 Urban Land Use	OBJECTIVES	KEY TERMS
	• Urbanization is the migration of people from rural to urban areas. • When cities grow more rapidly than infrastructure can be built, they tend to suffer from substandard housing and traffic problems. • Unplanned growth of a city results in urban sprawl, as low-density development spreads into the surrounding countryside. • Land-use planning is essential if urban areas are to be pleasant places to live.	urbanization infrastructure urban sprawl heat island land-use planning geographic information system (GIS)

SECTION 3 Land Management and Conservation	OBJECTIVES	KEY TERMS
	• Farmland is used to raise crops and livestock. • Rangeland is land used primarily for grazing livestock. Rangeland is easily degraded by overgrazing. • Trees are harvested for many purposes. Deforestation can cause soil erosion and may threaten forest plants and animals with extinction. • National lands are used for many purposes, including lumber, mining, and recreation. Wilderness is national land that is protected from all exploitation for the benefit of future generations.	overgrazing deforestation reforestation wilderness

CHAPTER 14 Review

Reviewing Key Terms

Use each of the following terms in a separate sentence.

1. *rangeland*
2. *infrastructure*
3. *urbanization*
4. *ecosystem services*
5. *geographic information system*

For each pair of terms, explain how the meanings of the terms differ.

6. *heat island* and *urban sprawl*
7. *overgrazing* and *deforestation*
8. *urban* and *rural*
9. *selective cutting* and *clear-cutting*
10. **Concept Map** Use the following terms to create a concept map: *geographic information system, land-use planning, infrastructure, population,* and *urban area.*

Reviewing Main Ideas

11. Building a mass transit system is likely to have which of the following effects?
    a. increasing air pollution
    b. traffic congestion
    c. increasing the temperature of the urban heat island
    d. none of the above
12. National parks and wilderness areas are designed to do which of the following?
    a. provide recreation
    b. protect wildlife
    c. preserve natural areas
    d. all of the above
13. Which of the following is *not* an example of urbanization?
    a. Immigrants settle in New York City.
    b. A farmer who can no longer afford to lease farmland moves to a city.
    c. A drop in timber prices in Oregon causes a lumberjack to lose his job and he moves to Portland.
    d. An Indian family moves to the city of Calcutta after a landslide destroys their village.
14. Which of the following is *not* an example of infrastructure?
    a. a railroad
    b. a school
    c. a telephone line
    d. a dairy farm
15. Which of the following is a likely result of deforestation?
    a. The amount of carbon dioxide removed from the atmosphere is reduced.
    b. Wind blows soil away because the plant cover has been removed.
    c. Water runs off the land more rapidly and causes floods.
    d. all of the above
16. Which of the following is *not* likely to cause the degradation of rangeland?
    a. adding more animals to a herd grazing on rangeland
    b. a three year drought
    c. planting native grasses on the land
    d. driving a vehicle off-road
17. Which of the following is an example of reforestation?
    a. replanting forest land that has been clear-cut
    b. planting a cherry tree in your backyard
    c. planting oak trees in a city
    d. all of the above
18. Which of the following is *not* an ecosystem service provided by rural lands?
    a. oxygen in the air
    b. plastic for making bottles
    c. aesthetic beauty
    d. wood for making paper

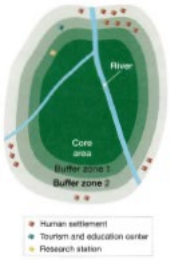
Short Answer

19. Explain one way rangeland can be degraded.
20. Do national parks and forests in the United States protect ecosystems from human activities? Explain your answer.
21. What is the difference between a U.S. wilderness area and a national park?
22. Are national parks located only in the United States?
23. How can building a mass transit system improve living standards in an urban area?

Interpreting Graphics

The map below shows a typical UN Biosphere Reserve. Use the map to answer questions 24–26.

24. **Explain** Where is the reserve's research station located, and why has it been placed there rather than anywhere else in the reserve?
25. **Infer** What indicators can you see that this reserve might be an ecotourism destination?
26. **Examine** What does the map tell you about the function of buffer zone 2?

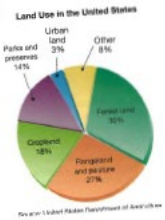


Critical Thinking

27. **Recognizing Relationships** Read about clear-cutting under the head "Harvesting Trees." What effects does clear-cutting a hillside have on the environment?
28. **Drawing Inferences** If we see many invasive plant species and large areas of bare soil on rangeland, what conclusions can we draw about the land management practices on this rangeland? Explain your answer.
29. **Evaluating Assumptions** We tend to think that the main use of livestock is for meat. However, the Masai herders of Africa do not slaughter their cattle. They use the milk. They also bleed the cattle and use the blood to make a protein-rich sausage. What other uses for livestock can you think of that do not involve killing the animals?
30. **History** Find out how deforestation has affected a community. If you live in a forest biome, you can document the effects of deforestation on local rivers and farmland. If not, you will probably have to find an example on the Internet or in a magazine. Write a paragraph for your answer, using at least three key terms from this chapter.
31. **Research** Diagram the growth of your community over the last 100 years. Express this as a graph that shows the growth of the population and a map that shows the area of ground the community covers. There are various possible sources for the data you will need. If there is a local historical society, this is probably the best source. Otherwise, city hall or the local newspaper will probably have the information.

Analyzing Data

The graph below shows land cover in the United States in 1997. Use the graph below to answer questions 32–33.



32. **Analyzing Data** If the percentage of cropland increased to 25 percent, and all other land cover categories except for rangeland and pasture remained the same, what percentage would rangeland and pasture be?
33. **Making Calculations** If 11 percent of cropland is idle (unplanted), what percentage of the United States is planted in crops at any one time?

Making Connections

34. **Communicating Main Ideas** In what ways does urban sprawl reduce the quality of life for people in the suburbs as well as in the town or city?

CASESTUDY

35. Describe how using conservation practices in land planning benefits both human societies and the environment.
36. Explain how the statement "Build up, not out," relates to land planning and urban sprawl.

Why It Matters

37. Describe how urban sprawl is affecting both humans and the environment.

STUDYSKILL

Flash Cards With a partner, make flash cards for the key words and most important ideas in the chapter. Take turns quizzing each other about the content of the course. Do another round, and this time the person being asked questions should try to use each key word and idea in a complete sentence.

EXPLORATIONLAB
Modeling

Creating a Land-use Model

Objectives

Create a simulated land-use model.

Recognize conflicts of interest that arise during a negotiation.

Analyze and draw conclusions about the effect of compromise on the desired outcome for each interested party in a land-use plan.

Materials

colored pencils
graph paper
pens

Land-use plans are drawn up by planners, but they are created with the combined input of various members of a community. Along with three other people, you are meeting to plan the development of 400 acres of land for your growing city. Your team is composed of the following four members:

Team Members

The **Planner** is concerned with creating a plan that encourages the sort of growth that will attract businesses and new citizens to the area.

The **Developer** bought the land from the city and is interested in the right to build housing and a shopping center.

The **Conservationist** is interested in preserving open space and natural areas from further development.

The **Law Enforcer** ensures that all of the laws and regulations are met for any new development project.

Laws

At least 10 percent of each type of habitat must be preserved.

Landfills must be at least 250 meters away from all housing, wetlands, and freshwater sites.

Roads and bridges may cross rivers and wetlands but they must go around large natural areas.

Roads must be connected to all developed areas of the city.

There must be no building over wetlands, slopes, or fresh water. Only parks may partially cover these habitats. Roads and bridges may cross them.

Procedure

1. Have each team member select one of the four jobs above.
2. Use all or part of a large piece of graph paper as your map. Mark off an area that will represent 400 acres. Determine the approximate scale, and label the sides of your area accordingly.
3. The planner will color in the map as follows:
   a. 40 acres will be fresh water (rivers and/or lakes) and will be colored light blue.
   b. 80 acres will be wetlands that are right next to some of the fresh water and will be colored light purple or lavender.
   c. 40 acres will be land that is too sloped for building and will be colored tan.
   d. 240 acres is land that is good for development and will be colored light green.
4. Once the land is colored in, it cannot be altered. That will be the land you work with.
5. After the area is colored in, the group must discuss how and where to put the following items:
   a. 40 acres for a landfill.
   b. 20 acres for utilities such as power plants and water treatment facilities.

Smart Grapher
HMDScience.com

c. 40 acres for parks and wildlife.
d. 40 acres for housing. Try to put the houses near a beautiful area.
e. 40 acres for shopping.
f. 20 acres for anything that the group agrees to add. For example, you could add a few acres for community gardens or for sports and playing fields. The law enforcers cannot suggest anything, but if the group can't agree on what to add, the law enforcer may cast the deciding vote.
g. 40 acres of roads and bridges (you can divide an acre up so that you can build long, thin roads rather than create short, fat roads that are an entire acre thick). Make sure at least one road goes into and out of town.
6. The law enforcer should make sure that the plans abide by the planning regulations by checking the map for violations.
7. Use the key under the map to mark which areas are which. For example, an R denotes a road or bridge. Use a pencil and write in the things softly at first in case changes are to be made. You may need a second copy of the map in case you make mistakes the first time.

Example Map This is an example of what your land-use model might look like.

Analysis

1. **Describing Events** Did everyone on your team agree on the plan, or were there conflicts of interest? Explain.
2. **Describing Events** Were you able to get everything your team wanted into the plan or did you face any problems? Describe what happened.
3. **Identifying Patterns** How did the features of the land constrain the plan that you made? Did you encounter any problems?

Conclusions

4. **Evaluating Results** Does the plan your group created meet the needs of all of the group members? Does it allow for development while preserving the environment?
5. **Evaluating Models** How do you think this land planning "simulation" compares to the real-life process of land-use planning?

Extension

6. **Research and Communications** Look in the newspaper or on the Internet for a story about a land-use controversy in your area. Identify the different members involved. Role-play with your team to see what forces will bear on this controversy.

Chapter 15

Section 1 Feeding the World
Section 2 Crops and Soil
Section 3 Animals and Agriculture

Why It Matters

In order to survive, everybody needs to eat. Agriculture can be thought of as one of the most important relationships people have with the environment. As the world population grows, so too does the need for food.

How does the production of food affect the environment?

CASESTUDY

Learn about the importance of menhaden, a type of fish, to the commercial fishing industry in the case study Menhaden: The Fish Behind the Farm on pages 396–397.

Food and Agriculture

ONLINE ENVIRONMENTAL SCIENCE
HMDScience.com

Go online to access additional resources, including labs, worksheets, multimedia, and resources in Spanish.

Feeding the World

In 2011, lack of rain, loss of soil, and war caused crops to fail in Somalia. This catastrophic combination resulted in **famine,** which is widespread starvation caused by a shortage of food. Events like the famine in Somalia present a frightening picture of the difficulty of feeding Earth's growing population. By 2050, the world's farmers will need to feed about 9 billion people. In this chapter, you will learn why feeding all the world's people a nutritious diet is difficult, and how food production can be increased without irreversibly damaging the environment.

SECTION 1

Objectives

- Identify the major causes of malnutrition.
- Compare the environmental costs of producing different types of food.
- Explain how poverty is a major cause of malnutrition.
- Explain the importance of the green revolution.

Key Terms
famine
malnutrition
diet
yield

Humans and Nutrition

The human body uses food both as a source of energy and as a source of materials for building and maintaining body tissues. The amount of energy that is available in food is expressed in *Calories*. One Calorie (Cal) is equal to 1,000 calories, or one kilocalorie. As shown in **Figure 1.1,** the major nutrients we get from food are carbohydrates, proteins, and lipids. Our bodies need smaller amounts of vitamins and minerals to stay healthy.

Malnutrition is a condition that occurs when people do not consume enough Calories or do not eat a sufficient variety of foods to fulfill all of the body's needs. There are many forms of malnutrition. For example, humans need to get eight essential amino acids from proteins. This is easily done if a variety of foods are eaten. However, in some parts of the world, the only sources of food may be corn or rice. Both corn and rice contain proteins, but they lack some essential amino acids, vitamins, and minerals. Protein-energy malnutrition results, affecting the normal physical and mental development of children.

FIGURE 1.1

MAJOR NUTRIENTS IN HUMAN FOODS

Nutrient	Composition	Sources	Energy yield	Function
Carbohydrates	sugars	wheat, corn, and rice	4 Cal/g	is the main source of the body's energy
Lipids (oils and fats)	fatty acids and fatty alcohols	olives, nuts, and animal fats	9 Cal/g	helps form membranes and hormones
Proteins	amino acids	animal food and smaller amounts from plants	about 4 Cal/g	helps build and maintain all body structures

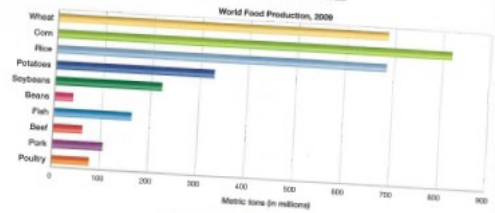
Connect to BIOLOGY

Essential Amino Acids

Animals make their own proteins from amino acids. Essential amino acids are those that must be supplied in the diet because the body needs them but cannot make them from other amino acids. A lack of essential amino acids in the diet can lead to the human diseases kwashiorkor and marasmus, which can cause brain damage in children.

FIGURE 1.2

World Food Production This bar graph shows that in 2009, more grains (wheat, corn, and rice) were produced than any other food. Wheat and corn are eaten by humans and are fed to farm animals.



Sources of Nutrition

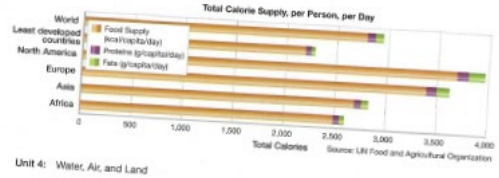
A person's **diet** is the type and amount of food that he or she eats. A healthy diet is one that maintains a balance of the right amounts of nutrients, minerals, and vitamins. In most parts of the world, people eat large amounts of food that is high in carbohydrates, such as rice, potatoes, and bread. As shown in **Figure 1.2,** the foods produced in the greatest amounts worldwide are *grains,* which are plants of the grass family whose seeds are rich in carbohydrates. Besides eating grains, most people eat fruits, vegetables, and smaller amounts of meats, nuts, and other foods that are rich in fats and proteins.

Diets Around the World

People worldwide generally consume the same major nutrients and eat the same basic kinds of food. But diets vary by geographic region, as shown in **Figure 1.3.** People in more-developed countries tend to eat more food and a larger proportion of proteins and fats than people eat in less-developed countries. For example, in the United States, almost **half** of all Calories people consume come from meat, fish, and oil.

FIGURE 1.3

Total Calorie Supply People in developed countries generally eat more food and more proteins and fats than people in less developed countries eat.



The Ecology of Food

As the human population grows, farmland and suburbs replace forests and grasslands. Feeding everyone while maintaining natural ecosystems becomes more difficult. Different kinds of agriculture have different environmental impacts and different levels of efficiency.

Food Efficiency

The *efficiency* of a given type of agriculture is a measure of the quantity of food produced on a given area of land with limited inputs of energy and resources. An ideal food crop is one that efficiently produces a large amount of food with little negative impact on the environment.

On average, much more energy, water, and land are needed to produce a Calorie of food from animals than to produce a Calorie of food from plants. Animals that are raised for human use are usually fed plant matter. Because less energy is available at each higher level on a food chain, only about 10 percent of the energy from the plants gets stored in the animals. Thus, a given area of land can usually produce more food for humans when it is used to grow plants than when it is used to raise animals. The efficiency of raising plants for food is one reason why diets around the world are largely based on plants. However, meat generally provides more nutrients per gram than does most food from plants.

Old and New Foods

Researchers hope to improve the efficiency of food production by studying plants and other organisms that have high **yield**—the amount of food that can be produced in a given area. Researchers are interested in organisms that can thrive in various climates and that do not require large amounts of fertilizer, pesticides, or fresh water. Some organisms have been a source of food for centuries, while other sources are just being discovered, as shown in **Figure 1.4.**

Connect to MATH

Extra Calories

An active man who weighs 70 kg maintains his weight if he eats 2,700 Cal per day. Unused Calories are converted into stored fat at the rate of 1 kg of fat per 9,000 Cal that are unused. If this active man consumes 3,600 Cal per day, how much weight does he gain each year?

FIGURE 1.4

Food Sources Marine algae, or seaweeds, (left) have been harvested and eaten by humans for centuries. Glasswort (right) is a salad green that may become an important food source in the future because it can grow in salty soil.

FIGURE 1.5

Lack of Resources Refugees in Somalia wait in line for food assistance.

World Food Problems

The world's farmers produce enough grain to feed up to 10 billion people an adequate vegetarian diet. However, no one is satisfied with eating just the minimal amount of food needed for survival. And, many of us consume about a third of our Calories from animals, not grain.

Poverty and Violence

Malnutrition today is largely a result of poverty and violence, as indicated in **Figure 1.5**. In 2010, the United Nations Food and Agriculture Organization (UNFAO) estimated that 925 million people around the world were undernourished. Poverty affects both rural and urban people, especially in the least developed regions. About 1.3 billion people live on less than $1.25 per day, so they have few resources to purchase food. In addition, diverting crops to use as biofuels raises food prices, which increases malnutrition problems. *Subsistence agriculture*—farming to grow only enough food for local use—is challenged by drought, degrading soil quality, high levels of conflict, and changing climate.

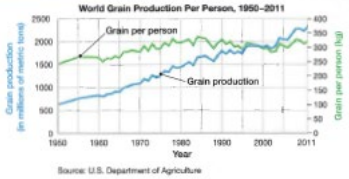
CHECK FOR UNDERSTANDING
Summarize What could be done to increase the productivity of the land worked by subsistence farmers?

More Income and More Food

The number of people living in extreme poverty has declined by nearly half a billion since 1980. This achievement is largely the result of rapid economic development in East Asia, especially in China and India. However, **Figure 1.6** shows that although the world's grain production has increased for 50 years, it has not grown as fast as the world's population. To feed the people of the world in 2050, we will need to produce more food. As well, we will need to abolish poverty, among both rural and urban people. Increasing the productivity of the world's subsistence farmers would help achieve both goals.

FIGURE 1.6

Grain Production Worldwide grain production has increased steadily over time, but not as rapidly as the population has grown.



Source: U.S. Department of Agriculture

The Green Revolution

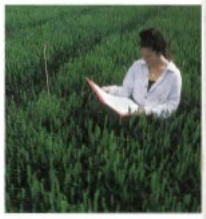
Between 1950 and 1970, Mexico increased its production of wheat eightfold and India doubled its production of rice, without increasing the area of farmland used. These spectacular increases were called *the green revolution*. They resulted from new varieties of grain. The new varieties produce large yields if they are supplied with enough water, fertilizer, and pesticides. The green revolution reduced the price of food and improved the lives of millions of people.

The green revolution had limitations, however. Most of the increases that resulted from the green revolution came from large farms, which continue to increase their productivity. Because subsistence farmers often live in extreme poverty, they do not have the money to acquire the water and chemicals that the new crop varieties need.

In addition, subsistence farmers cannot use much machinery because their farms generally consist of less than two acres. Subsistence farmers need small-scale irrigation systems and high-value crops, such as vegetables and fruits, that they can sell. As shown in **Figure 1.7**, much research today is devoted to developing plant varieties that produce high yields of nutritious food on poor soil, using as little water and expensive chemicals as possible. Distributing the seeds and technology to scattered rural farms remains a problem to be solved.

FIGURE 1.7

Wheat Varieties This agricultural research scientist is checking the growth of wheat in an experimental plot.



Section 1 Formative Assessment

Reviewing Main Ideas

1. **Identify** the major causes of malnutrition.
2. **Compare** the environmental costs of producing different types of food.
3. **Explain** how malnutrition today is linked to poverty and violence.
4. **Describe** the importance and effects of the green revolution.

Critical Thinking

5. **Identify Relationships** Study the graph in **Figure 1.6**. World grain production increased during the 1990s. Why did the amount of grain per person decline during that decade?
6. **Infer Relationships** Write a short paragraph that explains how a decrease in the production of grain worldwide could lead to a shortage of other food sources.

SECTION 2

Objectives

- Distinguish between traditional and modern agricultural techniques.
- Describe fertile soil.
- Describe the need for soil conservation.
- Explain the benefits and environmental impacts of pesticide use.
- Explain what is involved in integrated pest management.
- Explain how genetic engineering is used in agriculture.

Key Terms

topsoil
erosion
desertification
compost
salinization
pesticide
biological pest control
genetic engineering

Crops and Soil

Much of Earth's surface cannot be farmed. Only about 37 percent of Earth's land surface is agricultural, or land that can be used to grow crops. Urban areas occupy about 3 percent of Earth's land surface and are expanding, often into agricultural land. We need to use our remaining agricultural land as efficiently as possible for it to continue to grow enough food for the world while maintaining natural resources.

Agriculture: Traditional and Modern

The basic processes of farming include plowing, fertilization, irrigation, and pest control. In traditional agriculture, plows are pushed by the farmer or pulled by livestock. Plowing helps crops grow by mixing soil nutrients, loosening soil particles, and uprooting weeds. Organic fertilizers, such as manure, are used to enrich the soil so that plants grow strong and healthy. Fields are irrigated by water flowing through ditches. Weeds are removed by hand or machine. These traditional techniques have been used since the earliest days of farming, centuries before tractors and pesticides were invented.

In industrialized countries, the basic processes of farming are now carried out using modern agricultural methods. Machinery powered by fossil fuels is now used to plow the soil and harvest crops, as shown in **Figure 2.1**. Synthetic chemical fertilizers are now used instead of manure and plant wastes to fertilize soil. A variety of overhead sprinklers and drip systems may be used for irrigation. Synthetic chemicals are used to protect crops by killing pests.

FIGURE 2.1

Modern Agriculture In modern agriculture, machinery is used to do much of the work previously performed by humans and animals.

Fertile Soil: The Living Earth

Soil that can support the growth of healthy plants is called *fertile soil*. Plant roots grow in **topsoil**, the surface layer of soil, which is usually richer in organic matter than the subsoil is. Fertile topsoil is made up of living organisms, rocks, water, air, and organic matter, such as dead organisms.

Most soil starts to form when rock is broken down into smaller and smaller fragments by wind, water, and chemical weathering. *Chemical weathering* happens when the minerals in the rock react chemically with substances such as water to form new materials. Temperature changes and moisture cause rock to crack and break apart, which creates smaller particles on which the seeds of pioneer plants fall and take root. The dead material from plants and other organisms add to the soil. It can take hundreds or even thousands of years to form a few centimeters of soil.

Other processes also help to produce fertile topsoil. The rock particles supply mineral nutrients to the soil. Fungi and bacteria live in the soil. They decompose dead plants and organic debris, and add more nutrients to the soil. Earthworms, insects, and other small animals help plants grow by breaking up the soil and allowing air and water into it.

As you can see in **Figure 2.2**, several layers of soil lie under the topsoil. The bottom layer is bedrock, which is the solid rock from which most soil originally forms.

CHECK FOR UNDERSTANDING
Identify Name two processes that help to make soil fertile.

FIGURE 2.2

Soil Profile Soil is made of rock particles, air, water, and dead and living organisms. The number and characteristics of the soil layers may be different in different types of soil.

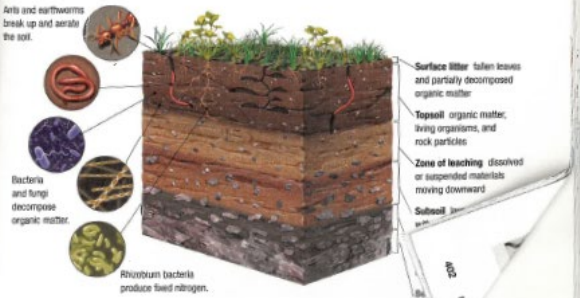
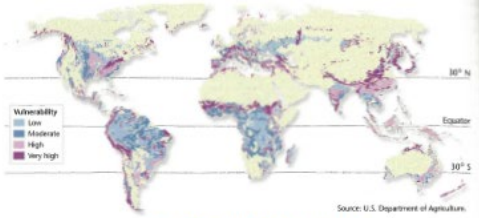


FIGURE 2.3

Soil Erosion This map shows the vulnerability of soils worldwide to erosion by water.



Source: U.S. Department of Agriculture.

Soil Erosion: A Global Problem

Erosion is the movement of rock, soil, and sand by wind and water. Eroded soil washes into nearby rivers or is blown away in clouds of dust. In the United States, about half of the original topsoil has been lost to erosion in the past 200 years. **Figure 2.3** shows potential soil erosion worldwide. Without topsoil, crops cannot grow.

Most farming methods increase the rate of soil erosion. Plowing loosens the soil and removes plants that hold the soil in place. When water runs off the land, it carries some of the soil with it.

QUICKLAB

Preventing Soil Erosion

Procedure

1. Obtain three trays and fill one with sod, one with topsoil, and one with a layer of topsoil covered with a type of mulch, such as hay.
2. Raise one end of each tray by a minimum of 30 cm. Place the lower end of each tray into another, empty tray for which you have determined the mass.
3. Punch multiple holes in the bottom of a plastic coffee can.
4. Fill a plastic 2-L bottle with water.
5. Pour the water slowly through the holes in the plastic coffee can onto one tray to simulate heavy rainfall. Repeat for the remaining trays.
6. Use a balance to find the mass of each tray of runoff. Subtract the mass of the tray to find the mass of the soil and water eroded from each type of surface.

ANALYSIS

1. Which tray had the most soil erosion and water runoff? Which tray had the least? Why?

Land Degradation

Land degradation happens when human activity or natural processes damage the land so that it can no longer support the local ecosystem. In areas with dry climates, desertification can result. **Desertification** is the process by which land in arid or semiarid areas becomes more desertlike.

Desertification is occurring in the Sahel region of northern Africa. In the past, people who lived in the drier parts of the Sahel grazed animals. People who lived in parts of the Sahel with more rainfall planted crops. The grazing animals were moved from place to place to find food. The cropland was planted for only a few years, and then the land was allowed to lie *fallow*, or to remain unplanted, for several years. These practices allowed the land to support the people in the Sahel. But the population in the region grew, and the land has since been farmed, grazed, and deforested faster than it can regenerate. Now, too many crops are planted too frequently, and fallow periods are being shortened or eliminated. As a result, the soil is losing its fertility and productivity. Because of overgrazing, the land has fewer plants to hold the topsoil in place. So large areas have become desert and can no longer produce food.

FIGURE 2.4

Soil Conservation Terracing (left) levels soil in multiple, small, level fields. Contour plowing (right) follows the natural contours of the land. Both methods prevent soil erosion by keeping water from running directly downhill.

Soil Conservation

There are many ways of protecting and managing topsoil to reduce erosion. Soil usually erodes downhill, and many soil conservation methods are designed to prevent downhill erosion, as shown in **Figure 2.4.** Building soil-retaining terraces across a hillside may be cost-effective for producers of valuable crops, such as wine grapes and coffee. On gentler slopes, *contour plowing* is used. This method includes plowing across the slope of a hill instead of up and down the slope. An even more effective method of plowing is leaving strips of vegetation across the hillside instead of plowing the entire slope. These strips catch soil and water that run down the hill. Overhead irrigation tends to wash away soil. Soil (and water) can be conserved by using drip irrigation instead.

In traditional farming, plowing turns over soil to expose pests and to loosen soil for new seeds. In *no-till farming*, plowing is eliminated. Instead, the seeds of the next crop are planted among the remains of the previous crop, as shown in **Figure 2.5.** The remains of the first crop hold the soil in place while the new crop develops. No-till farming saves time compared with conventional methods. It can also reduce soil erosion to one-tenth of the erosion caused by traditional methods. However, no-till farming may not be suitable for some crops, especially where pests are poorly controlled by chemicals.

FIGURE 2.5

No-Till Farming A second crop is grown through the remains of the previous crop. This method helps prevent erosion.

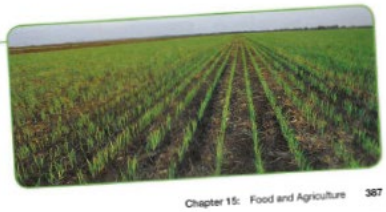
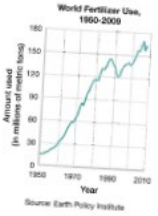


FIGURE 2.6

World Fertilizer Use The use of inorganic fertilizers has increased dramatically worldwide since 1950.



Source: Earth Policy Institute

Enriching the Soil

In traditional farming, the soil is enriched by adding organic matter, such as manure and leaves, to the soil. As the organic matter decomposes, it adds nutrients to the soil and improves the texture of the soil. However, inorganic fertilizers that contain nitrogen, phosphorus, and potassium have changed farming methods. Without these fertilizers, world food production would be less than half of what it is today. Over the past 50 years, the use of such fertilizers has increased rapidly, as shown in **Figure 2.6.**

A modern method of enriching the soil is to use both organic and inorganic fertilizers by adding compost and chemical fertilizers to the soil. **Compost** is partly decomposed organic material. Compost comes from many sources. For example, you can buy composted cow manure in a garden store. Also, many cities and industries now compost yard waste and crop wastes. This compost is sold to farmers and gardeners, and the process is saving costly landfill space.

Salinization

The accumulation of salts in the soil is known as **salinization** (sal uh nie ZAY shuhn). Salinization is a major problem in places such as Australia, California, and Arizona, which have low rainfall and naturally salty soil. In these areas, irrigation water comes from rivers or groundwater, which is saltier than rainwater. When water evaporates from irrigated land, salts are left behind. Eventually, the soil may become so salty that plants cannot grow, as shown in **Figure 2.7.**

Irrigation can also cause salinization by raising the groundwater level temporarily. Once groundwater comes near the surface, the groundwater is drawn up through the soil like water is drawn up through a sponge. When the water reaches the surface, the water evaporates and leaves salts in the soil. Salinization can be slowed if irrigation canals are lined to prevent water from seeping into the soil, or if the soil is watered heavily to wash out salts.

FIGURE 2.7

Salinization This agricultural field is barren due to salinization.

FIGURE 2.8

Crop Pests Examples of major crop pests include fungi (left), plant-eating insects (center), and weeds (right).

Pest Control

In North America, insects eat about 13 percent of all crops. Crops in tropical climates suffer even greater insect damage because the insects grow and reproduce faster in these climates. In Kenya, for example, insects destroy more than 25 percent of the nation's crops. Worldwide, pests destroy about 33 percent of the world's potential food harvest.

Different types of pests are shown in **Figure 2.8.** A *pest* is any organism that occurs where it is not wanted or that occurs in large enough numbers to cause economic damage. Humans try to control populations of different types of pests, including many plants, fungi, and microorganisms.

Wild plants often have more protection from pests than do crop plants. Wild plants grow throughout a landscape, so pests have a harder time finding and feeding on a specific plant. Crop plants, however, are usually grown together in large fields, which provides pests with a one-stop source of food. Wild plants are also protected from pests by a variety of pest predators that live on or near the plants. Some wild plants have even evolved defenses to many pests, such as poisonous chemicals that repel them.

Pesticides

Many farmers rely on pesticides to produce their crops. **Pesticides** are chemicals used to kill insects, weeds, and other crop pests. During the last 60 years, scientists invented many new pesticides. The pesticides were so effective that farmers began to rely on them almost completely to protect their crops from pests. However, pesticides can also harm beneficial plants and insects, wildlife, and even people.

ECOFACT

Crop Rotation

Farmers and gardeners have known for centuries that you get higher yields and less pest damage if you plant different crops each year on a piece of land. This method works because most pests are specialists and will only eat one or a few types of plants. The tomato hornworm is an example of one of these pests. If you plant tomatoes in one place every year, the hornworm population grows rapidly and will destroy the crop. If beans are planted in place of the tomatoes in alternate years, the hornworms cannot find food and will die.

FIGURE 2.9

Cropdusting A cropduster sprays pesticide on a field of pineapples in Hawaii. Cropdusting is an easy way to apply pesticide to a large area.

Connect to LAW

Pesticide Regulation

The only pesticides that are fully regulated in the United States are newly introduced pesticides designed for use on some food crops. Many older pesticides in use have not been adequately tested for toxicity and are not effectively regulated. According to the National Academy of Sciences, much of the cancer risk from pesticides in our diet comes from older pesticides used on foods such as tomatoes, potatoes, and oranges.

Pesticide Resistance

You might think that the most effective way to get rid of pests is to spray crops often with large amounts of pesticides, as shown in **Figure 2.9**. However, over time, this approach usually makes the pest problem worse. Pest populations can evolve *resistance*, which is the ability to survive exposure to a particular pesticide. More than 500 species of insects have developed resistance to pesticides, and this number grows annually.

Human Health Concerns

Pesticides are designed to kill organisms, so they may also be dangerous to humans. Problems may arise from toxicity or from the similarity of some chemicals to natural hormones. For example, cancer rates among children in areas of high pesticide applications are sometimes higher than the national average, and nervous system disorders may be common. Workers in pesticide factories or those who apply pesticides to crops may also become ill.

Pollution and Persistence

The problem of pesticides harming people and other organisms is especially serious with pesticides that are persistent. *Persistent* pesticides do not break down rapidly into harmless chemicals when they enter the environment. As a result, they accumulate in the water and soil. Some persistent pesticides have been banned in the United States, but many of them remain in the environment for many years. DDT, a persistent pesticide banned in the United States in the 1970s, can still be detected in the environment and has even been found in women's breast milk.

CHECK FOR UNDERSTANDING

Explain Why can spraying pests with large amounts of pesticides become ineffective over time?

Biological Pest Control

Biological pest control is a form of *pest management* that uses living organisms to control pests. Every pest has enemies in the wild. These enemies can sometimes be used to control pest populations, as shown in **Figure 2.10**. Biological pest control may work well, but it can also have unintended negative consequences. The cane toad was introduced to Australia to control the damaging cane beetle. There is no evidence that the cane toad has reduced cane beetle populations, and the toads are spreading and negatively impacting native species.

FIELDSTUDY

Go to Appendix B to find the field study **What A Pest!**

Pathogens

Organisms that cause disease, called *pathogens* (PATH uh juhnz), can also be used to control pests. One of the most common pathogens used to control pests is the bacterium *Bacillus thuringiensis* (buh SIL uhs THUHR in JIEN sis), often abbreviated *Bt*. This bacterium can kill the caterpillars of moths and butterflies that are considered to be pests.

Plant Defenses

Scientists and farmers have bred plant varieties that have defenses against pests. For example, if you buy tomato plants or seeds, you may see that they are labeled "VNT" or "VFF." These labels mean they are resistant to certain fungi, worms, or viruses. Examples of plant defenses include chemical compounds that repel pests and physical barriers, such as tougher skin.

Chemicals from Plants

Another type of biological pest control also makes use of plants' defensive chemicals. For example, chemicals found in chrysanthemum plants are now sold as pesticides. Most insect sprays that contain these chemicals are designed for use in the home because they are less harmful to humans and pets. These products are biodegradable, which means that they are broken down by bacteria and other decomposers.

FIGURE 2.10

Biological Pest Control A parasitic wasp injects its eggs into an aphid (left). A predatory mite attacks another mite species (right).

Connect to CHEMISTRY

Organic Chemistry

All food contains organic chemicals, but the term *organic* is used differently in the field of chemistry than in agriculture. The term generally means "of or pertaining to living organisms." In chemistry, an *organic chemical* is any chemical compound that contains carbon. Most organic chemicals are derived from living organisms, but chemists can now synthesize organic chemicals—and even invent new ones—in the lab. In contrast, *organic agriculture* is the practice of raising crops or livestock without using synthetic chemicals. Foods labeled as *organic* in the grocery store have been raised using organic methods.

Disrupting Insect Breeding

If you have a dog, you may feed it a pill once a month to keep it free of fleas. The pill likely contains a *growth regulator*, which is a chemical that interferes with some stage of a pest's life cycle. When a flea sucks the dog's blood, the flea ingests the growth regulator. The regulator stops the flea's eggs from developing into adult fleas.

Pheromones (FER uh mohnz), chemicals produced by one organism that affect the behavior of another organism, can also be used in pest control. For example, female moths release pheromones that attract males from miles away. By treating crops with pheromones, farmers can confuse the male moths and interfere with their mating behavior. Another way to prevent insects from reproducing is to make it physically impossible for the males to reproduce. For example, male insects are treated with X rays to make them sterile and then are released. When they mate with females, the females produce eggs that do not develop.

Integrated Pest Management

Integrated pest management is a modern method of controlling pests on crops. The steps involved in integrated pest management are shown in **Figure 2.11**. The goal of integrated pest management is to reduce pest damage to a level that causes minimal economic damage. A different management program is developed for each crop. The program can include a mix of farming methods, biological pest control, and chemical pest control. Each of these methods is used at the appropriate time in the growing season. Fields are monitored from the time the crops are planted. When significant pest damage is found, the pest is identified. Then a program to control the pest is created.

Biological methods are the first methods used to control a pest. Natural predators, pathogens, and parasites of the pest may be introduced to control it. Cultivation controls, such as vacuuming insects off the plants, can also be used. As a last resort, small amounts of insecticides may be used. The insecticides are changed over time to reduce the ability of pests to evolve resistance.

CHECK FOR UNDERSTANDING

Describe What is one strategy that can be used to control insect pests?

FIGURE 2.11

Integrated Pest Management This flow diagram shows the steps involved in integrated pest management.

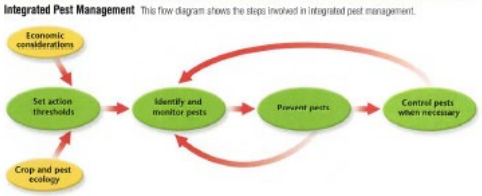
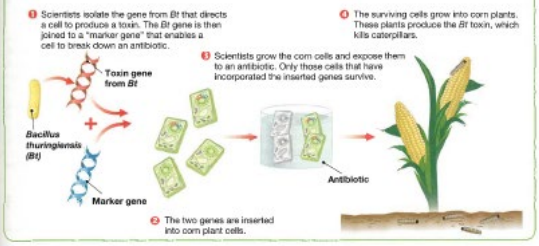


FIGURE 2.12

Genetic Engineering This diagram shows the main steps used to produce a genetically modified plant—in this case, corn that produces its own insecticide.



Engineering a Better Crop

Genetic engineering is a technique in which genetic material in a living cell is modified for medical or industrial use. Genetic engineering involves isolating genes from one organism and implanting them into another. Scientists may use genetic engineering to transfer desirable traits, such as resistance to certain pests. The plants that result from genetic engineering are called *genetically modified* (GM) plants.

Figure 2.12 shows an example of the steps used to produce a GM plant. In this case, the gene introduced into the plant is not a plant gene. It is an insecticide gene from *Bt*, a bacterium that produces a chemical that kills plant-eating caterpillars but does not harm other insects. Plants that have the *Bt* gene make this insecticide within their leaves. Hundreds of gene transfers have now been performed to create many other GM crops.

Implications of Genetic Engineering

In the United States, we now eat and use genetically engineered agricultural products every day. Many of these products have not been fully tested for their environmental impacts, and some scientists warn that these products will cause problems in the future.

For example, genes are sometimes transferred from one species to another in the wild. Suppose a corn plant that was genetically engineered to be resistant to a pesticide were to pass the resistance genes to a wild plant. That wild plant might be a pest that could then no longer be killed by that pesticide.

Connect to BOTANY

Artificial Selection

Plant breeding has been used since agriculture began. Farmers select seeds that have the tastiest tomatoes and the least pest damage. They save seeds from these plants to use in planting the next crop. The selected seeds are more likely to contain the genes for large, tasty fruits and for pest resistance than are seeds from other plants.

ECOFACT

Nitrogen Fixation

One of the most valuable families of crop plants is the legumes (LEG yoomz), which include peas and beans. Legumes produce higher grade proteins than do most plants, so legumes are part of diets in many parts of the world. Planting legumes also improves the soil. Their roots have nodules containing bacteria that take nitrogen gas from the air and convert the nitrogen into a form other plants can use to build proteins.

Sustainable Agriculture

Large-scale modern farming has allowed production to grow tremendously. It has had some negative effects, too. In addition to the loss of topsoil, salinization, groundwater contamination, and nutrient pollution, it also has led to declines of family farms, poor conditions for many workers, and other social issues. Now, many people are working toward sustainable agriculture. Sustainable agriculture seeks to ensure environmental health, economic benefits, and social responsibility. A key part of sustainable agriculture is ensuring that farming can occur on a particular piece of land over the long-term without a loss of crop quality. To do this, sustainable agriculture maximizes soil quality and minimizes the use of energy, water, pesticides, and fertilizers. It also means that the right crops have to be selected for a particular location, as shown in **Figure 2.13**.

Organic farming is part of sustainable agriculture. In many countries, including the United States, specific rules have been set up for goods to be certified as organic. Although organic goods may cost more than those produced by other methods, many people are willing to pay this extra amount to help ensure sustainable practices.

FIGURE 2.13

Sustainable Agriculture At the Land Institute in Salina, Kansas, sustainable agriculture techniques are being used to increase seed quantity in wheatgrass (background) and to increase yield in young sunflowers (foreground).

Section 2 Formative Assessment

Reviewing Main Ideas

1. **Explain** the differences between traditional and modern farming methods.
2. **Explain** why soil conservation is an important agricultural practice.
3. **Compare** the benefits and environmental impacts of pesticide use.

Critical Thinking

4. **Infer Relationships** Write a paragraph to explain the similarities and differences between traditional plant breeding and genetic engineering.
5. **Predict Consequences** Read the description of integrated pest control in this section. Why do you think this pest control technique is not practiced everywhere?

Animals and Agriculture

SECTION 3

Objectives

- Explain how overharvesting affects the supply of aquatic organisms used for food.
- Describe the current role of aquaculture in providing seafood.
- Describe the importance of livestock in providing food and other products.

Key Terms

domesticated
overharvesting
aquaculture
livestock
ruminant

We have seen that an acre of land can grow more food from plants than from animals. However, most animal proteins contain more essential amino acids than do proteins found in plants, and most humans include some animal products in their diet. Food from animals has been the basis of life for some human populations for many thousands of years.

Our ancestors obtained animal proteins by hunting and fishing, but today most people get animal proteins from domesticated species. About 50 animal species have been **domesticated**, which means that they are bred and managed for human use. Domesticated animals include chicken, sheep, cattle, honey bees, silkworms, fish, and shellfish. In many parts of the world, goats, pigs, and water buffalo are also important domesticated animals.

Food from Water

Because fish are an important food source for humans, the harvesting of fish has become an important industry worldwide, as shown in **Figure 3.1**. However, as shown in **Figure 3.2**, when too many fish are harvested over a long period of time, ecological systems can be damaged.

Overharvesting

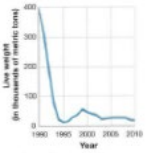
Catching or removing from a population more organisms than the population can replace is called **overharvesting**. Many governments are now trying to stop overharvesting. They have created no-fishing zones so that fish populations can recover. Research shows that fishing in areas surrounding no-fishing zones improves after no-fishing zones have existed for a few years. For the fishing industry to prosper in the future, better management is needed.

FIGURE 3.1

Fish Market Whole, fresh tuna are one of the many types of seafood for sale at the Tokyo fish market, the largest fish market in the world.

FIGURE 3.2

Cod Fishery Collapse The North Atlantic cod fishery has collapsed because of overharvesting.



Source: Department of Fisheries and Oceans, Canada

FIGURE 3.3

Aquaculture This oyster farm in Washington shows how aquaculture concentrates seafood production.

Aquaculture

Fish and other aquatic organisms provide up to 20 percent of the animal protein consumed worldwide. To meet demand, there has been a rapid increase in **aquaculture** (AK wuh kuhl chuhr), the raising of aquatic organisms for human use or consumption. Aquaculture is not a new idea. This practice likely began in China about 4,000 years ago. Today, China leads the world in using aquaculture to produce freshwater fish.

Today, most of the catfish, oysters, salmon, crayfish, and rainbow trout eaten in the United States are the products of aquaculture. In the 1980s, domestic production of these species quadrupled, and imports of these species increased even faster. Worldwide, about 50 percent of seafood now comes from aquaculture.

There are a number of different methods of aquaculture. The oyster farm shown in **Figure 3.3** represents one such method. Fish farms are widely used for aquaculture, and there are several types. Open pens and cages allow fish to be farmed in lakes and coastal oceans. There are serious concerns about the use of these pens in many places, such as salmon farms in British Columbia, Canada. The large number of fish kept in one area discharges large amounts of waste and pollutes surrounding waters. Diseases and parasites that occur when fish are kept in high densities can affect wild populations. If farmed fish escape, they can also interfere with wild populations. In addition, some wild fish populations are being overharvested to provide food for farmed fish.

Many fish are raised in small ponds or in tanks where water is recirculated. Often, there are many individual ponds that each contain fish at a specific stage of development. Clean water is circulated through the ponds, bringing in oxygen while taking away carbon dioxide and fecal wastes. The fish grow to maturity in the ponds and then are harvested. Wastes can be treated before water is released back into natural bodies of water. These systems are less likely to have fish escape into wild populations. One important consideration for ponds and tanks is their location. If there are not adequate supplies of fresh water, local water supplies can be depleted. Also, aquaculture development in some areas has destroyed important ecosystems. For example, millions of acres of mangroves have been removed for shrimp aquaculture around the world.

Despite the associated environmental issues, aquaculture will continue to be an important source of protein for the human diet. Therefore, like sustainable agriculture, it is important that methods are developed that ensure that aquaculture is done in a way that minimizes environmental damage and can be sustained into the future.

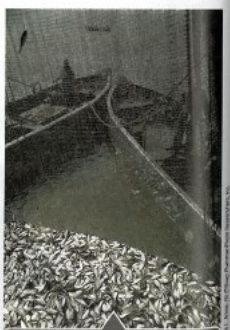
CASESTUDY

Menhaden: The Fish Behind the Farm

One of the largest commercial fish catches in the United States each year is of a species that most people have never heard of—the menhaden (man HAYD 'n). Menhaden are small, silver, oily fish in the herring family and are found in the Atlantic Ocean from Maine to Florida. Menhaden make up more than one-third of the weight of commercial fish caught on the East Coast each year. But menhaden are so full of bones that they are inedible. So why are these small fish so important?

When the first colonists arrived in the area we now call New England, local Native Americans showed them how to fertilize their crops using menhaden. This was the origin of the belief that the best corn is grown by planting a fish with each seed. Later, menhaden oil was used in oil lamps, and ground menhaden was added to cattle feed.

Today, the menhaden catch is processed to produce fishmeal and fish oil. The oil is used in cooking oils and margarine. The fishmeal has a high protein content, and is added to the feed of pets, chickens, turkeys, hogs, cattle, and farm fish. Menhaden are also used by recreational fishers as bait for fish such as striped bass, shark, and tuna.



A menhaden catch is unloaded from purse seine nets in Chesapeake Bay, Virginia.

Menhaden spawn in the ocean. The eggs hatch into larvae, which are carried into estuaries where they spend their first year. After the menhaden mature, they return to the ocean and usually live within 50 km of the coast. The Chesapeake Bay is one of the most important nurseries for this species.

Menhaden live in large schools near the surface, so they are easily caught with purse seine nets, which are nets that hang down from the surface of the water. Boats towing the nets encircle the fish, which are captured when the lower margin of the net is pulled closed.

An adult menhaden is an important member of the marine ecosystem. Menhaden are filter feeders that scoop up large mouthfuls of water and filter out the plankton for food. An adult menhaden can filter a million gallons of water in six months.

The Chesapeake Bay Ecological Foundation estimates that the manhaden population removes up to one-fourth of the nitrogen pollutants dumped into the Chesapeake Bay each year. Because nitrogen runoff from lawns and farms is a major pollutant of the Chesapeake Bay, this function of the fish is important. Sport fishers also value menhaden as bait because they are the natural food of many sportfish.

Both environmentalists and the sport fishing industry were worried when the menhaden catch declined during the 1990s. The catch in 2000 was the second-lowest catch on record. Both groups believe that overharvesting by commercial fishing boats was the reason for the reduced catch. As a result, the Atlantic Menhaden Management Board, which manages the menhaden fishery, has been restructured to have fewer members who represent the commercial fisheries. Even with this change, according to the National Oceanic and Atmospheric Administration (NOAA), more menhaden were harvested than is sustainable in 2006.

Critical Thinking

1. **Apply Ideas** Many different groups have potentially conflicting interests in the future of the menhaden fishery. Write a paragraph that explains the opposing points of view of two of these groups.
2. **Express Viewpoints** If you were on the Atlantic Menhaden Management Board, what changes would you suggest to prevent the fishery from declining? Write a paragraph that explains these changes.

FIGURE 3.4

Livestock Operations Modern livestock operations, such as this pig farm, are large and efficient.

GLOBAL ESTIMATES OF ANIMAL POPULATIONS

	Global Livestock Populations		
Species	**1961**	**2009**	**Increase**
Chickens	3.9 billion	18.6 billion	377%
Sheep	1 billion	1.1 billion	10%
Cattle	942 million	1.4 billion	49%
Pigs	406 million	942 million	132%
Goats	349 million	880 million	152%
Horses, donkeys, and mules	110 million	113 million	2.7%

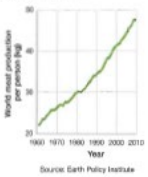
Source: UN Food and Agriculture Organization

Livestock

Domesticated animals that are raised to be used on a farm or ranch, or to be sold for profit, are called **livestock.** Large livestock operations, such as the pig farm shown in **Figure 3.4**, produce most of the meat that is consumed in developed countries. Meat production per person has increased worldwide since 1950, as shown in **Figure 3.5.** Livestock are also important in developing countries. In these countries, livestock provide leather, wool, eggs, and meat, and serve many other functions. Some are used as draft animals to pull carts and plows. Other livestock provide manure, which is used for fertilizer or as a heat source or as fuel for cooking. In arid ecosystems, livestock provide sustenance where crops could be grown only with expensive irrigation.

FIGURE 3.5

Meat Production Worldwide meat production per person has increased significantly since 1960.



Source: Earth Policy Institute

Ruminants

Cattle, sheep, and goats are **ruminants** (ROO muh nuhnts), which are cud-chewing mammals that have three- or four-chambered stomachs. *Cud* is the food that these animals regurgitate from the first chamber of their stomachs and chew again to aid digestion. Ruminants have microorganisms in their intestines, which allow the animals to digest plant materials that humans cannot digest. When we eat the meat of ruminants, we are using them to convert plant material, such as grass stems and woody shrubs, into food that we can digest.

Humans have created hundreds of breeds of cattle that are suited to life in different climates. Cattle are most common in North America, India, and Africa. But the cattle are not always slaughtered for meat. In Africa, for example, traditional Masai herders drink milk and blood from their cattle. India has almost one-fifth of the world's cattle. However, many of these cattle are not killed or eaten because cows are sacred to Hindus, who make up a large part of India's population. These cattle instead produce milk and dung, and are used as draft animals.

Poultry

Since 1961, the population of chickens worldwide has increased by a greater percentage than the population of any other livestock. Chickens are a type of *poultry*, or domesticated birds raised for meat and eggs, which are good sources of essential amino acids. In more-developed countries, chickens and turkeys are usually raised in factory farms, as shown in **Figure 3.6.** This industry has been criticized because the animals typically live in cramped, artificial environments.

Fewer ducks and geese are raised worldwide than chickens, but in some areas ducks and geese are economically important. For example, the Chinese use ducks not only for meat, but also as part of an integrated system that produces several types of food at one time. The ducks' droppings are used to fertilize fields of rice called *rice paddies*. The rice paddies are flooded several times per year with water from nearby ponds. Mulberry trees, which feed silkworms, are also irrigated by the ponds. Plant materials and filtered sewage are dumped in the ponds and serve as food for carp and other fish. The integrated system uses little fresh water, recycles waste, and produces ducks, silk, rice, and fish.

FIGURE 3.6

Industrial Farms Modern chicken farms, such as this one, are often huge, industrial-scale operations.

Section 3 Formative Assessment

Reviewing Main Ideas

1. **Explain** why the percentage of seafood produced by aquaculture is increasing so rapidly.
2. **Explain** how overharvesting affects the supply of fish such as salmon.
3. **Describe** the importance of livestock to cultures that consume no meat.

Critical Thinking

4. **Infer Relationships** Read the description of poultry above and explain why chickens are an important source of food for many humans.
5. **Apply Ideas** Look at the graph in **Figure 3.5.** Write a short paragraph explaining why meat production has increased so rapidly.

Points of View

Genetically Modified Foods

A scientist examines experimental samples of genetically modified fruit trees.

Genetically modified (GM) foods have been on sale in the world's supermarkets since 1994. We do not recognize them because the U.S. Food and Drug Administration (FDA) does not require that GM foods be labeled as such.

As the world's population rises, so does the need for food. Genetic engineering provides a way to increase food production. Biotechnologists can develop desirable characteristics in an organism by altering its genes or by inserting new genes into the organism's cells. For example, soybeans, corn, and other crop plants have been genetically modified to make proteins that protect them from the action of herbicides. Farmers who plant these GM crops can spray herbicides to control weeds without harming the crop.

GM foods are not limited to plant crops. GM animals have also been developed, including a strain of salmon that grows twice as fast as other salmon. The FDA has not yet cleared any GM animals for human consumption. But it has cleared many GM plant foods for sale. Not only is labeling of GM foods not required, it is actually unlawful to label foods that do not contain GM organisms. In 2011, consumer groups brought legal action against the U.S. government to force new labeling laws. Following are two points of view on GM foods.

Although these cans are labeled, genetically modified foods are not required to be labeled as such in the United States.

This farmer from Oaxaca, Mexico, holds up ears of traditional corn varieties. Some people fear that genes from genetically modified varieties could accidentally be introduced into native varieties.

ECOZine at HMDscience.com Go online for the latest environmental science news and updates on all EcoZine articles.

The Benefits Outweigh the Risks

People who support development of GM plants and animals view the process as an extension of previous breeding techniques. Traditionally, farmers altered the genetic makeup of a species by crossbreeding different strains to combine their best traits into one strain. However, the direct manipulation of genes through genetic engineering makes it possible to control genetic changes more precisely and efficiently. It even makes it possible to insert genes from one species into another.

The potential to increase crop yields is one advantage of GM food plants. Some GM crops, including corn that contains *Bt* genes, produce their own insecticides. These GM crops not only have the potential for higher yields, but also can reduce the expense and toxic exposure associated with pesticide and herbicide use. Crops that have been genetically engineered to tolerate herbicides can reduce the cost and fuel emissions associated with using farm machinery to get rid of weeds.

Other beneficial characteristics of GM fruits and vegetables include development of produce that stays fresh longer or contains added nutrients. For example, inserting a gene that increases the amino acids in a plant food could give it more nutritional value. To combat world hunger, scientists might be able to develop seeds that grow well in areas with poor soil or little water.

The Risks Outweigh the Benefits

Critics of GM foods think that these products are significantly different from foods developed through traditional methods. Scientists can use genetic engineering to place genes from any species into another. Opponents are concerned about the safety of foods that contain these "foreign" genes.

One safety concern is the possibility of allergic reactions. Some foods, such as peanuts and shellfish, cause allergic reactions in many people. If genes from these foods are placed in entirely different products, people who eat these new products without knowing they contain the foreign genes may suffer allergic reactions.

Other critics object to GM foods for religious or ethical reasons. Certain religions prohibit eating pork and other foods. People may object to the insertion of genes from pigs or other prohibited foods into foods they normally eat. Similarly, vegetarians might object to eating foods that contain animal genes. Such insertions are particularly worrisome when the sources of modifications are not noted on packaging.

Another major concern is pesticide resistance. Insects can rapidly develop the ability to survive exposure to pesticides. When they do, farmers lose the ability to combat infestations and significant crop losses can result. Farmers who grow genetically engineered crops that make their own pesticides, such as *Bt* corn, must take special precautions against the development of pesticide resistance.

Some scientists are concerned that genetically engineered plant and animal species could accidentally be introduced into the wild. For example, fast-growing GM salmon that escape from aquaculture enclosures might thrive at the expense of wild species. Wild species could become extinct, thus reducing biodiversity and potentially affecting ecosystem stability.

These people in Montreal, Quebec, are protesting the importation of genetically modified organisms (GMOs). Many countries have not accepted genetically engineered crops as much as the United States has.

What Do You Think?

Some people propose that genetically modified foods should have labels that identify them as such. Could such a measure decrease criticism about the safety of genetically modified foods? Based on what you have read, decide whether you would buy genetically modified foods at the grocery store. Explain your reasoning.

CHAPTER 15 Summary

SECTION 1 Feeding the World

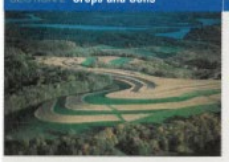
OBJECTIVES

- The foods produced in the greatest amounts worldwide are grains, the seeds of grass plants.
- Malnutrition is a condition that occurs when people do not consume enough Calories or do not eat a sufficient variety of foods to fulfill all of the body's needs.
- More food is needed each year to feed the world's growing population. Poverty and violence are the main reasons for hunger in the world today.
- The green revolution introduced new crop varieties with increased yields through the application of modern agricultural techniques.

KEY TERMS

famine
malnutrition
diet
yield

SECTION 2 Crops and Soils



OBJECTIVES

- The basic processes of farming are plowing, fertilization, irrigation, and pest control. Modern agricultural methods have replaced traditional methods in much of the world.
- Fertile soil is soil that can support the growth of healthy plants. Soil conservation methods are important for protecting and managing topsoil and reducing erosion.
- Pests cause considerable crop damage. The use of pesticides has both positive and negative effects on the environment. Integrated pest management can minimize the use of chemical pesticides.
- Genetic engineering is the process of transferring genes from one organism to another. Plants that result from genetic engineering are called genetically modified plants.

KEY TERMS

topsoil
erosion
desertification
compost
salinization
pesticide
biological pest control
genetic engineering

SECTION 3 Animals and Agriculture

OBJECTIVES

- Overharvesting has reduced the populations of many aquatic organisms worldwide.
- Aquaculture is the raising of aquatic animals, and shares many similarities to agriculture on land.
- Livestock are important for the production of food and other products. Worldwide meat production per person has increased greatly over the past several decades.

KEY TERMS

domesticated
overharvesting
aquaculture
livestock
ruminant

CHAPTER 15 Review

Reviewing Key Terms

Use each of the following terms in a separate sentence.

1. *overharvesting*
2. *erosion*
3. *livestock*
4. *yield*
5. *genetic engineering*

For each pair of terms, explain how the meanings of the terms differ.

6. *pesticide* and *biological pest control*
7. *compost* and *topsoil*
8. *livestock* and *ruminant*
9. *malnutrition* and *famine*
10. *salinization* and *desertification*
11. **Concept Map** Use the following terms to create a concept map: *contour plowing, no-till farming, organic farming, careful irrigation, soil erosion, nutrient depletion,* and *salinization.*

Reviewing Main Ideas

12. Malnutrition can be caused by
    a. a lack of enough Calories.
    b. a lack of carbohydrates.
    c. a lack of essential amino acids.
    d. all of the above
13. Humans need which of the following nutrients?
    a. carbohydrates and minerals
    b. lipids and vitamins
    c. proteins
    d. all of the above
14. Which of the following is *not* one the six most produced foods worldwide each year?
    a. potatoes
    b. beef
    c. rice
    d. wheat
15. Which of the following statements about human diets in all parts of the world is true?
    a. Most people eat pork.
    b. An adequate diet includes carbohydrates, proteins, and fats.
    c. Most people do not have protein in their diets.
    d. Most people are obese.
16. Malnutrition is largely a result of
    a. war.
    b. soil erosion.
    c. poverty.
    d. salinization.
17. Which of the following is *not* found in fertile soil?
    a. rock particles
    b. worms
    c. high concentrations of salts
    d. high concentrations of organic matter
18. Which of the following is *not* a soil conservation method?
    a. contour plowing
    b. salinization
    c. no-till farming
    d. terracing
19. Which of the following statements is a disadvantage of using chemical pesticides?
    a. Pesticides can pollute waterways.
    b. Pests evolve resistance to pesticides.
    c. Pesticides kill beneficial insects.
    d. All of the above.
20. How do pesticides that regulate growth work?
    a. They kill fleas.
    b. They disrupt the pest's life cycle.
    c. They attract predators of the pest.
    d. They prevent the pest from attacking the plant by poisoning its nervous system.

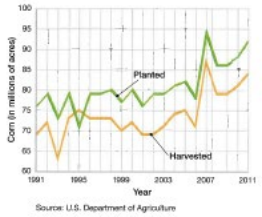
Short Answer

21. Why does it cost more to produce a kilogram of meat than to produce a kilogram of plants?
22. How does plowing soil increase soil erosion?
23. Why are biological controls for killing pests sometimes more effective than chemical pesticides are?
24. Why are ruminants valuable livestock?
25. Explain how soil degradation leads to loss of agricultural land.

Interpreting Graphics

Use the graph below to answer questions 26–28.

26. **Analyzing Data** In which year was the most corn planted? In which year was the least corn harvested?
27. **Analyzing Data** How many acres were planted with corn in 2007?
28. **Draw Conclusions** According to the graph, more acres of corn are planted than are harvested each year. Why?



Source: U.S. Department of Agriculture

Critical Thinking

29. **Make Predictions** Reread the text under the heading "World Food Problems." Write a paragraph to predict how increasing the productivity of the world's subsistence farmers would affect poverty and food production.
30. **Examine** What incentives to conserve soil do farmers in developed nations have?
31. **Infer Relationships** Read the text in this chapter under the heading, "Disrupting Insect Breeding." Are pheromones a type of pesticide? Explain your reasoning.
32. **Social Studies** Thousands of tons of dead fish are shoveled back into the ocean each year from fishing vessels because the fish are species that consumers do not want to buy. Identify some ways that humans might be able to reuse this protein.
33. **Economics** Hundreds of thousands of people starve to death every year. How is this problem related to the problem of poverty? Explain your answer.
34. **Prepare a Report** Environmental degradation caused by farming is not a new problem. The Dust Bowl of the 1930s is an example of an environmental disaster caused by farming practices that we would now consider to be damaging. Investigate the Dust Bowl, and write a report about it. Include information about the farming practices, laws, and regulations that were introduced in the United States as a result of the lessons learned during the 1930s.

Analyzing Data

Use the table below to answer questions 35–38.

WORLD FOOD PRODUCTION (IN MILLIONS OF TONS)

Food	1990	1995	1999	2009
Total Cereals	2000	2000	2000	2000
Wheat	590	540	590	690
Rice	520	550	610	690
Legumes	1000	1000	1000	1400
Poultry	41	54	65	92
Milk	542	540	570	702

35. **Analyzing Data** Compared to 1995, which foods had increased production in both 1999 and 2009?
36. **Analyzing Data** Which foods had lower production in 1995 than in 1990?
37. **Analyzing Data** Taking into account the 1999 data, can you think of any possible reasons for the answer to question 36?
38. **Analyzing Data** The human population of the world grew by 12 percent between 1990 and 2009. By what percentage did legumes production increase during this time?

Making Connections

39. **Communicate Ideas** Explain how insect reproduction enables insects to evolve pesticide resistance very rapidly.
40. **Analyzing Information** Explain why the pesticide DDT can still be detected in the environment even though its use was banned decades ago.

CASESTUDY

41. How is the menhaden fishing industry different from other fisheries?
42. Why are members of the sport fishing industry worried about the future of the menhaden catch?

Why It Matters

43. How has modern agriculture changed crop yield around the world?
44. What role might genetic engineering play in agriculture in the future?

STUDYSKILL

Making It a Habit Many people find that developing a routine helps them to study more effectively. Decide which time of day you feel most alert, and set it aside for studying. Make sure that any distractions around you will be minimal. When you regularly follow through with your study plan, you may find that you begin to learn more in less time.

EXPLORATIONLAB
Simulation

Managing the Moisture in Garden Soil

Objectives

Hypothesize ways to reduce the amount of water a home garden needs.

Compare the amount of water different soil samples can hold.

Explain how adding materials to a soil sample can help increase the sample's ability to hold water.

Materials

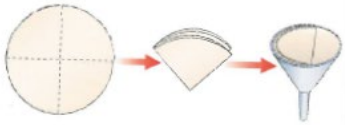
- beaker, 250 mL
- compost, 5 g
- crucible (or other heat-safe container)
- dry chopped grass clippings, 5 g
- eyedropper
- filter paper
- funnel
- heat source (hot plate or oven)
- metric balance
- sawdust, 5 g
- soil sample, 50 g
- stirring rod
- tongs
- watch (or clock)
- water

You work as a soil specialist with the Smith County Soil Conservation District. You are trying to help Latisha Norton, a local resident, solve an agricultural problem. Latisha has found that she must water her vegetable garden very often to keep it healthy. As a result, her family's water bills have skyrocketed! Latisha and her family may have to give up their garden project because of the added expense.

You realize that the water is probably draining out of the garden soil too quickly. To solve this problem, you need to find out how much water the soil can hold. You visit her garden and collect several soil samples. (Your teacher will provide you with soil samples.)

Procedure

1. Dry your soil sample without burning any of the organic matter. To do this, place about 50 g of soil in a crucible or other heat-safe container. Using tongs, gently heat the sample over a hot plate or put the sample in an oven. Stir the sample occasionally with a stirring rod to ensure that the sample becomes completely dry.
2. After the sample is completely dry, weigh about 10 g of dry soil. Record the mass in a data table.
3. Dampen a circle of filter paper until it is thoroughly moist, but not dripping. Weigh the moist filter paper, and record its mass in a data table.
4. As shown below, fold the moist filter paper into quarters. Next, open the filter paper to form a cup that fits in a funnel. Place the cup-shaped filter paper in the funnel.
5. Place the dry soil sample on the filter paper in the funnel. Place the funnel in the beaker.
6. Add water to the soil sample one drop at a time until all of the soil is moist and water begins to drip out of the funnel. Stop adding water, and let the funnel sit for 5 min.



Procedure Step 4 Fold the moist filter paper into quarters, and then open it to form a cup that fits in a funnel.

Smart Grapher
HMDScience.com

7. After 5 min, remove the filter paper and moist soil from the funnel, and weigh the paper and soil together. Record their mass in a data table.
8. Calculate the mass of the moistened soil sample by subtracting the mass of the damp filter paper from the mass of the completely moistened sample and the filter paper. Record the mass in a data table.
9. Calculate the amount of water that your soil sample can hold by subtracting the mass of the dry soil sample from the mass of the moistened soil sample. Record the result in a data table.
10. Calculate the percentage of water that your sample held. Divide the mass of water the soil held by the mass of the moistened soil sample, and multiply by 100. The higher the percentage is, the more water the soil can hold. Record the percentage in a data table.
11. Divide the remaining dry soil sample into three 5 g portions. To the first soil sample, add 5 g of dry compost. To the second soil sample, add 5 g of dry chopped grass clippings. To the third soil sample, add 5 g of dry sawdust. Weigh each mixed soil sample, and record the masses of the three samples in a data table.
12. Perform steps 3–10 for each of your mixed soil samples. Record your results in a data table.

Procedure Step 6 When adding water to the soil sample, add one drop at a time until all of the soil is moist and water begins to drip out of the funnel.

Analysis

1. **Organizing Data** Compare your results with the results of your classmates. Which soil samples held water the best? Why?
2. **Analyzing Data** Which of the additional materials improved the soil's ability to hold water?

Conclusions

3. **Evaluating Methods** Based on your results as well as your research, what could you recommend to Latisha to reduce the amount of water her garden needs?

Extension

4. **Designing Experiments** With the help of your teacher, choose one more material in addition to the three materials you used in step 11. Combine two of these materials, and mix them with a soil sample. Combine the remaining two materials with another soil sample. Perform steps 3–10 for these two mixed soil samples. Compare your results with the results you gathered earlier in the lab. Which combination of materials in the soil samples held water the best?

Appendix Q

THE GRAPES OF WRATH

BY

John Steinbeck

THE MODERN LIBRARY · NEW YORK

Chapter One

TO THE red country and part of the gray country of Oklahoma, the last rains came gently, and they did not cut the scarred earth. The plows crossed and recrossed the rivulet marks. The last rains lifted the corn quickly and scattered weed colonies and grass along the sides of the roads so that the gray country and the dark red country began to disappear under a green cover. In the last part of May the sky grew pale and the clouds that had hung in high puffs for so long in the spring were dissipated. The sun flared down on the growing corn day after day until a line of brown spread along the edge of each green bayonet. The clouds appeared, and went away, and in a while they did not try any more. The weeds grew darker green to protect themselves, and they did not spread any more. The surface of the earth crusted, a thin hard crust, and as the sky became pale, so the earth became pale, pink in the red country and white in the gray country.

In the water-cut gullies the earth dusted down in dry little streams. Gophers and ant lions started small avalanches. And as the sharp sun struck day after day, the leaves of the young corn became less stiff and erect; they bent in a curve at first, and then, as the central ribs of strength grew weak, each leaf tilted downward. Then it was June, and the sun shone more fiercely. The brown lines on the corn leaves widened and moved in on the central ribs. The weeds frayed

and edged back toward their roots. The air was thin and the sky more pale; and every day the earth paled.

In the roads where the teams moved, where the wheels milled the ground and the hooves of the horses beat the ground, the dirt crust broke and the dust formed. Every moving thing lifted the dust into the air: a walking man lifted a thin layer as high as his waist, and a wagon lifted the dust as high as the fence tops, and an automobile boiled a cloud behind it. The dust was long in settling back again.

When June was half gone, the big clouds moved up out of Texas and the Gulf, high heavy clouds, rain-heads. The men in the fields looked up at the clouds and sniffed at them and held wet fingers up to sense the wind. And the horses were nervous while the clouds were up. The rain-heads dropped a little spattering and hurried on to some other country. Behind them the sky was pale again and the sun flared. In the dust there were drop craters where the rain had fallen, and there were clean splashes on the corn, and that was all.

A gentle wind followed the rain clouds, driving them on northward, a wind that softly clashed the drying corn. A day went by and the wind increased, steady, unbroken by gusts. The dust from the roads fluffed up and spread out and fell on the weeds beside the fields, and fell into the fields a little way. Now the wind grew strong and hard and it worked at the rain crust in the corn fields. Little by little the sky was darkened by the mixing dust, and the wind felt over the earth, loosened the dust, and carried it away. The wind grew stronger. The rain crust broke and the dust lifted up out of the fields and drove gray plumes into the air like sluggish smoke. The corn threshed the wind and made a dry,

rushing sound. The finest dust did not settle back to earth now, but disappeared into the darkening sky.

The wind grew stronger, whisked under stones, carried up straws and old leaves, and even little clods, marking its course as it sailed across the fields. The air and the sky darkened and through them the sun shone redly, and there was a raw sting in the air. During a night the wind raced faster over the land, dug cunningly among the rootlets of the corn, and the corn fought the wind with its weakened leaves until the roots were freed by the prying wind and then each stalk settled wearily sideways toward the earth and pointed the direction of the wind.

The dawn came, but no day. In the gray sky a red sun appeared, a dim red circle that gave a little light, like dusk; and as that day advanced, the dusk slipped back toward darkness, and the wind cried and whimpered over the fallen corn.

Men and women huddled in their houses, and they tied handkerchiefs over their noses when they went out, and wore goggles to protect their eyes.

When the night came again it was black night, for the stars could not pierce the dust to get down, and the window lights could not even spread beyond their own yards. Now the dust was evenly mixed with the air, an emulsion of dust and air. Houses were shut tight, and cloth wedged around doors and windows, but the dust came in so thinly that it could not be seen in the air, and it settled like pollen on the chairs and tables, on the dishes. The people brushed it from their shoulders. Little lines of dust lay at the door sills.

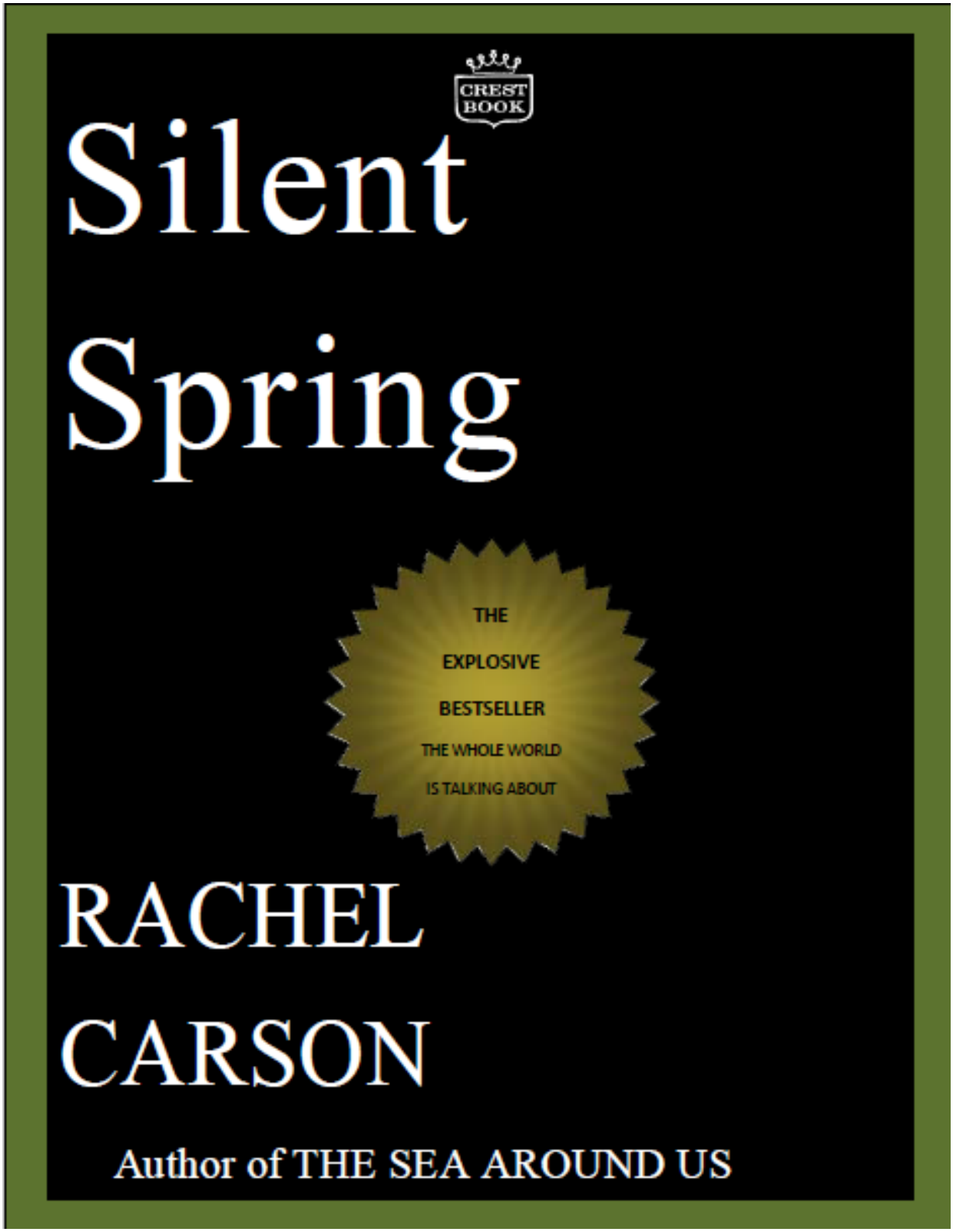
In the middle of that night the wind passed on and left the land quiet. The dust-filled air muffled sound more com-

pletely than fog does. The people, lying in their beds, heard the wind stop. They awakened when the rushing wind was gone. They lay quietly and listened deep into the stillness. Then the roosters crowed, and their voices were muffled, and the people stirred restlessly in their beds and wanted the morning. They knew it would take a long time for the dust to settle out of the air. In the morning the dust hung like fog, and the sun was as red as ripe new blood. All day the dust sifted down from the sky, and the next day it sifted down. An even blanket covered the earth. It settled on the corn, piled up on the tops of the fence posts, piled up on the wires; it settled on roofs, blanketed the weeds and trees.

The people came out of their houses and smelled the hot stinging air and covered their noses from it. And the children came out of the houses, but they did not run or shout as they would have done after a rain. Men stood by their fences and looked at the ruined corn, drying fast now, only a little green showing through the film of dust. The men were silent and they did not move often. And the women came out of the houses to stand beside their men—to feel whether this time the men would break. The women studied the men's faces secretly, for the corn could go, as long as something else remained. The children stood near by, drawing figures in the dust with bare toes, and the children sent exploring senses out to see whether men and women would break. The children peeked at the faces of the men and women, and then drew careful lines in the dust with their toes. Horses came to the watering troughs and nuzzled the water to clear the surface dust. After a while the faces of the watching men lost their bemused perplexity and became hard and angry and resistant. Then the women knew that they were safe and that there was no break. Then they asked, What'll we do?

And the men replied, I don't know. But it was all right. The women knew it was all right, and the watching children knew it was all right. Women and children knew deep in themselves that no misfortune was too great to bear if their men were whole. The women went into the houses to their work, and the children began to play, but cautiously at first. As the day went forward the sun became less red. It flared down on the dust-blanketed land. The men sat in the doorways of their houses; their hands were busy with sticks and little rocks. The men sat still—thinking—figuring.

Appendix R


CREST BOOK
Silent Spring
THE EXPLOSIVE BESTSELLER THE WHOLE WORLD IS TALKING ABOUT
RACHEL CARSON
Author of THE SEA AROUND US

2. The Obligation to Endure

THE HISTORY OF LIFE on earth has been a history of interaction between living things and their surroundings. To a large extent, the physical form and the habits of the earth's vegetation and its animal life have been molded by the environment. Considering the whole span of earthly time, the opposite effect, in which life actually modifies its surroundings, has been relatively slight. Only within the moment of time represented by the present century has one species—man—acquired significant power to alter the nature of his world.

During the past quarter century this power has not only increased to one of disturbing magnitude but it has changed in character. The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials. This pollution is for the most part irrecoverable; the chain of evil it initiates not only in the world that must support life but in living tissues is for the most part irreversible. In this now universal contamination of the environment, chemicals are the sinister and little-recognized partners of radiation in changing the very nature of the world—the very nature of its life. Strontium 90, released through nuclear explosions into the air, comes to earth in rain or drifts down as fallout, lodges in soil, enters into the grass or corn or wheat grown there, and in time takes up its abode in the bones of a human being, there to remain until his death. Similarly, chemicals sprayed on croplands or forests or gardens lie long in soil, entering into living organisms, passing from one to another in a chain of poisoning and death. Or they pass mysteriously by underground streams until they emerge and, through the alchemy of air and sunlight, combine into new forms that kill vegetation, sicken cattle, and work unknown harm on those who drink from once pure wells. As Albert Schweitzer has said, 'Man can hardly even recognize the devils of his own creation.' It took hundreds of millions of years to produce the life that now inhabits the earth—eons of time in which that developing and evolving and diversifying life reached a state of adjustment and balance with its surroundings. The environment, rigorously shaping and directing the life it supported, contained elements that were hostile as well as supporting. Certain rocks gave out dangerous radiation; even within the light of the sun, from which all life draws its energy, there were short-wave radiations with power to injure. Given time—time not in years but in millennia—life adjusts, and a balance has been reached. For time is the essential ingredient; but in the modern world there is no time. The rapidity of change and the speed with which new situations are created follow the impetuous and heedless pace of man rather than the deliberate pace of nature. Radiation is no longer merely the background radiation of rocks, the bombardment of cosmic rays, the ultraviolet of the sun that have existed before there was any life on earth; radiation is now the unnatural creation of man's tampering with the atom. The chemicals to which life is asked to make its adjustment are no longer merely the calcium and silica and copper and all the rest of the minerals washed out of the rocks and carried in rivers to the sea; they are the synthetic creations of man's inventive mind, brewed in his laboratories, and having no counterparts in nature.

To adjust to these chemicals would require time on the scale that is nature's; it would require not merely the years of a man's life but the life of generations. And even this, were it by some miracle possible, would be futile, for the new chemicals come from our laboratories in an endless stream; almost five hundred annually find their way into actual use in the United States alone. The figure is staggering and its implications are not easily grasped—500 new chemicals to which the bodies of men and animals are required somehow to adapt each year, chemicals totally outside the limits of biologic experience.

Among them are many that are used in man's war against nature. Since the mid-1940s over 200 basic chemicals have been created for use in killing insects, weeds, rodents, and other organisms described in the modern vernacular as 'pests'; and they are sold under several thousand different brand names. These sprays, dusts, and aerosols are now applied almost universally to farms, gardens, forests, and homes— nonselective chemicals that have the power to kill every insect, the 'good' and the 'bad', to still the song of birds and the leaping of fish in the streams, to coat the leaves with a deadly film, and to linger on in soil—all this though the intended target may be only a few weeds or insects. Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called 'insecticides', but 'biocides'. The whole process of spraying seems caught up in an endless spiral. Since DDT was released for civilian use, a process of escalation has been going on in which ever more toxic materials must be found. This has happened because insects, in a triumphant vindication of Darwin's principle of the survival of the fittest, have evolved super races immune to the particular insecticide used, hence a deadlier one has always to be developed—and then a deadlier one than that. It has happened also because, for reasons to be described later, destructive insects often undergo a 'flareback', or resurgence, after spraying, in numbers greater than before. Thus the chemical war is never won, and all life is caught in its violent crossfire.

Along with the possibility of the extinction of mankind by nuclear war, the central problem of our age has therefore become the contamination of man's total environment with such substances of incredible potential for harm—substances that accumulate in the tissues of plants and animals and even penetrate the germ cells to shatter or alter the very material of heredity upon which the shape of the future depends.

Appendix S

Pesticides Are Killing the Organisms That Keep Our Soils Healthy

They harm worms, beetles and thousands of other subterranean species that are vital to agriculture

- By Nathan Donley, Tarl Gunstone on June 1, 2021

Scoop up a shovelful of healthy soil, and you'll likely be holding more living organisms than there are people on Earth. Like citizens of an underground city that never sleeps, tens of thousands of subterranean species of invertebrates, nematodes, bacteria and fungi are constantly filtering our water, recycling nutrients and helping to regulate the planet's temperature.
But under fields covered in tightly knit rows of corn, soybeans, wheat and other monoculture crops, a toxic soup of insecticides, herbicides and fungicides is wreaking havoc, according to our recent analysis in the journal *Frontiers in Environmental Science*. The study—to our knowledge the most comprehensive review ever conducted on how pesticides affect soil health—should trigger immediate and substantive changes in how the Environmental Protection Agency assesses the risks posed by the nearly 850 pesticide ingredients approved for use in the U.S.

Regulations currently ignore pesticides' harm to soil species. Our study leaves no doubt that this disregard must change. For our analysis, conducted by researchers at the Center for Biological Diversity, Friends of the Earth and the University of Maryland, we looked at nearly 400 published studies comprising more than 2,800 experiments on how pesticides affect soil organisms. Our review encompassed 275 unique species or types of soil organisms and 284 different pesticides or pesticide mixtures.

In just over 70 percent of those experiments, pesticides were found to harm organisms critical to maintaining healthy soils—harms that have never been considered in the EPA's safety reviews. Pesticide-intensive agriculture and pollution are driving factors in the precipitous decline of many soil organisms, such as ground beetles and ground-nesting bees. They have been identified as the most significant driver of soil biodiversity loss in the past decade.

Yet pesticide companies and our pesticide regulators have ignored that research. The EPA, which is responsible for pesticide oversight in the U.S., openly acknowledges that somewhere between 50 and 100 percent of all agriculturally applied pesticides end up on the soil. Yet to assess pesticides' harms to soil species, the agency still uses a single test species—one that spends its entire life aboveground in artificial boxes—to estimate risk to all soil organisms: the European honeybee.

The fact that the EPA relies on a species that literally may never touch soil in its entire life to represent the thousands of species that live or develop underground offers a disturbing glimpse of how the U.S. pesticide regulatory system is set up to protect the pesticide industry instead of species and their ecosystems. What this ultimately means is that pesticide approvals happen without any regard for how those chemicals can harm soil organisms.

To add to this, as principles of regenerative agriculture and soil health gain popularity around the world, pesticide companies have jumped on the bandwagon to greenwash their products. Every major company now has Web materials touting its role in promoting soil health, often advocating for reducing tilling and planting cover crops.

As general tenets, both these practices are indeed good for soil health and, if adopted responsibly, are great steps to take. But companies know that these practices are often accompanied by increased pesticide use. When fields are not tilled, herbicides are frequently used to kill weeds, and cover crops are often killed with chemicals before crop planting. This "one step forward, one step back" approach is preventing meaningful progress to protect our soils. Pesticide companies have so far been successful in coopting "healthy soil" messaging because our regulators have shown no willingness to protect soil organisms from pesticides.

The long-term environmental cost of that failure can no longer be ignored. Soils are some of the most complex ecosystems on Earth, containing nearly a quarter of the planet's biodiversity. Protecting them should be a priority, not an afterthought. Our research indicates that achieving this will require that we reduce the world's growing and unsustainable reliance on pesticide-intensive agriculture. And it will require that the EPA take aggressive steps to protect soil health.

Appendix T

By —John Flesher, Associated Press

Factory Farms Provide Abundant Food, but Environment Suffers

Feb 6, 2020 2:33 PM EDT

AKRON, Iowa (AP) — In recent years, Fred Zenk built two barns housing about 2,400 hogs between them — long, white, concrete-and-metal structures that are ubiquitous in the Midwestern countryside.

The Iowa farmer didn't follow state requirements to get construction approval and file a manure disposal plan. But Zenk's operation initially flew under the radar of regulators, as have many others across the United States because of loopholes and spotty enforcement of laws intended to keep the nation's air and water clean.

Beef, chicken, and pork have become more affordable staples in the American diet thanks to industry consolidation and the rise of farms with tens of thousands of animals. Yet federal and state environmental agencies often lack basic information such as where they're located, how many animals they're raising and how they deal with manure.

The animals and their waste have fouled waters. The enclosures spew air pollutants that promote climate change and are implicated in illnesses such as asthma. The stench of manure — stored in pits beneath barns or open-air lagoons and eventually spread on croplands as fertilizer — can make life miserable for people nearby.

For most of the nation's history, meat and dairy products came from independent farms that raised animals in barnyards, pastures and rangeland. But the system now is controlled by giant companies that contract with farmers to produce livestock with the efficiency of auto assembly lines inside warehouse-like barns and sprawling feedlots.

The spread of corporate animal farms is turning neighbor against neighbor in town halls and courtrooms. Iowa, the top U.S. producer of swine and egg-laying chickens, has been a major battleground.

"It's a fight for survival," said Chris Petersen, who still raises pigs in outdoor pens.

Michele Merkel, a former EPA attorney who quit over the agency's reluctance to punish polluting mega-farms and is co-director of the advocacy group Food & Water Justice, said the industry "has avoided any effective regulation and accountability for a long time."

Industry groups say there are plenty of regulations and livestock agriculture is simply adapting to improved technology, equipment and methods.

"We're responding to what the market is giving us," said Brady Reicks, whose company runs numerous large hog structures in northeastern Iowa. "We're doing it responsibly; we're passionate about doing it. It increases growth in rural Iowa and it helps feed the world."

The U.S. Environmental Protection Agency began to count the nation's factory farms during the Obama administration but retreated when industry groups sued. Instead, the agency uses state data to produce annual statistics about only the biggest operations.

As of 2018, the nationwide EPA tally was about 20,300 — a roughly five-fold increase over nearly four decades.

Yet it's a tiny fraction of all confined animal operations. The U.S. Department of Agriculture estimates there are more than 450,000, most too small for inclusion in the EPA count.

Iowa has 80 million farm animals and 3 million people. Yet in 2017, regulators didn't know how many livestock farms were in the state. Under federal pressure, the Department of Natural Resources pored over aerial photos, discovering 4,200 previously unknown facilities.

Zenk's Plymouth County farm was among them.

"We knew nothing about his operation," said Sheila Kenny, an environmental specialist with the state agency.

Zenk acknowledged breaking the rules but said no harm was done. He paid a $4,500 fine.

"You think you can get by with something once in a while and you can't," he said, strolling among his barns, tractor and feed bins.

To state regulators, such discoveries mean the system works. Critics say the Iowa experience shows how easily livestock operations can escape detection.

Putting thousands of animals in one enclosure produces huge amounts of manure. Unlike human sewage, which is treated and released to waterways, animal waste is stored, then spread on croplands as fertilizer.

Farmers insist they are careful.

"We take soil tests, we decide how much manure it needs and that's how much we apply," Reicks said.

Environmental groups say fields often can't handle the volumes of manure produced, leading to runoff. Such pollution is exempt from regulation under the 1972 Clean Water Act, even though agriculture is the biggest contaminator of rivers and streams, according to the EPA.

In Emmett County, Iowa, small farmer Gordon Garrison sued a nearby operation with 4,400 hogs, contending manure from its croplands fouls a creek that runs through his property and feeds the Des Moines River.

"They're using me for a waste disposal site," Garrison said.

Livestock farms generate about 70% of the nation's ammonia emissions, plus gases that cause global warming, particularly methane.
Yet they aren't required to get permits under the Clean Air Act. The government hasn't decided how to measure emissions from barns, feedlots, storage lagoons and croplands.

And under President Donald Trump, EPA has exempted livestock operations from requirements under other laws that industries report significant releases of air pollutants including ammonia and hydrogen sulfide.

Critics say yesteryear's barnyard whiffs were nothing like the overpowering stench from today's supersized operations.

"You don't want to be anywhere near them," said Brad Trom, a crop producer in Minnesota's Dodge County, who lives within three miles of 11 structures housing 30,000 swine. He says he's been staggered by powerful odors barreling across his fields.

Farmers say they're trying to reduce the smells but contend they're a normal part of country life.

"I've never lived on a farm that didn't have nature's fragrances on it," said Gary Sovereign, a swine producer in Iowa's Howard County.

Research has linked proximity to factory farms to various health risks. But scientists acknowledge it's nearly impossible to pin someone's illness on a certain polluter.

Jeff and Gail Schwartzkopf say after a hog mega-barn was built a quarter-mile from their home in northern Iowa, they developed burning and itching eyes, throat soreness and body rashes. They fear the manure odors are making them sick and ruining their home.

"Nobody's going to want to buy it. We're stuck," Jeff Shwartzkopf said.

Appendix U

How Fertilizers Harm Earth More Than Help Your Lawn

Chemical runoff from residential and farm products affects rivers, streams and even the ocean

- July 20, 2009

Dear EarthTalk: What effects do fertilizers, pesticides and herbicides used on residential lawns or on farms have on nearby water bodies like rivers, streams—or even the ocean for those of us who live near the shore?
-- Linda Reddington, Manahawkin, NJ

With the advent of the so-called Green Revolution in the second half of the 20th century—when farmers began to use technological advances to boost yields—synthetic fertilizers, pesticides and herbicides became commonplace around the world not only on farms, but in backyard gardens and on front lawns as well.

These chemicals, many of which were developed in the lab and are petroleum-based, have allowed farmers and gardeners of every stripe to exercise greater control over the plants they want to grow by enriching the immediate environment and warding off pests. But such benefits haven't come without environmental costs—namely the wholesale pollution of most of our streams, rivers, ponds, lakes and even coastal areas, as these synthetic chemicals run-off into the nearby waterways.

When the excess nutrients from all the fertilizer we use runs off into our waterways, they cause algae blooms sometimes big enough to make waterways impassable. When the algae die, they sink to the bottom and decompose in a process that removes oxygen from the water. Fish and other aquatic species can't survive in these so-called "dead zones" and so they die or move on to greener underwater pastures.

A related issue is the poisoning of aquatic life. According to the U.S. Centers for Disease Control (CDC), Americans alone churn through 75 million pounds of pesticides each year to keep the bugs off their peapods and petunias. When those chemicals get into waterways, fish ingest them and become diseased. Humans who eat diseased fish can themselves become ill, completing the circle wrought by pollution.

A 2007 study of pollution in rivers around Portland, Oregon found that wild salmon there are swimming around with dozens of synthetic chemicals in their systems. Another recent study from Indiana found that a variety of corn genetically engineered to produce the insecticide Bt is having toxic effects on non-target aquatic insects, including caddis flies, a major food source for fish and frogs.

The solution, of course, is to go organic, both at home and on the farm. According to the Organic Trade Association, organic farmers and gardeners use composted manure and other natural materials, as well as crop rotation, to help improve soil fertility, rather than synthetic fertilizers that can result in an overabundance of nutrients. As a result, these practices protect ground water supplies and avoid runoff of chemicals that can cause dead zones and poisoned aquatic life.

There is now a large variety of organic fertilizer available commercially, as well as many ways to keep pests at bay without resorting to harsh synthetic chemicals. A wealth of information on growing greener can be found online: Check out OrganicGardeningGuru.com and the U.S. Department of Agriculture's Alternative Farming System Information Center, for starters. Those interested in face-to-face advice should consult with a master gardener at a local nursery that specializes in organic gardening.

Appendix V

Genetically Modified Foods

This article was medically reviewed by **Samantha Cassetty**, MS, RD, a nutrition and wellness expert with a private practice based in New York City.

GMO produce tends to be less expensive. Hybrid Images/Getty Images

- **GMO foods are designed to be healthier and cheaper to produce.**
- **Advantages of GMO foods include added nutrients, fewer pesticides, and cheaper prices.**
- **Disadvantages of GMO foods can be allergic reactions or increased antibiotic resistance.**

Genetically modified organisms (GMOs) are living organisms that have had their genes altered in some way — also called "bioengineering."

GMOs can be animals or bacteria, but most often they are crops like corn or potatoes that have been tweaked in a lab to increase the amount or quality of food they produce.

There are many advantages of GMO crops, but some groups have raised concerns that GMOs may have negative health effects. Here's what you need to know about the pros and cons of GMO foods and whether you should avoid them.

What are GMOs?

Humans have been altering the genetics of plants for thousands of years through the slow process of cross-breeding between crops. Today, scientists can take a shortcut to modify plants by editing their DNA in a lab setting.

Chances are, you've eaten GMO foods without even realizing it – in 2018, around 92% of corn and 94% of soybeans grown in the US came from genetically modified seeds.

The process of creating a GMO plant is complex, but it follows these basic steps:

1. Researchers identify the genes in a plant that cause specific traits, such as resistance to insects.

2. They then make copies of these insect resistance genes in a lab.

3. Scientists next insert the gene copies into the DNA of another plant's cells.

4. These modified cells are then used to grow new, insect-resistant plants that will go through various reviews and tests before they are sold to farmers.

Pros	Cons
• **Fewer pesticides** • **Often cost less** • **May have more nutrients**	• May cause allergic reactions • May increase antibiotic resistance

Pros of GMOs

"GMOs are designed to be extra — extra healthy, extra fast-growing, and extra resistant to weather or pests," says Megan L. Norris, PhD, a biomedical researcher at the UT Southwestern Medical Center.

Because scientists can select the most ideal traits to include in GMO crops, there are many advantages of modified foods, including:

GMOs may have fewer pesticides

Many GMO crops have been altered to be less vulnerable to insects and other pests. For example, Bt-corn is a GMO crop that has a gene added from Bacillus thuringiensis, a naturally occurring soil bacteria.

This gene causes the corn to produce a protein that kills many pests and insects, helping to protect the corn from damage. "Instead of having to be sprayed with a complex pesticide, these crops come with an innate 'pesticide'," Norris says.

This means that farmers don't need to use as much pesticide on crops like Bt-corn – a 2020 study found that farmers with GMO crops reduced their pesticide use by 775.4 million kilograms (8.3%) between 1996 and 2018.

Quick tip: The use of fewer pesticides in crops may lead to fewer health risks for people eating them and less damage to the environment.

GMOs are usually cheaper

GMO crops are bred to grow efficiently – this means that farmers can produce the same amount of food using less land, less water, and fewer pesticides than conventional crops.

Because they can save on resources, food producers can also charge lower prices for GMO foods. In some cases, the costs of foods like corn, beets, and soybeans may be cut by 15% to 30%.

GMOs may have more nutrients

Certain GMO crops are designed to provide more nutrients like vitamins or minerals. For example, researchers have been able to create a modified form of African corn that contains:

- 2 times as much folate when compared to traditional crops
- 6 times as much vitamin C when compared to traditional crops
- 169 times more beta-carotene than traditional crops

Important: This may be especially helpful in regions where people suffer from nutritional deficiencies.

Cons of GMOs

GMO crops can offer many advantages in costs and nutrition, but some experts worry that they carry health risks, as well.

GMOs may cause allergic reactions

Because GMO foods contain DNA from other organisms, it's possible that the new DNA can trigger allergies in people who wouldn't normally be allergic to the food.

In one instance, a GMO soybean crop created using DNA from a Brazil nut was unsafe for people with nut allergies and couldn't be released to the public.

However, GMO foods go through extensive allergen testing, so they shouldn't necessarily be riskier than conventional crops.

GMOs may increase antibiotic resistance

When GMO scientists insert new DNA into plant cells, they will often add in an additional gene that makes the modified cells resistant to antibiotics. They can then use an antibiotic to kill off any plant cells that didn't successfully take in the new DNA.

However, researchers are finding that these antibiotic-resistant genes don't always go away once you digest GMO foods, but can actually be passed through your feces into sewage systems. Some experts worry that these genes may be absorbed into harmful bacteria found in sewers or your gut that can cause serious illnesses like staph infections. This means that the usual antibiotic treatments would be powerless against these new super-bacteria.

Not all experts agree on this concern, however – some scientists argue that this type of gene transfer is very unlikely and there is little risk to humans.

Insider's takeaway

GMO crops have many advantages for your health, such as greater nutritional value and fewer pesticides. They may also be cheaper for farmers to grow, allowing for lower food prices.

Though there are possible risks, major agencies like the US Food and Drug Administration and the Environmental Protection Agency tightly regulate GMO foods and ensure that they are safe for people to eat. "I consume GMO products and feed them to my family without hesitation," Norris says.