Literacy

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INTRODUCTION

WHAT DO WE MEAN BY LITERACY?

Educators use the term literacy in several ways. Sometimes they are referring to English language literacy—the ability to comprehend written material, express one's ideas in writing, and understand and respond to oral communication in English. In science education another common use of the word literacy is as part of the phrase "scientific literacy," which is defined by the National Science Education Standards as, "the knowledge and understanding of scientific concepts and processes required for personal decision-making, participation in civic and cultural affairs, and economic productivity." (National Research Council, 1996.) For the classroom science teacher both meanings are relevant in helping students achieve success in science.

The *Science and Sustainability* program provides constant opportunities for students to improve their English language skills. Students are expected to read informational text and procedures. The Analysis questions and designing investigations activities, and science journal entries all require that students write clearly. Students practice their oral language skills in discussions, debates, and presentations. Teachers who are looking for new ways for science classes to help students develop language literacy will find these exercises particularly helpful.

Teachers' most frequently asked questions about the strategies are:

HOW DO I START IMPLEMENTING LITERACY STRATEGIES?

Begin by reviewing each strategy with the class before they experience it. Explain how the strategy works, either by doing part or all of the first exercise involving the strategy as a class, or by creating a model that employs the strategy. For a Read, Think, and Take Note strategy, for example, model the strategy with a short news article projected on the board. Read the article aloud and stop to write notes next to lines of the article in which a word or phrase sparks a thought. This way, students have a visual example of the strategy. Once students understand the strategy, have them work in groups or pairs to implement it. Eventually students will use the strategies independently.

As you work with these strategies, ask students about how they think about what they are reading, writing, or presenting. Research shows that the most successful students are those who understand how they think. Metacognition, or having an awareness of one's own thinking, is important in the development of learning in all areas, including reading and writing (Donovan, et al., 1999; Schoenbach et al., 1999). Having access to a range of appropriate strategies improves students' understanding of text (Biancarosa and Snow, 2004). As you discuss with students the strategies for improving their reading comprehension, guide them to reflect on their own thinking and how to make these strategies part of their learning skills.

Additional resources on literacy strategies appear after the reference list at the end of this chapter.

HOW CAN I SUPPORT THE LITERACY STRATEGIES BEING USED IN OTHER CLASSES?

Writing skills are usually taught in English classes. A science teacher might check with their students' English teacher(s) to find out what skills students are working on in this and other classes over the course of the year.

Discuss with students' the literacy skills they are learning in English class. Ask them to apply the same skills in science class. For example, if they are working on writing well-developed paragraphs, tell them that selected Analysis questions also require well-developed paragraphs. If they are working on five-paragraph essays in English class, assign them to write an essay related to an activity, extension, or unit topic, and discuss how the essay format is appropriate for discussing the scientific topics. Work with students the first time you assign an essay to show them how their work on writing for other classes applies to their science writing.

The table on the following page lists various literacy strategies.

LITERACY STRATEGIES

LITERACY CATEGORY	LITERACY STATEGY
Supporting reading comprehension	Anticipation Guide Reading scientific procedures Read, Think, and Take Note Three-level Reading Guide
Enhancing student writing	Writing frame Writing review
Facilitating group discussion	Informal Meeting of the Minds Discussion web Walking debate
Supporting concept development	Concept map KWL Scientific diagram Venn diagram

LITERACY STRATEGIES

Strategies for Supporting Reading Comprehension

In a science class, students frequently encounter text that they have trouble understanding. A number of strategies that help them improve their reading comprehension can be implemented before students begin a reading, some during a reading, and some after they have finished a reading.

ANTICIPATION GUIDE

What

Prereading exercises help students activate their background knowledge about a topic and generate curiosity about the material they will learn. An Anticipation Guide has students answer a set of prompts before reading, and after reading, students discuss how their predictions compared to the information in the reading.

Why to Use It

The value of an Anticipation Guide is in the discussion that occurs before and after the reading. Before reading, students discuss their predictions and reasons for them. During this discussion, the teacher gleans information about the depth of students' existing knowledge of and misconceptions about a topic.

How to Use It

On an Anticipation Guide, students individually respond to a series of statements related to the text they will read. They state whether they agree or disagree with a statement by marking it with a + (agree) or a − (disagree). The statements give students a sense of the key ideas in the reading and elicit their current ideas about the material. After completing the reading and participating in discussions as needed, students revisit the Anticipation Guide and record whether they now agree or disagree with each statement. They then cite information from the reading to explain how the text either supported or changed their initial ideas. A template for this strategy is on Literacy Transparency 1.

READING SCIENTIFIC PROCEDURES

What It Is

Reading scientific procedures is not a single strategy. It is a collection of suggested simple steps students might take when they have trouble making meaning of procedure steps. The steps listed do not require individual instruction. Instead, they serve as a guide for students to be self-supporting when they struggle to read scientific procedures.

Why to Use It

Following scientific procedures requires reading and comprehending a specific step-by-step process. Some students may struggle due to the complexity of individual steps, others because of the number of steps. It is helpful to provide students with support as needed.

How to Use It

Project Literacy Transparency 2, "Reading Scientific Procedures," and explain that students might look to these strategies if they become stuck while performing an investigation. Model the process with a procedure from the Student Book, stopping as you read the procedure to choose a strategy from the transparency that helps clarify a procedure step. Providing opportunities for students to practice the strategies will help them follow written procedures independently.

READ, THINK, AND TAKE NOTE

What It Is

Read, Think, and Take Note is a literacy strategy that helps students externalize their thinking as they read. Students mark on a sticky note their thoughts about the reading and place it in the margin of the text near the word, phrase, or paragraph that prompted the thought. Alternatively, they may mark the text directly if it is provided as photocopied pages of the Student Book.

Why to Use It

Asking students to record thoughts on sticky notes as they read helps with literacy development in two ways. First, it provides a structure for students to record the thinking process as they read. Students may later return to that record to clarify misconceptions, add depth to the thoughts they wrote down, discuss their understanding with their classmates, find references for writing assignments, and track how these discussions change as their reading ability improves. Secondly, the notes provide a way for the teacher to see how students think as they read. This provides a way for the teacher to select an appropriate support mechanism based on the content recorded on a student's sticky notes. For example, a student who is unsure of the meaning of a word benefits from the teacher's suggestion that the student look up the definition of the new word. Or perhaps a student notes that a phrase in a reading reminds him or her of an event that occurred last summer. The teacher may point out that this is a skill used by proficient readers; skilled readers make connections between what they read and their life experiences, and this helps them comprehend what they read.

How to Use It

Explain to students that as they follow this strategy they are learning some of the ways proficient readers think while reading. When students first use this strategy, take the opportunity to model it. First review with students the "Read, Think, and Take Note Guidelines" as shown on Literacy Transparency 3, and in the Student Book. Next, select a section of text from the Student Book and conduct a think-aloud to model how the students will use the strategy.

To guide students as they read, the teacher might display a poster of the guidelines provided on Literacy Transparency 3 found toward the end of this section. Point out that the guidelines also sometimes appear in the Student Book in the Procedure. As students are learning to use the strategy, keep in mind that there are many ways to respond to text. Each student will create a unique set of comments. It is important to emphasize to students that they should write thoughtful statements to reflect that they are thinking meaningfully about the text.

Conduct small group or a class discussion once students have completed the reading. This step is key in that it helps students clarify points of confusion, and provides the teacher with information about what they struggled with in the reading. During this discussion, students share their thoughts and reactions from the reading and the comments they recorded on sticky notes. Ask for student volunteers to share any points in the reading that gave them difficulty. To establish a culture in which students will communicate the challenges they face while reading science content, remind them that everyone has questions about the content in the reading, that everyone in the room is learning, and that they should all be respectful of each other's ideas and questions.

Then tell students that when other readings in the unit call for this strategy, they will work with their partner to list the places of confusion and questions they have about the reading, as flagged on their sticky notes.

Ask students what they can do to find answers to their questions and to understand what was confusing to them as they read. Make a list of students' suggestions on the overhead or board. Suggestions could include: ask a peer, ask an expert, look up a piece of information in a prior activity, and look up a word in the dictionary. Instruct students to use one of the suggestions on the list you just generated to understand a word or sentence, or to clarify one point of confusion from the reading. Encourage students to work together to make meaning of the text. Circulate around the room and monitor students' progress. If necessary, stop and discuss with students which suggestions are practical and which are not, given the resources available in a classroom setting. For example, it is easy to ask a peer, but an expert is not available. However, a peer may not be able to answer the question, or

may not have all the information needed. If you notice students getting frustrated, provide support by reinforcing that this is part of the process of becoming a strategic reader.

As part of students' introduction to Read, Think, and Take Note, the teacher may ask students to write a specified number of or specific types of notes. As students become more independent in recognizing what is confusing to them, they may decide the appropriate number and type of notes to write.

THREE-LEVEL READING GUIDE

What It Is

The Three-level Reading Guide is a reading strategy that focuses students on processing content in text. The three-level guide contains a series of statements from three levels of understanding: literal, interpretive, and applied. The following are examples of statements for each of the three levels:

Literal (taken directly from the student text): "Before building, engineers must model what happens to a building in an earthquake."

Interpretive (not stated directly in the text): "Buildings should be able to withstand even the largest earthquake possible without sustaining damage."

Applied (can be supported or refuted, based on information from the reading and students' background knowledge): "Earthquake damage cannot be predicted."

Why to Use It

The Three-level Reading Guide is a practical and structured way to guide students to become stronger readers. The strategy guides students from the literal level of understanding to the successively higher order levels of interpretation and application of the reading.

The teacher should explain to the class the types of statements in each of the three levels. While the literal statements guide students to look for ideas that are explicitly in the reading, in some cases appearing in identical words or phrases, fully understanding a text takes more than recognizing information. Good readers also think about the relationships and connections in the information and they interpret and integrate the information into what they already know. Applied statements do not have a correct response, but are there for students to either support or dispute based on information in the reading as well as their own ideas.

How to Use It

Students should read the statements on the Three-level Reading Guide before they begin reading. By getting a sense of some of the reading's concepts and ideas, they are better prepared to recognize key information in the text. Many students will benefit from a modeling of how to read the lines of text to recognize the literal information that is written. This is also a place to emphasize that the literal statements on the reading guide represent the most essential information in the text.

If students are having difficulty responding to the interpretive and applied statements, the teacher should model their responses to the first statement in those sections of the reading guide. To do this read the statement aloud and then paraphrase the information from the reading that responds to the statement. Have students respond to the rest of the statements in pairs or small groups. Literacy Student Sheet 1 contains a template for this strategy.

Strategies for Enhancing Students' Writing

In any classroom students may be asked to communicate in writing. Literacy strategies geared toward writing for science classes help students organize and deliver facts and clarify their understanding of scientific concepts.

WRITING FRAME

What It Is

A writing frame creates an outline. The two related student sheets are geared toward explanatory writing on evidence-and-trade-offs and designing investigations work. Through prompts and spaces for students to fill in short responses to the prompts the writing frame leads students to develop headings, sentences, and main content points.

Why to Use It

Writing frames are an excellent way for students to develop their ideas prior to writing extended Analysis Question responses or to organize their ideas prior to completing a writing assignment. In *Science and Sustainability,* writing frames are most useful where the teacher will assess students with the EVIDENCE AND TRADE-OFFS (ET) and the DESIGNING INVESTIGATIONS (DI) scoring guides.

How to Use It

Teachers first provide direct instructions on the appropriate type of writing frame and the components it includes. For example, when introducing the EVIDENCE AND TRADE-OFFS (ET) Writing Frame (see Literacy Student Sheet 2a), instruct students on the components essential to the structure of the essay, including an opening sentence that states the decision or conclusion the student has come to, inclusion of evidence that supports the decision or conclusion, and a discussion of the trade-offs associated with the conclusion. Literacy Student Sheet 2b provides the template for Designing an Investigation Writing Frame. A sample writing frame is shown in below.

Sample Student Response to Analysis Question 4

There is a lot of discussion about *the issue of introducing nonnative oysters to Chesapeake Bay.*

My decision is that *the nonnative oysters should be introduced to the bay.*

My decision is based on the following evidence:

First, *it will increase the number of oysters in the bay. The nonnative oysters breed and grow quickly and can grow in the poor water conditions that presently exist in the bay.*

Second, *having more oysters will mean more jobs and more income for families and businesses that depend on the oyster catch.*

Third, *the presence of more oysters will lead to more filtering of the water in the bay. This will help to improve the water quality of the bay and will help increase the native oyster population.*

Some trade-offs of my decision are that
we do not know all of the effects of introducing the nonnative oyster into the bay, especially how it will affect other organisms and whether it will stay in the bay or spread into other areas.

WRITING REVIEW

What It Is

A writing review is a peer-review activity that is especially useful in guiding students to write complete and coherent Analysis Question responses, procedures, and essays that others can understand.

Why to Use It

A reviewer student learns to recognize flaws in logic, gaps in information, or other writing problems that they also may be prone to. The student being reviewed works with his or her peer's constructive comments to improve or revise an Analysis Question response. With successive writing frame opportunities students learn how to provide and accept constructive feedback to help each other improve their class work.

How to Use it

Literacy Student Sheet 3, "Writing Review," lists a set of questions for students to respond to in reviewing another student's work. Explain to students that the most useful feedback is detailed and constructive. For example, the comment "this is a bad answer" does not provide any details for how the author can improve the writing. If the teacher will eventually score the piece of writing with a Scoring Guide, direct students to apply specific criteria from the Scoring Guide to critique each other's writing. For writing subject to the EVIDENCE AND TRADE-OFFS (ET) Scoring Guide, for example, the reviewer student should note all scoring guide criteria for securing a Level-3 score. Once students have reviewed each other's work, they should revise their writing according to the feedback from the other student's evaluation of their work. If necessary, the teacher might have students conduct another round of review and revision to make sure each student's piece is complete and correct.

Strategies for Facilitating Group Discussion

Oral communication opportunities in the classroom can be either informal or formal. Informal communication refers to the conversations that happen among students in pairs, in small groups, or as part of a class discussion. This informal talk allows students to express their ideas and modify them

as they listen to others' ideas, and is an important step in the development of their thinking. Formal communication refers to oral presentations in which students present information or ideas and others listen. In both cases, it is essential to be clear to students about the purpose(s) of the discourse and what it must accomplish. Because the Student Book and/or Teacher's Edition lists expectations for formal communications, most of the suggestions described below refer to improving informal communication in the classroom.

When beginning or assigning an informal discussion, explain to students its purpose. Students might be asked to share opinions, review ideas presented in class, solve problems, compare data, or cement their understanding of new material. Then identify the tasks involved for students to achieve the purpose. For example, the teacher may ask students to first share their opinions in small groups, then identify one person in their group to summarize these opinions for a class discussion, listen to groups' summaries as a class, and comment on the summaries as a class.

A challenge for classroom discussions is to make sure all students contribute. In many cases, providing students adequate time to think or jot down their ideas will enhance participation and the level of thought during a discussion. After the teacher poses a question or an idea, he or she might instruct students to think about their responses for an appropriate amount of time. Discourage quick thinkers from raising their hands or shouting responses before this time period is over. Once discussion begins, if too few students offer responses to the question, the teacher may need to revise or rephrase the question. The teacher may also record or monitor the frequency with which he or she calls on certain students to be sure all feel encouraged to speak.

Another challenge that often arises is how to keep the majority of students engaged and participating. Identify the goals of the discussion, and help maintain this focus. Expect students to be good listeners and to not repeat what has been said. If necessary, clarify or ask questions, but encourage students to speak for themselves. Typically, problems encountered in group discussion are compounded by problems that students have in working together. The following strategies can be used to encourage participation in discussions.

INFORMAL MEETING OF THE MINDS

What It Is

An Informal Meeting of the Minds is a discussion strategy similar to the think-pair-share method. It engages students in an evidence-based discussion about an investigation, laboratory results, or issue-related question.

Why to Use It

This strategy allows students time in one or more pairs to informally discuss, in critical thought, what they observed, what they can conclude, or their reasoning related to an issue, problem, or experiment. They express their thoughts and listen to those of others, which helps them process information. In addition, an Informal Meeting of the Minds simulates the informal conversations that occur between collaborating scientists.

How to Use It

After students collect evidence from an investigation or laboratory, they will pair up with a person from another group of four to conduct an information discussion. Each student presents to the other student the opinions, findings, and/or evidence derived from the work of his or her own group. The two then discuss the similarities and differences in their information or thinking. The teacher may then open the exercise into a whole class discussion. For example, two students from two groups might start by discussing their findings from a laboratory investigating variables that affect the rate of enzyme action. They compare their results and discuss, perhaps, what may have gone wrong in one of the investigations and why it happened. In a class discussion then, each student has a broader base of understanding from which to present his or her ideas about what conditions are needed for a controlled experiment. Additionally, if different groups have different results, you might ask the class to discuss the types of errors or factors that lead to the variety of results among the class.

DISCUSSION WEB

What It Is

A discussion web is a graphic organizer that helps students arrange evidence they have gathered primarily from readings. Literacy Student Sheet 4 provides a template for this strategy. Discussion webs may also be used to process evidence and information from activities and additional sources. They use this evidence in group discussion to arrive at a conclusion. In the center of the web is a question or position that is central to the discussion. It is posed in a way that presents at least two options to consider, such as pro or con. In the columns on either side of the central question students record evidence in support of each of the two sides before arriving at a conclusion.

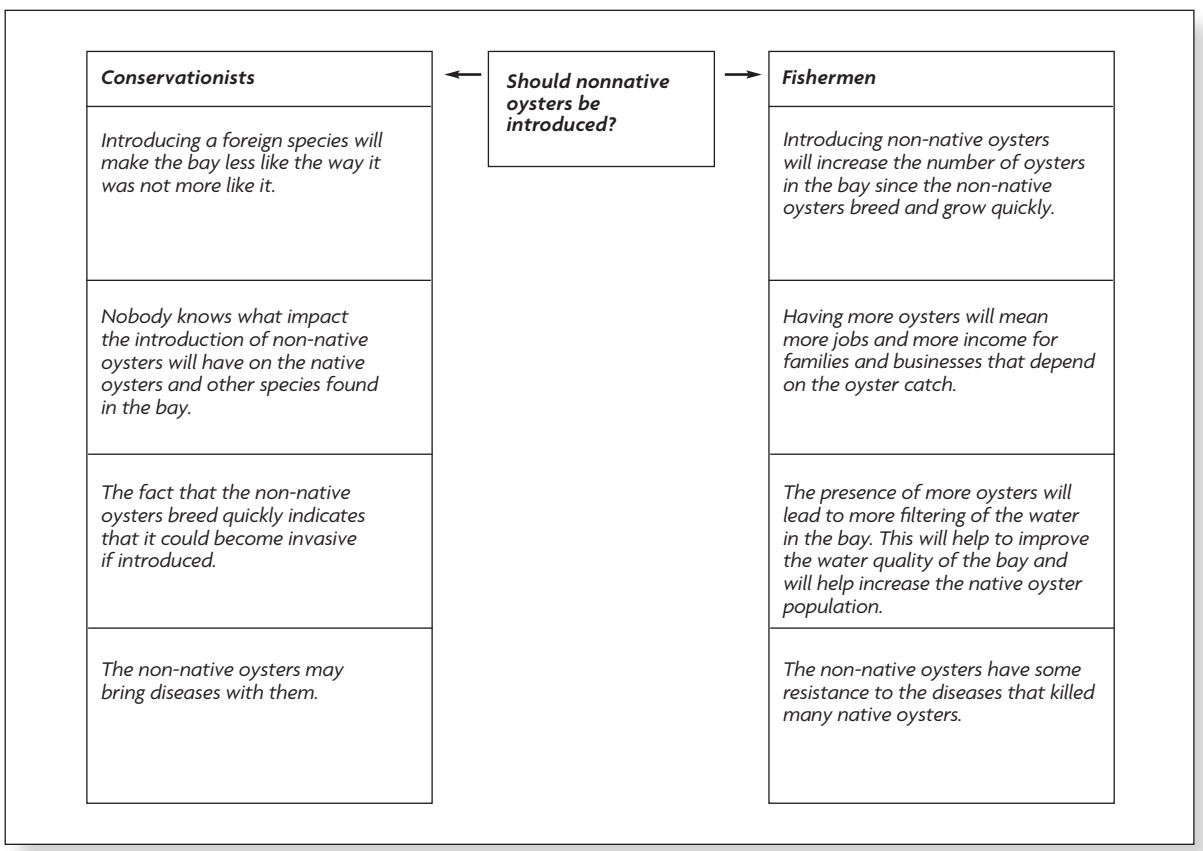
Why to Use It

Discussion webs support students in engaging with information from text and other sources and then with each other to come to an evidence-based conclusion. Any question or issue that involves two viewpoints or more than one potentially acceptable answer can be explored using this strategy. This strategy can be used as a preface or follow-up to group discussions.

How to Use It

Introduce students to the question they will be considering, and tell them where to enter it on the discussion web student sheet. The teacher may initiate students' use of a discussion web with any question or issue that provokes more than one answer or perspective. Questions may come from the challenge of an activity, an analysis question, or any question that has more than one correct response. If using this strategy with a reading, prepare students for reading by activating their existing knowledge, asking them to predict what they will read about, and have them pose questions about the topic they will read about. During the reading pairs of students fill out one discussion web student sheet with ideas and evidence from the text. It is not essential that they fill in all lines, but they should collect as much evidence as possible from the reading and/or

Sample Completed Discussion Web



additional sources for both sides. Groups of four work together toward consensus and a conclusion about the evidence they have collected or in response to the question they are exploring. The groups select the evidence from their discussion web that best supports their conclusion. In a class discussion representatives from each group report their conclusion and their supporting evidence. Each student writes his or her response to the question, including supporting evidence both from the whole class discussion and the evidence recorded on the Discussion Web.

Variations: Once students are comfortable with this tool, adjust the social arrangements for completing and discussing the question to encourage more independent work. Students may complete the web individually and discuss the evidence with a partner instead of with a group and the entire class.

WALKING DEBATE

What It Is

A walking debate allows students to express their opinions about an issue by moving from one area of the room to another. Each area represents a certain side of an issue. Students select an area to stand in based on the side of an issue they agree with. The "sides" then discuss the issue and present their arguments to the other groups. Students can opt to change their location if the presentations given change their opinions about the issue.

Why to Use It

In asking students to choose a position and stand in the corresponding area of the room, the Walking Debate requires students to physically commit to a position. This serves several purposes. First, it requires that students take a position. Secondly, students will more clearly see the distribution of thoughts, ideas, or opinions among their classmates. Possibly most importantly, the debate involves movement, which, researchers suggest, provides sensory input to the brain that enhances learning (Jensen, 1998). Walking Debate allows students yet another way to practice identifying evidence and reasoning in a group setting, which is an important component of scientific argumentation.

How to Use It

Begin by identifying the question or issue that is being debated, and designate different parts of the classroom as representing certain points of view. For example, for the question "should Jaffrey City charge new taxes?" one corner of the room would be designated as the "yes" area and another the "no" area. Students walk to the corner that best represents their point of view and talk within that group to come up with a convincing argument to bring people from other areas to their own area. The groups make their presentations, students ask questions of the other groups, and those who change their minds move to the area that represents their final position.

Over the course of one activity, several activities, or a unit, the class may encounter more evidence related to the debate issue. If the first Walking Debate was successful, the teacher might give students a chance to repeat the debate and decide if they will change positions. It is helpful to have students keep a record of the evidence they will consider for the Walking Debate, especially when they are new to the strategy. Have students record their evidence on an index card to which they can easily refer during the debate. Students might do this in pairs when they are becoming familiar with the strategy.

Strategies for Understanding Concepts

The following strategies help students synthesize concepts and vocabulary.

CONCEPT MAP

What It Is

In a concept map, the main concept is written on a page (sometimes within a circle), subtopics are placed around it, connecting lines are drawn between each subtopic and the central concept, and a brief description of the relationship is written on or near the line. Concept maps demonstrate students' understanding of connections between topics.

Why to Use It

Concept maps ask students to describe connections between main ideas and subtopics, as well as among the subtopics themselves.

How to Use It

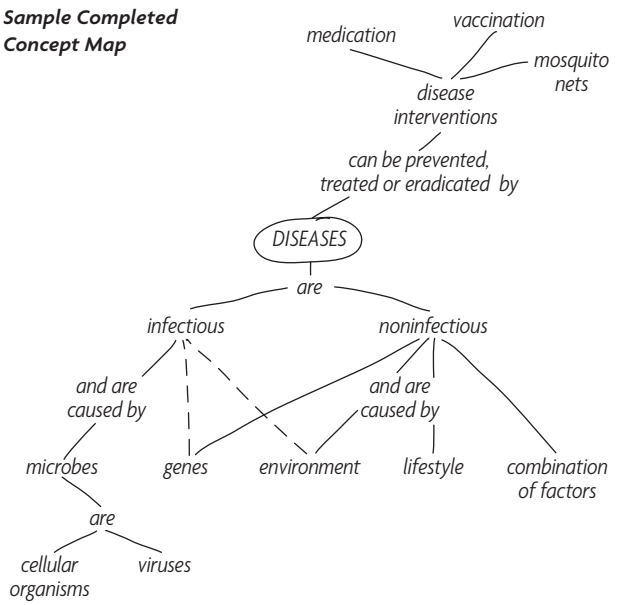
There are many ways for students to create a concept map. Initially, they may find it helpful to be given a list of words that must be included on the map, or be provided with an incomplete concept map to fill in.

For subsequent concept maps, students might brainstorm words that should be included or create a map independently. When students create their own concept maps, they may find it helpful to write each subtopic on an index card or sticky note so that they can physically manipulate and lay out the map before transferring it to paper.

Literacy Transparency 4 provides a set of instructions for constructing a concept map.

If your students are unfamiliar with concept maps, model the process using a familiar central idea, such as school. Write school on the board, and with the class brainstorm subtopics to place around it (i.e. what are words and ideas associated with school?). Off to the side, organize these subtopics in a hierarchy, listing the more general ideas first, and the more specific ones toward the bottom. Arrange the ideas spatially on the map, with the more general ideas closer to the central topic and the more specific ideas radiating out from the general ideas. Link the general ideas to the central concept with ideas, words, or short sentences defining the connection between the concepts. Then add links explaining the connection between the general and more specific ideas.

Sample Completed Concept Map



KWL

What It Is

KWL is a strategy that begins with students writing down what they know about a topic (K), then asks them to think about and write down what they want to know about it (W), and leads them to record what they have learned about the topic during and after instruction (L). Students record these three aspects of the KWL strategy in a three-column chart, such as the one shown on Literacy Student Sheet 5, and in the sample on the next page.

Why to Use It

The KWL allows students to first determine what they already know about the topic or concept before learning more. This is important because their current level of knowledge and understanding will help the teacher know how to focus instruction. Because it reveals students' existing knowledge and possible misconceptions, a KWL serves as a formative assessment. By repeatedly engaging in this strategy throughout the course students become experienced in an independent learning technique as they monitor what they know, what they do not know, and what they are interested in knowing more about.

How to Use It

Over the course of the topic or unit, have students keep track of new ideas and answers to their questions by completing the third column (L) of their sheets. Help them think about new ideas by asking such questions as Which questions have been answered? What did you learn that you did not expect? What new questions do you have about the topic? You may also ask students to write in their science notebooks a more formal summary of what they learned.

Sometimes it is appropriate to conduct this strategy with the whole class. In such cases, a large piece of chart paper may be posted in the classroom to keep track of students' ideas over the course of a unit or topic. The KWL may also be done in pairs or groups of four instead of individually.

Sample Student Response, KWL: Stem Cells

Know	*Want to know*	*Learned*
• *Blood is produced from blood-forming stem cells (Activity 13).* • *Stem cells can differentiate into more than one kind of specialized cell (Activity 14).*	• *Why can't scientists just use adult stem cells to treat diseases?* • *What kinds of diseases are treated with stem cells?* • *At what stage of an embryo's development are stem cells taken from human embryos?*	• *There are several types of stem cells.* • *Stem cells vary in the kinds of cells they produce, from totally potent, to pluripotent, to multipotent.* • *Because embryonic stem cells are totipotent—they can produce any kind of cell—they might be more useful in treating many diseases.* • *Adult stem cells are usually multipotent, and can only produce certain cell types.* • *Embryonic stem cells are obtained from early-stage embryos in which the cells have not begun to differentiate.* • *Getting stem cells from an embryo destroys the embryo. That's why embryonic stem cell research is controversial.* • *Stem cells are most likely to work at treating or curing non-infectious diseases that affect one kind of cell.*

SCIENTIFIC DIAGRAMS

What It Is

Scientific Diagrams are useful when students are asked to construct diagrams to visually communicate their ideas about a concept. After completing an activity or activities, they adjust the picture to represent their new understanding. The strategy asks students to explain how their diagram, and thus their understanding, has changed. Literacy Student Sheet 6 is a template for this strategy.

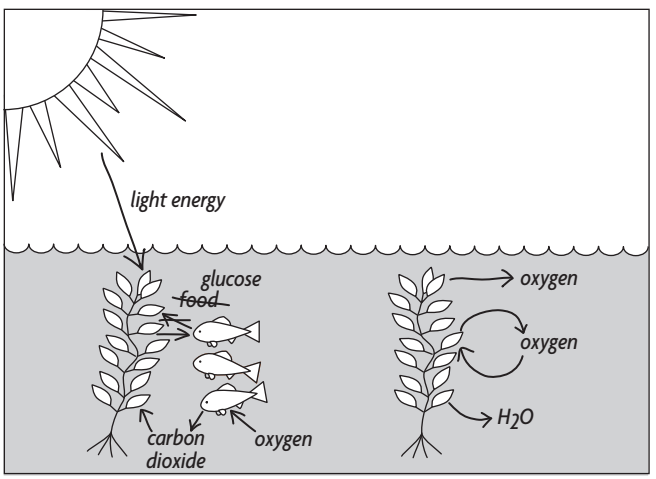
Why to Use It

When constructing a scientific diagram both before and after an activity students experience the reflective process by which skilled science learners incorporate new conceptual understanding with previously held ideas. Scientists create diagrams to describe concepts and hypotheses, and they go back and refine those models as necessary. This draw-and-explain strategy is also helpful to visual learners.

How to Use It

Before students begin a learning activity the teacher hands out the student sheet and asks students to draw what the exercise calls for and write explanations on it as instructed. After the activity, the teacher has students return to their initial drawings and record thoughts or changes, or create a new drawing that represents their more developed conceptual

Sample Scientific Diagram



understanding. An example of a completed scientific diagram appears below. Once complete, ask students to discuss with a partner how their ideas changed. This opportunity to verbalize their revised impressions encourages students to reflect on how their understanding has changed and reinforces their new understanding.

The teacher may incorporate a scientific diagram whenever it is appropriate for students to express their understanding in pictorial form. Always provide an opportunity for students to return to their diagram, make adjustments based on their new understanding, and discuss the changes with a partner.

VENN DIAGRAM

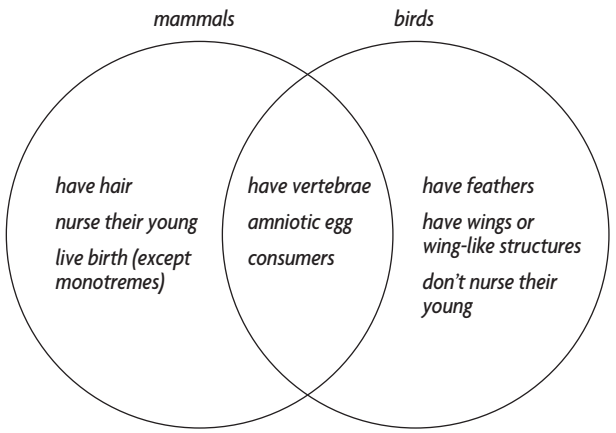
What It Is

A Venn diagram involves drawing two or more overlapping circles in which words or phrases are inserted to help visually depict the similarities and differences of two or more things, concepts or categories. Each circle is labeled according to the subjects being compared, and students write in the outer part of each circle information that is unique to the subject of the circle. In the overlapping space they write down the elements common to both subjects.

Why to Use It

A Venn diagram allows students to visually map characteristics that are both unique and shared among a set of concepts or things. The diagram is flexible and easily adjusted by adding additional circles to compare up to four ideas.

Sample Venn Diagram



How to Use It

Direct students to set up the diagram with the appropriate number of circles, one for each subject being compared. The circles must intersect so that there is an overlap for each category, as shown below. Venn Diagrams may be completed as a class, in groups, in pairs, or by individual students.

Model the strategy using a simple, two-circle design to compare two familiar things, such as mammals and birds. Label one circle "Mammals" and the other "Birds," leaving the overlapping section blank. Ask the students how mammals differ from birds. For each feature the students list, write it in the appropriate circle. Then ask the students what mammals and birds have in common, and record their responses in the section of the circles that overlaps.

The completed diagram helps students compare and contrast things in both discussion and writing. Literacy Student Sheet 7 is a template for this strategy.

SCIENCE NOTEBOOKS

A science notebook is a useful tool for students and teachers in terms of student learning and classroom management. Keeping a science notebook helps students track data, record questions as they arise in investigations and discussion, and build science-writing skills. As a literacy tool, science notebooks allow for student reflection and facilitate student discourse. All *Science and Sustainability* activities are set up to encourage the use of science notebooks. Following are some suggestions of ways to set up a science notebook at the beginning of the course.

- The notebook should have sturdy covers, whether it is fixed-page composition-style, spiral bound, or other type of notebook that will not lose pages easily.
- Students should make a title page and table of contents pages. The table of contents must allow space for the activity titles and notebook page numbers for easy reference after students have completed activities.
- Have students number each page.

- Students should set up a column on the left third of each page that leaves room for reflections, questions, and notes on key ideas and vocabulary. The teacher may also use this space to record feedback on students' work.
- Have students make entries in a specific format that is the same for every activity. For example:
  - Purpose (copied from Student Book)
  - Materials (summary of what they will use and a place for a check mark when they have collected all the materials they need)
  - Data (data tables, notes from readings, what they discussed as a group)
  - Analysis questions
- If students are conducting an investigation, show Literacy Transparency 6, "Setting up a Laboratory Investigation," to guide the information they record in their science notebook.
- Post guidelines for notebook formatting and follow this format when writing any assignments on the board or overhead.
- If students need to make corrections they can neatly cross out the old information and insert the new information after it. This reflects how scientists maintain their own data records.
- Copy student sheets at a size that students can paste or tape into their notebooks. Have tape, glue sticks, or staplers available for students at all times. Whenever possible, have students write directly in their notebooks rather than on the student sheets.

WRITING A FORMAL INVESTIGATION REPORT

The formal investigation report outlined on Literacy Transparency 7 helps students summarize the purpose, hypothesis, results, and conclusion in an abstract. The abstract is followed by a summary of the experimental design, procedure description, data, data analysis, and conclusion. These sections parallel those of Literacy Transparency 6, "Setting up a Laboratory Investigation."

VOCABULARY DEVELOPMENT

A textbook lesson or laboratory experience often begins with the teacher introducing new terms by listing them on the board. The number of new words may be overwhelming. In many cases, students learn that memorizing these words and their definitions helps them to succeed on the "end-of-the-chapter test." However, they soon forget the memorized words, unless they need to learn them for another exam.

Science and Sustainability introduces new words operationally. To understand a word is to know more than a single definition; it is also to know the meaning of the word in different contexts and how it relates to other concepts. Therefore, knowledge of a word is conceptual knowledge. In *Science and Sustainability,* students learn about a word in context and master definitions through their observations and discussions of phenomena. For example, when students work with descriptions of relationships between organisms, they have to categorize several organisms based on those relationships. Each relationship is an example of parasitism, mutualism, commensalism, or amensalism—but those terms are not initially introduced. After the students have categorized the examples, they must develop their own descriptions of each type of relationship. Only then are they given the scientific terms and formal definitions. As a result of making their own meaning of the relationships, students master the new terms more easily. This enhances their ability to communicate effectively about science.

Teachers might use any of the following steps to provide direct instruction if students are struggling to determine the meanings of specific vocabulary words:

1. Give a description, explanation, or example of the new word or phrase.
2. Ask students to restate the description, explanation, or example in their own words.
3. Ask students to construct a graphic or symbol to represent the word or phrase.
4. Ask students to discuss the words and phrases with each other from time to time.

5. Ask students to revise their words or phrases as they get new information or new understanding.

The index at the back of the Student Book contains page references for all key vocabulary. In addition, a glossary is provided at the end of the Student Book with definitions for each key vocabulary word. Students should refer to the glossary after they have worked with the word in context and reached the point in the unit where the term has been formally defined (as indicated by bold text). Research has shown that students develop a deeper understanding of terms if they determine their meaning through context and experience. The glossary is best used only after this understanding has been developed.

THE PERSONAL VOCABULARY LOG

A personal vocabulary log is a tool students use to record and monitor their understanding of new words. SEPUP suggests that students try to determine the meanings of words they do not know, and keep track of these words in a personal vocabulary log.

Two possible formats for personal vocabulary logs are shown below. Either one may be modified to best meet student needs.

Personal Vocabulary Log

WORD	DESCRIPTION OF MEANING	DRAWING OR DIAGRAM	EXAMPLE

Personal Vocabulary Log

Word _____

It is related to _____

The specifc context is _____

_____

_____

I think it means _____

_____

_____

The correct definition is _____

_____

_____

_____

It reminds me of _____

_____

_____

The use of the word in a sentence is

_____

_____

ADDITIONAL LITERACY TOOLS

RESEARCH PROJECTS

Typically, a research project in *Science and Sustainability* addresses a series of questions embedded in the Student Book or on an accompanying student sheet. Additional suggestions and guidelines appear in the Teacher's Edition's Teaching Suggestions section for the activity in which the research project is described and begun. The teacher should decide how students will choose or be assigned a particular topic to research, and whether students should complete the project individually or in small groups. When giving the assignment the teacher must be sure to explain how he or she plans to assess students' work. One or more of the scoring guides from the SEPUP Assessment System, such as the COMMUNICATION SKILLS (CS) Scoring Guide, may be the appropriate assessment tool.

Guide students by establishing expectations and interim deadlines. Such deadlines would include:

- Finding sources. (For many students, going to the library to find information or collecting data requires the greatest amount of time.)
- Using sources to obtain information.
- Summarizing the research findings.
- Creating the final product and/or presentation.

If students are going to use the Internet for research, establish expectations for sources of reliable and current information. Encourage students to summarize or paraphrase their findings, and not to just copy language from the original source. Suggest that students look for graphics to help communicate key ideas.

Depending on your student population, the project might be conducted outside of class time, on a class schedule (for example, one class period a week for four weeks), or a combination of the two. Let students know how much time will be allocated for the project, both in class and at home. If students are expected to work in groups, be sure to provide some class time for them to collaborate.

After students have begun their initial research, help them organize their materials and synthesize their ideas. This can be done by sitting with each student or group for a few minutes and discussing the work that they have completed to date. Ask them such questions as: What have you learned about this topic so far? What do you still need to find out? Where will you find this information?

Some groups may need help with task allocation. Groups that include students with special needs may require particular attention to make sure all students are appropriately included in the group's work. Be sure each student in a group has an opportunity to demonstrate his or her competence. For example, a student who has trouble synthesizing information may be more successful at finding resources or providing graphics or talent for presentations. Review with each group what they still need to do to be ready to present their project to the class.

ORAL PRESENTATIONS

Oral presentations are a form of formal oral communication. Literacy Transparency 4, "Oral Presentations," can be used to help students organize what they will say. These presentations are usually constructed by student groups rather then individuals, and so teachers may use both the GROUP INTERACTION (GI) and COMMUNICATION SKILLS (CS) scoring guides to assess the presentations.

Students who are speaking on an issue may be asked to present all sides of an issue to help the audience make a fair decision, or they may be asked to present one side while another student (or group) presents the other side, as in a debate. In many cases, there is more than one resolution, each with its respective trade-offs. Keeping personal biases and opinions out of the presentation is challenging for some students, and they may need to practice on a small audience of one or two beforehand. The teacher might discuss why it is a good idea to present unbiased information when people are trying to make decisions.

REFERENCES

Biancarosa, G., & Snow, C. E. (2004). *Reading next: A vision for action and research in middle and high school literacy. (A report from Carnegie Corporation of New York.)* Washington, DC: Alliance for Excellent Education.

Donovan, S., Bransford, J. D., & Pellegrino, J. W. (Eds.). (1999). *How People Learn: Bridging Research and Practice.* Washington, D.C.: National Research Council Committee on Learning Research and Educational Practice.

Douglas, R., Klentschy, M., Worth, K., & Binder, W. (Eds.). (2006). *Linking science and literacy in the K-8 classroom.* Arlington: NSTA Press.

Freedman, R. L. H. (1999). *Science and writing connections.* White Plains, NY: Dale Seymour Publications.

Kanare, H. M. (1985). *Writing the laboratory notebook.* Washington, D.C.: American Chemical Society.

Jensen, E. (1998). *Teaching with the brain in mind.* Alexandria, VA: Association for Supervision and Curriculum Development.

Marzano, R. J., Pickering, D. J. (2005). *Building academic vocabulary: Teacher's manual.* Alexandria: Association for Supervision and Curriculum Development.

Marzano, R. J. (2003). *What works in schools: Translating research into action.* Alexandria: Association for Supervision and Curriculum Development.

National Research Council (NRC). (1996) *National science education standards.* Washington, DC: National Academy Press.

Saul, W. E. (Ed.). (2004). *Crossing borders in literacy and science instruction.* Newark, DE: International Reading Association.

Schoenbach, R, Greenleaf, C., Cziko, C., & Hurwitz, L. (1999). *Reading for understanding: A guide to improving reading in middle and high school classrooms.* San Francisco: Jossey-Bass.

Scott, J. (Ed.). (1993). *Science & language links: Classroom implications.* Portsmouth, NH: Heinemann.

Thier, M. & Daviss, B. (2002). *The new science literacy: Using language skills to help students learn science.* Portsmouth, NH: Heinemann.

Tierney, B., & Dorroh, J. (2004). *How to...Write to learn science.* Arlington, VA: NSTA Press.

Topping, D., & McManus, R. (2002). *Real reading, real writing: Content area strategies.* Portsmouth, NH: Heinemann.

Tovani, C. (2004). *Do I really have to teach reading? Content comprehension, grades 6–12.* Portland, ME: Stenhouse Publishers.

Tovani, C. (2000). *I read it, but I don't get it: Comprehension strategies for adolescent readers.* Portland, ME: Stenhouse Publishers.

Vacca, R.T. & Vacca, J. A. L. (2002). *Content area reading: Literacy and learning across the curriculum.* Boston, MA: Allyn and Bacon.

Wellington, J. & Osborne, J. (2001). *Language and literacy in science education.* Buckingham, UK and Philadelphia: Open University Press.

Wood, K. D. (2001). *Literacy strategies across the subject areas: Process-oriented blackline masters for the K-12 classroom.* Boston: Allyn and Bacon.

Wood, K. D., Lapp, D., & Flood, J. (1992). *Guiding readers through text: A review of study guides.* Newark, DE: International Reading Association.

Worsley, D. & Mayer, B. (1989). *The art of science writing.* New York: Teachers & Writers Collaborative.

Anticipation Guide Template

Before starting the activity, mark whether you agree (+) or disagree (−) with each statement below.

After completing the activity, mark whether you agree (+) or disagree (–) with each statement below. Under each statement, explain how the activity gave evidence to support or change your ideas.

BEFORE **AFTER**

_____ _____ 1. _____

_____

_____ _____ 2. _____

_____

_____ _____ 3. _____

_____

_____ _____ 4. _____

_____

_____ _____ 5. _____

_____

Reading Scientific Procedures

The purpose of reading the full description of a scientific procedure is to find out exactly what to do, when to do it, and what materials you need to do it, so that you can correctly complete an investigation.

Always read through the procedure steps before you begin an investigation to make sure you have all of the tools, materials, and space you will need.

If you read a step and are not sure what to do, try these strategies:

- Reread the step. Sometimes rereading clarifies the information.
- Reread the previous step.
- Ask your partner if he or she understands what the step says to do.
- Ask your partner to read the step aloud as you listen and try to do what your partner describes.
- Try to explain the purpose of the step to your partner.
- Look for the clues in the pictures in the Student Book.
- Reread the purpose (Challenge) of the investigation.
- Look at what other groups are doing, and listen to see if they are completing the step that confuses you.
- Tell your teacher exactly what you are confused about and why it doesn't make sense.

"Read, Think, and Take Note" Guidelines

As you read, from time to time, write one of the following on a sticky note:

- Explain a thought or reaction to something you read.
- Note something in the reading that is confusing or unfamiliar.
- List a word that you do not know.
- Describe a connection to something you learned or read previously.
- Make a statement about the reading.
- Pose a question about the reading.
- Draw a diagram or picture of an idea or connection.

After writing the sticky note, place it next to the word, phrase, sentence, or paragraph in the reading that prompted your note.

Oral Presentations

- Focus your presentation on the most important ideas you want to communicate.
- Communicate clearly by planning your words in advance. When speaking, talk slowly and loudly, and look at your audience.
- Include graphs, maps, and other helpful visuals when possible. Make sure the images are large enough for everyone in the audience to see them.
- Even if you have your own opinions on a topic, it is important that you present unbiased and complete information. Your audience can then make their own conclusions from the evidence you present.
- Make sure that all the members of your group participate.
- Because any group member may be asked to answer questions from the class, all group members should fully understand the presentation.
- For a group presentation, you might each play the role of a different expert. The class would represent the community members who would be making a decision on the issue.

Instructions for Constructing a Concept Map

1. Work with your group to create a list of 15–20 words related to the main topic.
2. Discuss with your group how all of the words on your list are related, and sort your list of words into 3–5 categories based on these relationships. Listen to and consider the ideas of other members of your group. If you disagree with others in your group, explain to the rest of the group why you disagree.
3. Identify words that describe each category.
4. Work with your group to create a concept map on this topic. Follow these steps:
    a. Write the topic in the center of your paper, and circle it.
    b. Place the words describing each category around the topic. Circle each word.
    c. Draw a line between the topic and each category. On each line, explain the relationship between the topic and the category.
    d. Repeat steps 4b and 4c as you continue to add all of the words on your list to your concept map.
    e. Add lines to connect other related words. Explain the relationship between the words on the line.
5. View the concept maps of other groups. As you look at their concept maps, observe similarities and differences between their maps and yours. Discuss your observations with your group members.

Setting up a Laboratory Investigation

The following is a guide for conducting an investigation and recording it in your science notebook. Depending on the investigation, you may not always need all of the steps below or use them in the same order.

Title: Choose a title that describes the investigation.

Purpose: What are you looking for?

Write what you are trying to find out in the form of a question.

Background: What do you know about the topic?

Write a summary of background information you have on the topic that led to the purpose for the investigation.

Hypothesis: What do you predict will happen?

Write a statement that answers the question that you posed in your Purpose section. Explain what data you predict you will see and why you are making that prediction.

Experimental Design: How will you answer the question?

- Describe the investigation methods you will use to answer the Purpose question.
- Write short, numbered steps that are easy to follow.
- Make a list of the materials you will need.
- Identify the independent and dependent variables and whether you will have a control.

Data: What are you finding?

Record all observations and measurements. Create a data table if appropriate for organizing and easily comparing the data. Do not forget to record results using proper units of measurement, and write clear labels for your table columns.

Setting up a Laboratory Investigation (Continued)

Data Analysis: Represent the data in a way that is easily interpreted.

Use graphs, diagrams, or charts where appropriate to help explain what occurred.

Results and Conclusions: What does the data mean?

At the end of your investigation:

- Summarize the results.
- Make inferences or draw conclusions about the data:
  The data show that...
  This result likely occurred because...
- Think about any errors that occurred during the investigation:
  What did not go as planned?
- What limitations of the design, materials, or instruments might have affected the accuracy of the results?

Think of questions you still have that could lead to new investigations:

We would need to investigate further to determine if . . .
It is still unclear . . .

Keep track of new ideas that could lead to new investigations:

To investigate this further we might . . .
An interesting thing to do would be to . . .

Reflect on the outcomes of the investigation:

This investigation successfully demonstrated that . . .
This investigation did not demonstrate . . .
If this investigation were repeated, the results would be clearer if . . .

Writing a Formal Investigation Report

Use the information from your science notebook to write a formal report on the investigation you performed.

Title: Choose a title that describes the investigation.

Abstract: What were you looking for in this investigation, and what did you find? Write a paragraph that summarizes what you already knew about the topic, your purpose, hypothesis, results, and conclusion.

Experimental Design: Describe the materials and investigational methods you used to answer the question. State what variables you worked with and any controls.

Data: What did you find? Report observations and measurements. Include an organized data table if appropriate to help someone reviewing your report to easily see the results. Don't forget to use proper units of measurement and write clear labels for your table columns.

Data Analysis: Represent the data in a way that can be easily interpreted. Use graphs, diagrams, or charts where appropriate to help a reviewer interpret your data.

Conclusion: What does the data mean?

- *Summarize the data.*
- *Discuss your conclusion based on the accuracy of your hypothesis and the data you collected.*
- *Discuss any errors that occurred that may have interfered with the results.*
- *Describe any changes that need to be made the next time the investigation is performed.*
- *Describe any new questions to be investigated based on the results of this investigation.*

NAME _____ DATE _____

Three-level Reading Guide Template

1. Check the statements below that you believe agree with what the reading says. Sometimes, the exact words found in the reading are used. At other times, other words may be used to communicate the same meaning.

   _____ a.

   _____ b.

   _____ c.

   _____ d.

2. Check the statements below that you believe represent the intended meaning of the reading.

   _____ a.

   _____ b.

   _____ c.

   _____ d.

3. Check the statements below that you agree with, and be ready to support your choices with ideas from the reading and from your own knowledge and ideas.

   _____ a.

   _____ b.

   _____ c.

NAME _____ DATE _____

Writing Frame—Evidence and Trade-offs

There is a lot of discussion about the issue of _____

_____

_____

_____

My decision is that _____

_____

_____

_____

My decision is based on the following evidence: _____

_____

First _____

_____

_____

_____

Second, _____

_____

_____

_____

Third, _____

_____

_____

_____

The trade-off(s) of my decision is (are): _____

_____

_____

_____

_____

NAME _____ DATE _____

Writing Frame – Designing Investigations

The purpose of my investigation is to _____

_____

The variable I am testing is _____

The variables that I am keeping the same are _____

_____

_____

I will need the following materials: _____

_____

_____

The data I will collect and record in my table in my science notebook will include:

_____

My conclusion is that _____

_____

The evidence and reasoning that led me to this conclusion is _____

_____

_____

_____

NAME _____ DATE _____

Writing Review

Use these questions to review someone else's writing. Answer the following questions after you have read or heard this person's answer at least twice.

Name of person whose writing you reviewed _____

1. State the topic of the writing.

_____

2. a. Are all of the facts clear and accurate? _____

   b. If you answered "no," which facts need to be clearer or need correction?

_____

_____

_____

3. a. Do all of the facts support the writer's position?

   b. If you answered "no," which facts do not support the writer's position?

_____

_____

_____

4. List any statements or ideas that the writer did not support with facts.

_____

_____

_____

5. Do you agree with the writer's conclusion? Explain why or why not.

_____

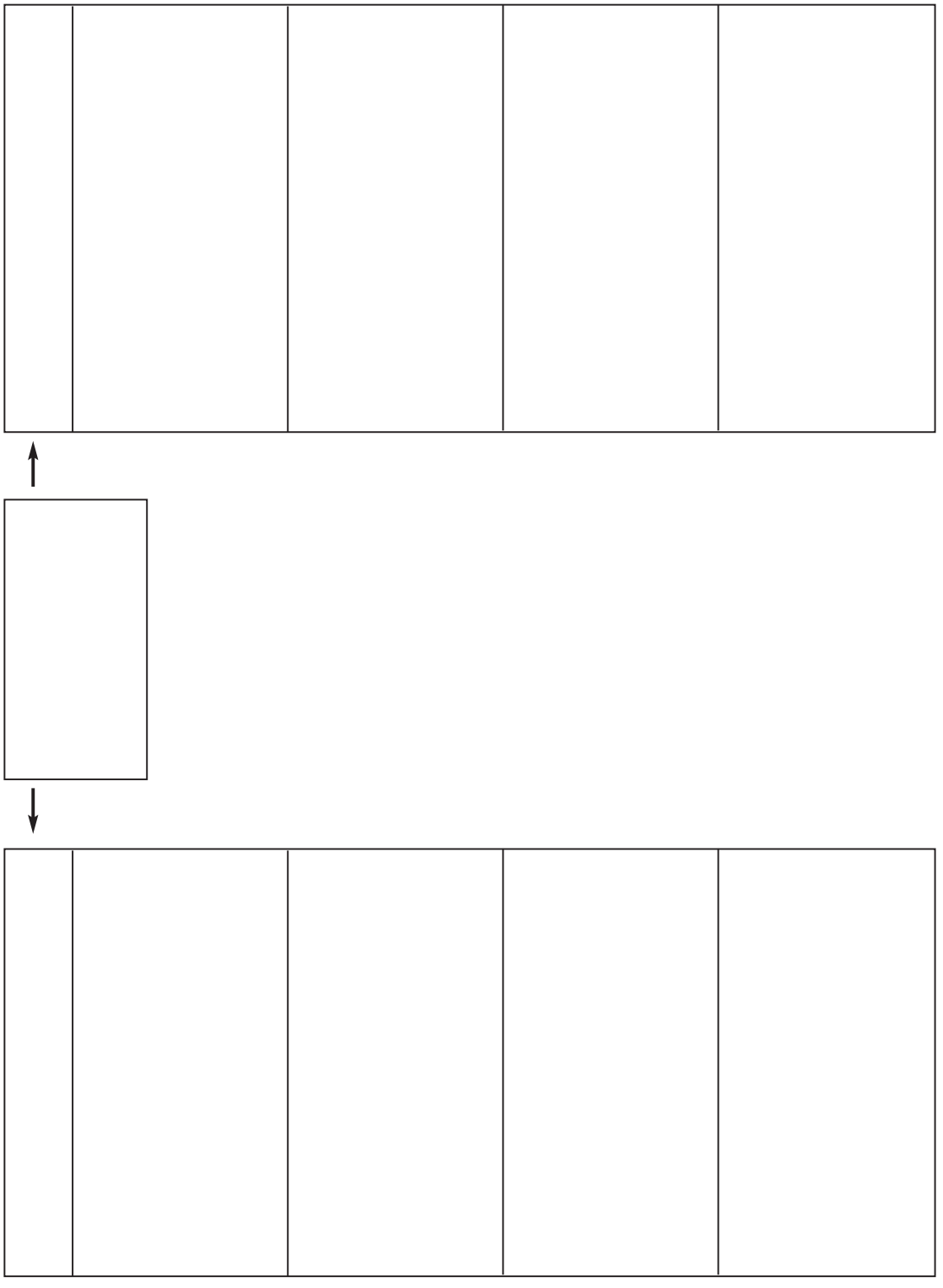
_____

_____

_____

NAME _____ DATE _____

Discussion Web



NAME _____ DATE _____

KWL

What I know	*What I want to know*	*What I learned*

NAME _____ DATE _____

Scientific Diagram Template

1. Close your eyes and think about _____.

   Now, open your eyes and draw what you imagined.

2. You have completed the activity. Now, draw a second picture to show what you have learned.

3. In the space below, tell what you changed in your "after" picture.

NAME _____ DATE _____

Venn Diagram Template

Compare these two ideas by recording unique features of each term on the far side of each circle. Record features that are common to both of these terms in the space that overlaps.