SCHOOLWIDE

The Write Path I

Science

Teacher Guide

Developers

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Acknowledgments

We would like to thank the accomplished *AVID Write Path* science Staff Developers who have shared their expertise and field-tested lessons and activities in this book at AVID Summer Institutes, and in their classes. They have contributed valuable feedback and ideas. We especially want to thank Martin Teachworth and Mark Fairbank for their collaboration and the lessons they provided for the book. In addition, we want to acknowledge the authors and contributors of the previous edition of *The Write Path 1 Science* for the foundation upon which we built: Karen Molloy, Charles R. "Chuck" Downing, Leslie Hays, Brendan Casey, and Mary Catherine Swanson.

We would also like to extend our appreciation to Mark Wolfe, AVID National Director of Curriculum, and Roz Hafner, AVID Assistant Director of Curriculum and Publications, for their support, guidance, and encouragement throughout the process of producing the revised *Write Path* book. We are also very appreciative of the remarkable work of Ben Evans, our editor, Chris Stell, our graphic designer, and Tom Vigliotti, AVID Center's Curriculum and Publications Coordinator, on this project.

Our deepest appreciation is for the students who take the journey of learning science each day with us and inspire us to be better teachers and learners.

Kathy Arno, Mary Martin, Karen Molloy, and Deedra Robinson, 2012

About the Developers

Kathy Arno

Kathy Arno has worked with AVID for 10 years, originally as an AVID District Director and currently as the Science Strand Manager and AVID Program Manager overseeing a grant focusing on math and science. She has an M.S. in chemistry and taught Advanced Placement® Chemistry and Pre-AP® Chemistry for many years. During this time she was also a College Board® chemistry consultant and exam reader. After moving from the classroom to administrative positions, Kathy was the Advanced Academics Coordinator and Science Coordinator in McKinney ISD, Texas. She has conducted workshops for or made presentations to numerous regional, state, and national groups as a science consultant and as an AVID staff member. Kathy developed the national curriculum for four AVID Math and Science Summer Bridge Programs, and was a co-writer and developer of the Science I Summer Institute curriculum. Kathy and her husband live in Texas and hike, bike and travel as often as possible.

Mary Martin

Mary Martin is a dynamic teacher with a Master's Degree in Multi-Cultural Education and Language Acquisition. She has credentials in Mathematics, Biology and Chemistry. Mary has worked for 14 years at Union Middle School in California where she teaches seventh- and eighth-grade science. She also teaches a class for special education students and English Language Learners to help them acquire the science skills they need for high school science courses. Mary has been the AVID coordinator for 11 years and the AVID Elective teacher for nine years at her school. As an AVID science Staff Developer for seven years, Mary has made presentations and conducted trainings at numerous state, local, and national events. She has been the co-writer and co-lead trainer of the AVID Science 1 Summer Institute curriculum for three years. She has also co-authored the curriculum for the ELL Science Path training and developed the online training modules for the AVID Science Summer Bridge Program. Mary currently resides in San Jose, California with her husband and practices yoga almost daily to keep the peace of mind needed for a middle school teacher.

Karen Molloy

Karen Molloy is a National Board Certified teacher at Chantilly High School in Virginia. Her 16-year career includes over 10 years of Advanced Placement teaching experience in Biology and Chemistry. Her teaching career focuses on increasing achievement for special education and limited English proficient students in science with a focus on chemistry, and creating Honors science curriculum for students in mainstreamed classes who may not traditionally enroll in advanced level courses. Karen has presented at national, state and local conferences on Interactive Notebooks, writing-to-learn, graphic organizers and professional learning communities. Having worked with AVID since 1999, she is an author of *The Write Path 2: Life and Physical Science Teacher Guide*, and an AVID Lead Staff Developer and Trainer of Trainers. Karen lives in Fairfax County, Virginia, and enjoys leading her daughters' Girl Scout troops and traveling to visit National Parks with her husband.

Deedra Robinson

Deedra Robinson, M.Ed., has 25 years of experience as a science educator. She is currently the instructional leader and science department chair at Maury High School in Norfolk, Virginia. As an instructional leader in her district, Deedra has made presentations at more than 100 district, state, and national conferences and has earned numerous awards for her accomplishments. She is the co-author of an environmental resource guide and was a teacher reviewer for the Prentice Hall 2000 and 2004 *Science Explorer Physical Science* textbooks. Deedra has worked with AVID since 1995, serving as an AVID Elective teacher or coordinator for nine years, in addition to teaching science. She is also an AVID science Staff Developer and has been the co-writer and co-lead trainer for the AVID Science 1 Summer Institute curriculum for three years. Deedra lives in Virginia Beach, Virginia, and enjoys reading, cooking and traveling with her husband, Gary, and their sons, Christopher and Chandler.

Unit 1

Organizing to Learn

Learning is a messy process that rarely results from a linear flow of thought. It usually requires convolutions, detours, recycling, and thoughtful processing to distill information into facts and synthesize a product. Each student and teacher has to determine the best way to present or learn information.

Information is most useful when it is organized (*Science for All Americans*, 1990). The common denominator for all learning, however, is its active nature. A person must interact with a concept to retain the knowledge and to truly understand it: gather and process information, gather more information, draw conclusions, and process the information again in light of the new findings. The active nature of learning makes it difficult to capture the results in the traditional course notebook which is, by nature, a linear tool. Organizing learning can be cumbersome and often represents a static picture of what a student does (or should) know. This unit will approach the organization of classroom learning by addressing the physical arrangement of materials, recording lesson content, and processing the content to be learned. Using the effective AVID strategies of Interactive Notebooks and Cornell notes will help students physically and mentally organize their learning into one cohesive whole.

Organizing content provides schema or scaffolded structures to aid the brain in understanding science content. Using the techniques outlined in this section will provide paths to help students become successful in classes as well as become critical thinkers who can handle rigorous course content. Knowing how to approach learning sets the learner at ease and allows him or her to move forward to conquer the content of the course. Cornell notes and Interactive Notebooks are two tools that will assist students as they "organize to learn."

Cornell notes and Interactive Notebooks rely on three parts of learning. The first is simply to *record* the information to be learned—referred to as "input." The second part is to *revisit* the "input" by working with the ideas, developing understanding, and making sense of the information. This is the processing stage of learning and it helps students remember the information. Finally, there is the need to *synthesize* and apply the information into a product, the "output." The product can be verbal, as in a summary for Cornell notes, or more creative, such as an original graphic in the Interactive Notebook. Each product requires interacting with the science content, probing further, and thinking about the ideas.

NOTE-TAKING (CORNELL NOTES)

Students' note-taking skills can be greatly enhanced through the use of Cornell notes. Actively recording information to recall and reference later is enormously important in the organization of content material. Note-taking is active involvement in the thinking and learning process. When used effectively, notes can be the key to understanding material and learning science. Developed by Walter Pauk at Cornell University, Cornell notes create a format for reviewing and recalling information. Cornell notes provide multiple opportunities for students to interact with the information on the notes. Using this method, students write notes, develop questions on the content, and summarize the information. Students who take notes and interact with them to process information will gain a powerful tool for academic success.

THE INTERACTIVE NOTEBOOK

Physically organizing the class materials is the first step in becoming an effective learner and successful student. While this is common sense to educators, it is a difficult concept to many students. Students are typically given two options in organizing class materials: follow the teacher's directions on organization in order to earn a grade, or choose your own method of dealing with class materials. These options provide minimal opportunity to consider how material might otherwise be organized.

The Interactive Notebook (INB) is a learning tool to strengthen student learning of content material through increased student participation. It provides a vehicle to organize all notes, worksheets, problem sets, responses to videos, and lab investigations. The notebooks also provide students with a place to interact with the material, develop their understanding, and be involved in making decisions about their learning. The end result is a complete record of how and what a student learned during a class, week, unit, semester, or year.

PROCESSING THE CONTENT

There are many ways for students to process or interact with the content beyond answering assigned questions. A collection of *Processing Activities* in the appendix includes many examples of creative ways for students to process learning. Each of these processing (or "output") activities includes a graphic and an explanation component, and will further clarify students' comprehension of the material to be learned.

Section 1.1

Focused Note-Taking: Cornell Notes

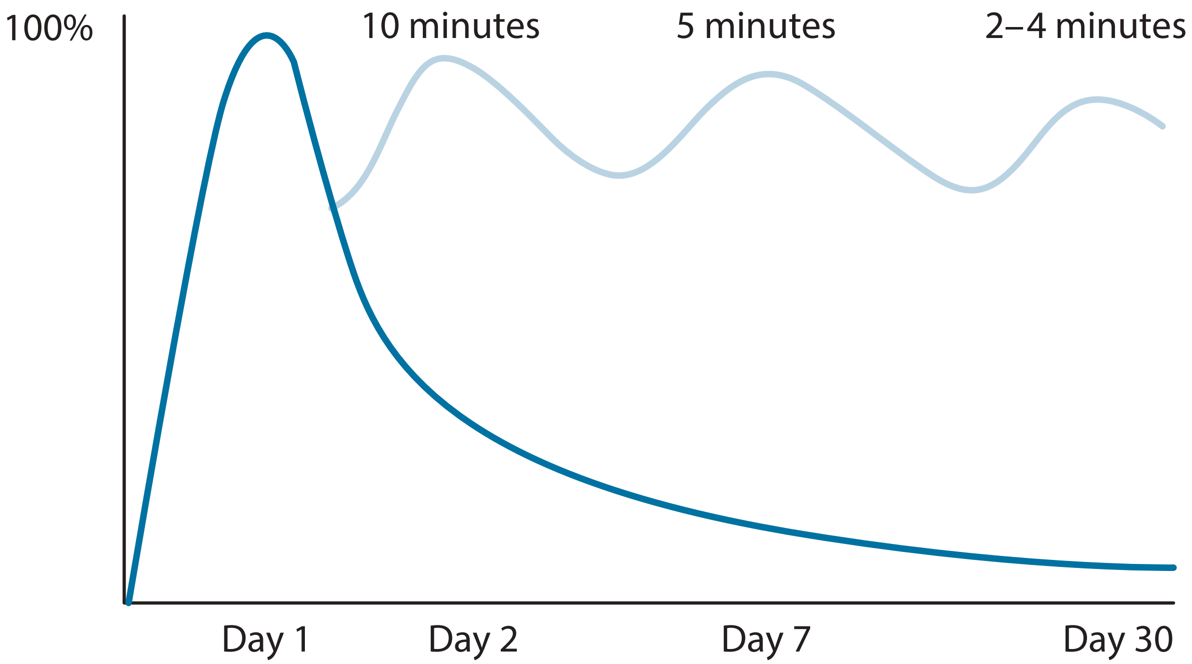
Overview of the CORNELL WAY

One of the cornerstone AVID strategies is Cornell notes. Cornell notes were developed at Cornell University in the 1950s by Walter Pauk. He realized the need for students to process the contents of their notes (beyond recitation), and the value of summary writing for retention of content information. In a letter concerning Cornell notes Pauk wrote, "One learns through the processing of information by the brain. Words very, very seldom imprint themselves on the brain; but one's thinking does" (*Focused Note-Taking CD*, 2010). The note-taking system Pauk developed is still supported by current research regarding "the curve of forgetting" done in the area of memory and learning theory (*The Student Success Path*, 2011), as well as research in brain development and function. Cornell note-taking is much more than a way of recording information from lectures, movies, readings, etc.—it teaches students what to do with their notes once they have taken them.

Mastery of Cornell note-taking will take time; however with sufficient time and practice, it will become a valued skill and tool to improve student retention and comprehension of content covered in class. Cornell note-taking does not change how teachers deliver information, but it changes how students record and interact with the information.

The components of the CORNELL WAY focused note-taking system are presented in this section as separate segments. Teachers may choose to teach the components as separate segments, which can be particularly useful for younger students who need more scaffolding of instruction, or they may choose to present the entire system through the final lesson that requires use of all the steps.

The Curve of Forgetting



The Curve of Forgetting describes how we retain or get rid of information that we take in. It's based on a one-hour lecture.

On Day 1, at the beginning of the lecture, you go in knowing nothing, or 0% (where the curve starts at the baseline). At the end of the lecture, you know 100% of what you learned, however well you know it (where the curve rises to its highest point). By Day 2, if you have done nothing with the information you learned in that lecture, didn't think about it again, read it again, etc., you will have lost 50%–80% of what you learned. Our brains are constantly recording information on a temporary basis: scraps of conversation heard on the sidewalk, what the person in front of you is wearing. Because the information isn't necessary, and it doesn't come up again, our brains dump it all off, along with what was learned in the lecture that you actually do want to hold on to! By Day 7, we remember even less, and by Day 30 we retain about 2%–3% of the original hour! This nicely coincides with midterm exams, and may account for feeling as if you've never seen this before in your life when you're studying for exams—you may need to actually relearn it from scratch.

You can change the shape of the curve! A big signal to your brain to hold on to a specific chunk of information is if that information comes up again. When the same thing is repeated, your brain says, "Oh, there it is again—I better keep that." When you are exposed to the same information repeatedly, it takes less and less time to "activate" the information in your long-term memory and it becomes easier for you to retrieve the information when you need it.

Here's the formula, and the case for making time to review material: Within 24 hours of getting the information, spend 10 minutes reviewing and you will raise the curve almost to 100% again. A week later (Day 7), it only takes 5 minutes to "reactivate" the same material and again raise the curve. By Day 30, your brain will only need 2 to 4 minutes to give you the feedback, "Yup, I know that. Got it."

Often students feel they can't possibly make time for a review session every day in their schedules—they have trouble keeping up as it is. However, this review is an excellent investment of time. If you don't review, you will need to spend 40–50 minutes relearning each hour of material later—do you have that kind of time? Cramming rarely plants the information in your long-term memory where you want it and can access it to do assignments during the term as well as be ready for exams.

Depending on the course load, the general recommendation is to spend half an hour or so every weekday, and 1 1/2 to 2 hours every weekend in review activity. Perhaps you only have time to review 4 or 5 days of the week, and the curve stays at about the mid range. That's OK; it's a lot better than the 2%–3% you would have retained if you hadn't reviewed at all.

Many students are amazed at the difference reviewing regularly makes in how much they understand and how well they understand and retain material. It's worth experimenting for a couple weeks, just to see what difference it makes to you!

Counseling Services, Study Skills Program

University of Waterloo

Ebbinghaus, H. (1885). *Memory: A contribution to experimental psychology*. Berlin, Germany.

Section 1.2

Note-Taking:
Format and Taking Notes

Introduction

Setting up Cornell notes is a simple process. The power of this system comes in interacting with the notes multiple times. The use of Cornell notes is an AVID strategy that takes time and repetition throughout the year. Teaching students to take meaningful notes and use the notes for processing information requires careful instruction and feedback on the part of the teacher. This segment of the Cornell note process concentrates on teaching students the format for their notes and the general note-taking process. More specific information on each additional segment of the process is presented in Sections 1.3–1.7.

Timeline

- 10 minutes for explaining the format of the notes
- 30–40 minutes for whole-group instruction on subject-matter content using the 10-2-2 format

Objectives: The Students Will . . .

- Set up the Cornell note format
- Practice effective note-taking
- Process information in their notes

WICOR Strategies

Writing:	Write notes, questions, and summaries in the Cornell note format
Inquiry:	Develop questions on the content of the notes
Collaboration:	Collaborate with the class to write summaries of the notes
Organization:	Organize information using Cornell notes
Reading:	Read notes to process and summarize content

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Materials

- Cornell note paper
- Highlighters or colored pens/pencils

Handouts

Teacher Reference 1.2.1:	*10 Steps of the CORNELL WAY*
Student Handout 1.2.2:	*Cornell Note Format*
Student Handout 1.2.3:	*Cornell Note Template*
Teacher Reference 1.2.4:	*10-2-2 Note-Taking Structure*
Student Handout 1.2.5:	*Common Science Abbreviations*

Teacher Directions

- Project and/or distribute the *Cornell Note Format* and the *Cornell Note Template* (reference only) and teach students the basic format for Cornell notes. Discuss each section of the format with students, including the purpose and the importance of each section. Some points are provided below to get you started.

  Set-Up: Show students how to prepare the paper (fold vertically to produce 1/3 and 2/3 sections). Teach them where to write the heading, topic, and essential question. Briefly discuss the purpose of the essential question and how it guides the discussion and summary of the notes. When teaching the Cornell note-taking system, the essential question should be, "How do I set up my note-taking system to help me remember the important information in my classes?"

  (***Teacher Note:*** Writing the essential questions will be discussed in Section 1.3 of the Cornell note information.)

  Taking Notes: Review the type of information that goes in the right column.

  Asking Questions: Teach students that the left column is used to write questions that reflect different levels of thinking

  (***Teacher Note:*** The levels of thinking will be discussed in Section 1.5 of the Cornell note information.)

  Summarizing: Show students where the summaries are written and discuss the value of writing concise summaries of readings or classroom instruction.

  (***Teacher Note:*** Writing summaries will be discussed in Section 1.6 of the Cornell note information.)

- Review with students the importance of taking notes in understanding and retaining content. (You may want to refer to "the curve of forgetting.") Students must do more than just take notes; they must use them as tools in their education.
- Teaching students to take meaningful notes and to use the notes for processing information requires careful instruction and feedback on the part of the teacher. Daily practice with Cornell notes should include organizational schemes, teaching students how to be good listeners, and reading for main ideas.

- Teach students how to abbreviate words and phrases and to use symbols and other notations to capture the ideas *quickly and efficiently*. (See the *Common Science Abbreviations* handout.) You may want to have students glue this handout into their Interactive Notebooks.
- Introduce students to the 10-2-2 note-taking structure. By breaking longer periods of lecture or discussion into shorter periods (or chunks) of information, you can help students process and reflect on the information in manageable portions.
- In the 10-2-2 note-taking structure, students…

  take notes from whole-group instruction for 10 minutes.

  process the segment of notes for two minutes by working collaboratively in partners/small groups to share and refine the notes and create questions.

  independently summarize the information in one sentence.
- This process is repeated until all information is presented or read. After all information is given and notes are taken, students can interact with the teacher to resolve unanswered questions or clarify information.
- Conduct a practice content discussion (or a regular classroom discussion) with the students so they can set up their Cornell notes and take notes using the 10-2-2 structure.
- After the note-taking session, ask students to provide feedback on the process.

Differentiation Strategies

- For younger students or as an initial note-taking exercise, prepare the notes section for the students and have them mark the key words and main ideas during the class discussion. Guide the students as they write questions in the left column and write a summary.
- For younger students or those who require accommodations, provide guided-lecture notes with a word bank at the top of the page for the students to use as a reference to fill in the blanks during the class.
- Provide sentence frames for students to use in writing the summary.
- Allow students already proficient with Cornell note-taking to be teachers in small groups or models to demonstrate each step of the note-taking process.

10 Steps of the CORNELL WAY

I. NOTE-TAKING:

Reading or hearing information for the first time while jotting down and organizing key points to be used later as a learning tool.

C	Create Format	Step 1:	CREATE Cornell notes format and complete heading
O	Organize Notes	Step 2:	ORGANIZE notes on right side

II. NOTE-MAKING:

Within 24 hours of having taken the notes, revise these notes, generate questions, and use collaboration to create meaning.

R	Review and Revise	Step 3:	REVIEW AND REVISE notes
N	Note Key Ideas	Step 4:	NOTE key ideas to create question
E	Exchange Ideas	Step 5:	EXCHANGE ideas by collaborating

III. NOTE-INTERACTING:

Interact with notes taken by creating a synthesized summary. Use Cornell notes as a learning tool to increase content class achievement.

L	Link Learning	Step 6:	LINK learning to create a synthesized summary
L	Learning Tool	Step 7:	Use completed Cornell notes as a LEARNING TOOL

IV. NOTE-REFLECTING:

Use written feedback to address areas of challenge by setting focus goals to improve future notes. The Cornell Note Reflective Log Handout provides the opportunity to reflect on the notes and the learning.

W	Written Feedback	Step 8:	Provide WRITTEN feedback
A	Address	Step 9:	ADDRESS written feedback
Y	Your Reflection	Step 10:	Reflect on YOUR learning

STUDENT HANDOUT 1.2.2

Cornell Notes

TOPICS/STANDARD/OBJECTIVE

Heading

ESSENTIAL QUESTIONS:

The overall question that guides the content of the notes. It is based on the standard or objective in the heading. The summary should provide the answer to the essential question.

QUESTIONS:

Left 1/3 of page

- Identify the main ideas in the notes.
- Create study questions that are answered by each main idea.
- Write higher-level questions (Costa's Levels 2 & 3) for the main ideas. *(Some material in the notes may not lend itself to higher-level questions.)*
- Use the questions to study for quizzes and exams.

NOTES:

Right 2/3 of page

- Be prepared to actively listen and take notes.
- Take notes in *your own words* while listening to the teacher, reading a textbook, watching a video, solving a math problem, or participating in a science lab.
- Record *facts, explanations, definitions, graphs*, etc.
- Use *abbreviations and visuals* that work for you.
- Write in *phrases* (not complete sentences).
- Don't worry about spelling except on important terms.
- Write *important information*, not every word that is said or read.
- *Listen* for important points emphasized by the teacher.
- Fill in details, mark important information and vocabulary, and delete irrelevant information after class.
- Use symbols (star, checkmark, etc.) to indicate what is significant.
- Use memory cues: *underline, highlight, draw diagrams*, etc.
- Use *different colors* to indicate changes in topics or to mark important vocabulary words or phrases.
- *Review notes* with a partner whenever possible.
- *Review notes 10-24-7 (after 10 minutes, 24 hours, and 7 days)*.

Note any points that need to be clarified with the instructor.

SUMMARY:

- Address the essential question of the lesson.
- Answer the higher-level questions from the left side to tie together the main ideas.
- Paraphrase (use your own words) the answers to the questions.

Cornell Notes Template

STUDENT HANDOUT 1.2.3 (1 of 2)

CORNELL NOTES

AVID Proven Achievement. Lifelong Advantage.

TOPIC/OBJECTIVE:

NAME:

CLASS/PERIOD:

DATE:

ESSENTIAL QUESTION:

QUESTIONS:	NOTES:

SUMMARY:

STUDENT HANDOUT 1.2.3 (2 of 2)

QUESTIONS:

NOTES:

SUMMARY:

10-2-2 Note-Taking Structure

10-2-2 Structure & Rationale:	• The structure involves the following: **10 minutes:** presenting information/note-taking **2 minutes:** Processing information **2 minutes:** Summarizing information • Allows students the necessary time to process information and concepts presented in whole group instruction The structure allows for: Greater retention of information Improvement in the quality of notes, question, and summaries
10 Minutes: Whole Group Instruction	• The instructor lectures/presents information or gives and audio-visual presentation for **ten minutes** while the students take Cornell notes. • Encourage students to use abbreviations and short-cuts while taking notes.
2 Minutes: Partners/Small Groups	• The instructor then pauses for **two minutes** while the students take time to process the information by working collaboratively in partners/small groups to do the following: Share notes Revise/refine notes Fill in gaps in notes Clarify information/concepts presented Create questions on the left side • During this time students are not allowed to ask the instructor questions; students should rely on the support of peers to assist them in processing the information.
2 Minutes: Independently	• The students then take **two minutes** silently to individually process the information and create a one-sentence summary to be placed across the page just below the chunk of notes. • The teacher may choose to have students share out their sentence summary as a way to check for understanding.
Repeat the Process	• Repeat the process until all information is presented.
Last 5 Minutes of Class: Whole Group	• Reserve the **last five minutes of the period** for the students to interact with the teacher. Students can ask questions to: Resolved unanswered questions Get clarification about information presented Sort out misconceptions/gaps

STUDENT HANDOUT 1.2.5

Common Science Abbreviations

Common Shortcuts for Note-Taking—Abbreviations/Acronyms

for	4
to	2
between	b/w
with	w
without	w/o
within	w/i
point	pt
and	& or +
negative	-
positive	+
equal/same	=
not equal	≠
atomic weight	at. wt.
atomic number	at. no.

because	b/c
energy	e
difference/change	Δ
infinity	∞
approximately equal	≈
therefore	∴
yields/produces	→
increase/up	↑
decrease/down	↓
calorie	cal
question	Q or ?
important	!
greater than	>
less than	<

Additional Suggestions

- Make names and titles into acronyms after writing them the first time.

kinetic energy	KE
no reaction	NR

- Write the first few syllables of long words and complete the word when reviewing the notes.

electricity	elect
equilibrium	equil

- Write some words deleting vowels until notes are reviewed.

standard	std

Think of some of your own shortcuts.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________

Section 1.3

Note-Taking: Creating and Using Essential Questions

Introduction

Framing the classroom instruction based on state and district standards is a key component of teaching. The essential question guides the lesson and its contents whether from lectures, videos, readings, investigations, labs, or assessments. Making the connection between the content and the essential question helps students learn how to study. In Cornell notes, the essential question tightly connects to the content knowledge communicated in the notes, helps students write their questions for the notes, and frames the summary. Using essential questions will lead students to deeper levels of scientific thinking by focusing their critical thinking processes.

Timeline

20 minutes

Objectives: The Students Will . . .

- Create the essential question to guide and frame the note-taking, questions, and summary
- Develop questioning skills that increase the higher-order processing of content of notes

WICOR Strategies

Writing:	Write essential questions for a discussion or other assignment
Inquiry:	Develop questions that synthesize the content of notes or other assignment
Collaboration:	Collaborate in groups to develop essential questions
Organization:	Organize information using Cornell notes
Reading:	Read notes to process and summarize content

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Materials

- State and district content standards

Handouts

None

Teacher Directions

- Using your state and district standards, create the essential questions that guide your lessons for a given topic or unit. Some sample questions are provided.

TOPIC	ESSENTIAL QUESTION
Diffusion and Osmosis	How do the processes of diffusion and osmosis operate in tissue membranes?
Atomic Structure	Describe the forces within an atom and their relationship to chemical and nuclear reactions.
Acids and Bases	What are acids and bases, and how are they alike and different?
Latitude and Longitude	How can latitude and longitude be used to determine a specific location?

- Use your district summative assessments to ensure that all test questions have been addressed in the essential questions. These must be correlated for aligned instruction and to demonstrate that students have met the required standards.
- Practice writing essential questions as a whole class; then have students work in small groups to create essential questions from the given topic/standard/objective.
- Determining essential questions to guide a class discussion, individual student reading assignments, or viewing of a video can be done on a daily basis.
- The essential questions can be used in several ways:

  The Cornell note summary should answer the essential question. This can be the first sentence in the summary, which should also include answers to the student questions in the left column of the notes.

  Responding to the essential question can be a quickwrite prompt. (See information on quickwrites in Unit 2.)

  The answer to the essential question can be used as an "exit ticket" as students leave the classroom or as an "entrance ticket" for the following class day. These can be used to guide the teacher's instruction and re-teaching of material based on student understanding presented in this formative assessment.

Differentiation Strategies

- For younger students or in the early days or weeks of using Cornell notes, determine and provide the essential question to students.
- Students in advanced courses or students who have been using Cornell notes for a length of time can write their own essential questions. After they have taken notes and are writing summaries, they should re-evaluate the appropriateness of their essential questions.

Section 1.4

Note-Making: Reviewing and Revising

Introduction

Within 24 hours of taking the notes, students should review and revise them, note key ideas, generate questions, and use collaboration to exchange ideas and create fuller meaning for the notes. To maximize the usefulness of taking notes, students must review and revise notes daily. This process reinforces mastery of the material as discussed in the curve of forgetting, and allows students to interact with the information to form a deeper and more comprehensive picture of the content.

Timeline

- 10–15 minutes for class time instruction
- 10–15 minutes for student revision after class

Objectives: The Students Will . . .

- Review and revise notes for critical information.
- Use interactive methods to process and retain information in the notes..

WICOR Strategies

Writing:	Write notes, questions, and summaries in the Cornell note format.
Inquiry:	Develop questions that synthesize the content of notes.
Collaboration:	Collaborate to revise notes and process information.
Organization:	Organize information using Cornell notes.
Reading:	Read notes to process and summarize content.

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Materials

- Highlighters or colored pens/pencils

Handouts

Teacher Reference 1.4.1: *Cornell Notes Student Sample*
Student Handout 1.4.2: *Cornell Note-Taking Revision Checklist*

Teacher Directions

- Distribute the *Cornell Note-Taking Revision Checklist* to students. The class will use this list to guide revision of the notes to increase their effectiveness.
- Using a set of notes that students took in class, have students number the main ideas or new concepts in the notes. Have students do a pair-share collaboration (see *Active Learning Strategies* in Unit 4) and discuss their choices. With the whole class, review the main ideas that you see in the notes. Number these as you use a document camera, white board, or another method so students can see an example of the numbering. If they do not agree, discuss and come to consensus on the main ideas.
- Repeat this process by circling key terms. It is critical to review and discuss the actual terms as a class to ensure that students complete these processes correctly. While not all words must be identical, you are the content expert and know which key words students must master. Encourage students to use highlighters or colored pencils to mark the revisions.
- Continue down the *Cornell Note-Taking Revision Checklist* having students work with partners to discuss the revisions, and then discussing as a class. During this process, change the pairings several times so that students are partnered with different people in order to hear different perspectives.
- Model the process of reviewing and revising class notes frequently so that students become accustomed to using this process.

Differentiation Strategies

- As an initial discussion for younger students, mark the revisions on previously prepared Cornell notes.

Student Sample

TEACHER REFERENCE 1.4.1

CORNELL NOTES

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Lifelong Advantage.

TOPIC/OBJECTIVE: Introduction to Matter

NAME:

CLASS/PERIOD:

DATE:

ESSENTIAL QUESTION: What is matter and how can we describe it?

QUESTIONS:

What do you use to measure matter?

What are some ways to describe both chemical and physical properties?

Define mass.

Does all matter have chemical properties?

NOTES:

What is matter and how can we describe it?

Description of Matter	Tool to Measure	Details
Mass	balance	amount of matter; unit = kg
Volume	water displacement	amount of space matter occupies; unit = cc or mL
Weight	scale	gravitational pull on matter; unit = Newton (N)
Physical Properties	5 senses to observe	density, malleability, color, ductility, state of matter, thermal & electrical conductivity
Chemical Properties	unknown until it is changed	can it burn? does it react with water or acid or base?

SUMMARY:
This information is all about different kinds of matter. Matter is anything that has mass and volume. Mass is measured with a balance, volume is measured by water displacement, and weight by a scale. There are types of properties, chemical and physical. They are very different. They describe matter. They are both everywhere, as is matter.

STUDENT HANDOUT 1.4.2

Cornell Note-Taking Revision Checklist

Directions: Review and revise notes taken in the right column. Use the symbols below to revise your notes.

COMPLETED	SYMBOL	REVISION
☐	1, 2, 3... A, B, C...	1. Number the notes for each new concept or main idea.
☐	Key Word	2. Circle vocabulary/key terms in pencil.
☐	Main Idea	3. Highlight or underline main ideas in pencil.
☐	∧	4. Fill in gaps of missing information and/or reword/ rephrase in red.
☐	~~Unimportant~~	5. Delete/cross out unimportant information by drawing a line through it with a red pen.
☐	?	6. Identify points of confusion to clarify by asking a partner or teacher.
☐	*	7. Identify information to be used on a test, essay, for tutorial, etc.
☐	Visual/symbol	8. Create a visual/symbol to represent important information to be remembered.

Section 1.5

Note-Making: Writing Questions and Prompts

Introduction

Interacting with the information in the notes to process the meaning and connections is the key to learning. Writing questions on the content of the notes enables students to think about information at deeper levels and helps students identify the factual information. Using the questions as study guides is also a powerful learning tool.

To frame the thinking process, AVID uses Costa's Levels of Thinking. Level 1 thinking involves recall or basic understanding of information. It requires one piece of information to answer the question (e.g., define, list, identify). Without knowing the information that is presented at this level, Levels 2 and 3 thinking cannot occur. Level 2 thinking requires interaction between two ideas. A Level 2 question may require connecting two different ideas on a page of text or making an inference related to an idea (e.g., compare and contrast, classify, prepare a graph). Level 3 thinking requires more information than is present in the text because it focuses on supporting an answer, providing evidence, justifying, and predicting an outcome.

There are several scaffolding tools provided in this unit to help students learn to write effective questions. It is tempting to use the example words given on the Costa's Levels of Thinking chart as indicators of the question levels; however, a person must read the question and consider what the question or prompt is asking before assigning a level to it. For example, the question, "Predict the benefits of writing higher levels of questions for your notes," is a Level 1 question if the information was explained forthrightly in a lecture, in spite of using the word "predict." There will also be some questions that you know are higher level, but you cannot readily quantify them as Level 2 or 3. The key factor is not giving a strict level designation for the questions, but that students are writing questions that elevate their thinking to higher levels.

Timeline

30 minutes for this lesson, but many class periods revisiting how to write questions at Level 2 and Level 3 thinking

Objectives: The Students Will . . .

- Write questions that demonstrate all levels of Costa's Levels of Thinking
- Use inquiry methods to develop questions about science content
- Develop questioning skills that increase the higher-order processing of note content

WICOR Strategies

Writing: Write notes, questions, and summaries in the Cornell note format
Inquiry: Develop questions that synthesize the content of notes
Collaboration: Collaborate to revise questions
Organization: Organize information using Cornell notes
Reading: Read and review notes

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Handouts

Student Handout 1.5.1: *Costa's Levels of Thinking* (Three-Story House)
Student Handout 1.5.2: *Moving on Up*
Student Handout 1.5.3: *Costa's Levels of Thinking and Questioning: Science*
Student Handout 1.5.4: *Bloom's Taxonomy: Science and Math*
Student Handout 1.5.5: *Vocabulary: Costa's Levels of Thinking and Questioning*
Teacher Reference 1.5.6: *Cornell Notes and Questions*

Teacher Directions

- Provide students with the *Costa's Levels of Thinking* and *Moving on Up* handouts.
- Discuss the concept of levels of thinking as presented in the introductory notes and emphasize that science depends on thinking at Levels 2 and 3 to understand the concepts.
- Relate the levels of thinking to the questions created in the left column of Cornell notes when the notes are reviewed. Have students use the Level 1 prompts on the *Moving on Up* handout to create Level 2 and 3 questions about the story. Depending on your students, you may want to provide a copy of the fairy tale to those not familiar with the story.
- After you feel that students are able to write higher-level questions using this template, use a set of notes from your science class to have students create varying levels of questions. Require that students write at least two Level 2 and two Level 3 questions. Keep in mind that some Level 1 questions are important: facts, definitions, etc.
- Distribute to students the *Costa's Levels of Thinking and Questioning: Science* handout to use as they write the questions for their science notes. You can also use the *Bloom's Taxonomy: Science and Math and Vocabulary: Costa's Levels of Thinking and Questioning* handouts.

- Have students "pair-share" their questions with a partner. One person will share his/her questions and explain why it is a Level 2 or Level 3 question, then the partners will exchange roles. After the partners have shared their questions and explanations, have them share their responses with the class as a whole. During the class sharing, model how to revise and refine questions to master content material.
- Illustrate how students can use these questions as a study guide by covering up the content side of the notes and answering the questions they developed in the left column.

Differentiation Strategies

- As an initial practice in taking notes and developing questions at Levels 2 and 3, prepare the notes section with only headings and Level 1 questions in the question column. Have students fill in the content information during the class discussion. As a class, discuss how to rewrite some of the Level 1 questions as Level 2 or 3 questions.

  (***Teacher Note:*** Students should be "weaned" from fill-in-the-blank notes or "completion" notes as quickly as possible so they develop the skill and habit of taking Cornell notes.)

- Allow students already proficient with Cornell note-taking to be teachers in small groups or models to demonstrate each step of the note-taking process.

STUDENT HANDOUT 1.5.1

Costa's Levels of Thinking

3–Applying

"Off the page" or "From the brain"

- Evaluate
- Judge
- If/Then
- Generalize
- Predict
- Hypothesize
- Imagine
- Speculate
- Forecast

2–Processing

"Between the Lines" or "From the book and brain"

- Compare
- Sort
- Infer
- Contrast
- Distinguish
- Analyze
- Classify
- Explain (Why?)

1–Gathering

"On the page" or "From the book"

- Complete
- Identify
- Recite
- Define
- List
- Select
- Describe
- Observe

Moving on Up:
Writing Higher-Level Questions

Directions: Complete the table below by writing Level 2 and 3 questions that correspond to each Level 1 question provided for the fairy tale "Cinderella." The first set has been completed for you as an example.

Level 1	Level 2	Level 3
What are the names of the three stepsisters?	Compare and contrast Cinderella to one of her stepsisters.	Justify the reasons why Cinderella's stepsisters are so undesirable to the prince.
Who is the person that grants Cinderella her wish of attending the ball?		
What was Cinderella's coach made out of?		
What happened at midnight?		
Who found Cinderella's glass slipper?		
After Cinderella and the prince were married, how did they live?		
What was the slipper made of?		
What changes happened as a result of the fairy godmother's magic?		
How did Cinderella get her name?		
Describe the ball at the palace.		

STUDENT HANDOUT 1.5.3

Costa's Levels of Thinking and Questioning:
Science

LEVEL 1

- What information is given?
- What are you being asked to find?
- What formula would you use in this problem?
- What does _________mean?
- What is the formula for…?
- List the…
- Name the…
- Where did…?
- What is…?
- When did…?
- Describe in your own words what ________ means.
- What science concepts does this problem connect to?
- Draw a diagram of…
- Illustrate how _______works.

LEVEL 2

- What additional information is needed to solve this problem?
- Can you see other relationships that will help you find this information?
- How can you put your data in graphic form?
- How would you change your procedures to get better results?
- What method would you use to…?
- Compare and contrast _________ to _________.
- Which errors most affected your results?
- What were some sources of variability?
- How do your conclusions support your hypothesis?
- What prior research/formulas support your conclusions?
- How else could you account for…?
- Explain the concept of…
- Give me an example of…

LEVEL 3

- Design a lab to show…
- Predict what will happen to _______ as ________ is changed.
- Using a science principle, how can we find…
- Describe the events that might occur if…
- Design a scenario for…
- Pretend you are…
- What would the world be like if…?
- What would happen to ___ if _____ (variable) were increased/decreased?
- How would repeated trials affect your data?
- What significance is this experiment to the subject you're learning?
- What type of evidence is most compelling to you?
- Do you feel ___________ experiment is ethical?
- Are your results biased?

Bloom's Taxonomy: Science and Math

KNOWLEDGE

recalling information

- What information is given?
- What are you being asked to find?
- What formula would you use in this problem?
- What does ______ mean?
- What is the formula for . . . ?
- List the . . .
- Name the . . .
- Where did . . . ?
- What is . . . ?
- Who was/were . . . ?
- When did . . . ?

COMPREHENSION

understanding meaning

- What are you being asked to find?
- Explain the concept of . . .
- Give me an example of . . .
- Describe in your own words what ________ means.
- What (science or math) concepts does this problem connect to?
- Draw a diagram of . . .
- Illustrate how ________ works.
- Explain how you calculate… results.

APPLICATION

using learnign in new situations

- What additional information is needed to solve this problem?
- Can you see other relationships that will help you find this information?
- How can you put your data in graphic form?
- What occurs when . . . ?
- How would you change your procedures to get better?
- Does it make sense to . . . ?
- What method would you use to . . . ?

ANALYSIS

ability to see parts and relationships

- Compare and contrast _____ to _____.
- What was important about…?
- Which errors most affected your results?
- What were some sources of variability?
- How do your conclusions support your hypothesis?
- What prior research/formulas support your conclusions?
- How else could you account for…?

SYNTHESIS

parts of information to create new whole

- Design a lab to show…
- Predict what will happen to ______ as ______ is changed.
- Using a principle of (science or math), how can we find…?
- Describe the events that might occur if…?
- Design a scenario for…
- Pretend you are…
- What would the world be like if…?

EVALUATION

judgment based on criteria

- How can you tell if your answer is reasonable?
- What would happen to ______ if ______ (variable) were increased/decreased?
- How would repeated trials affect your data?
- What significance is this experiment/formula to the subject you're learning?
- What type of evidence is most compelling to you?
- Do you feel ______ experiment is ethical?
- Are your results biased?

STUDENT HANDOUT 1.5.5

Vocabulary:
Costa's Levels of Thinking

LEVEL 1

Remember	Define	List	Recall	Match
	Repeat	State	Memorize	Identify
	Name	Describe	Label	Record
Show Understanding	Give examples	Rewrite	Review	Tell
	Restate	Reorganize	Locate	Extend
	Discuss	Explain	Find	Summarize
	Express	Report	Paraphrase	Generalize

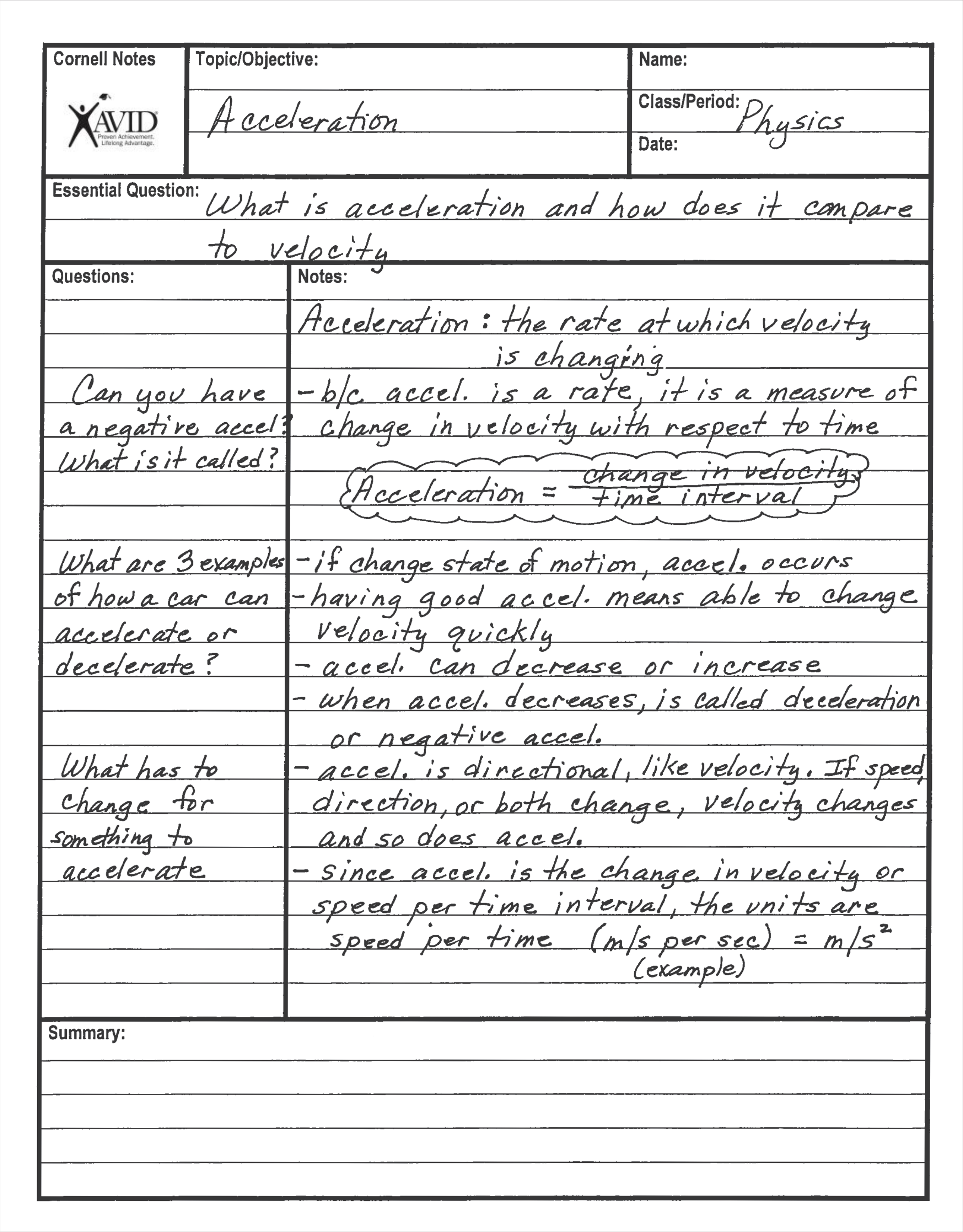
LEVEL 2

Use Understanding	Dramatize	Use	Translate	Interpret
	Practice	Compute	Change	Repair
	Operate	Schedule	Pretend	Demonstrate
	Imply	Relate	Discover	Infer
	Apply	Illustrate	Solve	
Examine	Diagram	Question	Analyze	Criticize
	Distinguish	Inventory	Differentiate	Experiment
	Compare	Categorize	Select	Break down
	Contrast	Outline	Separate	Discriminate
	Divide	Debate	Point out	
Create	Compose	Draw	Plan	Modify
	Design	Arrange	Compile	Assemble
	Propose	Suppose	Revise	Prepare
	Combine	Formulate	Write	Generate
	Construct	Organize	Devise	

LEVEL 3

Decide	Judge	Rate	Choose	Conclude
	Value	Justify	Assess	Summarize
	Predict	Decide	Select	
	Evaluate	Measure	Estimate	
Supportive Evidence	Prove your answer Support your answer	Give reasons for your answer	Explain your answer Why or why not?	Why do you feel that way?

Student Sample



Cornell Notes	Topic/Objective:	Name:
	Acceleration	Class/Period: Physics
		Date:

Essential Question: What is acceleration and how does it compare to velocity

Questions:	Notes:
	Acceleration: the rate at which velocity is changing
Can you have a negative accel? What is it called?	- b/c accel. is a rate, it is a measure of change in velocity with respect to time $\text{Acceleration} = \frac{\text{change in velocity}}{\text{time interval}}$
What are 3 examples of how a car can accelerate or decelerate?	- if change state of motion, accel. occurs - having good accel. means able to change velocity quickly - accel. can decrease or increase - when accel. decreases, is called deceleration or negative accel.
What has to change for something to accelerate	- accel. is directional, like velocity. If speed, direction, or both change, velocity changes and so does accel. - since accel. is the change in velocity or speed per time interval, the units are speed per time (m/s per sec) = m/s^2 (example)

Summary:

Section 1.6

Note-Interacting: Summarizing

Introduction

Summarizing notes is a synthesis process to bring out the main ideas in order to capture the essence of a lecture without getting mired in an excessive level of detail. This brings out higher-level thinking skills and provides a third opportunity to examine the information in a new light. This is often completed after a lecture but can be used in the 10-2-2 structure throughout the instructional lesson to help students maintain focus. The summary should address the essential question framed at the start of the lesson.

Note-taking and note-making require a summary of the content. This is completed within 24 hours of taking the notes and addresses the main ideas and key points of the instruction to answer the essential question. It is written in a person's own words and paraphrases the notes. The purpose of a summary is to synthesize the information into a concise segment. Reflections on learning are personal and occur immediately after the event. Their purpose is for students to connect ideas, examine learning, and think critically about an activity. These are appropriate for learning logs, Interactive Notebook units, and tutorials.

SUMMARY	REFLECTION
Focus: main ideas and key information	Focus: the learning process
Addresses the essential question	Connects learning to prior learning
Main ideas paraphrased/stated in own words	Critical thinking and mental processing about learning and experiences
Includes important content and vocabulary	Includes important content and vocabulary
Used to process information	Considers impact of ideas on life and experience
Personal input and editorial is absent	Personal thoughts and learning experience

Timeline

10 minutes following each instructional period

Objectives: The Students Will . . .

- Summarize a set of notes into one paragraph to answer an essential question and the questions created within the notes
- Develop skills in synthesizing summaries

WICOR Strategies

Writing:	Write summaries for Cornell notes
Inquiry:	Respond to questions
Collaboration:	Collaborate to revise summaries
Organization:	Organize information using Cornell notes
Reading:	Read notes to summarize content

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Materials

- Students' science notes

Handouts

Student Handout 1.6.1: *Cornell Note-Taking Summary Template*

Teacher Reference 1.6.2: *Cornell Notes and Summary*

Teacher Directions

- Students have been introduced to the various components of writing a summary and now will put those components together to write a synthesized summary. It will take several modeling sessions for writing notes, creating questions, and writing summaries before students will be confident in their abilities to write good summaries.
- Have students use a set of their science notes and the handout *Cornell Note-Taking Summary Template* as they write their summaries.

- Review the steps on the handout with the students.
- Ask students to individually write a complete sentence in response to the essential question, then share and revise it with a collaborative partner. Allow a few students to share their summaries. If you are using a document camera, show the work so students see and hear the ideas of their peers.
- Ask students to respond to each of the questions they created in the notes. The response to each question is a sentence in the final summary.
- Have students exchange their Cornell notes and summaries with a partner. When a student has a suggestion to improve the summary that he or she is reading, that student should write the suggestion in a different color. Instruct the partners to discuss the suggested modifications.
- Allow students to revise or rewrite their summaries.
- Ask a few students to share their full summaries with the class.

Differentiation Strategies

- Provide sentence frames for students to use in writing the summary.
- Have students write the summary as a class, using the terms highlighted within the notes.
- Allow students already proficient with Cornell note-taking to be teachers in small groups or models to demonstrate each step of the note-taking process.

STUDENT HANDOUT 1.6.1

Cornell Note-Taking Summary Template

Steps for Writing a Complete Summary

Step 1:	**Read the essential question**/objective at the top of the Cornell notes.
Step 2:	**Respond** to the essential question/objective in one sentence—this is the introduction to the summary. Use your own words in writing your summary.
Step 3:	**Review the first chunk** of notes on the right side and the corresponding question on the left side.
Step 4:	**Write a one-sentence response** to the left side question, using content-based vocabulary and information from the right side of notes. DO NOT rewrite the whole right side of your notes; the goal is to paraphrase your notes into one sentence.
Step 5:	**Repeat this process** until all your questions are incorporated into the summary—accounting for all the main ideas in your notes.
Step 6:	**Reread your summary** for clarity and accuracy, rewriting as needed and adding transitions, when possible.
Step 7:	**Review your summary** to study for tests/quizzes, write essays, etc.

Summary Paragraph Template

Essential question/objective introduction:

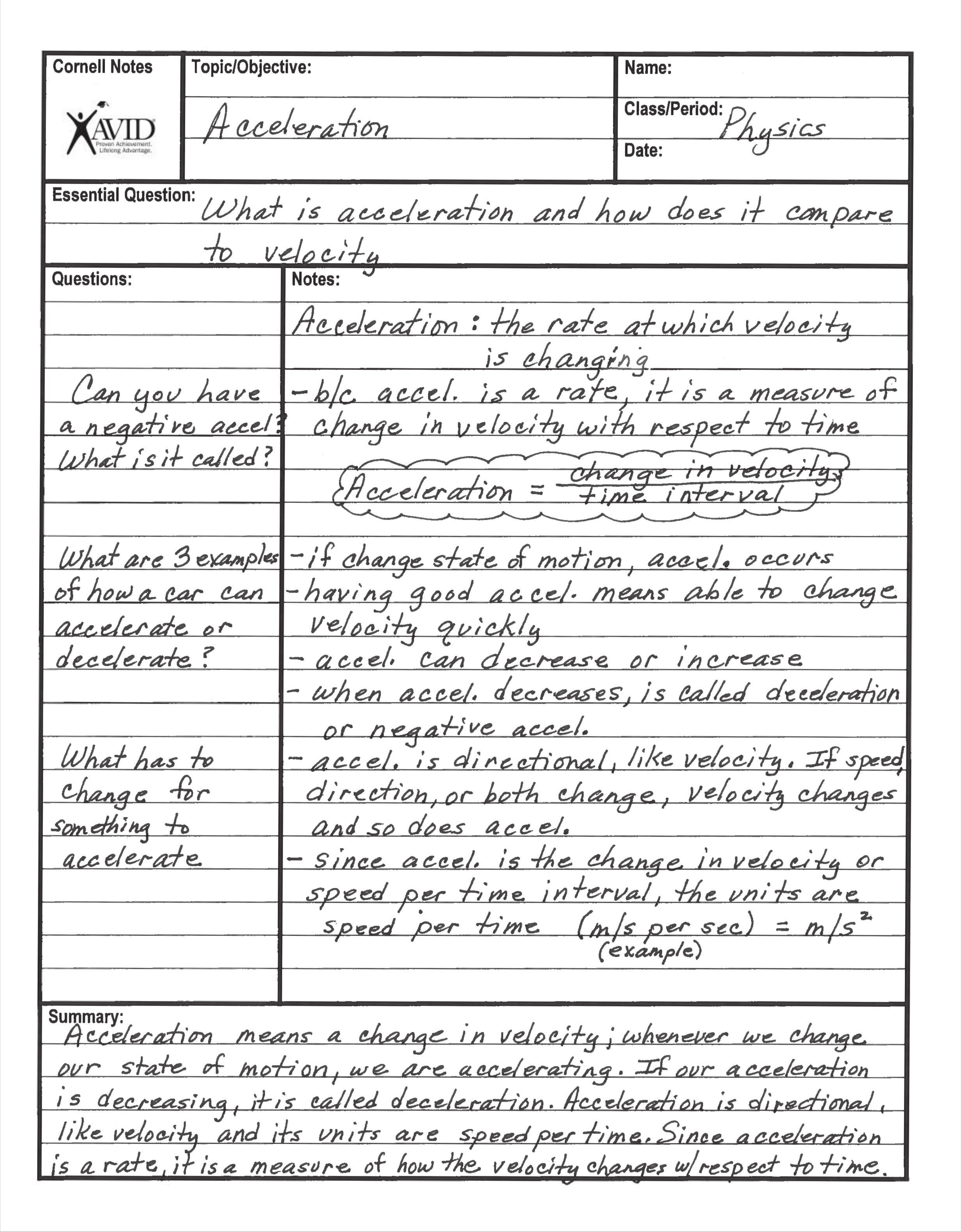
Response to the question for the 1st chunk of notes:

Response to the question for the 2nd chunk of notes:

Response to questions for all additional chunks of notes:

TEACHER REFERENCE 1.6.2

Cornell Note Sample with Summary



Cornell Notes

Topic/Objective: Acceleration

Name:

Class/Period: Physics

Date:

Essential Question: What is acceleration and how does it compare to velocity

Questions:	**Notes:**
	Acceleration: the rate at which velocity is changing
Can you have a negative accel? What is it called?	- b/c accel. is a rate, it is a measure of change in velocity with respect to time $\text{Acceleration} = \frac{\text{change in velocity}}{\text{time interval}}$
What are 3 examples of how a car can accelerate or decelerate?	- if change state of motion, accel. occurs - having good accel. means able to change velocity quickly - accel. can decrease or increase - when accel. decreases, is called deceleration or negative accel.
What has to change for something to accelerate	- accel. is directional, like velocity. If speed, direction, or both change, velocity changes and so does accel. - since accel. is the change in velocity or speed per time interval, the units are speed per time (m/s per sec) = m/s^2 (example)

Summary: Acceleration means a change in velocity; whenever we change our state of motion, we are accelerating. If our acceleration is decreasing, it is called deceleration. Acceleration is directional, like velocity and its units are speed per time. Since acceleration is a rate, it is a measure of how the velocity changes w/respect to time.

Section 1.7

Preparing a Lesson Using Cornell Notes

Introduction

You may choose to teach all the parts of the Cornell note-taking and note-making process separately (particularly for younger students or those needing scaffolded instruction) or through a lesson that combines all steps of the note-taking system. The handouts referred to in this section are contained within Parts I–V of the Cornell note-taking sections.

When Cornell notes are new to the students, reviewing the required elements and checking that they were completed should happen on a consistent basis. Use stamps, initials, peer sharing, or rubrics to hold students accountable for the format and completion of the notes.

Timeline

Varies, depending on length of class instruction

Objectives: The Students Will . . .

- Become effective note takers using Cornell notes
- Use interactive methods to process and retain information in the notes
- Develop questioning skills that increase the higher-order processing of the note content
- Develop skills in synthesizing a summary of daily notes
- Improve note-taking skills through feedback and reflection

WICOR Strategies

Writing:	Write notes, questions, and summaries in the Cornell note format
Inquiry:	Develop questions that synthesize the content of notes
Collaboration:	Collaborate to revise notes and process information
Organization:	Organize information using Cornell notes
Reading:	Read notes to process and summarize content

National Science Education Standards

All content standards are addressed as students use this note-taking system to organize, acquire, process, and assess their learning in a science class.

Materials

- Pens/pencils of different colors
- Highlighters

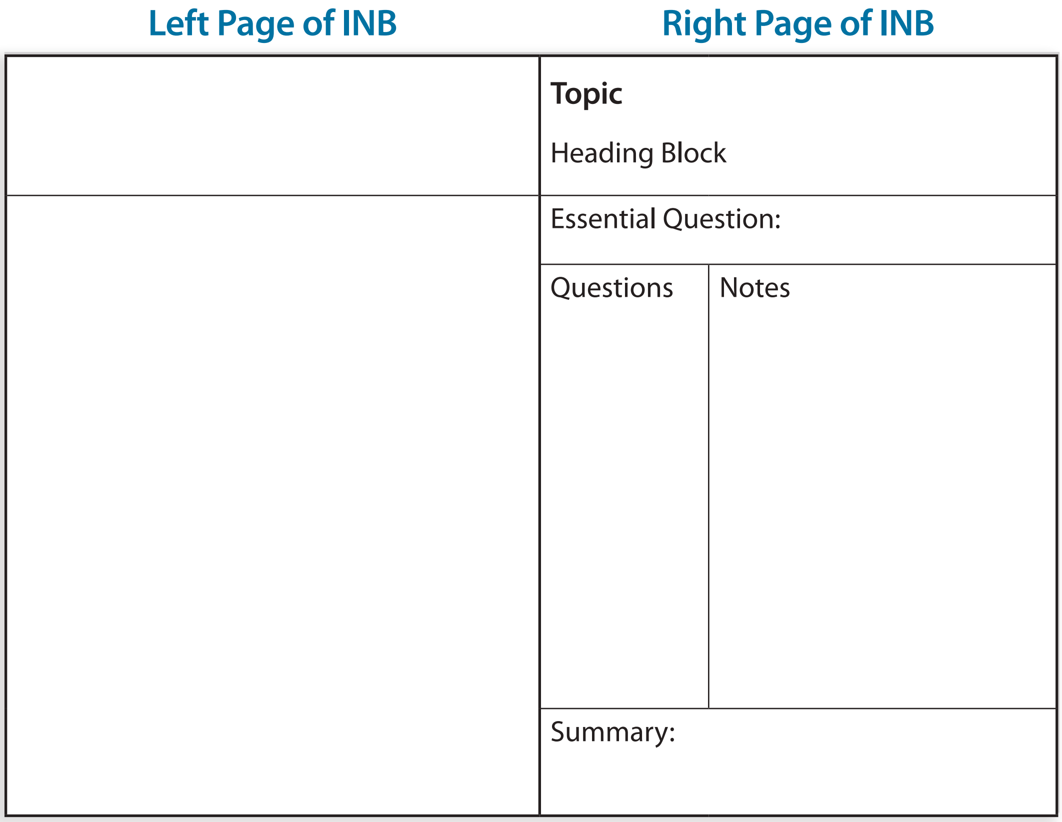
Handouts

See student handouts and teacher references from previous Cornell notes sections.

Teacher Directions

- If you have not already done so, teach students how to set up their Cornell note format and review the components of the note format. Also address how to use symbols and abbreviations to capture ideas quickly and efficiently. (See the *Common Science Abbreviations* handout.) Prepare a short lecture/discussion about an essential question you want the students to address in your content. The *10-2-2 Note-Taking Structure* teacher reference reviews the importance of lesson chunking during a class period and is a good resource for the instructor in planning the lesson timing. Refer to the Part II information for "guidance on creating and using essential questions" by converting one of the state standards, district standards, or objectives to an essential question.
- With your students, set up the Cornell note paper on the right side of the Interactive Notebook in one-third and two-thirds columns with the heading, the essential question, and space for the summary.
- This process must be modeled so that you are illustrating the steps the students will take. Use the *Cornell Note Format* and *Cornell Note Template* handouts as references.

Suggested INB Set-Up



- Present a lecture/discussion using Teacher Reference 1.2.4: *10-2-2 Note-Taking Structure*.
- Pause after each 10 minutes and allow students to pair-share their notes with classmates for two minutes to ensure an accurate format of the notes and to review the contents. (You can also use another *Active Learning Strategy* from Unit 2 for sharing.) Throughout the lecture/discussion, point out various words than can be abbreviated, or after the lecture, have students highlight words that could have been abbreviated.
- Upon completion of the notes, have the students read the essential question again. Review the notes, and identify "chunks" of the notes. In the column to the left of the notes, have students identify the main idea of each chunk and create a question that is answered by that section of the notes.
- Students can quiz their partners using the questions in the left column of the notes. They can also cover up the content side of the notes so that only the left column of the main ideas and questions is visible as a way to quiz themselves and review for an exam.
- Have the class identify and highlight key vocabulary terms within the notes that they think are important to include in their summary.
- Walk students through writing the summaries by using Student Handout 1.6.1: *Cornell Note Summary* Template. The summary sentences should answer the essential questions and the left-column questions and should include key terms. Longer sets of notes with many chunks will require more sentences in the summary.
- Distribute Student Handout 1.4.2: *Cornell Note-Taking Revision Checklist* to students. Using a set of notes or modeling the notes on the document camera, work through each part of the checklist, asking students to add any missing elements to the notes as you review the checklist with them.

- To ensure that students see the value of good note-taking, consider allowing students to use their notes on a quiz or in a review for an upcoming test. When you consistently model note-taking and align the exam content with the content of the student notes, students are more likely to take notes regularly and interact with them for maximum effectiveness and increased understanding of the course content.
- Use the checklist periodically to have students self-evaluate or peer-evaluate their notes and summaries. Then have them work together to revise their notes based on the checklist feedback.
- As students become more familiar with note-taking, the checklist can be collected at the time of completion or the grade can be noted at the top of the page in their notebooks for collection at a later date by the instructor.

Differentiation Strategies

- For younger students or as an initial note-taking exercise, prepare the notes section for the students and have them mark the key words and main ideas during the class discussion. Guide the students as they write questions in the left column and write a summary.
- For younger students or those who require accommodations, provide guided-lecture notes with a word bank at the top of the page for the students to use as a reference to fill in the blanks during the class.
- Provide sentence frames for students to use in writing the summary.
- Have students write the summary as a class, using the terms highlighted within the notes.
- Allow students already proficient with Cornell note-taking to be teachers in small groups or models to demonstrate each step of the note-taking process.
- Offer more sophisticated or longer texts to practice marking and taking notes.
- Invite students to add visuals, color-coding, and other kinds of personalization to their notes.

  (Teacher Note: These techniques will help all students, but those who are gaining mastery faster should be challenged to do it first as models for other students later.)

Higher-Level Questions:

- How does the Cornell notes system address the curve of forgetting?
- Create a processing symbol/picture to represent and help someone remember the CORNELL WAY method.

ADDITIONAL RESOURCES

King, A. (1992, June 20). Comparison of self-questioning, summarizing, and notetaking—Review as strategies for learning from lectures. *American Education Research Journal, 29*(2), 303-323.

Section 1.8

Interactive Notebooks: The INB

The practice for organizing scientific research is the use of laboratory notebooks which include procedures, data, interpretations, graphs, and commentary. Science students can engage in a similar practice by using Interactive Notebooks (INBs). This organizational tool works most effectively where the teacher plans lessons as part of a unit in which student-centered activities are structured to build learning over time. These activities focus on the student's processing of information in order to build strong mental connections. WICOR strategies are used constantly with the Interactive Notebooks as students take notes, write summaries and explanations, develop questions, creatively process information, collaborate with peers, and read and process texts.

Students take responsibility for their learning more clearly with INBs because they can see the relationship between what they recorded from a lecture, lab, or reading and the products created from the information. Students can be given a choice of the type of product they create or the content that they process, which accommodates many different learning styles such as visual, verbal, auditory, and kinesthetic. The Interactive Notebooks can also address varying paces and levels of understanding for different learners.

Students reflect on what they have learned and how they have learned it throughout the year and make these comments in the INBs. Students develop their own style within the framework of the INB structure. They organize their own learning over time and develop higher-level thinking skills as they process the learning in individually meaningful ways rather than strictly by teacher-directed work.

With an Interactive Notebook, all student work is collected and located in one place so that individual pieces of work are no longer unaccounted for. This is not to say that a student cannot lose a notebook, but when students use their notebooks daily and are the authors of their own learning, the incidence of loss is much less than with a three-ring binder repository that holds papers in separate sections.

USING THE INTERACTIVE NOTEBOOK

Setting Up the INB

An Interactive Notebook should be a spiral or bound notebook with a durable cover. To decide the size that fits your needs, you should consider how your curriculum year is set up, what type of population you teach, and what works best for your situation. One large five-subject notebook with a heavy-duty cover may last the entire year. If you develop your teaching around separate quarters, semesters, or units, you may prefer to use several smaller one-subject spiral notebooks. If you are concerned that students may lose their notebooks, you might want to have students use several smaller notebooks over the course of the semester or year.

In the lesson that follows the introduction to the Interactive Notebook, students will set up their notebooks by numbering pages and gluing reference pages into them. The reference pages included are samples of the kinds of pages you can use. You may determine that other pages will meet the needs of your students better.

INB Right Sides

Students use the right-side pages of the Interactive Notebook to record information, thoughts, notes, quotes, or diagrams. Students write down the ideas that resonate with them, the content vocabulary, and the concepts they need to remember. They will return to their notes later in the class or day to add questions about the content as well as write a summary that captures the essence of the lesson. The right side of the notebook is the **INPUT**, the curriculum that students are expected to master.

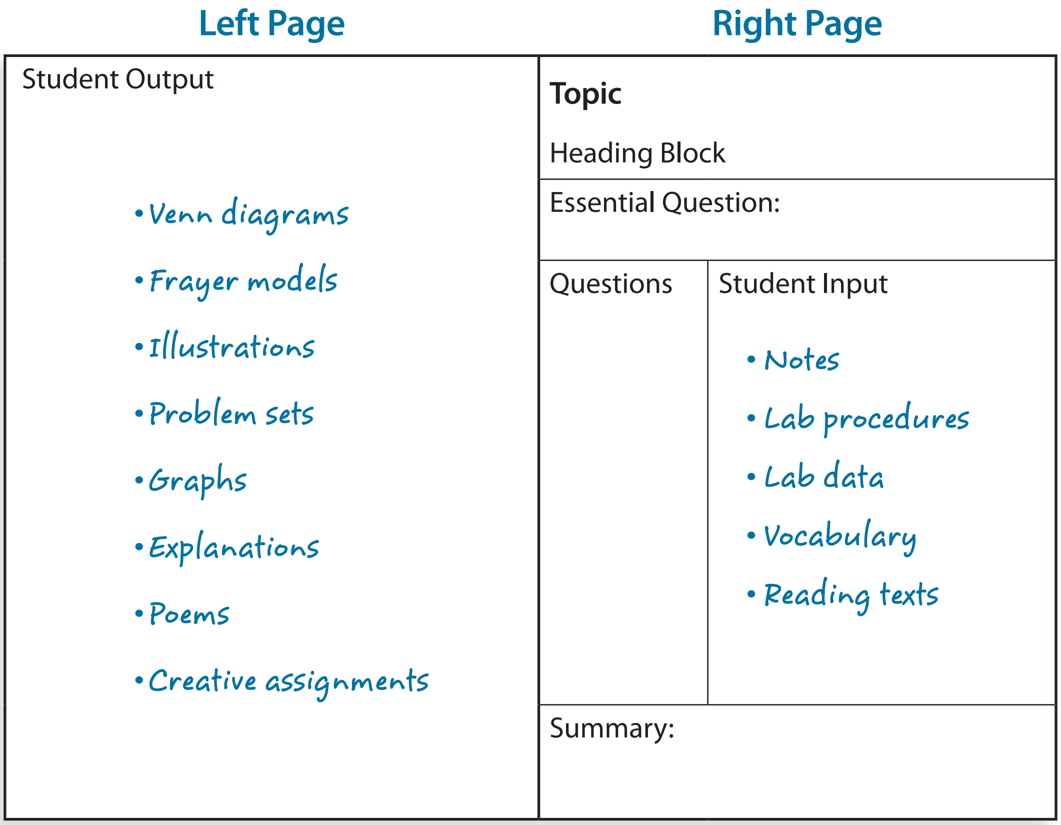
INB Left Sides

After students have captured the important information for later reference, they use the left-side pages in the notebooks to create products that demonstrate their understanding and processing of the material in a different form. The left side is synonymous with **OUTPUT**. The output can serve several purposes in your classroom, including checking for understanding, activating prior knowledge, developing understanding over time, and assessing learning.

Processing Activities

The *Processing Activities* in the appendix include many examples of ways students can process their learning. Each of these OUTPUT methods, when selected carefully to match student objectives or learning targets, will further clarify a student's comprehension of the INPUT, leading to a deeper understanding that results in a greater and longer retention rate. This is similar to creating a unique book representing a student's understanding of the science content of the class.

Suggested INB Set-Up



Make the Interactive Notebooks work for you and your students—adapt use of the INBs to agree with and complement your teaching style and your students. It is the concept of WICOR with an emphasis on analyzing information and deep learning that is important, not a strict format for placement of items.

Reflections

At the conclusion of a unit, students will reflect on their learning and organize their thoughts about the unit based on some required questions. They will review their work for the entire unit, decide which pieces they consider their best work, and describe what elements made the work high-quality. Students will then examine their notebooks as a whole and rate them according to the rubric. Following the reflection, parents are asked to review their student's work and comment on the learning. These processes help students to improve their future work.

BENEFITS OF USING INTERACTIVE NOTEBOOKS: THE TEACHER PERSPECTIVE

- Interactive Notebooks can be empowering for teachers as well as students. Using INBs makes learning more democratic and inclusive. Students are encouraged to reach for higher levels at rates they can handle. Because students are creating this product rather than simply receiving and recording information, they own the ideas and the content.
- This academic tool allows you to monitor student progress over time. Because all work is maintained in the INB, you can see how students are improving or where they might need to strengthen their skill sets, and provide targeted feedback. Having a portal through the INBs into the students' thinking means that you can view their thinking more readily on a daily basis rather than by grading papers. Using the INB also allows you time to help students develop ideas over the course of a unit and comment on the summation of the unit for a grade. This encourages improvement of skills and learning on behalf of the student.
- Teachers also have the unique opportunity to reflect on their teaching when they see the sum total of activities they have provided to students to learn material. This often gives a teacher an opportunity to truly consider the purpose of each activity and how it supports student learning. Teachers can then release the lower-quality items in favor of those that make a larger difference, creating a tool for teacher improvement.
- The INB's Adult Input Page and Parent Review are effective parent-teacher communication tools. Parents review the INB on a regular basis to see student progress and give feedback about the contents, assignments, and explanations. Students must teach a parent, guardian, or other adult something learned during the week or grading period. The adult must explain what the student taught. The Adult Input Page review is designed to implement the concept of "See One, Do One, Teach One." Seeing and applying information increases learning, but teaching information greatly increases understanding, comprehension, and retention.

DIFFERENTIATING FOR STUDENT POPULATION GROUPS

Most teachers see immediate implications of using the Interactive Notebooks for their general education students on the college preparatory track. The INBs also works for all populations including special needs students.

Special Needs Students

The INB left-side activities naturally lend themselves to differentiation in the classroom. Students who have IEPs and 504s are ideal candidates for using the INBs because they can still master the material with specialized support from the teacher. Students stretch themselves based on the connections the teacher helps them make and the left-side activities that are so effective for learning. As an example, you can instruct students to write a haiku poem about an element. By asking students to choose their words carefully and guiding the scope of their ideas, they focus only on the most important traits of the element. When students have to process information at this level, they are building connections between ideas. This helps the students distill the information into smaller segments and focus on the most important concepts (Maranzo, Pickering, & Pollock, 2001).

English Language Learners

Another population that often struggles in vocabulary-rich science classes is the English language learners (ELL). These students also benefit from the INB because there is now a venue for teachers to incorporate vocabulary development and usage on a daily basis. It becomes an integrated part of the science classroom rather than an add-on.

Honors, Advanced Placement, International Baccalaureate

The students in rigorous advanced academics classes can also use the INBs effectively. These students tend to absorb information easily. Because the classroom management is often easier in these demanding classes and students prefer (and are successful with) lectures, one might believe the INB to be a waste of time. However, these learners will be taking the most rigorous courses and will need a variety of strategies to be successful in the long run. These students benefit from the INB by creating their individual "textbook" that focuses on processing information to learn at deeper levels. At the AP level, teachers can use the INB to isolate the key information and help students develop ways to organize and learn the vast quantity of material.

Teachers may need to have AP or IB students keep the laboratory reports in a separate lab book since some universities require submission of lab reports in order to receive credit in a science lab course.

HELPFUL HINTS FOR TEACHERS

- Patience is a necessity—it may take a few weeks to slowly introduce the use of Cornell notes and processing activities to students. You also need to show students how to write lab data and reports or other types of assignments in the INBs, and how to grade the notebooks and processing activities. Introducing the parts and methods over a few weeks will make it easier to understand and not as overwhelming for students.
- *Make it work for you!* Prepare extra packets of the handout pages to be glued into the INB and store them near the extra notebooks. Have student assistants or responsible students assemble several extra INBs for students that may transfer to the class after notebooks are assembled. Students transferring into the class can be given

a packet and shown by another student how to physically put the notebook together.

- Assemble a sample INB for each period you teach. Use the notebook as a model to help keep students on track and organized through the semester. Use the notebook during your lectures and discussion and to keep track of scoring.
- Occasionally use open-INB quizzes to inspire students to use good note-taking skills and create great INBs.
- *Share excellent student work often!*
- Review and grade the INBs soon after they are introduced in class to correct any mistakes that students make with format or instructions. Show parents the INB's at Back to School Night and conferences to reinforce usage.
- Listen, watch, and learn from the students. Encourage feedback from students on what they liked or disliked and what works best so that use of the INB becomes smoother and stronger.

FREQUENTLY ASKED QUESTIONS ABOUT INBs

Should the INB page numbers be the same for all students?

This depends on you and the level of control that you feel is best for your students. Because there is natural variation in handwriting size and the amount of information that students need to write, variation is expected.

What if a student skips a page number?

It is not the page numbers that are important but that there is a reference point for the table of contents so that a student can find work later. However, students should not tear out numbered pages from their Interactive Notebooks.

Should I let students take their notebooks home regularly? What happens if they lose their notebooks?

Student notebook management is a choice of the individual teacher. Students should take notebooks home to process information, create study questions, and write summaries. Some teachers may decide to store the notebooks for students while others put the entire responsibility for the notebook on the students. Students value and appreciate the organization and success fostered by the notebooks. The use of the creative processing activities increases the value to students. This investment makes the work important and more understandable to students. If they see the INB as vital to daily instruction, they will relate success in the class to using the INB.

Typically, few students lose their INBs, but when that happens, they often panic. Suggested options to help a student cope with the loss of a notebook are:

- Have the student immediately start a new notebook and recreate the lost right-side portion using your model notebook for the unit. You might also allow the student to photocopy the right-side material from another student's notebook.
- The student should create the left-side processing assignments, if possible, to review information and to make up the missing grade points.
- The score for the final notebook could be figured from the point the new notebook was begun. Or the score could be the one possessed by the student prior to losing the notebook.

Is it mostly handouts that go into the Interactive Notebooks?

While INBs may have several photocopied pages, great INBs are exemplified by the work of processing the curriculum content (left-side work). These student-generated pages are of primary importance to the INB. In addition, including quizzes, tests, and graded assignments in the notebooks allows parents to have a clearer picture of their student's performance. If you feel that your students are spending too much time gluing or taping pages into the INBs, step back and evaluate the purpose of the handouts you are using.

How often should I collect INBs for grading?

The frequency of notebook checks is entirely at the discretion of the teacher. Some teachers do weekly checks (either grading of content or just spot checks), while others grade at the end of a unit. INBs are quick to evaluate with a holistic rubric, and it can be done in class on test day. Of course, you will provide verbal feedback on a more daily basis as you work with students in class and give formative assessments throughout the unit. You can also set up a peer review system for grading the INBs.

How do I include lab work?

Lab work is modified to fit the left and right sides in the INBs. The introductory information, data, and procedures are usually put on the right side. Graphs, interpretations, and analyses are usually left-side items. Refer to the previous information on INPUT and OUTPUT, and let that guide you. If you require students to submit formal lab reports, these can be stapled into the notebook after it is graded.

ADDITIONAL RESOURCES

History Alive! Interactive Student Notebook. (1999). Rancho Cordova, CA: Teachers' Curriculum Institute.

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

Section 1.9

Setting Up The Interactive Notebook

Introduction

The AVID science organizing tool is the Interactive Notebook (INB). It is a tool that teachers and students can use to organize the content information of the course. The INB is quite similar to a scientist's lab notebook filled with data, hypotheses, conclusions, and new experiments.

In this lesson students will set up their spiral or bound Interactive Notebooks so they can be used to record information (INPUT), filter it (PROCESS), and produce a product (OUTPUT). They will number the INB pages and glue reference pages into the notebooks. For many of the students, this will be their first time to use this organizational tool. In the beginning they may not see the value of the notebooks, but as the course progresses, they will soon find that the notebooks are important to their academic success in science and that this method of organizing, learning, and thinking is enjoyable.

Timeline

50–60 minutes to set up the INB the first time. Time will vary over the course of the first few weeks after the set-up depending on the classroom management and room set-up. The time requirement decreases daily as students become familiar with using the INB.

Objectives: The Students Will . . .

- Set up and use the Interactive Notebook organizational system

WICOR Strategies

All of the WICOR strategies are used when the notebooks are implemented in a content class

National Science Education Standards

Standard A (Grades 5–8): Science as Inquiry

- Identify questions that can be answered through scientific investigations.
- Develop descriptions, explanations, predictions, and models using evidence.
- Communicate scientific procedures and explanations.

Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations.
- Communicate and defend a scientific argument.

Materials

- Scissors
- Colored pencils or markers
- Spiral or bound notebook with heavy cover
- Pens/pencils
- Highlighters
- Glue sticks

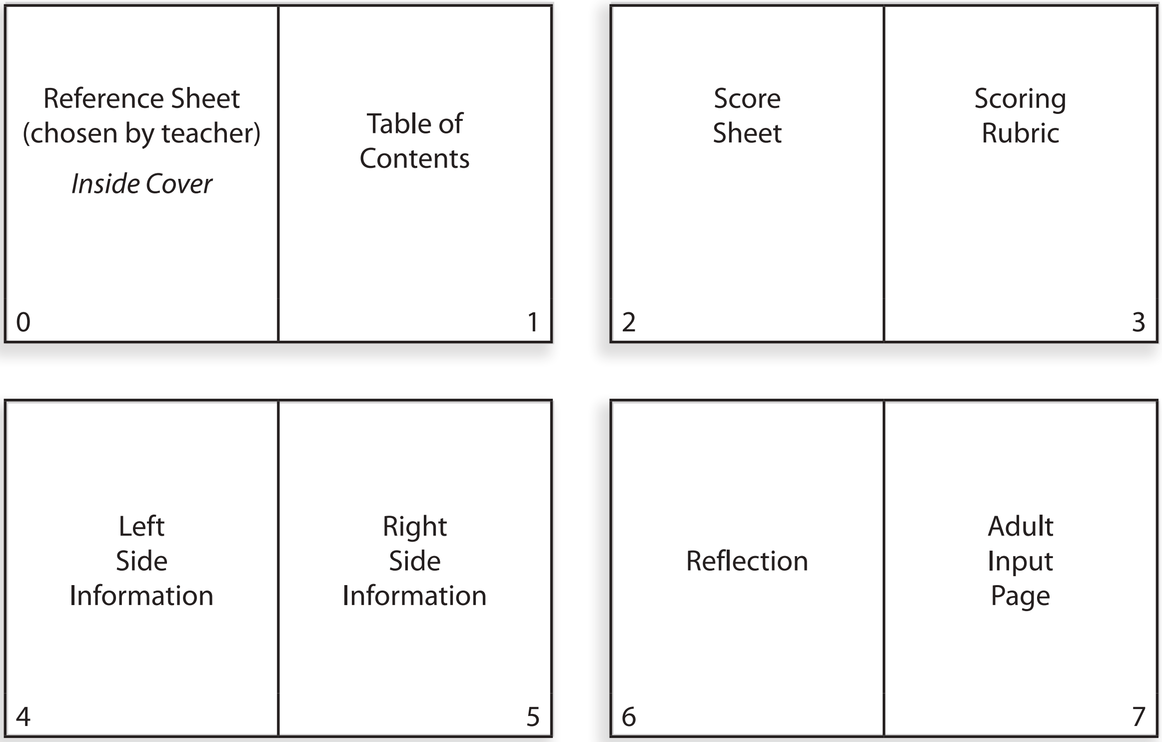
Handouts

Student Handout 1.9.1: *INB Letter-Grade Rubric*
Student Handout 1.9.2: *INB 5-Point Scoring Rubric*
Student Handout 1.9.3: *INB Score Sheet*
Student Handout 1.9.4: *Interactive Notebook Table of Contents*
Student Handout 1.9.5: *Keeping Interactive Notebooks in Science: The Right Side*
Student Handout 1.9.6: *Keeping Interactive Notebooks in Science: The Left Side*
Student Handout 1.9.7: *Keeping Interactive Notebooks in Science: The Reflection*
Student Handout 1.9.8: *Adult Input Page (Multiple Response)*
Student Handout 1.9.9: *Adult Input Page (Single Response)*
Teacher Reference 1.9.10: *Processing Activity Samples*
Teacher Reference 1.9.11: *Interactive Notebook Sample*

Teacher Directions

- Read and review the introductory information on Interactive Notebooks before beginning this lesson.
- Introduce students to the INB by briefly explaining what it is and how it will be used. Emphasize to students that the INBs are valuable organizational and learning tools.
- Build your own skeleton INB as the students build theirs.
- Ask students to number the pages of their notebooks starting with 1 on the lower right side of the first blank page—right-side pages are odd numbers, and left-side pages are even numbers. They should number pages 1–20 in their INBs. The remainder of the pages can be numbered later.
- In keeping with the idea that students are creating an individual book, they will create a reference section at the start of the INB. This will require scissors, glue sticks, and photocopies of the handouts. The reference sheets provided are important ones for students to keep in their INBs, but you may also choose to use additional reference pages that are important for your content area.
- Distribute the handout sheets to the students. Have them trim the edges of each handout so that it fits on the appropriate page of the INB as shown in the diagram below. Do this together as a class to ensure accuracy.

Suggested INB Set-Up



- If desired, you can have students place an important reference page specific to your course on the inside cover of the INB. This can be a periodic table, formula sheet, lab report format, unit syllabus, or any other page that would be useful to the students. You could also have students create a table for recording important terms or equations and their page numbers in the INB.

- Briefly introduce how each of the handout pages will be used:

  Letter-Grade Rubric or *5-Point Scoring Rubric:* Choose which of the rubrics you prefer to use (5-point rubric, letter-grade rubric, or another one of your choice). The rubrics describe the general, basic criteria for assignments and can be used when the teacher reviews student work or when students review their own assignments. You can substitute number grades in the letter grade rubric or use your school's number grades that correspond to the letter grades.

  Score Sheet: The score sheet provides a location to enter INB grades on an ongoing basis.

  Table of Contents: Students should enter the title and page numbers at the time of each activity.

  Keeping Interactive Notebooks in Science: The Right Side: This page provides guidelines and examples for the INPUT information for the INB.

  Keeping Interactive Notebooks in Science: The Left Side: This page lists examples of the types of processing assignments students can use to illustrate understanding of content information.

  Reflections: Students will use this page to reflect on their learning at the end of a unit, which will help them improve their future work.

  Adult Input Page (multiple response or single response format): The adult input page provides a place for the parent/guardian or other adult to review and comment on student work. The multiple response format can be glued onto the inside back cover of the INB. The single response format will be used after a unit or grading period and can be glued under the student reflection page for the unit.

- After the notebooks are prepared for use, emphasize to students how extremely valuable the INBs will be to them throughout the science course. Also let them know how you will use the INBs and how and when they will be graded.

Differentiation Strategies

- Refer to the "Differentiation for Student Population Groups" information in the introduction to the Interactive Notebook, Section 1.8.

Rubrics

- The rubrics provided use a holistic overview of the INB based on student implementation of the left page-right page guidelines. A required element is commentary from a parent or another adult. Other options include creating a checklist for the required elements or assignments for the unit.

STUDENT HANDOUT 1.9.1

INB Letter-Grade Rubric

A	• Contents are complete, dated, and labeled • Left sides/right sides show mastery pattern of organization • Notes are Cornell style with excellent questioning as well as going beyond basic requirements • Notebook integrates other sources of information • Demonstrates extensive left-side processing of information • Uses color in a meaningful way throughout notebook • Includes effective diagrams and pictures • Shows excellent, in-depth reflection about the work • Includes adult signature and comments • Pages are numbered correctly
B	• Contents are mostly complete (~2–3 missing/incomplete pieces) • Pages are numbered, dated, and labeled and table of contents current • Left sides/right sides show basic pattern of organization • Notes are Cornell style with questions • Demonstrates some left-side processing of information • Uses color, includes diagrams and pictures • Shows reflection about the work • Includes adult signature
C	• Contents are somewhat complete (~4–5 missing/incomplete pieces) • Pages are numbered, dated, labeled, and legible • Notes are Cornell style with some questions • Left sides/right sides show developing pattern of organization • Left sides include some processing of information • Uses color, includes diagrams and pictures • Contains reflection • Includes adult signature
D	• Contents are partially complete • Pages are numbered, dated, labeled, and legible • Notes are Cornell style • Left sides/right sides show random pattern • Few left sides include processing of information • Has minimal reflection
F	• Contents are too incomplete to evaluate • Some attempt at maintaining entries is made • Left sides/right sides show little pattern • Minimal left-side processing of information/No reflection

STUDENT HANDOUT 1.9.2

5-Point Scoring Rubric

5	• All requirements exceed expectations • Notebook contents are complete, dated, labeled, and organized • Information on right-side and left-side topics is correct • Notes are Cornell style, with questions • Displays superior understanding of content material • Well-developed processing assignments that use color and effective diagrams • In-depth reflection about the work done
4	• All requirements are evident • Notebook contents are almost complete, dated, labeled, and organized • Information on right-side and left-side topics is correct • Notes are Cornell style, with questions • Displays good understanding of content material • Satisfactory processing assignments that use color and effective diagrams • Thorough reflection about the work done
3	• Most requirements are evident (one or two are missing) • Notebook contents are almost complete, dated, labeled, and organized • Notes are Cornell style, with some questions • Information on right-side and left-side topics is mostly correct • Displays limited concept of understanding of content material • Processing assignments incomplete or lack use of color and effective diagrams • Shows reflection about the work done
2	• Most requirements are evident • Notebook contents are incomplete or not dated, labeled, or organized • Notes are Cornell style, with few or no questions • Information on right-side and left-side topics is partially correct • Displays superficial understanding of content material • Processing assignments show minimal processing of information • Shows little reflection about the work done
1	• Many requirements not present • Product is very poorly done and poorly organized • Few or no processing assignments included

INB Score Sheet

Grading Period: ________________ Name: ________________________________

Week #	Notebook Pages	Notebook Score	Teacher Stamps (# and highlight stamps)	**WEEKLY POINT TOTAL**	Peer Initials	Teacher Initials or Stamps
1		____/5	_____ / _____	_____ / _____		
2		____/5	_____ / _____	_____ / _____		
3		____/5	_____ / _____	_____ / _____		
4		____/5	_____ / _____	_____ / _____		
5		____/5	_____ / _____	_____ / _____		
6		____/5	_____ / _____	_____ / _____		
7		____/5	_____ / _____	_____ / _____		
8		____/5	_____ / _____	_____ / _____		
9		____/5	_____ / _____	_____ / _____		
10		____/5	_____ / _____	_____ / _____		

Name of Special Assignment	**Score**	**Date Scored**	Peer Initials	Teacher Initials or Stamps
	_____ / _____			
	_____ / _____			
	_____ / _____			
	_____ / _____			
	_____ / _____			
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	_____ / _____			

STUDENT HANDOUT 1.9.4

AVID®
Proven Achievement.
Lifelong Advantage.

Interactive Notebook

Table of Contents

Unit: ________________________________

Name: ________________________________ Date Submitted: ________________

Left-Side Items	Page	Right-Side Items	Page

Notebook Feedback:

Frequent Issues

☐ Weak reflection/no signature
☐ Left side/right side confusion
☐ Missing assignments
☐ Content processing does not support content learning

Keeping Interactive Notebooks in Science

The Right Side

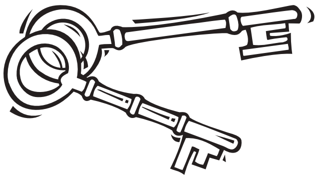
Interactive notebooks will be used in class daily to help you learn and remember important science concepts. The right-side notebook page contains the information you put into the notebook and the information you need to learn—the INPUT.

What goes on the right side?

INPUT goes on the right side! Input is all the information that you are supposed to learn. Some examples of input include the following:

- Notes from a lecture or guest speaker
- Text or other source
- Vocabulary words
- Video and film notes
- Procedures
- Readings
- Questions and answers
- Sample problems

The Keys to Fantastic Right Sides



- Right sides have **ODD** numbered pages. Always start the page with the date and title at the top of the page.
- The right page is for writing down information you are given in class. Use Cornell notes for lecture, discussion, text, sample problems, etc. Write up your study questions ASAP.
- Write legibly. Use highlighting and color to make important information stand out.
- Write summaries at the bottom of each page of notes to reduce the amount of information you have to study.

Costa's Levels of Thinking

Level 3	Apply Judge	Evaluate Predict	Hypothesize Speculate	Imagine
Level 2	Analyze Infer	Compare Sequence	Contrast Synthesize	Group
Level 1	Define Name	Describe Observe	Identify Recite	List Scan

STUDENT HANDOUT 1.9.6

Keeping Interactive Notebooks in Science

The Left Side

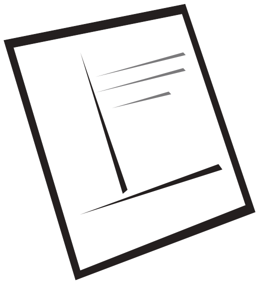
The left page demonstrates your understanding of the information from the right side of the page. You work with the input and interact with the information in creative, unique, and individual ways. The left side incorporates and reflects how you learn science as well as what you learn in science.

What goes on the left side?

Output goes on the left side. These are products that demonstrate understanding of the topic or content. Some examples of output include the following:

- Brainstorming
- Concept maps
- Riddles
- Illustrations
- Cartoons
- Poetry and songs
- Metaphors and analogies
- Venn diagrams
- Data and graphs you generate
- Analysis writing
- Reflection writing
- Quickwrites
- Four-square analogies
- Mnemonics
- Flowcharts
- Graphic organizers
- Writing prompts
- Other creative avenues for processing information

Things to Know About Left Sides



- Left sides have even-numbered pages. Every left-side page gets used and relates to a right side.
- Always use color (minimum of three per page) for learning. It helps the brain learn and organize information.
- Quizzes, tests, and other summative assessments are left-side items.
- Homework problems are left-side items (but they don't take the place of processing your notes!).

12. Make an illustration explaining the topic.

1. Write the lyrics for a song.

2. Create a bookmark for this topic.

3. Write a haiku poem.

4. Create vocabulary cards for 5 most essential terms.

5. Paraphrase information in one sentence.

6. Write four "What if" questions about the topic

7. Write a letter about the topic to your grandmother.

8. Create an analogy and an illustration.

9. Write and solve problems using the information.

10. Create a Venn diagram to compare/contrast.

11. Create a graph.

Keeping Interactive Notebooks in Science

The Reflection

Toward the end of each unit of study, you will be called upon to reflect upon your work. This writing sample begins on the left side on the notebook and continues on the right. While there is no required length, high-quality reflection uses one to two pages of the notebook. ***Attach the parent feedback form*** (with comments and signature) at the bottom of the right-hand page as required.

1. **High-Quality Reflection of Work:** Select up to four items that represent your best work: two from the left side, two from the right side. Address the specific reasons why you chose these items as your best work as well as what these assignments reflect about your skills as a scientist-student. *Please note: Reasoning that it was "fun" or just that you liked it, is NOT adequate reflection.* Some ideas to consider include:

   What about the left-side activities helped you better understand and recall the material?

   How did you use different levels of questions to help you reach a deeper level of understanding?

   What did you learn from the activity (both content-wise and learning-wise)?

   What aspects of the work were high quality and why?

   What you would do differently in the future (and why)?

2. **Assessment of Skill Set:** A high-quality reflection also examines your skills as a student and as a scientist. Skills you might discuss are your organization, analysis, logic, creativity, thoroughness, accuracy of information, ability to put new information together, understanding new concepts, etc. What specific study skills have you employed to be successful in this class? Which organizational strategies that appear in the notebook helped you learn the most? Elaborate.

3. **Assessment of Unit Work as a Whole:** Indicate your overall rating of your notebook based on the rubric. Justify your rating with specific examples. Has your notebook improved from past notebooks? Explain.

4. **Looking to the Future:** What are your goals for improvement in this class? List specific areas in which you feel you need to improve or need help improving. What specific changes would you like to see in this class? Explain.

Adult Input Page (Multiple Response)

To the adult: Completing this page will help your student to have a better understanding of the material learned in class. When a person teaches another, both learn, but the "teacher" often learns much more than the "student." Your student should discuss and teach you a concept covered in class. Please write down one or two sentences explaining what YOU LEARNED from the discussion and tutoring.

Date	What I LEARNED	Adult Signature

Adult Input Page (Single Response)

Dear Parent/Guardian/Other Adult:

This Interactive Notebook represents your student's learning to date and should contain the work your student has completed in science class. Please take some time to look at his or her Interactive Notebook, read the reflection written in the notebook, and respond to any of the following:

The work I found most interesting was ____________________________________ *because...*

What does the notebook reveal about your student's learning habits or talents?

My student's biggest concern about this class is...

Parent/Guardian/Other Adult Signature: ____

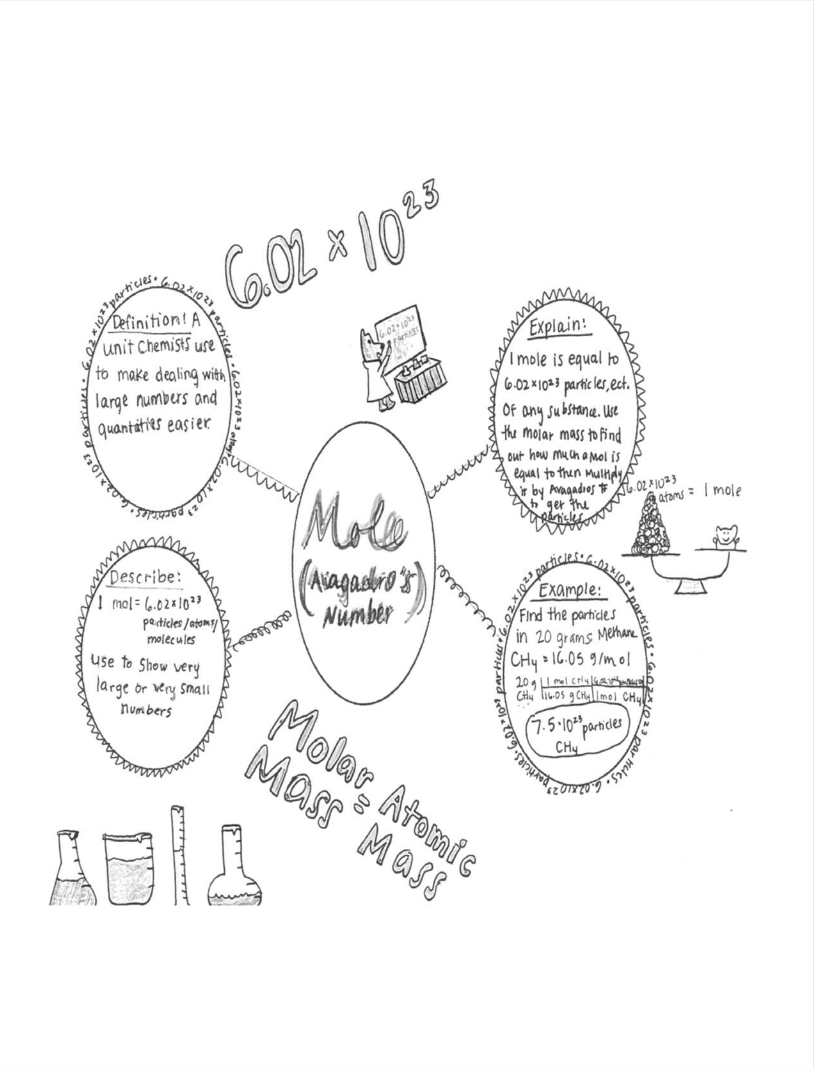
If you have immediate concerns, please contact your student's teacher via phone ________________

or email _________________________________.

TEACHER REFERENCE 1.9.10

Interactive Notebook

Student Sample



Definition! A unit Chemists use to make dealing with large numbers and quantities easier.

Explain: 1 mole is equal to 6.02×10^{23} particles, ect. Of any substance. Use the molar mass to find out how much a Mol is equal to then Multiply it by Avagadros # to get the particles

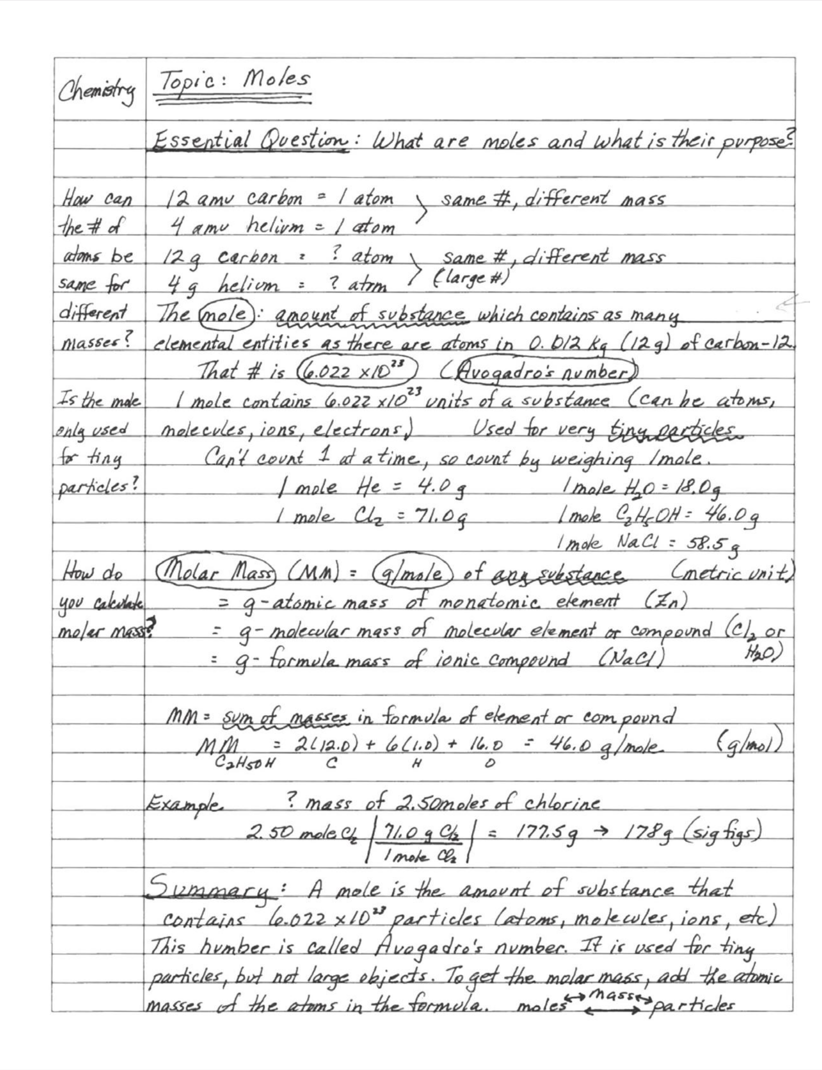
Describe: 1 mol = 6.02×10^{23} particles/atoms/molecules

Use to Show very large or very Small numbers

Example: Find the particles in 20 grams Methane. CH_4 = 16.05 g/mol

$$20\,g\,CH_4 \left| \frac{1\,mol\,CH_4}{16.05\,g\,CH_4} \right| \frac{6.02\times10^{23}\,particles}{1\,mol\,CH_4}$$

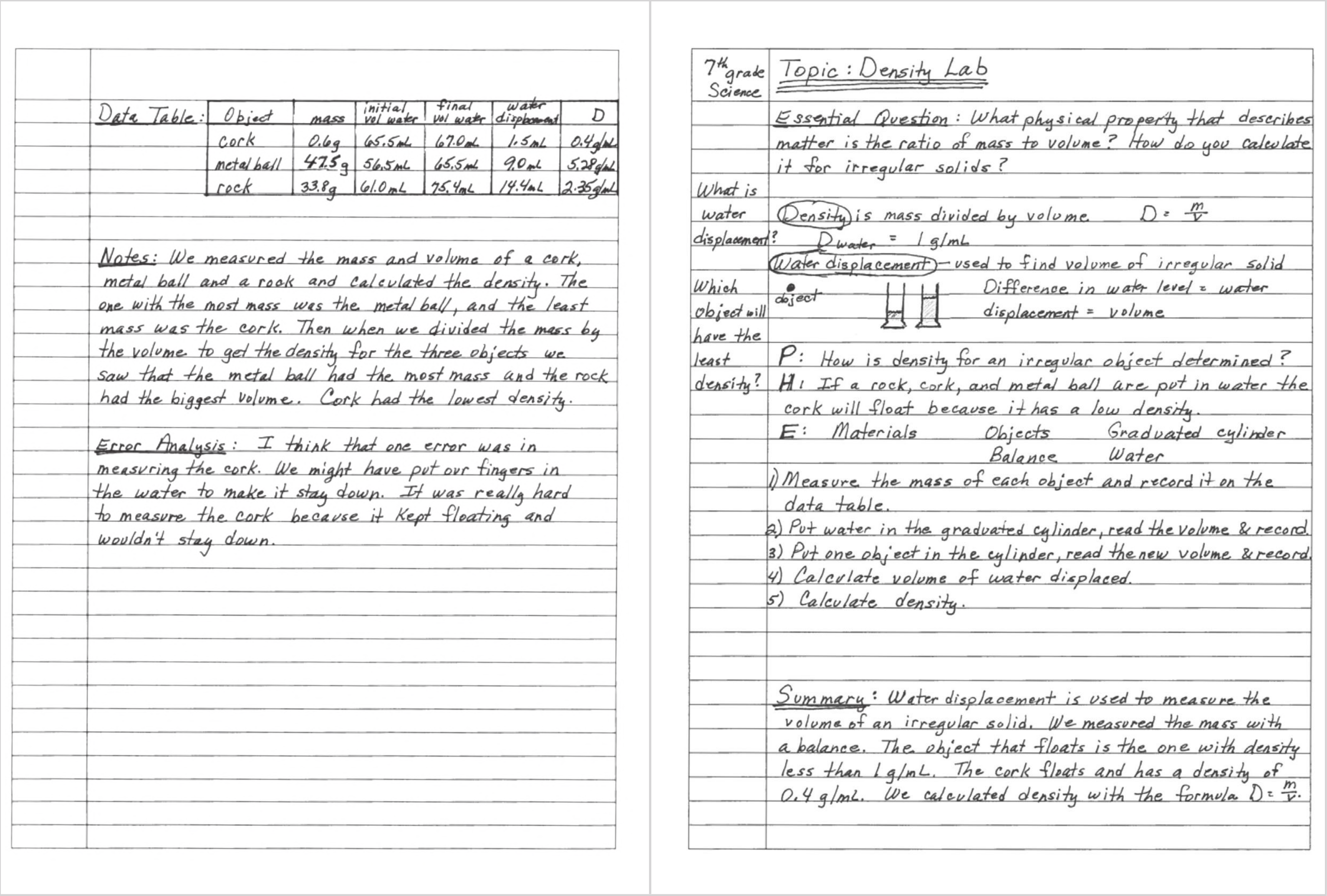
$7.5\cdot10^{23}$ particles CH_4



Chemistry	Topic: Moles
	Essential Question: What are moles and what is their purpose?
How can the # of atoms be same for different masses?	12 amu carbon = 1 atom, 4 amu helium = 1 atom } same #, different mass 12 g carbon = ? atom, 4 g helium = ? atom } same #, different mass (large #) The mole: amount of substance which contains as many elemental entities as there are atoms in 0.012 kg (12 g) of carbon-12. That # is 6.022×10^{23} (Avogadro's number)
Is the mole only used for tiny particles?	1 mole contains 6.022×10^{23} units of a substance (can be atoms, molecules, ions, electrons) Used for very tiny particles. Can't count 1 at a time, so count by weighing /mole. 1 mole He = 4.0 g 1 mole Cl_2 = 71.0 g 1 mole H_2O = 18.0 g 1 mole C_2H_5OH = 46.0 g 1 mole NaCl = 58.5 g
How do you calculate molar mass?	Molar Mass (MM) = g/mole of any substance (metric unit) = g-atomic mass of monatomic element (Zn) = g-molecular mass of molecular element or compound (Cl_2 or H_2O) = g-formula mass of ionic compound (NaCl)
	MM = sum of masses in formula of element or compound $MM_{C_2H_5OH} = \underset{C}{2(12.0)} + \underset{H}{6(1.0)} + \underset{O}{16.0} = 46.0$ g/mole (g/mol)
	Example ? mass of 2.50 moles of chlorine $2.50\,mole\,Cl_2 \left| \frac{71.0\,g\,Cl_2}{1\,mole\,Cl_2} \right| = 177.5\,g \rightarrow 178\,g$ (sig figs)
	Summary: A mole is the amount of substance that contains 6.022×10^{23} particles (atoms, molecules, ions, etc) This number is called Avogadro's number. It is used for tiny particles, but not large objects. To get the molar mass, add the atomic masses of the atoms in the formula. moles $\overset{mass}{\longleftrightarrow}$ particles

Interactive Notebook

Student Sample



7th grade Science

Topic: Density Lab

Essential Question: What physical property that describes matter is the ratio of mass to volume? How do you calculate it for irregular solids?

What is water displacement?

Density is mass divided by volume. $D = \frac{m}{V}$

$D_{water} = 1 g/mL$

Water displacement — used to find volume of irregular solid

Which object will have the least density?

object

Difference in water level = water displacement = volume

P: How is density for an irregular object determined?

H: If a rock, cork, and metal ball are put in water the cork will float because it has a low density.

E: Materials Objects Graduated cylinder Balance Water

1) Measure the mass of each object and record it on the data table.

2) Put water in the graduated cylinder, read the volume & record.

3) Put one object in the cylinder, read the new volume & record.

4) Calculate volume of water displaced.

5) Calculate density.

Summary: Water displacement is used to measure the volume of an irregular solid. We measured the mass with a balance. The object that floats is the one with density less than 1 g/mL. The cork floats and has a density of 0.4 g/mL. We calculated density with the formula $D = \frac{m}{V}$.

Data Table:

Object	mass	initial vol water	final vol water	water displacement	D
cork	0.6g	65.5mL	67.0mL	1.5mL	0.4g/mL
metal ball	47.5g	56.5mL	65.5mL	9.0mL	5.28g/mL
rock	33.8g	61.0mL	75.4mL	14.4mL	2.35g/mL

Notes: We measured the mass and volume of a cork, metal ball and a rock and calculated the density. The one with the most mass was the metal ball, and the least mass was the cork. Then when we divided the mass by the volume to get the density for the three objects we saw that the metal ball had the most mass and the rock had the biggest volume. Cork had the lowest density.

Error Analysis: I think that one error was in measuring the cork. We might have put our fingers in the water to make it stay down. It was really hard to measure the cork because it kept floating and wouldn't stay down.

Unit 2

Writing to Learn

Science teachers face the daily challenge of determining students' depth of comprehension of skills and concepts. In sports, a coach observes how an athlete is executing a skill and provides individual and group feedback immediately. Most of the time, the understanding of concepts in science is not as easily visible. Learning occurs in the brain when a student internalizes concepts and understandings. When teachers require students to make the learning evident, they can redirect and refocus efforts to refine the learning. While not easy, this is achievable with careful lesson design that includes opportunities for students to demonstrate their mastery with writing-to-learn activities.

Writing is a tool for learning that goes far beyond creating a story or writing a poem. It is a way to communicate a person's thinking and understanding of concepts and ideas. The writing process requires science students to move beyond recall of scientific facts (Costa's Level 1 thinking) to communication of concepts and ideas that require processing of information (Costa's Levels 2 and 3 thinking).

This unit presents a number of methods to encourage students to show what they know as well as to refine what they have learned. Many of the science process skills are found in this section including observation, inference, and writing lab procedures, comparisons, and summaries. Also included are quickwrites, learning logs, reflections, and creative processing activities.

The lessons included here reinforce the scientific process skills as well as content requirements. They integrate several AVID methodologies to show how to incorporate multiple learning strategies into an effective lesson. Students can review the science skills and utilize them during the lesson as you tailor it to the specific science content that you teach.

Many states and districts have incorporated engineering and technology standards in their curricula. The *Think It-Build It-Write It* lesson reinforces the importance of written instructions and procedures while students design machines with variable purposes. The *Photo Project* provides the opportunity for students to analyze photos and written explanations of the related science within the photos. Through the activity, students connect classroom ideas to common life experiences—they become engaged in the learning process by discovering science in the world around them.

Today's workplaces require that the employees think critically to problem-solve and to communicate their thinking through writing. At all levels in science classrooms, writing should be a valuable part of the academic instruction. As we teach students to write, we teach them the lifelong skills of thinking and reasoning—requirements for all fields of study and careers.

Section 2.1

Quickwrites

Introduction

William Zinsser (2001, p. 149) asserts "writing is thinking on paper." When a student writes, he is thinking critically. One way to engage students in writing is the quickwrite, a one- to five-minute response to a prompt that helps students access their prior knowledge on a topic or record ideas on a stated topic. Quickwrites are focused and yet not threatening, because they are short, and students are usually responding to a prompt that stimulates their thinking.

Quickwrite responses can be categorized into four types: application of a concept, imaginative ideas, offering an opinion, and justifying a point of view (Angelo and Cross, 1993). The key to successful quickwrites is interesting the students in the prompt so that they provide thoughtful responses. You might ask students to:

- Summarize an experiment they design or a piece of literature/reading.
- Justify a view point based on scientific observations.
- Draw conclusions from a demonstration, lab, or discrepant event.
- Write about their background knowledge or learning process for new material.
- Respond to an open-ended question based on scientific phenomena.

Timeline

15 minutes

Objectives: The Students Will . . .

- Write a response to a science content prompt

WICOR Strategies

Writing:	Write a free-style response to a prompt
Inquiry:	Connect to prior knowledge
Collaboration:	Discuss ideas within small groups
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read and interpret passages, graphs, or data

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Reference items for quickwrite (e.g., graphs, data)

Handouts

Teacher Reference 2.1.1:	*Sample Science Quickwrite Prompts*
Teacher Reference 2.1.2:	*Science Quickwrite Prompts Based on Costa's Levels of Thinking*
Teacher Reference 2.1.3:	*Quickwrite Student Sample*

Teacher Directions

- The *Sample Science Quickwrite Prompts* contains sample prompts that fit the categories described in the introductory section.
- The prompts provided on *Science Quickwrite Prompts Based* on *Costa's Levels of Thinking* are open-ended question stems that promote higher-order thinking, corresponding to Costa's Levels 1, 2, and 3. The questions activate prior knowledge, help students process and connect concepts, and nurture the wonderings of more thoughtful questions to explore.
- After announcing to students the duration of the quickwrite, present or post the prompt and ask them to write their detailed free-style response in their INBs on a left side or right side. The left side is appropriate when you are eliciting prior knowledge, starting a unit, reviewing the homework, or have another purpose that would cause the student to process information as an OUTPUT. The right side acts as INPUT and can be justified in any number of ways. If students are examining a data set for trends that they must learn, considering how to graph a set of data or relating information from class to their personal experience during a lecture to develop a list of examples, the right side is wholly appropriate.
- Students can share their responses to small groups or to the entire class.

Differentiation Strategies

- The choice of topics and the time allotment are simple differentiations for students.
- Students can be given sentence starters or key words to use in the quickwrites.

Sample Science Quickwrite Prompts

Summary of a piece of literature, reading, diagram, or graph	**Justify a viewpoint based on scientific observations**	**Draw conclusion from a lab, demo, or discrepant event**	**Remembering based on background knowledge or a learning process**	**Open-ended question**
Examine the diagram of the water cycle and write an inference about the topic.	Is Oobleck a solid or liquid? Justify your answer.	[Based on a series of demos]: Explain how hydrogen bonding affects the properties of water.	What do you know about global warming?	Is Pluto a planet?
Analyze the heating curve graph on page ___ of the textbook and explain how energy changes affect the phases of matter.	Provide evidence that the burning of a candle is a physical and a chemical change.	[After a dissection]: Describe the flow of food through the digestive system of a frog.	Describe the process used to find the density of a regular solid vs. an irregular solid.	Is water a universal solvent?
Read the procedures for the lab and describe what safety rules are most important and which equipment should be used.	Argue for or against genetically modified organisms.	Explain how… (Magic Sand, Happy/Sad Balls, Drinking Bird, Lava lamp) works…based on the principle of…?	Jot down everything you remember from the reading on "Types of Organic Compounds."	How is matter conserved?
Read Dalton's postulates and identify the inconsistencies of his atomic theory based on the current atomic models.	What type of evidence is most compelling to you about…?	What experiment could you design to test…[a phenomenon or discrepant event]?	Illustrate how photosynthesis works.	If ice had a greater density than water, how would that affect Earth's environment?
Read On the Origin of a Species and prepare five interview questions for Darwin about his contributions to the theory of evolution.	What is the significance of this experiment/formula to the topic on…?	Before the demo I thought…; now after the demo I wonder…	Describe the steps used in the scientific process.	What would happen if all the microbes on Earth died?

Science Quickwrite Prompts Based on Costa's Levels of Thinking

Costa's Level 3 Thinking

- Is there a better solution to…?
- Judge the value of…?
- Can you defend your position about…?
- What changes to…would you recommend?
- How effective are…?
- What influences will…have on…?
- What are the pros and cons of…?
- What would happen if…?
- How does…relate to everyday life?
- What conclusions can I draw about…?

Costa's Level 2 Thinking

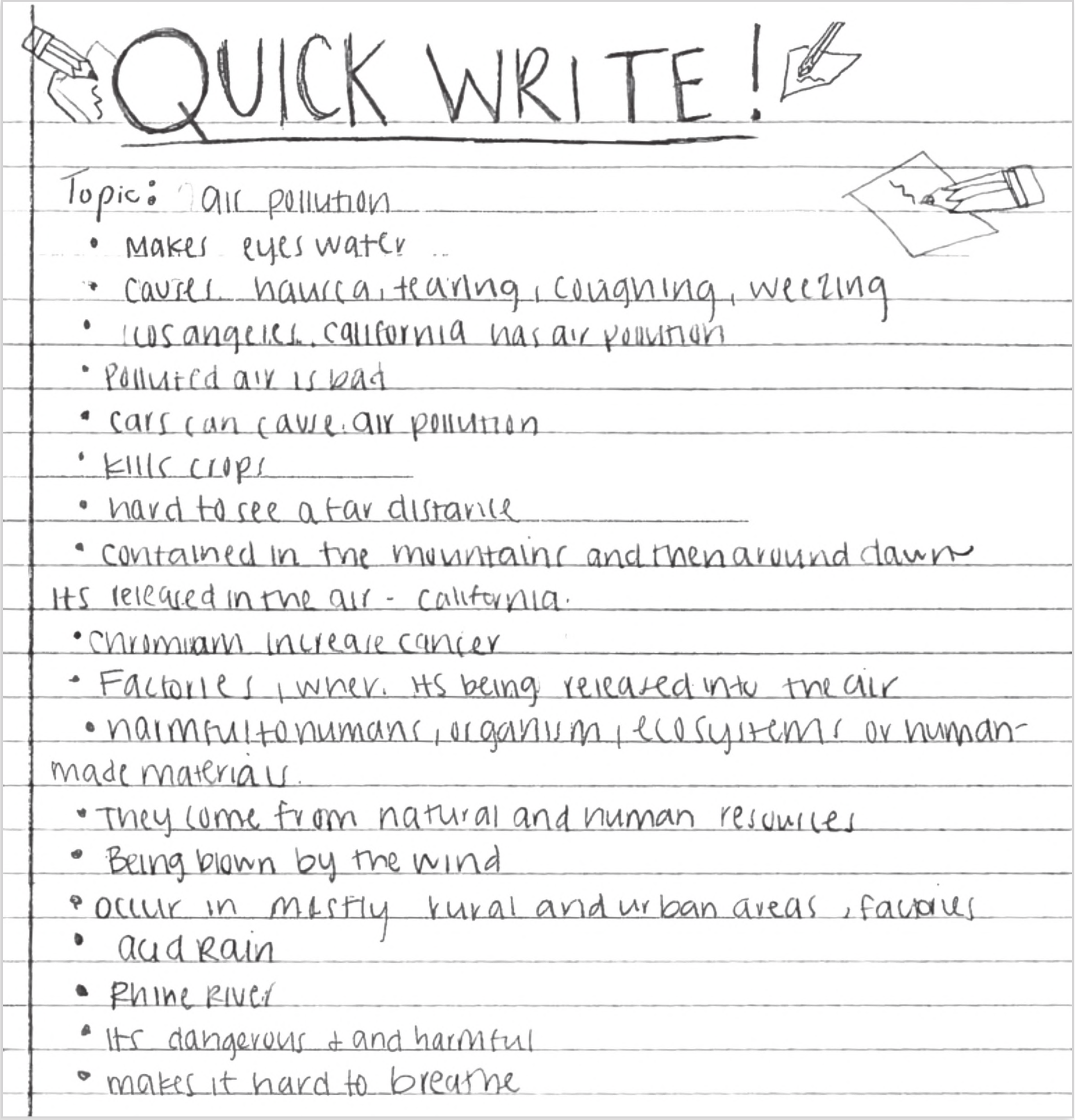
- What factors would you change if…?
- What question would you ask of a cell about the reproductive cycle?
- Which events could not have happened?
- If…happened, what might the ending have been?
- How is…similar to…?
- What do you see as other possible outcomes?
- Why did…changes occur?
- What are some of the problems of…?
- Can you distinguish between…?
- What is the difference between…and…?

Costa's Level 1 Thinking

- Create a concept map of the topic.
- Describe what happens after…
- Write a one-minute summary of the demo.
- Paraphrase the paragraph/chapter on…
- Can you explain why…?
- What was the main idea…?
- What kind of data would support…?
- What causes…?
- How do scientists…?
- What is another way to explain…besides…?

Quickwrite

Student Sample



QUICK WRITE!

Topic: air pollution

- Makes eyes water
- Causes naucea, tearing, coughing, weezing
- Los angeles, california has air pollution
- Polluted air is bad
- cars can cause air pollution
- kills crops
- hard to see a far distance
- contained in the mountains and then around down its released in the air - california.
- Chromiam increase cancer
- Factories, when its being released into the air
- harmful to humans, organism, ecosystems or human-made materials.
- They come from natural and human resources
- Being blown by the wind
- occur in mostly rural and urban areas, factories
- acid Rain
- Rhine River
- its dangerous + and harmful
- makes it hard to breathe

Section 2.2

Learning Logs

Introduction

- Learning logs are specific, open-ended writing tasks that help students focus on learning through exploration of what they know. They are reflective in nature compared to a summary which focuses on a brief overview of the content. (Refer to Section 1.6 for a comparison of summary versus reflection.) Learning logs are a student's reflections on specific subject material where they clarify ideas and articulate their understanding of the concepts. Students can make personal connections through this type of writing. Using learning logs repeatedly over time will improve writing fluency and depth of thought.

Timeline

15 minutes

Objectives: The Students Will . . .

- Explore their thinking through writing

WICOR Strategies

Writing:	Write reflective learning logs
Inquiry:	Connect to prior knowledge
Collaboration:	Discuss ideas within small groups
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Reciprocal teaching

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Communicate scientific procedures and explanations.
- Develop descriptions, explanations, predictions, and models using evidence.

Science Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Writing prompts

Handouts

Student Handout 2.2.1:	*Science Learning Log Template 1 and Science Learning Log Template 2*
Teacher Reference 2.2.2:	*Learning Log Templates Student Samples*
Teacher Reference 2.2.3:	*Learning Logs and Costa's Levels of Thinking*

Teacher Directions

- Select the type of learning log topic or prompt on which you want the students to write their reflective responses (e.g., new learning they acquired from the class or another assignment, observations they made of an experiment).
- Provide different levels of prompts based on student interests and levels of concepts. Allowing students to choose the topic or prompt allows them to engage at higher levels as they usually choose prompts that are most interesting to them.
- Encourage students to write what they really think, not what they think you want them to say.
- Use the learning logs as formative assessments to inform your instruction as you collect and read each response.
- Have students share and discuss their reflections with each other. Ask a few students to share their learning logs orally with the class. Discuss any questions that students still have about the content or the process of learning the content.
- The learning logs are usually placed on the left side of the INB since they are used to process learning.

Suggested INB Set-Up

<table>
<tr><th>Left Page</th><th colspan="2">Right Page</th></tr>
<tr><td rowspan="4">Learning Log</td><td colspan="2">Topic
Heading Block</td></tr>
<tr><td colspan="2">Essential Question:</td></tr>
<tr><td>Questions</td><td>Student Input
• Notes
• Lab procedures
• Lab data
• Vocabulary
• Reading texts</td></tr>
<tr><td colspan="2">Summary:</td></tr>
</table>

Differentiation Strategies

- The choice of topics or prompts is a simple way to differentiate for students.
- Students can be given sentence starters or key words to use in their responses.

STUDENT HANDOUT 2.2.1

Learning Log Templates

Name: ______________________________

Learning Log Template 1

Date: ______________________________

Questions	Notes
What did you learn today?	
What did you find most interesting in what you learned?	
What questions do you still have about what you learned today?	

Name: ______________________________

Learning Log Template 2

Date: ______________________________

Questions	Notes
What were the main ideas in today's lesson?	
What did you understand best?	
How do these ideas relate to what you have already learned?	

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Learning Log Templates

Student Samples

Name: Student A

Science Learning Log Template 1

Date:

Questions	Notes
What did you learn today?	I learned about Darwin's evolution. I also learned about taxonomy and the different scientists and their achievements.
What did you find most interesting in what you learned?	The most interesting topic of this lesson was the fact that this many scientists had to work on this field to completely understand the subject.
What questions do you still have about what you learned today?	I had a question about when exactly the Binomial Nomenclature system was invented and also when the organisms were organized in their taxonomy levels.

Name: Student B

Science Learning Log Template 2

Date:

Questions	Notes
What were the main ideas in today's lesson?	I learned about muscles and how the different components interact when they contract. I also learned about the sensory receptors.
What did you understand best?	I best understood the functions of the actin, myosin, and tropomyosin and how they come together to get work done by exerting force.
How do these ideas relate to what you have already learned?	We have previously learned that proteins are very important for the well-being of humans. This lesson indicates the many proteins needed to simply exert little force to do a very important job.

TEACHER REFERENCE 2.2.3

Learning Logs and Costa's Levels of Thinking

Students' reflections in their learning logs can be correlated to Costa's Levels of Thinking. The table below provides guidance on asking reflective questions of varying depths to which students can respond. This allows for scaffolding of the learning log writings as students become more proficient in writing reflections on their learning, and it provides sample questions for differentiation for students' abilities.

Gathering Knowledge **Level 1 Thinking**	• What did you learn in class today? • What did you find interesting? • What questions do you have about what you learned?
Processing Knowledge **Level 2 Thinking**	• What did you understand best today? • What questions do you still have about what you learned? • Compare and contrast two ideas (vocabulary terms, concepts, etc.). • How does this relate to what you have already learned in class?
Applying Knowledge **Level 3 Thinking**	• Apply the concepts you learned in class today to your life. How do they affect your everyday life? • How would your life be different if the concepts you learned about today suddenly changed or ceased to exist? • Propose a solution to ____________ based on what you learned in class. (Use a real-world problem for this blank that relates to your content.) *[This prompt is great for adding engineering and environmental objectives. Some ideas include building a bridge to replace the Golden Gate Bridge, stabilizing the Gulf Stream current to ensure maintained temperatures around the globe, and eliminating an invasive species. These prompts can lead to larger explorations and projects.]* • Use the newspaper, television news, or an Internet news source to describe a recent or unfolding event that relates to what we are learning in class. Describe the event in detail and relate the event to the concepts in class. Why does this event interest you? What are your feelings about this event? What do you predict will be the outcome of this event? *[These questions can be used as a series of days in class once the event is selected. Some ideas in science include: the Olympics for physiology, earthquakes and volcanoes for earth and space sciences, space station news for physics, and drug development in chemistry.]*

Section 2.3

GIST Summary

Introduction

The GIST method helps synthesize ideas into an effective summary. Students determine key concepts, main ideas, and significant details of class notes, a scientific concept, event, experiment, or theory. Then, using the GIST structure, students organize their clear and coherent summaries.

Timeline

30 minutes for initial lesson; decreasing time requirement for each subsequent use

Objectives: The Students Will . . .

- Write an organized summary of a science concept

WICOR Strategies

Writing: Summarize class notes using the GIST method

Inquiry: Identify key concepts

Collaboration: Pair-share writing samples

Organization: Plan and organize using note-taking and Interactive Notebooks

Reading: Analyze notes or texts

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Communicate scientific procedures and explanations.
- Develop descriptions, explanations, predictions, and models using evidence.

Science Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Cornell notes
- Colored pencils or highlighters

Handouts

Student Handout 2.3.1: *GIST Summary*

Teacher Reference 2.3.2: *GIST Summary Student Example*

Teacher Directions

- Provide students a page of Cornell notes. Using photocopies of one student's Cornell notes for the entire class will provide a consistent model for the lesson. Ask them to glue or tape the page onto a right-side page in the INBs.
- Provide students five minutes to review the notes and underline the most important concepts. Focus student's attention on aspects that the teacher noted as important and on areas of confusion.
- Have students discuss their underlined sections with an elbow partner for three to five minutes. Each student should explain what they underlined and why.
- Review the GIST Summary with the class and allow student pairs five minutes to generate a 20-word summary of the sample notes that integrates the important concepts they underlined.
- Select students to share their GIST summaries with the entire class. Solicit positive comments about the summaries from other class members. Provide constructive feedback to students that highlight excess ideas as well as quality information.
- The GIST handout can be glued or taped on the left side in the Interactive Notebook if you are using the entire handout. Students should fold the handout so that the summary is visible. The page can also be inserted as a fold-out page at the end of the section of notes. As students develop writing proficiency, they will create their summaries at the bottom of their Cornell notes in their INBs.
- Transitioning students to independently writing their GIST summaries requires reviewing the process weekly and discussing the summaries so that students get feedback quickly and often until they are confident enough to write good summaries each time.

Suggested INB Set-Up

<table>
<tr><th>Left Page</th><th colspan="2">Right Page</th></tr>
<tr><td rowspan="4">**GIST Summary**
(Student Handout 2.3.1)</td><td colspan="2">**Topic**
Heading Block</td></tr>
<tr><td colspan="2">Essential Question:</td></tr>
<tr><td>Questions</td><td>Reading selection or Cornell Notes
(folded as a flip page so article is visible)</td></tr>
<tr><td colspan="2">Summary:</td></tr>
</table>

Differentiation Strategies

- Provide sentence starters for the students.

GIST Summary

Gist is a word that means "the essence." A GIST summary conveys the meaning of the scientific concept, event, experiment, or theory without including all of the details. When you can summarize the main points in your own words, you are one step closer to mastery of the concept.

Include the following in a GIST summary:

- Explain what you are summarizing.
- Describe the concept that you are learning about.
- Highlight or write five key phrases/words that encompass what the notes are about.
- Use your five key phrases/words to write three to five complete sentences that summarize your notes.
- Check your summary to be sure that the details support the topic from your notes.

Topic:____

Main idea of concept (complete sentence): ____________________________

____

____

Five key phrases/words (in your own words) that explain what the notes or text are about:

1. ____
2. ____
3. ____
4. ____
5. ____

Write a paragraph (3–5 sentences, or 20 words) using the key phrases/words to summarize the "gist" of this concept.

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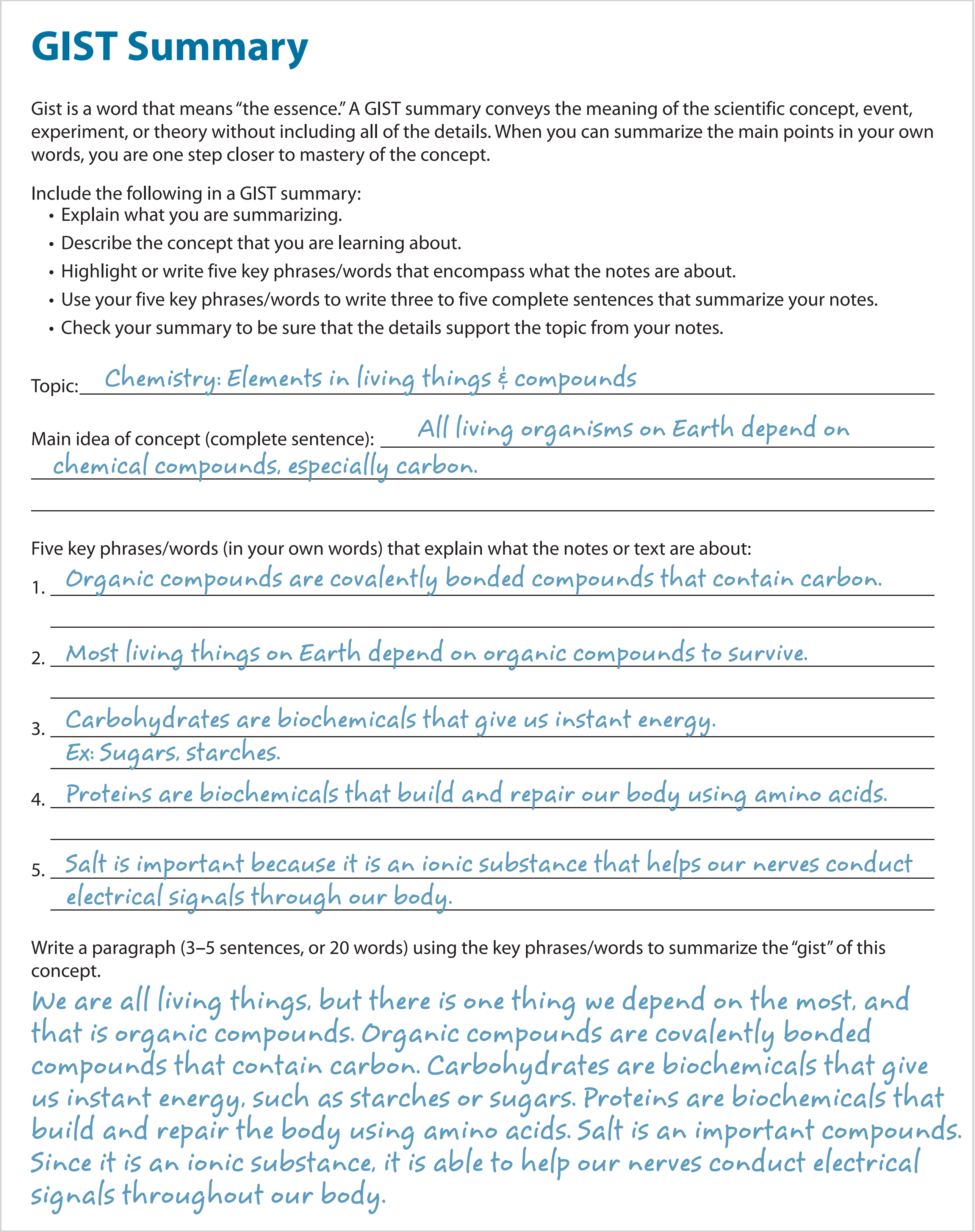
Student Sample



GIST Summary

Gist is a word that means "the essence." A GIST summary conveys the meaning of the scientific concept, event, experiment, or theory without including all of the details. When you can summarize the main points in your own words, you are one step closer to mastery of the concept.

Include the following in a GIST summary:

- Explain what you are summarizing.
- Describe the concept that you are learning about.
- Highlight or write five key phrases/words that encompass what the notes are about.
- Use your five key phrases/words to write three to five complete sentences that summarize your notes.
- Check your summary to be sure that the details support the topic from your notes.

Topic: Chemistry: Elements in living things & compounds

Main idea of concept (complete sentence): All living organisms on Earth depend on chemical compounds, especially carbon.

Five key phrases/words (in your own words) that explain what the notes or text are about:

1. Organic compounds are covalently bonded compounds that contain carbon.
2. Most living things on Earth depend on organic compounds to survive.
3. Carbohydrates are biochemicals that give us instant energy. Ex: Sugars, starches.
4. Proteins are biochemicals that build and repair our body using amino acids.
5. Salt is important because it is an ionic substance that helps our nerves conduct electrical signals through our body.

Write a paragraph (3–5 sentences, or 20 words) using the key phrases/words to summarize the "gist" of this concept.

We are all living things, but there is one thing we depend on the most, and that is organic compounds. Organic compounds are covalently bonded compounds that contain carbon. Carbohydrates are biochemicals that give us instant energy, such as starches or sugars. Proteins are biochemicals that build and repair the body using amino acids. Salt is an important compounds. Since it is an ionic substance, it is able to help our nerves conduct electrical signals throughout our body.

Section 2.4

Observation Versus Inference

Introduction

This lesson challenges students to differentiate between observation and inference. The lesson fits well in a unit on the nature of science at the beginning of a course when discussing observations or discrepant events. Following the general *Observation Versus Inference* lesson is a similar lesson on atomic structure that can be used in a general science or chemistry class.

Detailed observations, in the form of both qualitative and quantitative data, are the key to recording good data for lab investigations in science. For example, color, texture, and odor are often as important as the temperature or the time a reaction takes. Making evidence-based inferences from these detailed observations is another key element of lab investigations. Observations develop from the senses, while inferences are mental judgments about the observations and require critical thinking.

In order to become proficient at making careful observations, students need guidance on the type of observations that are required from a new experience. Direct instruction or prompting will help them see, hear, feel, or smell the most appropriate observations that you as an expert in your science discipline know to observe. Students will also need guidance in developing inferences based on their careful observations.

Timeline

30–50 minutes

Objectives: The Students Will . . .

- Make careful observations of scientific phenomena
- Make inferences based on their observations

WICOR Strategies

Writing: Take notes, write summaries, compare and contrast with a graphic organizer

Inquiry: Make observations and inferences, classify terms

Collaboration: Collaborate in "expert groups," pair-share, and individual work

Organization: Plan and organize using note-taking and Interactive Notebooks

Reading: Read and analyze a science textbook

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Identify questions that can be answered through scientific investigations.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.

Science Standard G (Grades 5–8): History and Nature of Science

- Nature of science
- History of science

Science Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.

Materials

- Specimen, objects, or processes for students to observe
- Word Sort cards (or display the image of the Word Sort list)

Handouts

Student Handout 2.4.1: *Word Sort Words*

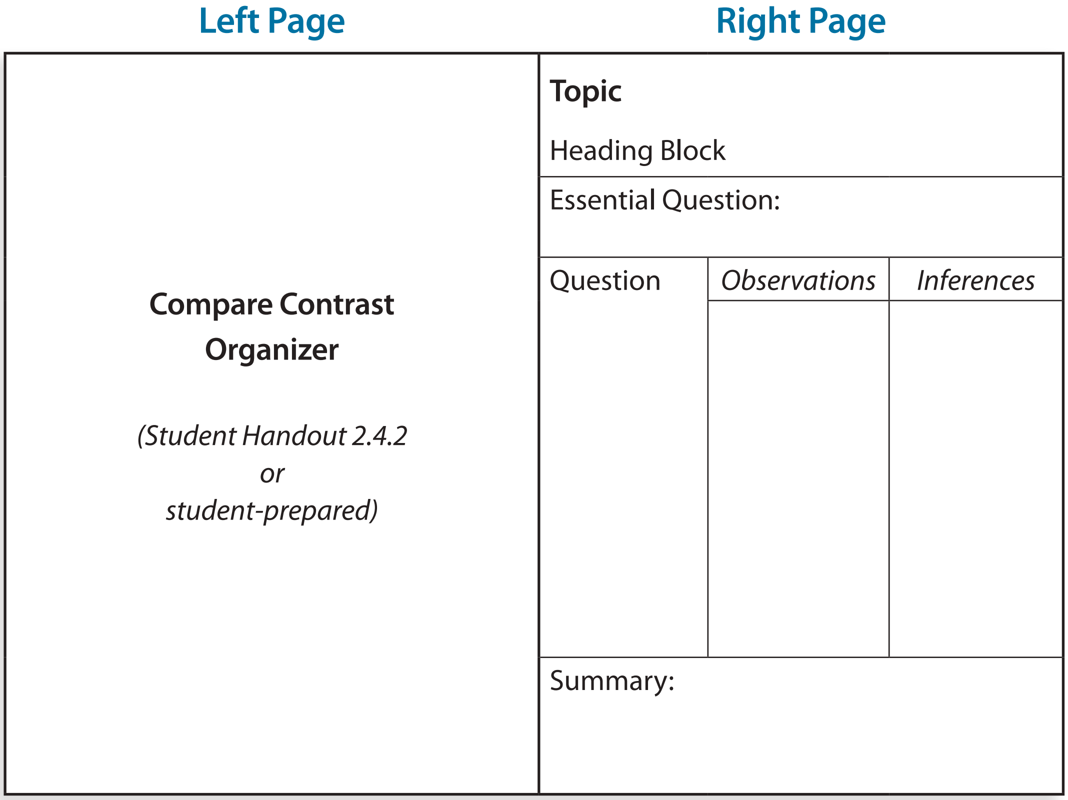
Student Handout 2.4.2: *Compare and Contrast Organizer*

Teacher Reference 2.4.3: *Rubric: Observation Narrative*

Teacher Directions

- Have students set up Cornell notes on a right page in their INBs. Provide the following essential question for the students: "How are observations and inferences different from each other and what are their roles in the scientific process?"

Suggested INB Set-Up



Part 1: Defining the Terms

- Have students conduct a word sort using Student Handout 2.4.1: *Word Sort Words*. Display the words or provide the words on strips of paper or cards to the students so that they can manually sort the words.
- Ask students to read and sort the words into separate stacks based on which words are associated with observation and which are associated with inference.

  The words associated with observation are: see, taste, hear, smell, fact, measured, qualitative, quantitative, and statement. *The words associated with inference are:* judgment, opinion, conclusion, explains, and interpretation.
- Instruct students to conduct a think-pair-share on the key concepts of observation and inference based on their word sort results.
- "Popcorn" around the class to solicit the main ideas to be used in developing a definition for each word. As the expert in the room, guide students to the correct definitions of observation and inference. Students should now write the class definitions in the notes section of their Cornell notes page.

  An observation *is a factual statement based on information garnered from the senses, while an* inference *is the act of drawing conclusions based on facts or observations.*

Part 2: Making Observations

- Have students set up a T-chart for the remainder of the page above the summary space. Label the left column "Observations" and the right column "Inferences."
- Set out several scientific specimens, objects, or chemical reactions to be observed, and assign two students to each station. Students could also describe other things such as the classroom, a small section of school grounds (no larger than one meter square), their lab partner, etc.
- Ask students to record as many observations with as much detail as they can on the left side of the T-chart. Limit the students' time to no more than 10 minutes.

Examples of Specimens and Processes:

Biology	dissected worm, flower, fruit that is cut open, whole organisms (plastic dinosaurs bought at the dollar store work just as well here)
Physical Sciences	burning candle, swinging pendulum
Geosciences	hillside, rocks, minerals, maps
Chemistry	chemical reactions, compound dissolving in water, periodic table, glassware, equipment

Part 3: Evaluating the Observations

- Once students have a set of observations, have them share their observations with another pair of students who did not observe a similar subject. As the two pairs of students share their observation lists, they should improve on the lists by adding three observations that the initial team did not record.
- As the pairs discuss the observations, they should also cross through items that are not actually observations based on the senses.
- Direct students to number the observations they have listed.

Part 4: Making Inferences

- Instruct each student pair to work together to develop four inferences about their observations and record the inferences on the right side of the T-chart. When they record each inference, they must write beside it the numbers of the observations that support the inference.

  Example of development of an inference: If students observed the common discrepant event of putting drops of water on a penny, they saw that the water on the penny has a curved surface and there are many drops that can be added to the penny. The inference could be that there are forces between water molecules that hold them together on top of the penny.

Part 5: Processing the Lesson

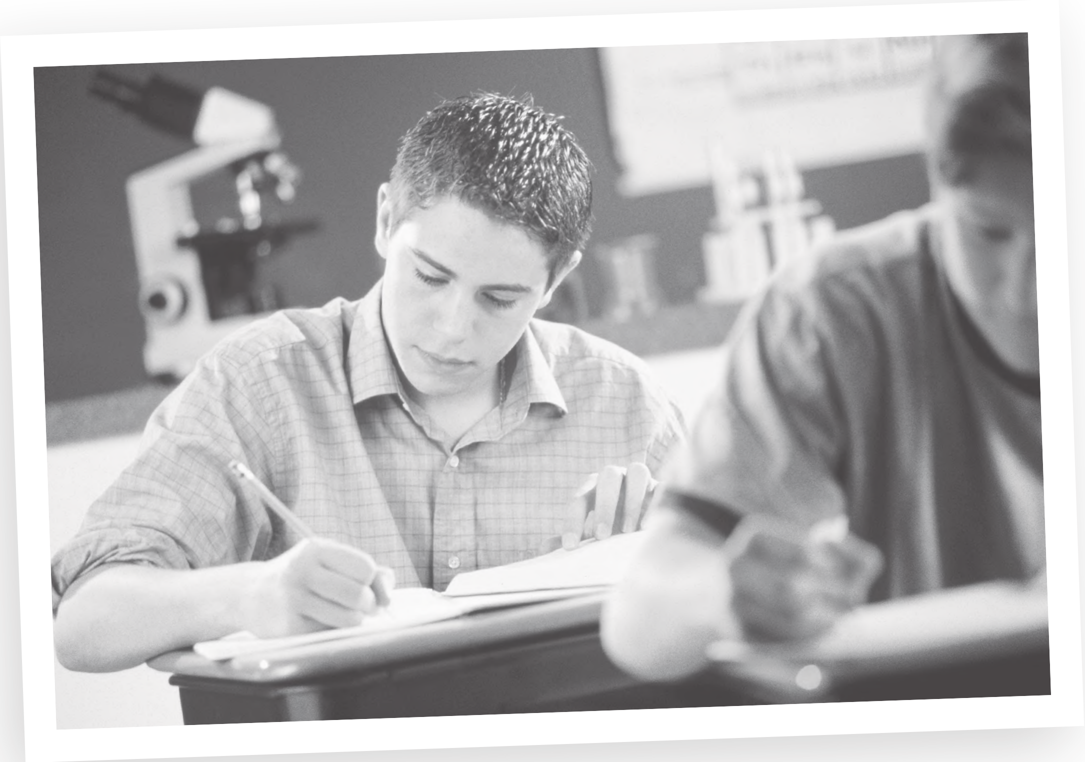
- Ask students to create four questions for the observation-inference lesson: one Level 1 question, two Level 2 questions, and one Level 3 question. A discussion related to these questions could include a review of the essential question and how closely the questions are aligned with the essential question.
- Have students use the *Compare & Contrast Organizer* to complete a graphic organizer on the left side of the INB to compare and contrast scientific observations and inferences.
- Have students write three- to five-sentence summaries of what they learned in this lesson.

Differentiation Strategies

- Provide a reading from a text source of varied levels addressing the terms observation and inference. Allow students to build background knowledge with content of the text, and then conduct the activities.
- Advanced students who require extension activities can write a narrative description of the object or process using the list of observations they developed. Students first need to plan how they will order their ideas and then describe the types of descriptors they will use. While good writing mechanics are helpful, this can be a quick unrefined assignment to practice writing qualitative observations of objects or events or a finished piece for a portfolio. The *Rubric: Observation Narrative* handout can be used to score the narratives.
- For English language learner students, provide dictionaries for the students to define the words in the *Word Sort* or provide pictures to help them with the academic vocabulary presented here. Completing vocabulary cards or a graphic organizer would also support student learning.

Higher-Level Questions

- Using your textbook, find an example of a scientific theory and list the observations and inferences that contribute to the strength of this theory. Some theory examples include: evolution, atomic theory, Newton's laws, theory of plate tectonics.



STUDENT HANDOUT 2.4.1

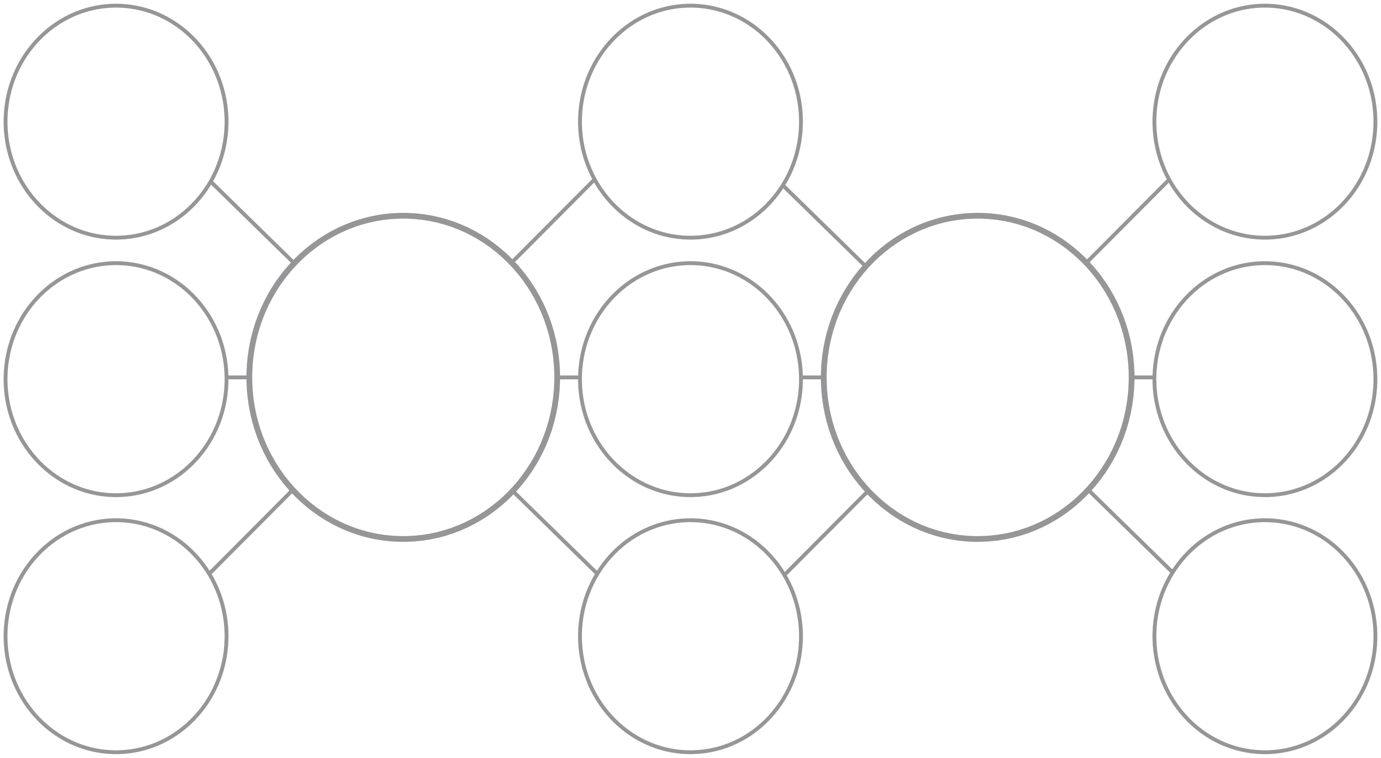
“Word Sort” Words

Sort the following words into two groups: Observation and Inference.

Conclusion
Explains
Fact
Hear
Interpretation
Judgment
Measured
Opinion
Qualitative
Quantitative
See
Smell
Statement
Taste

Compare and Contrast Organizer

This organizer compares and contrasts two concepts. The middle column of circles contains the common characteristics of the concepts being considered. The outer circles contain characteristics that are different between the two concepts. Write a summary of the concepts and include an illustration of the summary.



Summary and Illustration:

RUBRIC: Observation Narrative

The following rubric provides ideas about writing and evaluating observation narratives.

Area	1	2	3	4
Quality of Observation	Names object, specimen, etc., and describes using one or two words	Describes some details of the specimen or object. Description is unclear based on writing.	Describes many details of the specimen or object. You can almost picture the specimen or event from the description.	Observations have great details. You can picture the specimen or event exactly by the description.
Quality of Interpretation	No explanation of observations	Two observations are explained with a likely use or reason for being	Three or four observations are explained with a likely use or reason for being. Interpretations are explained clearly.	Five or more observations are explained with a likely use or reason for being. Interpretations are explained clearly.
Vocabulary and Sentence Structure	Vocabulary and sentence structure interferes with communication	Contains *either* inadequate vocabulary *or* poor sentence structure	Vocabulary is adequate and sentence structure is sound	Careful word choice and structure which emphasizes clear communication of observations
Mechanical Errors	Has many mechanical errors (4+ per page), and they interfere with understanding throughout the piece	Has many mechanical errors (4+ per page), but they interfere only occasionally with understanding of the piece	Has few mechanical errors (2–3 per page), but they do not interfere with understanding of the piece	Is free of mechanical errors (no more than one per page)

Observation and Inference

Atomic Structure

Introduction

This Observation and Inference lesson asks students to investigate the scientific investigations of several scientists who play key roles in advancing knowledge of atomic structure. Students will collaborate to share their observations and inferences on the major experiments for which the scientists are most well known. The lesson can be used in a general science or chemistry class at the start of the atomic structure unit or after discussing the modern theory of the atom.

Timeline

60 minutes

Objectives: The Students Will . . .

- Describe the work and experiments of Dalton, Thomson, Milliken, Rutherford, and Bohr
- Compare the observations and inferences from the experiments

WICOR Strategies

Writing:	Write Cornell notes and summaries
Inquiry:	Make observations and inferences, classify terms
Collaboration:	Share in collaborative groups
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read and analyze a science textbook

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Think critically and logically to make the relationships between evidence and explanations.

Science Standard G (Grades 5–8): History and Nature of Science

- Nature of science
- History of science

Science Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.

Science Standard B (Grades 9–12): Physical Science

- Structure of atoms

Materials

- Textbook or electronic sources with information on historical development of atomic theory

Handouts

None

Teacher Directions

- During this lesson on observations and inferences in the historical development of atomic theory, students must collaborate to create the best notes that they can. They will use the notes to teach others this information.
- Have students complete the *Word Sort* for observation and inference as discussed in the generic lesson and use the right side of the INB to define observation and inference.
- Rather than using a T-chart, students will use a three-column chart so that the right page looks as seen in the INB set-up graphic following the teacher instructions below.
- Ask students to select a scientist to be studied from the following list, and group the students according to their choice of scientists: Dalton, Thomson, Milliken, Rutherford, or Bohr.

  Mnemonic: **D**on't **T**ry **M**y **R**otten **B**ananas

- Explain to the students that they will become "expert groups" (see description in *Active Learning Strategies* in the appendix) who will read a variety of text sources containing information about their selected scientist. (Select the various texts, using different reading levels, if possible. The primary text might be your textbook and selected Internet materials that have been vetted by you for accuracy and information about the experiments for which the scientists are known.)
- Assign each member of the group a different text to be read and understood. Encourage students to take notes on their reading.
- After reading their texts, the expert groups will collaborate to complete the information on their scientists in the chart by describing the highlights of the experiments. They will also identify observations from the experiments and the inferences the scientists made about the atomic theory and provide a visual representation of the atom at the time the scientist's experiment was conducted.
- Have the expert group members number off from one to five within their groups, and have all students regroup by number. In the new groups students will share their observations and inferences on their scientists so that the whole class will receive information on all scientists.

- You may want to review with the entire class the information they should have recorded on each of the scientists.
- Ask students to complete the question column on their Cornell notes with at least two questions for each level of Costa's Levels of Thinking.
- On the left side of the INB, have students create a five-stanza poem using the format of a limerick. (Refer to the description of a limerick in the *Processing Activities* in the appendix.) Each stanza will be about one scientist and must include critical elements of the experiment, observations and elements. Students should write one limerick individually and collaborate in pairs to write the limericks for the other scientists.

Example of Limerick About John Dalton:

There once was a scientist who
Saw no experiments through;
Thought the atom was solid,
Just one indivisible ball it,
Dalton, his name, was the dude.

- In conclusion, students will write paragraph summaries in their Cornell notes on the evolution of the atomic theory. The summaries should answer the essential question and the student questions in the left column.

Suggested INB Set-Up

Left Page

5 stanzas,
each in limerick form

Stanza for Dalton
Stanza for Thomson
Stanza for Milliken
Stanza for Rutherford
Stanza for Bohr

Right Page

Topic

Heading Block

Essential Question:

Questions	**Scientists**	**Experiment & Observations**	**Inferences** *(requires words and pictures)*
	Dalton		
	Thomson		
	Milliken		
	Rutherford		
	Bohr		

Summary:

Differentiation Strategies

- For younger audiences, provide a more straight-forward text that contains the important information with fewer detractors. For more advanced audiences, provide computer access and have students select their own sources as well as develop an entry for Heisenberg, Planck, or another quantum theory physicist.
- To further differentiate for students who already know the development of the atomic theory, ask them to investigate the higher-order questions below and provide this information to classmates.

Higher-Level Questions

- How does scientific experimentation further our scientific theories and laws?
- What other scientific experiments and theories support the theory of the atom?

ADDITIONAL RESOURCES

(n.d.). Atomic Theories. In L. Lista *www.clickandlearn.org*. Retrieved from http://www.clickandlearn.org/gr9_sci/atoms/modelsoftheatom.html

Brody, D. E. & Brody, A. R. (1997). *The science class you wish you had…: The seven greatest scientific discoveries in history and the people who made them*. New York, NY: The Berkley Publishing Group/Perigree Books.

Capri, A. (2003). Atomic theory I: The early days. *Visionlearning, CHE-1*(2). Retrieved from http://visionlearning.com/library/module_viewer.php?mid=50

Rutherford's experiment. (2001). [Online interactive flash animation]. In R. Chang (Author), *Essential chemistry* (2nd ed.). Retrieved from http://mhhe.com/physsci/chemistry/essentialchemistry/flash/ruther14.swf

Wynn, C. M. & Wiggins, A. W. (1997). The five biggest ideas in science. Hoboken, NJ: John Wiley & Sons, Inc.

Section 2.5

Summarizing Informational Texts

Introduction

Science textbooks are usually dense with information and contain many vocabulary words that may be new to students. The more advanced the science book, the denser the text. Deciphering what is important and what is of secondary value challenges students as well as teachers. Teaching students to identify the main ideas and focus on the purpose of the text is vital to their success in college-level classes where there is less guidance about what information should be learned.

A sequence chart is used in this lesson to help students develop skills in summarizing informational texts. The chart can be used frequently as students learn how to write good summaries on their own. The strategies of marking the text and connecting information within the text that are used in this lesson are discussed fully in Unit 5.

Timeline

30 minutes to teach structure, 30 minutes to practice (varies with density of the text)

Objectives: The Students Will . . .

- Identify main ideas from text sources
- Describe supporting details to clarify the main idea

WICOR Strategies

Writing:	Summarize the text
Inquiry:	Write scaffolded questions using Costa's Levels of Thinking
Collaboration:	Peer review summaries
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Mark the text

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.

Science Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.

Materials

- Selected text(s)
- Colored pens/pencils

Handouts

Student Handout 2.5.1	*Steps in Summarizing Informational Texts*
Student Handout 2.5.2	*Summarizing Informational Text Learning Tool*

Teacher Directions

- The INB set-up for this lesson in summarizing text material should have the photocopied text on the right and the *Summarizing Informational Text Learning Tool* handout on the left. When students write text summaries on their own without such a handout, the summaries are placed on the right side in the INB because they are the learning that is supposed to occur. The summaries may also appear at the end of the notes taken on the text material as they would for Cornell notes.

Suggested INB Set-Up

Left Page	Right Page
Summarizing Informational Text Learning Tool *(Student Handout 2.5.2)*	**Photocopy of text**

- Select and photocopy the text section from an approved book that you will use for instruction of this summarizing strategy. Providing students with copies of the text allows them to annotate directly on the page.
- Distribute the *Steps in Summarizing Informational Texts* handouts to students. Explicitly teach the steps in this summarizing process as they are presented to the students. Model how to mark the text and connect ideas using a document camera, overhead projector, or PowerPoint slide. Verbally explain what you are doing and why you are doing it.

    Step 1: Set up the reading with a prereading activity that helps students understand what they are supposed to learn from the text they will be reading. Examples of prereading activities:

    - Survey the text: scanning titles, subtitles, and visuals.
    - Predict the main idea.
    - Read the first and last paragraphs.
    - Build key vocabulary.

    Step 2: Have students read the text. Discuss the type of text as guided in the summarizing handout.

    Step 3: Have students reread and mark the text and number the paragraphs.

    Step 4: Have students connect ideas in the text by annotating the article with lines, arrows, symbols, and notes to show the relationships between the text and the graphics.

    Step 5: Have students write a summary for each paragraph in the margin of the text.

    Step 6: Have students organize their learning for this section and write the final summary.

- Ask students to exchange papers with a partner and review the summaries. Direct them to use the "Tips for Writing Summaries of Text" at the bottom of the handout to make sure that the summaries are clear, consistent, and concise. When a student has a suggestion to improve the summary that he or she is reading, the suggestion should be marked in a different color so that the author can modify as desired.

Differentiation Strategies

- In advanced science classes where the readings are usually longer and more difficult for students, consider approaching the text summarization of sections or subsections rather than paragraphs. Paragraphs house much more specific information which can result in students drowning with detail in longer passages.

Higher-Level Questions

- How can you investigate bias through the summary process?
- How can using various texts affect learning about a particular topic?

STUDENT HANDOUT 2.5.1

Steps in Summarizing Informational Texts

Step 1	**Seek to understand the reading and writing task.** *What are you expected to know and do? What are you summarizing? What is the purpose in reading this text?*
Step 2	**Carefully read the text.** *Number the paragraphs or sections. Read the text once to get a general idea of what the text is about. Avoid getting bogged down in all the details. Read for the big ideas and the structure. Is this a scientific process, a description of a group, an analysis of an experiment, or some other scientific purpose?*
Step 3	**Reread and mark the text.** *Circle the terms and underline the information relevant to the reading and writing tasks.*
Step 4	**Pause to connect ideas within the text.** *Chart individual paragraphs in order to gain insight into the details. What visuals (charts, diagrams, and pictures) help to "see" what the author is saying? How does this idea connect to that idea?*
Step 5	**Write summary statements for each paragraph in the margin.** *What is the main idea of this paragraph or section?* *What are the ideas that support this main idea? If this is a process, what are the big steps? If this is a description, what are the most important features? If this is an experiment, what is the design and what were the results?*
Step 6	**Write final summary. Use the tips on the list that follows.**

Tips for Writing Summaries of Text

- Present ideas in an order that makes sense, starting with the main idea.
- Refer to your markings on the text when writing the summary.
- Use accurate verbs to describe the information. Active verbs are preferred over passive verbs.
- Include important vocabulary, using the class discussion as a guide for the key words.
- Use your own words in paraphrasing the information. Do not quote directly from the text.
- It is okay to use an idea that is not yours. Remember to cite it appropriately in the text using MLA or APA style as directed by your teacher.
- Limit the length of your summary to one-fourth to one-third the original length of the text.
- Reread your summary for clarity and accuracy.

Summarizing Information Text Learning Tool

This activity is designed to support students as they learn how to summarize expository texts. The work presented here could be done in Cornell notes on the right side of the INB.

Title of text:______________________________ Author: ____________________

Type of text: ______________________________ Section: ____________________

1. What is the purpose of reading this section?

2. What is this section or paragraph about? What is it saying? (You can use sentence starters such as: "This section discusses…"; "The author outlines…"; "The paragraph lists….")

3. Record information from the reading that is relevant to your reading purpose. Some ideas include: "The author presents ideas about…"; "The main idea is… "; "I learned that…"; "Paragraph three introduces…." Be sure to represent steps four and five from the *Steps for Summarizing Informational Texts* chart.

4. Craft a concise summary that includes the ideas from questions 2 and 3 above.

Section 2.6

Think It — Build It — Write It

Introduction

With the increased education emphasis on inquiry processes in science, students design the procedures more often than ever before (Backus, 2005). Creative thinking, delivering clear directions, and creating accurate models are crucial skills in many aspects of life, not just in science. This exercise is designed to help students polish these skills. Students will be placed in the roles of both writer and builder. Team members will provide each other with written instructions (no diagrams) from which they will construct a *Gemklocx* (a fictional object or tool)—then compare and individually write about the process.

For students to be successful in science, it is necessary to follow printed directions exactly in the sequential steps provided. This exercise gives students an "AH-HA" about how they write directions. When their team members have difficulty following the construction procedure, they realize the connection between written instructions and project success.

This lesson can be incorporated to meet engineering goal standards, as part of the nature of science or at any point in the year to strengthen student procedure writing. This type of activity is often part of Science Olympiad and other science competitions.

Timeline

50 minutes

Objectives: The Students Will . . .

- Develop skills in writing procedures
- Communicate in clear, precise language

WICOR Strategies

Writing:	Write detailed procedures for a process, edit peer reports, write reflections
Inquiry:	Plan and create a model
Collaboration:	Work with partners to write and analyze procedures
Organization:	Plan and organize using an Interactive Notebook
Reading:	Read and analyze instructions

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Understandings about scientific inquiry

Materials

- Digital camera—one per class *(optional)*

Per team of 2 students:

- 2 small paper plates
- 2 straws
- 1 small paper cup
- 3 rubber bands
- 8 cm of tape
- Opaque plastic bags or cloth *(optional)*
- 4 twist ties
- Aluminum foil 12 in x 12 in
- 2 paper clips
- 1 sheet of paper
- Bag for supplies

Handouts

Student Handout 2.6.1:	*Components of Good Procedure Writing*
Student Handout 2.6.2:	*Think It—Build It—Write It: The Gemklocx*
Teacher Reference 2.6.3:	*Think It—Build It—Write It: Student Sample*

Teacher Directions

- Prior to class prepare a bag of the above materials (except camera) for every pair of students.
- Discuss with students the importance of writing detailed procedures for protocols in science. Some everyday life ideas for writing good procedures can be found on Internet sites, including those listed in the references section. Complicated procedures require many directions so that the results will be as expected. Missing one step or incorrectly preparing a solution for an experiment may well cause the experiment to fail.
- •Provide students with the handout *Components of Good Procedures Writing* and explain that they will test these skills during the activity. Have students glue this page on a right page in the INB and write the essential questions above the handout.

  "What are the key components to writing a clear, repeatable procedure?"

  "What is the importance of a clear, repeatable procedure?"

Suggested INB Set-Up

<table>
<tr><th>Left Page</th><th>Right Page</th></tr>
<tr><td rowspan="4">The Gemklocx
<i>(Student Handout 2.6.2)</i>
<i>(With peer edits in different colors)</i>
Reflection on process</td><td>Topic
Heading Block</td></tr>
<tr><td>Essential Question:</td></tr>
<tr><td>Components of Good Procedure Writing
<i>(Student Handout 2.6.1)</i>
<i>(Directions of project can go here as a flip page or be recollected for reuse.)</i></td></tr>
<tr><td>Summary:</td></tr>
</table>

- Form teams of two students. Allow 20 minutes for the teams to create and build a model as well as record a procedure to repeat the construction. All materials must be used. Students will use the left side of the INB to record their procedure. Partners will have identical procedures since they are working together, but each person should have a copy in the INB.
- Teams must keep their original models hidden from the view of other teams. You may want to provide opaque plastic bags or cloth to help hide students' work from the other teams.
- After 20 minutes, pair each team with another team of two students and have them exchange INBs. Provide another set of building materials to each team. Have teams return to their original work area and remain separated from other teams. Allow students 10 minutes to build the new model from the new procedure.
- Ask the groups of four that exchanged procedures to reunite. Each pair will share its model and briefly discuss the results. Have the teams compare the "rebuild" with the original model.
- Using a different color ink or pencil, the team that created the rebuild will edit the original procedure to provide the team feedback on how to improve their procedures so that the rebuild would look more like the original.
- On the bottom of the left side of the INB below the procedure students will reflect on the process. If there is no room left on that page, they can create foldouts for that page. Instruct students to include a minimum of three paragraphs in their reflection on the following three questions:

  What parts of writing a procedure are easy, and why?

  What parts of writing a procedure were challenging, and why?

  What is the role of revision in the scientific process?

- Remind students to address the essential questions as they write their summaries.

- Use a digital camera to document the Gemklocxes (original and rebuild in the same photo) for students to put in the INBs as a record of the results. If no camera is available, students can sketch the two models.
- The Teacher Reference *Think It-Build It-Write It Student Sample* shows an example set of student directions written for this activity. It is a "B-" example, but the analysis of the sample will give you some guidance on what to look for in your students' samples.

Differentiation Strategies

- Provide a word bank of vocabulary for English language learners to use when they explain how they build the Gemklocx.
- Use a Socratic Seminar to analyze the important parts of writing a procedure at the end of the activity before students write their reflections so that ideas are shared among all students.

Higher-Level Questions

- Based on the design of the Gemklocx, what might it be used for?
- Predict the implications on everyday life of building the Gemklocx.
- To what class of machines does the Gemklocx belong?
- How are clear, effective procedures used in the workforce or everyday life?

Components of Good Procedure Writing

For scientists, it is critical for other researchers to repeat experiments to verify the results. Being able to repeat the results of an investigation allows us to strengthen the conclusions made in the first study. Precision is a key factor. This includes explaining how to set up the groups, how to control the constants, and how to measure the variables.

The following is a list of essentials for writing procedures:

- ☐ Use a numbered list of steps in the correct order.
- ☐ Organize the steps into small discrete directions in the order you would do them in a lab.
- ☐ Avoid using personal pronouns.
- ☐ Use commands. Be action oriented.
- ☐ Explain how you selected the samples you tested.
- ☐ Tell the reader to measure and record data when it is appropriate. Also explain what data to record and how to measure this data.
- ☐ Refer to measurements using only the metric system.
- ☐ Eliminate extraneous information.
- ☐ Sketch and label the experimental set-up. Refer to the sketch in the directions.
- ☐ Number multiple sketches, starting with "1." Refer to the sketch numbers in the procedure.
- ☐ Include all steps no matter how small one may seems. It may be the critical step.
- ☐ Explain how to keep all constants the same.
- ☐ All equipment listed in the materials section is referred to in the methods section.
- ☐ Tell the experimenter when to repeat steps.
- ☐ Be very specific.
- ☐ When in doubt about how much to include about your methods, include more.

Think It — Build It — Write It: The Gemklocx

Pamela Aura Yamaguchi Jordan, PAYJ as she is affectionately known, is a billionaire industrialist. PAYJ has some money she needs to spend quickly to avoid taxes. She has always wanted to sponsor an inventor. She is looking for a team of two to invent the *Gemklocx*. She doesn't care what the *Gemklocx* is or even what it does. She is looking for a team to design, build, and document the building process of the product in a 20-minute time period. She will then hire others to build the *Gemklocx* from the written directions. There are certain requirements for this project. PAYJ has a list of materials that must be included in the invention. Each item on the list is from one of her subsidiary companies.

Your team task is to invent a *Gemklocx*. But beware: PAYJ does not like pictures. You cannot use any diagrams or illustrations to explain your procedures. The team that produces a *Gemklocx* that looks most like the original will be sponsored by PAYJ's company. *Good luck!*

Materials

- 2 small paper plates
- aluminum foil 12 in x 12 in
- 3 rubber bands
- 4 twist ties
- 1 small paper cup
- 1 sheet of paper
- 2 straws
- 2 paper clips
- 8 cm of tape

Procedure

- Partner with another student to form a team and get one set of materials to use in building the Gemklocx. You will have 20 minutes to create and build a model as well as to record a procedure to repeat the construction. All materials must be used.
- Use the left side of your INB to record the procedure. Partners will have identical procedures since they are working together, but each person should have a copy in the INB.
- You must keep your original model hidden from the view of other teams. You can use plastic bags, cardboard boxes, or cloth to hide your work.
- After 20 minutes, pair with another team of students and exchange INBs. Each team will get a new set of building materials to build another *Gemklocx* following the procedure in the exchanged INBs. During the 10 minutes you have to build the second model, you will remain separated from other teams.
- Reunite with the team with which you exchanged INBs. Each team will share its model and briefly discuss the results. You will then compare the "rebuild" with the original model.
- Using a different color ink or pencil, the team that created the rebuild will edit the original procedure to provide the team feedback on how to improve their procedures so that the rebuild would look more like the original.

Writing the Reflection:

- Under the procedure on the left side in your INB draw a line across the page. Write a reflection that examines the following three ideas in complete sentences with well-developed paragraphs:

  Paragraph 1) What parts of writing a procedure are easy and why?
  Paragraph 2) What parts of writing a procedure were challenging and why?
  Paragraph 3) What is the role of revision in the scientific process?

Think It — Build It — Write It

Student Sample

1. Poke hole in top of cup with paper clip.
2. Twirl around to widen the width of one straw.
3. Insert straw with ribbed section outside of the cup.
4. Place cup on plate.
5. Push second plate over straw and slide to cup.
6. Poke hole in bottom plate, stick straw through to anchor cup.
7. Insert a second straw into protruding straw. Make sure straws are vertical.
8. Place 2 rubber bands around both plates, sandwiching the upside-down cup so they cross in the middle.
9. Place 1 rubber band around the cup so it touches all four rubber band wall things.
10. Insert 1 twist tie between each gap between the rib of the top plate and each of the 2 vertical rubber bands and twist. After inserting through the hole in the center of the aluminum foil.
11. Straighten each paper clip and insert one into the top of the straw and one into the bottom.

Teacher's Analysis:

This sample attempts to clarify writing with adjectives and specifics about the equipment. However, the sample also forgets that the procedure requires exact instructions. In step 4, how is the cup placed on the plate? It stands to reason that the opening is face down; however, the straw may be positioned to meet the stated criteria so that the open end of the cup is placed upwards. The terminology is at least average in this sample and the invention seems slightly complex. This sample rates a B- for the complexity and attempt at a clear procedure.

Section 2.7

Science Photo Project

Introduction

Combining technology with science content engages students in science lessons. In this project, students will develop and demonstrate an understanding of a specific concept covered in a unit or class by taking a photograph and explaining the science connections to the picture. With more schools and classrooms having access to digital cameras and color printers, this technology can be used to connect students to science by igniting their passions and interests. The Science Photo Project combines word processing, digital photography, and science content by allowing students to select and explain real-life examples of content or concepts. This may be done for all grade levels of students, with the depth of explanation increasing with students' grade levels. The project fits well as a summative assignment at the end of a specific unit or series of units of study.

Timeline

30 minutes in class to introduce and model the project; 1–2 hours outside class depending on student interest and level of technology proficiency. Students should be allowed two to four weeks to complete the assignments outside of class, with possible interim due dates stated.

Objectives: The Students Will . . .

- Explain science concepts shown through a digital photograph
- Use appropriate science content vocabulary to describe scientific concepts
- Use cross-curricular skills to increase the understanding of science content, vocabulary, and concepts

WICOR Strategies

Writing:	Write explanations of scientific concepts using appropriate content vocabulary
Inquiry:	Connect science concepts to ordinary events and pictures
Collaboration:	Peer edit and discuss scientific explanations
Organization:	Plan and organize using an Interactive Notebook
Reading:	Read background information on assigned topics and photography techniques

National Science Education Standards

Science Standard E (Grades 5–8): Science and Technology

- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

Science Standard E (Grades 9–12): Science and Technology

- Identify a problem or design an opportunity.
- Propose designs and choose between alternative solutions.

Standards A, B, C, D, F, and G can also be addressed in the Photo Project.

Materials

- Samples of pictures for introduction
- Digital camera (Students may also use photos taken in photography or graphic arts class.)
- Computer and printer access
- Photo paper (if available)

Handouts

Student Handout 2.7.1:	*Science Photo Project*
Teacher Reference 2.7.2:	*Science Photo Project Rubric*

Teacher Directions

- Distribute the *Science Photo Project* handouts to students and discuss the requirements for the project.
- Display sample pictures that you brought to help students generate ideas on pictures they could take. Ask students to record the brainstorming ideas on a left page in the INBs.
- Brainstorm with your class the community happenings that they could photograph and use as subjects. Discuss the difficulties of capturing some ideas and the simplicity of others where there is no science to explain. Emphasize to students that it may be a challenge to obtain a well-composed photograph (*contrived* photo) rather than a snapshot (a *natural* photo).
- Ask students to bring their pictures, postcards, or magazine pictures on an assigned date.

Part 1: Introductory Sample

- Provide students with magazine pictures, postcards, or actual photos. Ask students to glue their samples on the right side of the INBs, write and center the title of the lesson on the top line, and identify the main science concept addressed by the picture.
- Below the pictures students will write five-minute quickwrites that explain the science concept illustrated by the picture. Emphasize to students that they should include key vocabulary terms or phrases in their explanations of how the photos address the stated topic.

Suggested INB Set-Up

Left Page	Right Page
List of brainstormed ideas Two ideas for project Main science topic to be addressed in the photo Level 3 processing activity of science concept in sample photo	Title Main Science Concept *Postcard, magazine picture, or other photo* Explanation of Science: Student 1… Explanation of Science: Student 2…

- Have students switch INBs with partners and read the quickwrite in the INBs that they received. Students should now add to the first quickwrite entry for five minutes to provide another point of view. If desired, students can use a peer-editing process by sharing the photographs with others and describe how the photograph meets the criteria stated by the teacher. The peer discussion process about the photographs will aid some students in their writing about the assigned science concept and their use of the content vocabulary.
- Ask students to choose two ideas that they are interested in pursuing for their individual photo projects and write them in the INBs. The main topic should also be included.
- If time allows, have students complete a processing activity of the science concept discussed in the photo sample. (*See Processing Activities* in the appendix.)

Part 2: Individual Photo Projects

- The photo topics can be chosen by the students or they can be assigned by the teacher.
- Allow two to four weeks for students to complete the assignment. Interim due dates may be assigned as needed. The interim due dates could be assigned for the identification of what will be photographed, how the photograph will demonstrate the assigned concept or topic, and any special composition needed to take the photograph.
- You may want to set a due date that is a week before the essay is written. This will allow time at school to print the photographs they took and return the photographs to the students.
- The photo projects can be presented, displayed, or put into the INBs, depending on your choice of method.

  Display on poster boards around the room and conduct a gallery walk to review the products.

  Project in a plastic page protector with the photo facing out and the essay facing out on the other side.

  Photo placed on right side of the INB and the essay on the left side

- You can also offer students the option of creating a series of PowerPoint slides.

  One slide of the photograph

  One slide to identify the science topic and the explanation of the relationship of the photo to the topic

  One slide to explain any special or unique steps used to take the photo.

- To assist with the technology aspects of the project, the school's media tech or graphic arts department may be called upon for assistance in obtaining or using equipment. A guest lecturer may also address the class on how to take photos and how photography may be combined with science as a hobby or career.
- To avoid large amounts of class time being used by students waiting to use one printer, the photos can be downloaded onto one computer and printed later by the teacher.
- Technology access may be a problem for some students, so teachers must ensure the availability of digital cameras, computers, photo paper, colored printers, and colored ink.
- If desired, you can have students do collaborative assessments on their peers' products. The students can use the INB rubric to grade the presenter. The students must use content vocabulary to justify the score they gave.

Differentiation Strategies

- The English language learner students may discuss the assignment in their home language. Depending on the language level, the home language may be used to develop an understanding of the information with a supplemental explanation in English to develop fluency and content vocabulary. English should be used in the formal writing about the assigned science concept and how it was used. Students could verbally share the information that they have learned in small groups in addition to a written piece. It is sometimes easier for students to provide verbal explanations rather than written ones to demonstrate understanding of a concept.
- This project can be used with students from upper elementary to AP and IB classes. The level of writing, quality of photography, and explanation will depend on the skills, background, and sophistication of the students in the class.
- Photography, composition, and editing of photographs, and careers involving photography, lighting, color, and special effects are all topics of interest for some students. These may be addressed on a case-by-case basis with students interested in obtaining unique and interesting photographs.

Higher-Level Questions

- How can two photos together expand the topic that the student selected?
- What are the powerful scientific themes in the gallery of the science photos?

Rubrics

If the teacher uses a rubric to score the Science Photo Project assignment, the rubric should address the major components of the project. (See Teacher Reference 2.7.2: *Science Photo Project Rubric*.)

- Does the photo clearly represent the assigned topic?
- Does the student clearly explain how the photo addresses the assigned topic?
- Are the necessary vocabulary terms or phrases used in the explanation of how the photo addresses the assigned topic?
- Is the explanation of the "natural" or "contrived" aspects of the photo correct and clear?
- Does the photo meet the stated size and clarity?
- Is the photo the work of the student?

ADDITIONAL RESOURCES

Science Photo Library (http://www.sciencephoto.com/)

McCormack, S. & Ross, D. L. (2010, October 1). Teaching with technology. *The Science Teacher 77*(7), 40-45.

Science Photo Project

Take a photo that illustrates a particular topic of science, and write an essay to explain what aspect of science is shown in the photo. The photo must be 8 x 10 inches in size and may be in color or black and white. If the photo is taken with a digital camera, the electronic file must be submitted on a disk with the essay and printed photo.

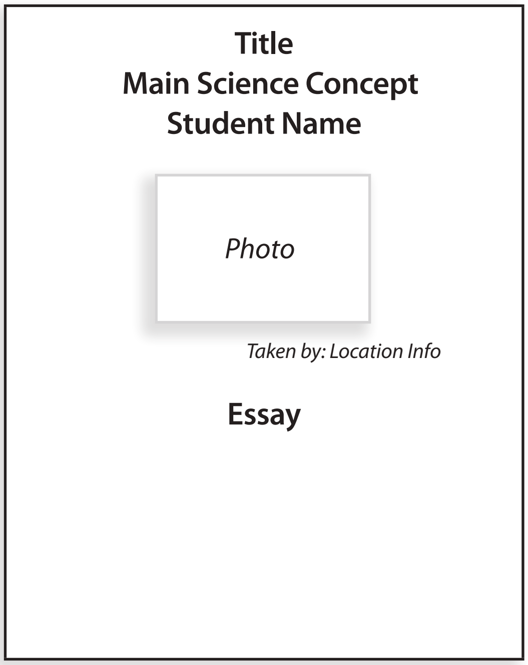
An essay of fewer than 250 words must explain the science concept shown in the photo. The essay must also address any special or unique steps needed to compose or take the photo. The science in the photo must be explained in simple terms and use key vocabulary for the concept addressed.

Format of the Display

- Use the page or poster size indicated by the teacher.
- Write and center the title at the top as the first line.
- Write and center on the second line the science concept shown in the photo.
- Write and center your name on the third line.
- Tape or glue the photo on the top part of the page with the name of the photographer (probably yourself) written in pencil under the bottom right side of the photo along with the location where the photo was taken (i.e., City, State or City, Country) under the signature.

The Essay

- The essay must have a maximum of 250 words.
- Identify the main science concept in the photo and use key vocabulary related to the concept.
- Explain how the photo illustrates the main science concept.
- Identify if the photo is *natural* or *contrived*, and explain any special or unique steps required to take the photo.



Science Photo Project Rubric

The following rubric should provide ideas for evaluating the Photo Project.

Criteria	Not Evident	Adequate Progress	Excellent Mastery
Photo represents the topic	Photo does not represent the topic	Photo can be identified with topic with support of explanation	Photo clearly shows the topic without explanation
Explanation of the science	Explanation is unclear with sparse detail. Relation between photo and science is marginal.	Clear explanation with limited details. Relates aspects of photo with science.	Clear and convincing with elaborate detail of scientific ideas. Relates aspects of the picture with science.
Language use to represent topic	Vocabulary is limited to express scientific principle	Vocabulary expresses idea but lacks clarity and accuracy	Vocabulary is clear, convincing, and accurate for topic
Natural or contrived	Missing	Mostly accurate and moderately clear	Accurate and clear
Display	Messy, lacks components, does not meet requirements	Missing components or compromised neatness	Pleasing display to show work

Unit

12**3**45

Inquiry

Science teachers are well acquainted with inquiry as integral to the understanding of science. The science content areas explore natural phenomenon by focusing on making careful observations, designing investigations, presenting data, analyzing evidence, and critically thinking about the scientific process. These processes require students to "wonder why," ask questions, and seek answers to those questions. This is the nature of inquiry.

"Inquiry engages students with their own thinking processes. It teaches students to think for themselves instead of chasing the 'right answer.' The result is student ownership of the learning process and a better understanding of concepts and values" (Donohue, 2009).

In an "AVID-ized" classroom, the types of science lessons and activities commonly seen in science classrooms, such as experimental design, graphing data, demonstrations, and lab investigations will become richer in the level of student thinking. Students are asked to use Costa's Levels of Thinking to examine the science content and develop the logic that they use to approach learning in general.

Increasing the rigor of the classroom is addressed in this inquiry section through developing experimental designs and testable hypotheses, preparing appropriate graphs for data presentations, and through scientific process skills in authentic situations. Statistical analysis tools are presented for student usage through the well-known drops-on-a-penny investigation. The integration of simple statistics helps students understand the ideas of certainty and probability. While all data is "good" data, students can begin to consider how a data set might be the result of chance or an unidentified variable rather than the variable being tested. This level of thinking is much more valuable than the memorization of simple facts.

As you consider implementing lessons and strategies in this section, it is important to think about the lessons that you enjoy and already use in your classroom. What facets of inquiry do you already include in your lessons and how could you modify your current lessons to provide a greater level of inquiry? Raising the inquiry level raises the level of rigor and encourages students to think more deeply about scientific concepts. Students who think deeply are better able to solve problems in the classroom and subsequently in the real world as engineers, chemists, geologists, and informed citizens.

Section 3.1

OBSERVATIONS: Candle Demonstration

Introduction

To think like scientists, students must make careful observations, think about those observations, and write questions about what they saw. This inquiry demonstration lesson using a burning candle can be used as a Cornell note-taking lesson as well as a lesson in making detailed observations and writing questions about the observations. After the demonstration the students will identify the levels of questions according to Costa's Levels of Thinking. The lesson can easily be expanded to include an emphasis on inferences, predictions, and hypotheses.

As an alternative, the teacher can use the video of the demonstration that is on the CD that accompanies this book.

Timeline

45 minutes

Objectives: The Students Will . . .

- Make detailed observations of a science demonstration
- Use Cornell notes for recording information
- Write questions about a scientific process

WICOR Strategies

Writing:	Write Cornell notes and summaries
Inquiry:	Develop questions about a scientific process
Collaboration:	Collaborate with partners to share observations and edit notes
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Take notes and summarize

National Science Education Standards

Standard A (Grades 5–8): Science as Inquiry

- Identify questions that can be answered through scientific investigations.
- Develop descriptions explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.

Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations.
- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Materials

- Number 7 rubber stopper
- Scrap wood (~ 4" x 4") for base
- 1¼" to 1½" screw to attach stopper to wooden base
- 1¼" wide by 8" to 12" long of metal
- 1½" outer diameter by 1¼" inner diameter by 12" Plexiglas® tube
- Lab candle
- Binder clip or clothespin
- Matches
- Smoke paper or some other smoke source.

Handouts

Student Handout 1.5.1: *Costa's Levels of Thinking*

Teacher Directions

Preparation of Demonstration Apparatus

- Affix a stopper with a screw to a small wooden square that will allow the tube to stand on its own when placed upon the stopper.
- Melt a small amount of wax from the candle and drip it on the stopper and affix the candle to the top of the stopper.
- If smoke paper is not available, burn a small piece of thick paper like cardstock until a glowing ember appears. Blow the flame out and the smoke will be enough to allow students to follow the air flow through the tube.
- ***CAUTION:*** *If using a plastic tube, the candle cannot be allowed to burn for an extended period of time as the plastic will heat and start to bubble, distort, and eventually catch fire.*

Discussion and Set-Up for the Demonstration

- Discuss with students that this activity will ask them to think like scientists. They will…

  Make careful ***observations*** ("what I can detect with my senses or measure"): collection of information from the five senses or scientific instruments designed to collect data; can be qualitative or quantitative.

  Make ***predictions*** ("what I think will happen"): Use previous knowledge of observations, experience, and reasoning to suggest a future step or event.

  Write ***questions*** ("what I would like to know about the demonstration").

- Have students set up Cornell notes on a right-side page in their INBs for taking notes (1/3 page for the question column and 2/3 page for the notes column). Provide them with the topic ("Burning candle demonstration") and the essential question ("Why are careful observations and questions important to understanding science?" or, "What occurs during the burning of a candle in a tube?"). The essential question will depend on your focus for the lesson.
- Have students mark the right column of their paper into five equal horizontal sections, labeling them with the following headings:
  1. Materials:
  2. Lit Candle:
  3. Lit Candle With Tube:
  4. Lit Candle With Tube + Divider:
  5. Lit Candle With Tube + Divider + Smoke:

Suggested INB Set-Up

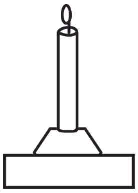
<table>
<tr><th>Left Page</th><th colspan="2">Right Page</th></tr>
<tr><td rowspan="8">Choice of
Processing Activity</td><td colspan="2">Topic
Heading Block</td></tr>
<tr><td colspan="2">Essential Question:</td></tr>
<tr><td rowspan="5">Column for questions</td><td>Materials:</td></tr>
<tr><td>Lit Candle:</td></tr>
<tr><td>Lit Candle With Tube:</td></tr>
<tr><td>Lit Candle With Tube + Divider:</td></tr>
<tr><td>Lit Candle With Tube + Divider + Smoke:</td></tr>
<tr><td colspan="2">Summary:</td></tr>
</table>

Step 1: Materials

- Display the materials that will be used for the demonstration, and have students record observations of the materials in the right column in their notes.
- Encourage students to share their observations and ask questions about the materials.

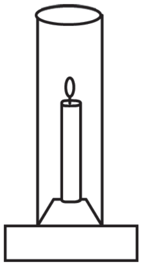
Step 2: Lit Candle

- Light the candle and let students make observations on the candle for a short time.
- "Popcorn" around the room to have students share their observations. Instruct them to add to their written observations as others are shared.
- Have students write questions in the left, question column of their notes as they think about the meaning of the observations they made. Again, have a few students share their observations with the class.
- Before proceeding to the next step, ask students to predict what will happen if the tube is placed over the lit candle.



Step 3: Lit Candle With Tube

- Have students continue with the observation as you place the tube over the lit candle. Once again have students write their questions in the question column.
- Before going to the next step, ask students to predict what will happen when a metal divider is place in the tube.



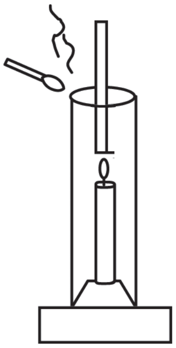
Step 4: Candle With Tube + Divider

- Use a clothespin or binder clip to hold the metal strip in the tube containing the lit candle. Have students record the observations and create their questions.

Step 5: Candle With Tube + Divider + Smoke

- Students may be puzzled by the previous set of observations. Tell students that you will help them understand what happened by introducing smoke into the tube.
- Light the paper, blow out the flame, and insert the smoking paper into the tube. Allow students to observe the convection current created within the tube, and keep in mind that if you are using a plastic tube, the candle should not remain lit for an extended period of time.
- Ask students to identify their left-column questions as Costa's Level 1, 2, or 3. (Refer to *Costa's Levels of Thinking* handout.)
- Assist the students in processing the demonstration by asking them to:

    Share their questions about the burning candle demonstration.
    Share their explanations of what was taking place during the demonstration.
    Suggest possible follow-up experiments.
    Ask any additional questions they may have.



- After the demonstration has been discussed, describe what was occurring during the process.

  A candle must have both fuel and oxygen to burn. When the candle is placed inside the tube, it quickly uses up the available oxygen and extinguishes. When the metal divider is placed in the tube, the candle burns brightly because a flow of air (convection current) is produced, bringing fresh air into the tube, as evidenced by the smoke produced by the paper).

- Have students write a summary that answers the essential question you used for the lesson.
- Ask students to process their learning from this demonstration by completing one of the processing activities from the appendix.

Differentiation Strategies

- For students that are comfortable with taking notes, you can expand the focus of the demonstration to include writing of predictions, inferences, and/or hypotheses for each step in the demonstration.
- A simple version of the demonstration can be used with younger students. You can direct them to closely observe a lighted candle and make any many observations as possible (or a set number that you specify) in the right column of their notes and record all of their questions in the left column. The activity can be expanded into an inquiry lab by having students write hypotheses about their observations and questions and develop a procedure to test their hypotheses.

Higher-Level Questions

- After students have identified their questions as Costa's Level 1, 2, or 3, ask them to create a higher-level question from each Level 1 or 2 question.

ADDITIONAL REFERENCES

Teachworth, M. (n.d.). Candle and tube demonstration video [Video file]. San Diego, CA. Retrieved from http://youtu.be/adafMTcNnpA

Section 3.2

Three-Hole Bottle

Introduction

Discrepant events are occurrences that seem counterintuitive. Demonstrations of these events are often excellent tools in science to foster questioning, hypothesis development, and data analysis. The three-hole bottle is a classic discrepant event that is easily applied to a variety of science topics in earth/space sciences, chemistry, physics, and biology. In this demonstration, students are asked to make predictions based on their life experiences.

Timeline

60–80 minutes, depending on students' prior knowledge of the concept

Objectives: The Students Will . . .

- Make observations and predictions, and form hypotheses
- Differentiate between prediction and hypothesis
- Explain observations of a discrepant event

WICOR Strategies

Writing:	Write observations and summaries
Inquiry:	Develop higher-level questions; develop and explain predictions and hypotheses
Collaboration:	Process the learning with partners
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Take notes and summarize

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Identify questions that can be answered through scientific investigations.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations.
- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Materials

- Colored pencils, 4 colors per student (can be shared)
- Bottle, prepared with 3 holes
- Water
- Bucket to catch water
- Chair (optional)

Handouts

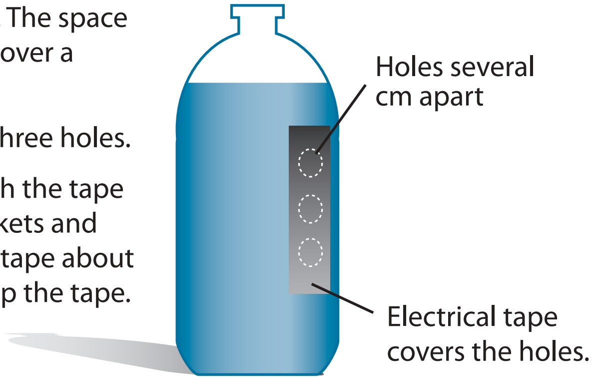
Student Handout 3.2.1:	*Developing a Testable Hypothesis*
Student Handout 3.2.2:	*Three-Hole Bottle Demonstration*
Teacher Reference 3.2.3:	*Three-Hole Bottle Demonstration Answer Guide*

Teacher Directions

Preparing the Three-Hole Bottle

- Clean an empty plastic bottle (1/2 L to 2 L) and remove all outside labels. The 2 L size is best for a classroom demonstration. The smaller bottles are appropriate if students are working directly with the bottles and testing their predictions and hypotheses.
- Heat a nail (about size 16) with a Bunsen burner, and melt three small holes in a vertical line a few cm apart on one side of the bottle. The space distance between holes is not critical, but spreading them out over a 10–12 cm length is appropriate.
- Cut a length of electrical tape longer than the distance of the three holes.
- Apply the tape to the bottle below the lowest hole, and smooth the tape toward the top of the bottle ensuring that there are no air pockets and the holes are completely covered. At the top, leave a length of tape about 2–3 cm long and fold the tape to stick to itself for a place to grip the tape. You can secure the bottom of the tape with a short piece of electrical tape perpendicular to the tape covering the holes.

Bottle filled with water



Introductory Discussion

- Define "hypothesis" for students. (Refer to the *Developing a Testable Hypothesis* handout.)
- Have students list characteristics of a high-quality hypothesis on the top of the left side of the INB. The left page is being used for a warm-up to introduce the lesson that will proceed on the right page.
- Ask a few of the students to share their ideas for expectations of a quality hypothesis. The ideas should include mention of qualitative variables and quantitative variables (e.g., independent and dependent variables) and a cause-and-effect statement about the variables.
- Distribute the handout *Developing a Testable Hypothesis* to students and discuss with them the difference between a prediction and a hypothesis and how initially writing a prediction can inform the writing of the hypothesis. Have students tape the handout over the hypothesis characteristics in their INBs after the demonstration and analysis is completed.

Suggested INB Set-Up

Left Page	Right Page
Characteristics of Hypothesis	**Topic** Heading Block
Developing a Testable Hypothesis *(Student Handout 3.2.1)* *(Tape in as a flip page.)*	**Three-Hole Bottle Demonstration** *(Student Handout 3.2.2 or student-produced)*
Processing Activity (choice)	Summary:

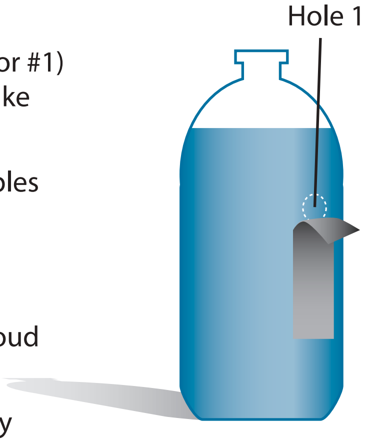
Performing the Demonstration

Teacher Note: *You will have the most impact if you stand on a chair (or maybe the demonstration table) to show students the three-hole bottle demonstration.*

- The teacher instructions for the demonstration provide directions when using student-prepared data tables in the INBs. To use a pre-made data template for the demonstration, distribute the Student Handout 3.2.2: *Three-Hole Bottle Demonstration* to students and have them glue or tape it into the INBs as a right page.
- If students are to prepare the data tables, have them set up the right side of the INB as a 4-column chart that extends to almost the bottom of the page. To make even vertical columns, have students fold the right page in half and crease it, then fold it in half again and crease. They can trace the folds for clear columns if desired. Label the columns as in the example below. (Refer to the student handout for the full layout of the data table.)

Question Column	Hole 1	Holes 1 and 2	All 3 Holes

Hole 1



- Have students label the Hole 1 column at the top with the word *Diagram* (use color #1) and sketch the bottle. Answer any questions about the bottle. Ask students to make their initial observations and sketches.
- Have students add the word *Prediction* (color #2) under the sketch on the data tables and write their predictions of what they think will happen when the first hole is uncovered.
- Have students use color #3 to write the word *Hypothesis*. They will now turn their prediction into a hypothesis that is measurable. Share some of the hypotheses aloud and comment on the positive points about the hypotheses.
- Have students use color #4 to write the word *Observations* and record high-quality observations as you remove the tape from hole 1. They should sketch the results as well as describe them.
- Cover the hole before the water level moves below hole 1.

Holes 1 and 2

- Have students repeat the same process as above (diagram, prediction, hypothesis, observation) when holes 1 and 2 are uncovered at the same time. Do not let the water fall below hole 1.

Holes 1–3

- Repeat the process until all three holes are uncovered. You can let the water run out as far as you like for this step.

After the Demonstration

- Have students create three questions in the question column, one for each of Costa's Levels of Thinking. Have a whole-group discussion of the science behind the demo. Have students list and define the key vocabulary with correct student-generated definitions on the left side as the terms are mentioned. Some examples include: vacuum, pressure, molecules, force, atmospheric/air pressure, water pressure, air, and displacement.
- Have students select a processing activity from the appendix to complete on the bottom of the left side using the vocabulary that they have learned.
- Ask participants to write a summary for the three-hole bottle demo at the bottom of the right side. The demo should use key terms discussed and address the following three points.
    1. Purpose of the demonstration
    2. Science explanation of the demonstration
    3. An application of this phenomenon

Optional Activity

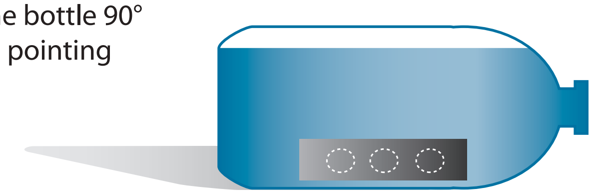
- Invite students to prepare their own bottles at home and perform the lab individually. They can then do a formal lab report with illustrations, experimental design, graphs, and analysis. The lab report format provided with this Write Path guide can be used.

Differentiation Strategies

- This activity can be varied depending on the grade level of the students and the content of the course. It is an excellent example of how to learn experimental design, specifically the difference between predictions and hypotheses in science. It also allows for practice in writing hypotheses that are measurable and demonstrates relationships between independent and dependent variables. At the high school level, this is appropriate to reinforce and practice experimental design and science process skills.
- The three-hole bottle demo can also be used for teaching the concepts of pressure and vacuums as you would insert them into the content of the subject-specific high school course. The differentiation inherent at the high school level is the depth of the content that is approached.
- Teachers can differentiate the learning environment by providing this as a self-directed demonstration at a "stations" lab or center, or as a small group activity for more homogeneously grouped students.
- The demonstration can be extended by having students collect quantitative data (i.e., collect and measure the water issuing from the holes) and create data tables and graphs.

Higher-Level Questions

- Predict what will happen for each hole if you turn the bottle 90° so the bottle is parallel to the ground with the holes pointing toward the ground.



ADDITIONAL RESOURCES

Colburn, A. (2003). Nature of science. In *The lingo of learning: 88 education terms every science teacher should know* (Chapter 11, pp. 95-96). Retrieved from http://science.nsta.org/enewsletter/2003-11/p95-96.pdf

Chiappetta, E. L & Koballa, Jr., T. R. (2004, November 1). Quizzing students on the myths of science. *The Science Teacher 71*(9). 59-61. Retrieved from http://science.nsta.org/enewsletter/2006-07/tst0411_58.pdf

Liem, T. L. (1990). *Invitations to science inquiry* (2nd ed.). Chino Hills, CA: Science Inquiry Enterprise.

Developing A Testable Hypothesis

Scientific methods and experimentation depend upon scientific observations. After making observations, the scientist thinks about what could be happening to cause the observation or what the effect would be of another factor on the observations.

Predictions are important in science since they help us think about how one environmental factor may affect another. An example of a prediction is, "Using my Interactive Notebook will increase my science grade." Predictions, however, do not go far enough. The next step is formalizing the prediction into a hypothesis, a tentative and testable statement about the relationship between two variables.

A ***hypothesis*** is based on observations, provides an explanation about the relationship of the variables, and clearly identifies a *testable* experiment within the statement. A student must be able to design an experiment that supports (or rejects) the hypothesis. The experiment will determine if one variable really does affect some other factor. In the case above, a possible hypothesis might be, "If I use my Interactive Notebook daily, then my science grade might improve because I learned the material in small chunks which is better for absorbing complex material like science." This is an example of a common form for a hypothesis: If…*(action of independent variable)*, then…*(action of dependent variable)*, because…*(explanation)*."

When developing a good hypothesis, you should be able to answer, "Yes" to the following four questions:

1. Is there a condition that sets up an effect? In other words, what do you think is the relationship between the independent and dependent variables?

This is a simple statement that explains what you think the relationship is. Many times it can be written in an ***"if…then…because…"*** format: If this *condition* occurs, then *this effect* is produced because *this is happening*. Having just the condition and effect is not enough. The variables have to be measureable.

Teacher Note: Students often confuse use of the words "then" and "than." Remember that the word THAN is a comparative while THEN signifies an order in time.

2. Does the hypothesis lead to an experiment?

The hypothesis must be something that can be tested. For example, a hypothesis such as, "An increase in asthma is due to the increase in atmospheric carbon dioxide," is not testable. However, "Plants subjected to classical music while growing will grow taller than plants that are subjected to silence," is a testable hypothesis.

3. Is it clear and objective?

A hypothesis must be easy to understand. The sentence structure should be mechanically correct and as short as possible, saying only what is necessary. A hypothesis is a formal statement that does not use the word "I." It is free of personal bias and is based on background information and research.

4. Does it explain the reason for the prediction?

Hypotheses explain predictions using previous observations, research, or other background knowledge. A hypothesis is not a guess, but is an educated statement that gives an explanation for an occurrence.

> **Example:** If "bubble wrap" is wrapped around exposed water pipes in the winter then the pipes will be less likely to freeze than if they were wrapped in newspaper because heat does not transfer as readily through the air in the bubble wrap.

STUDENT HANDOUT 3.2.2

Three-Hole Bottle Demonstration

Question Column	Hole 1	Holes 1 and 2	All 3 Holes
	Diagram: *(color 1)* **Prediction:** *(color 2)* **Hypothesis:** *(color 3)* **Observations:** *(color 4)*	**Diagram:** *(color 1)* **Prediction:** *(color 2)* **Hypothesis:** *(color 3)* **Observations:** *(color 4)*	**Diagram:** *(color 1)* **Prediction:** *(color 2)* **Hypothesis:** *(color 3)* **Observations:** *(color 4)*

Summary:

Three-Hole Bottle Demonstration

Answer Guide

Question Column	Hole 1	Holes 1 and 2	All 3 Holes
Sample Level 1 question: What happens when the first hole is uncovered?	**Diagram:**	**Diagram:**	**Diagram:**
	Prediction: There will be no change in the bottle condition. *[These will vary.]*	**Prediction:** No water will come out of the holes. *[These will vary.]*	**Prediction:** Water will come out of hole2 but not hole 1. *[These will vary.]*
Sample Level 2 question: What are the similarities and differences between uncovering two holes and uncovering all three holes?	**Hypothesis:** If hole 1 is uncovered, then no water will spurt out of the hole because the pressure outside the bottle exceeds the water pressure in the bottle.	**Hypothesis:** If holes 1 and 2 are uncovered, then water will spurt out of the hole 2 because air will move into the bottle at hole 1 to replace the water coming out of hole 2.	**Hypothesis:** If all holes are uncovered, then water will stream out of holes 2 and 3 with the water stream for hole 3 being farther away from the bottle than the stream from hole 2 because air will move into hole 1 allowing water to move out the other two holes.
	Observations: Drips of water come out of hole 1 due to a squeeze on the plastic bottle. No water streams out.	**Observations:** Initially, the water spurts until enough air moves into the bottle to allow a steady stream of water out of hole 1.	**Observations:** Large air bubbles move into hole 1. Water streams out of holes 2 and 3. The water stream from hole 2 ends shorter than the stream from hole 3.
Sample Level 3 questions: What is the effect of creating larger holes on the experiment? Predict the effect of turning the bottle so that the holes are pointing down at the ground.	**Explanation:** The water cannot move out of the bottle because there is nothing to replace the leaving water, thus creating a vacuum where nothing moves in or out of the bottle. The size of the hole affects this. The larger sized hole would allow water to stream out because air can move in the top of the hole and liquid can flow out the bottom.	**Explanation:** Water cannot move out of the bottle until air can move in. Air moves in hole 1 and water moves out hole 2 because the water pressure inside the bottle is greater at hole 2 due to the increased height of the water column and there being more water molecules above hole 2 than hole 1.	**Explanation:** The water pressure inside the bottle is larger at hole 3 which forces the water out farther, making a longer stream than hole 2.

Summary:

We investigated the effect of the height of the holes on the length of water that streamed out of an uncovered hole. Water can only move out of the bottle when two or more holes are uncovered because air must move into the bottle to replace the water that leaves. Water moves out of the lower hole at a higher rate because there is more water pressure forcing it out of the bottle (more water molecules above the lower hole than the upper hole). Air will move in the top hole because the air pressure is greater than the water pressure in the bottle.

Section 3.3

MAGAZINE AD: Experimental Design

Introduction

Designing well-controlled experiments is the key to successful science. Identifying the parts of experimental design helps students determine the causal agent as well as the effect of that agent on another variable. In the "Magazine Ad Experiment," the students will use an advertisement of a product they are interested in as the source in their own experimental design.

The purpose of the activity is for students to test the claim that is inherent in the advertisement. For example, "Detergent X makes clothes whiter." This can be tested in an experiment. By cleaning clothes in several types of detergent (including detergent X), one can determine how much dirt was removed from the clothing by rating the amount of stain left behind. In this experiment, the control group would be washing the clothes in plain water. This simple experiment could be repeated many times, validating the results by the repeated tests.

After the experimental design is completed, students will participate in a "gallery walk." A gallery walk is a collaborative activity where students examine or review the work of other students. The product is displayed for viewing on the wall or around the room in an easy-to-access pattern. The purpose of the gallery walk is to honor student work, develop questions to push the thinking to the next level, and allow students to see the variety of experiments that can be devised to test everyday claims.

Timeline

50–100 minutes

Objectives: The Students Will . . .

- Write and test a hypothesis
- Develop a valid scientific experiment to test the claim presented in an advertisement

WICOR Strategies

Writing:	Prepare a graphic organizer
Inquiry:	Develop a testable hypothesis
Collaboration:	Review with partners and through a gallery walk
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read and analyze a magazine advertisement

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Communicate and defend a scientific argument.
- Understandings about scientific inquiry

Materials

- Variety of magazine advertisements
- Newsprint or poster paper
- Markers
- Access to publication software to create professional products using technology
- Poster board or chart paper

Handouts

Student Handout 3.3.1:	*Magazine Ad Experiment*
Student Handout 3.3.2:	*Experiment Graphic Organizer*
Student Handout 3.3.3:	*Magazine Ad Rubric*
Student Handout 3.3.4:	*Components of Good Procedure Writing (Peer Review)*

Teacher Directions

- Locating magazine ads can be done in two ways: 1) find advertisements for the students and clip these before the class, or 2) have students locate their own ads. The latter is more difficult, since students need to identify an ad suitable for designing a well-controlled experiment.
- Suitable ads make the claim that one product does some measurable thing better than other similar products. Toothpaste, detergent, gasoline, or medication ads are usually good examples.

Introductory Discussion

- Review the *Experiment Graphic Organizer* handout with students and discuss the terminology that is critical to experimental design, including independent variable (IV), dependent variable (DV), control variable, repeated trials, and hypothesis. (Refer to the *Developing a Testable Hypothesis* handout.)
- To help students identify the critical terminology in experiments, supply them with various simple lab scenarios or abstracts and have them practice finding experimental design components in the scenarios. Choose a simple lab with plain variables.

- Ask students to use the *Experiment Graphic Organizer* (EGO) handout to develop an EGO for this sample experiment. You can also conduct or refer to several labs that employ good experimental design and have students prepare an experimental design graphic organizer.
- Have the students write a short description of the sample experiment.
- Distribute the *Magazine Ad Experiment* handout to students. Have students work in teams of two for this investigation.

Suggested INB Set-Up

Left Page	Right Page
EGO: **Experiment Graphic Organizer** *(Student Handout 3.3.2)* *(Glue in as flip page after sample EGO is completed.)* **Cometed EGO template for the sample lab.**	**Topic** Heading Block Essential Question: Questions **Student notes on introductory discussion** **Description of sample lab**
Teacher-provided guided practice *(identifying variables and writing hypotheses for experiments)*	**Developing a Testable Hypothesis** *(Student Handout 3.2.1)*
Magazine Ad Procedure **Magazine Ad Rubric** *(Student Handout 3.3.3)*	**Experiment Graphic Organizer** *(for magazine ad)*

Developing the Experimental Design and Procedure

- Once student teams select an advertisement, have them design an experiment that tests the claim made by the ad. The components of the experimental design can be expressed in the graphic organizer format (see the *Experiment Graphic Organizer* handout) or in a narrative format, if you prefer that format. The design is written on a right page in the INB.

Developing a Procedure to Test the Hypothesis

- Students will now prepare a repeatable procedure that could be carried out to investigate the claims of the magazine ad. This should be a numbered list of instructions (written on the INB left page facing the *Experiment Graphic Organizer*) that breaks down larger tasks into smaller steps. The handout *Components of Good Procedure Writing* (*Think It—Build It—Write It*, Unit 2) contains a list of details that help make procedures replicable.

Peer Review

- Combine the teams of two into groups of four. Distribute the *Components of Good Procedure Writing (Peer Review)* handout to students.
- Have team A explain the procedure to team B. Team B should review the list of ideas on the peer review handout for good procedures. Team B will give team A comments and suggestions about their procedure. The teams will then switch roles.

Revision

- Have the student teams return to their procedure and redraft it. Once a final draft is written, students can write the draft on a piece of white paper, chart paper, or poster board, according to your directions, and display their work.

Gallery Walk (Presenting the Posters)

- Have groups post their posters on the walls. Students will stand in front of their own posters, and on your cue, move to the next poster. (The gallery walk is also described in the *Active Learning Strategies* section in Unit 4.)
- Students will carefully read the posters they are viewing and individually develop questions that reflect Costa's Level 2 or 3 thinking. They will write their questions on sticky notes which they will place on the posters. As an alternative or addition, students can evaluate two posters using the *Magazine Ad Rubric*.
- The length of the gallery walk can be adjusted depending on the needs of your students and the time available, but it is important to include this activity in the process so students realize that their work is informative to other students and is not meant for only the teacher's eyes.

Differentiation Strategies

- The level of ads that you make available will differentiate the content. Groups that have advanced students should get more difficult ads in which the claim is more obscure or the group will have to develop a way to test the validity of the hypothesis. For novice learners, provide ads that are clear in the hypothesis and for which a method of testing is easy to deduce. Allowing students to self-select ads also differentiates by interest and will engage more students in scientific work.
- You can extend this lesson by asking students to choose a processing activity (see *Processing Activities* in the appendix) to process the activity and put their work on the left page of the INB. If there is content that the student should add to their notes, having them add it to the right side on the INB is appropriate.

Higher-Level Questions

- Predict the challenges for drug trials to cure diseases when human subjects are involved.
- What might happen if scientists did not control their experiments with strict protocols and specific constants?
- What are the benefits of designing a controlled experiment before the data is collected? What are the disadvantages?
- Do you think that there is a bias in the magazine ad that you reviewed? How might a bias affect scientific results? Do you think that science can be free of bias? Why or why not?

ADDITIONAL RESOURCES

Cothron, J. H., Giese, R. N., & Rezba, R. J. (2005). *Students and research: Practical strategies for science classrooms and competitions* (4th ed.). Dubuque, IA: Kendall/Hunt Publishing Company.

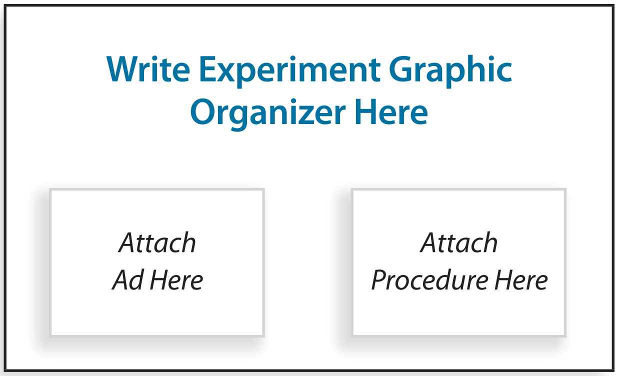
STUDENT HANDOUT 3.3.1

Magazine Ad Experiment

Experimental design is the way in which cause-effect relationships are discovered in science. To show what you know about experimental design, you will design an experiment to test the claims in a magazine advertisement.

Procedure

1. Select an advertisement from the magazines provided by the teacher, or as the teacher directs.
2. Neatly cut out the advertisement.
3. Design a valid experiment that focuses on what the magazine ad is claiming. The experiment must be within school regulations and must be G or PG rated.
4. Create an Experiment Graphic Organizer (EGO) showing the design of your valid experiment. This should be neatly written using markers.
5. Write a list of all steps for the procedure to complete this experiment. Things to consider might include: how much of the product to use, how to choose the reactants or participants, how to measure the responses or variables, how many times to conduct experiment, what other conditions must be kept constant and how to do this, what types of experimental groups are used, etc.
6. Peer review your procedure with another team, and redraft the procedure considering all revisions suggested.
7. Attach the ad and the procedure to the front of your poster. (See diagram below.)



Helpful Hints

All experiments need to have:

- Many repeated trials (Assume you have an unlimited money supply.)
- A minimum of three different IV groups
- A control group that is well defined
- Four legitimate constants (Equipment or environment will not qualify unless they specifically relate to the experiment.)
- A logical hypothesis
- A repeatable procedure with lots of details

Experimental Graphic Organizer (EGO)

Title:____

Independent Variable(s)

Paragraph that describes the independent variable and how it is measured. Important points include:

- What is the IV?
- How will it be measured? What SI units will be used?
- What are the IV groups that will be tested?
- How many times will you repeat the trial?

Dependent Variable(s)

Paragraph that describes the dependent variable and how it will be measured. Important points include:

- What is the DV?
- How will it be measured?
- What SI (metric) units will be used?

Hypothesis

Short paragraph (1–4 sentences) that describes the formal hypothesis. Begin with an "if…then…because…" statement and be sure to include:

- The specific relationship between the IV and DV
- An explanation based on background information

Constants

List the parts of the experiment that must be kept the same from trial to trial in order to ensure that the results change due to the IV. Be specific. If the volume of distilled water is critical, then list the exact volume of distilled water that you will use (e.g., 25.0 mL of distilled water).

Control Group

Describe the control group and explain why it was picked as the control group. How does it determine a baseline for comparison?

Sketch of Lab During Data Collection

Clearly represents the variables and constants

STUDENT HANDOUT 3.3.3

Magazine Ad Rubric

Required Elements	Scores				
Independent Variable Includes discussion that defines variable, explains how to measure it, states appropriate SI units, describes a minimum of 3 groups, states number of trials	0	2	4	6	8
Dependent Variable Includes discussion that defines variable, explains how to measure it, states appropriate SI units	0	1	2	3	4
Testable Hypothesis States reasonable relationship between IV and DV, explains rationale for relationship, sets up testable experiment	0	1	2	3	4
Constants Includes a minimum of 4 specific factors that remain the same in all trials with a reason why the factor could affects the results	0	1	2	3	4
Control Group Describes what treatments the control group will or will not have as well as why this group is the control	0	1	2	3	4
Procedure Step-by step procedure that describes how to collect and record data and how to set up the experiment, is repeatable, follows requirements of good procedure writing handout, provides clear and labeled sketch that includes constants as well as variables	0	2	4	6	8
Mechanics Writing is formal, free of grammatical error, logical, and well written.	0	1	2	3	4
Poster Professional work, clear writing, color usage, neat presentation	0	1	2	3	4

Note: This rubric is based on quality points in which a 4 represents an A, 3 represents a B, 2 represents a C, and 1 represents a D. To find a score, you add up the total points a divide by 10 because there are 10 categories. (Note that the IV and procedure categories are worth twice as much as the others.) If you wish to record scores on a 100-point scale, you will need to create a scale to determine the equivalent.

Components of Good Procedure Writing

Peer Review

For scientists, it is critical for other researchers to replicate experimental studies to verify the results. Being able to replicate the results of an investigation allows a researcher to strengthen the conclusions made in the first study. Precision is vital: This includes explaining how to set up the groups, how to control the constants, and how the measure the variables.

The following is a list of essentials for writing procedures. Be very specific. *When in doubt about how much to include about your methods, include more!*

Directions: Have a peer read your procedure and initial in the box next to the step to indicate that you completed that part of the procedure.

Peer #1	Peer #2	Criteria for Good Procedure
		1. Use a numbered list of steps.
		2. Organize the steps into small discrete directions in the order you would do them in lab.
		3. Avoid using pronouns.
		4. Use commands.
		5. Explain how you selected your sample of organisms or reagents.
		6. Tell the reader to measure and record data when it is appropriate. Also explain what data to record and how to measure this data.
		7. Refer only to measurements using the metric system (SI).
		8. Eliminate extraneous information.
		9. Sketch and label the experimental set-up. Refer to sketch in directions.
		10. Number multiple sketches, starting with 1. Refer to the sketch numbers in the procedure.
		11. Include every step no matter how small it seems. It may be the critical step.
		12. Explain how to keep all constants the same.
		13. All equipment listed in the materials section is referred to in the methods section.
		14. Tell experimenter when to repeat steps.

Section 3.4

LENSES:
Graph Analysis

Introduction

Reading is an essential component of the WICOR strategies as well as an important communication skill for scientists. Students must be able to read various types of science text, data, and research. This activity will use the science process skills to help students become proficient in reading and analyzing diagrams, pictures, data tables, and graphs. National, state, and district assessments require students to complete questions that use these skills. For example, students must apply science process skills, including interpreting visual representations of data on the ACT Science Reasoning assessment (Kaplan, 2010). All four Advanced Placement science exams require students to analyze graphs and charts in both the multiple-choice and free-response sections. This lesson will help students approach their analyses more critically and actively.

Timeline

45 minutes

Objectives: The Students Will . . .

- Analyze and interpret graphs
- Classify and compare scientific data to make predictions about future science trends and phenomena
- Apply Costa's Levels of Thinking by analyzing data in a progressive manner

WICOR Strategies

Writing:	Write descriptions and summaries of graphs
Inquiry:	Analyze and evaluate graphs
Collaboration:	None
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read and interpret scientific graphs

National Science Education Standards

Science Standard A (Grades 5–8): Science as Inquiry

- Develop descriptions, explanations, predictions, and models using evidence.
- Communicate scientific procedures and explanations.

Science Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Highlighter for each student
- Content-specific graph(s)

Handouts

Teacher Reference 3.4.1:	*LENSES Analysis*
Student Handout 3.4.2:	*LENSES Template*
Teacher Reference 3.4.3:	*LENSES Student Sample*
Student Handout 3.4.4:	*Graphing Resource*

Teacher Directions

- Choose graphs for the graph analysis that are essential for understanding in your content area. Sample types of graphs are listed in the chart below.

Biology/Life	**Physical/Chemical**	**Earth/Environmental**
Population Growth Bacteria	Mass vs. Volume— Density Solubility	Temperature— Cooling Rate of Crystals
Enzyme Activity	Heating Curves	Radioactive Decay
Percentage of Organic Molecules	Gas Laws Periodic Trends	Thermocline of Ocean HRT Diagram

- Provide each student with a sample graph to place on a left side in the Interactive Notebook.
- Distribute the *LENSES Template* handout or have students set up Cornell notes on the right page of the INB. The acronym LENSES should be written in bold letters in the question column with the final "S" in the summary section. The template provides guidance for students as they begin to use the LENSES format. You should push your students beyond a fill-in-the-blank document as soon as they are comfortable with this process.
- Model the analysis process for students by displaying a sample graph on an overhead projector, document camera, or whiteboard so they are able to follow along with the teacher during the analysis. Use the *LENSES Analysis* teacher reference as your guide.
- Students will need assistance in determining the type of relationship represented on the graph and phrasing this scientifically. The handout *Graphing Resource* provides information on direct and inverse relationships. It can be used as a handout or as a master copy to be displayed.

Suggested INB Set-Up

Left Page	Right Page
Sample graph for analysis *(from course content)*	**LENSES Template** *(Student Handout 3.4.2 or student-prepared)*
	Summary:

Differentiation Strategies

- For young students or as initial exercises, the students can be asked to describe the relationship between the variables rather than state an equation for the relationship.

LENSES Analysis

Label & List	Observe the graph and use a highlighter to label the items listed below. List the essential components on the corresponding Interactive Notebook right page in the note section under the “L.” • Title: • Independent Variable: Units: • Dependent Variable: Units: • High and Low Data Points: Review **DRY MIX** to help students understand the **I**ndependent or **M**anipulated variable is always on the x axis and the **D**ependent or **R**esponding variable is always on the y axis.
Equation	What is the relationship between the variables? Choose the appropriate category based on the type of equation that would result: • **Direct relationship:** As the independent variable increases (or decreases) so does the dependent with constant rate of change. • **Inverse relationship:** As one variable increases, the other variable decreases. • **Linear relationship:** Straight line with an equation of $y = mx + b$; can have positive or negative slope depending on direct or inverse relationship • **Exponential relationship:** The rate of the change continues to either increase or decrease as time passes; as one variable changes, the other variable is raised to a power (exponent); curved line for quadratic equations **State this relationship specifically on the chart: As the IV *(fill in appropriate IV)* increases or decreases (choose one), the DV *(fill in appropriate DV)* increases or decreases *(choose one)*. This is a ______ relationship. The equation for this graph is…**
Notice	What do you notice happening? • Identify the properties of the graph. • Calculate the slope of the graph. Show your work. **Each graph has different important features that make it useable in specific types of problems or data.**
Speculate	What can you speculate or predict about the graph? • Predict an intermediate data point. • Hypothesize what will happen to the dependent variable if the independent variable increases. • Extrapolate the next data point and record it on the graph. • What inferences can be made about this graph?
Explain/ Evaluate	Explain your predictions from the *Speculate* section and how they relate to the observations. • What question is not addressed by the graph that would allow for a better understanding of the topic?
Summary	What content have you learned? Name the specific scientific concept in the graph and write a summary of the information found in the graph.

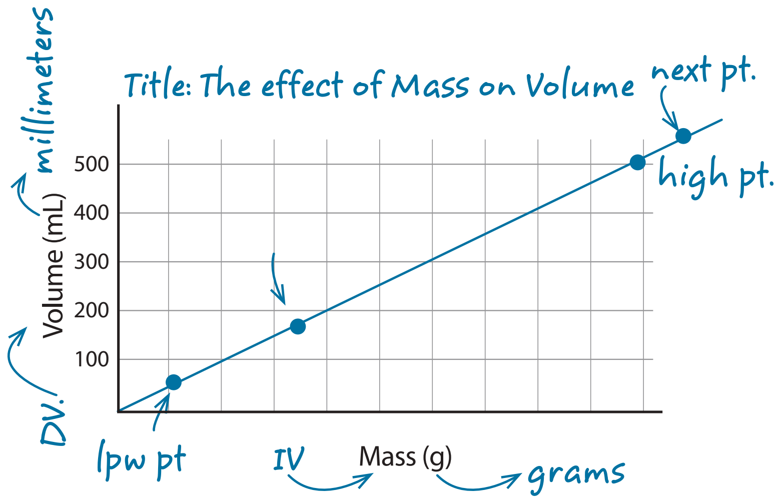
STUDENT HANDOUT 3.4.2

LENSES Template

Label & List	Title: Independent Variable With Units: Dependent Variable With Units: High and Low Data Points:
Equation	State the relationship for this graph… Direct, inverse, linear, exponential, other As the IV ________________, the DV _________________. The equation for this graph is…
Notice	What do you notice happening? • Identify the properties of the graph. • Calculate the slope of the graph. Show your work.
Speculate	What can you speculate about the graph? • Predict an intermediate data point. • Hypothesize what will happen to the dependent variable if the independent variable increases. • Extrapolate the next data point and record it on the graph. • What inferences can be made about this graph?
Explain/ Evaluate	Explain your predictions from the *Speculate* section and how they relate to your observations. • What question is not addressed by the graph that would allow for a better understanding of the topic?
Summary	What content have you learned?

LENSES

Student Sample



Label & List	The effect of mass on volume I.V. = Mass units → grams D.V. = Volume units → mL High pt 500g/500ml Low pt 50g/50mL
Equation	As the mass increases the volume increases ⟹ Direct ↑↑ Slope = $\frac{rise}{run}$
Notice	: Mass is increasing by 50s ↑ volume is increasing by 50s ↑ Slope = $\frac{rise}{run} = \frac{500-300}{500-300} = \frac{200g}{200ml} = 1g/ml$
Speculate	If mass was 125g → volume 125mL If the mass increases then the volume will increase The next data pt could be 550g/550ml
Explain/Evaluate	This graph represents the relationship between mass/volume w/ Density D = $\frac{m}{V}$ → What is the Substance?
Summary	I learned that the mass of the Substances Increases in increments of 50g which causes the volume to increase by 50ml. This direct relatimsh is called DENSITY

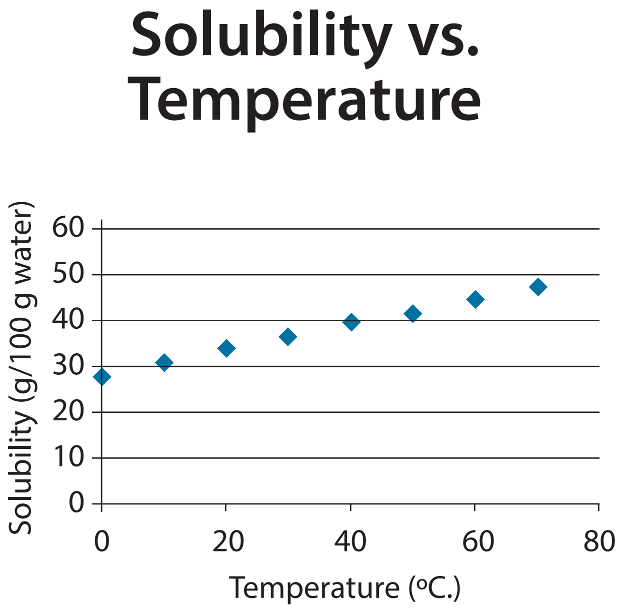
Graphing Resource

Direct Relationship

Both variables increase; positive relationship

Linear: straight line $y = mx + b$

Exponential: curves $y = ax^2 + b$ quadratics



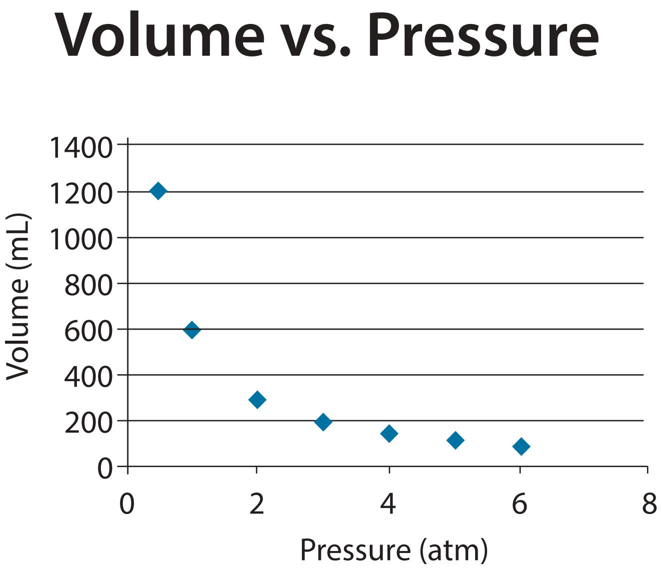
Inverse Relationship

One variable increases, the other decreases; negative relationship

Linear: straight line $y = -mx + b$

Exponential: curves $y = -ax^2 + b$

Inverse variation: $y = \frac{k}{x}$



Section 3.5

Data Collection

Introduction

Knowing how to collect and present data in the science classroom is an essential skill for all science students. In addition, being able to make precise statements about the relationships between variables is a critical skill in an inquiry-based science class. Classroom teachers may feel that their students already have these skills; however, it is important to review data and graphing within each science class. As you move your students toward more inquiry-based laboratory experiences, they need training in how to organize data effectively. Students should be able to design data tables in order to collect data in an organized, consistent manner. This lesson will introduce how to efficiently set up data tables to collect data during an experiment utilizing independent and dependent variables.

Timeline

50 minutes, with homework or additional time during the following class periods to finish the activities and review answers

Objectives: The Students Will . . .

- Identify independent and dependent variables and controls for an experiment
- Design a data table to be used in an experiment

WICOR Strategies

Writing:	Explain the relationships within data
Inquiry:	Interpret data
Collaboration:	Collaborate in peer revision of data
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Interpret data

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.
- Understandings about scientific inquiry

Materials

- None

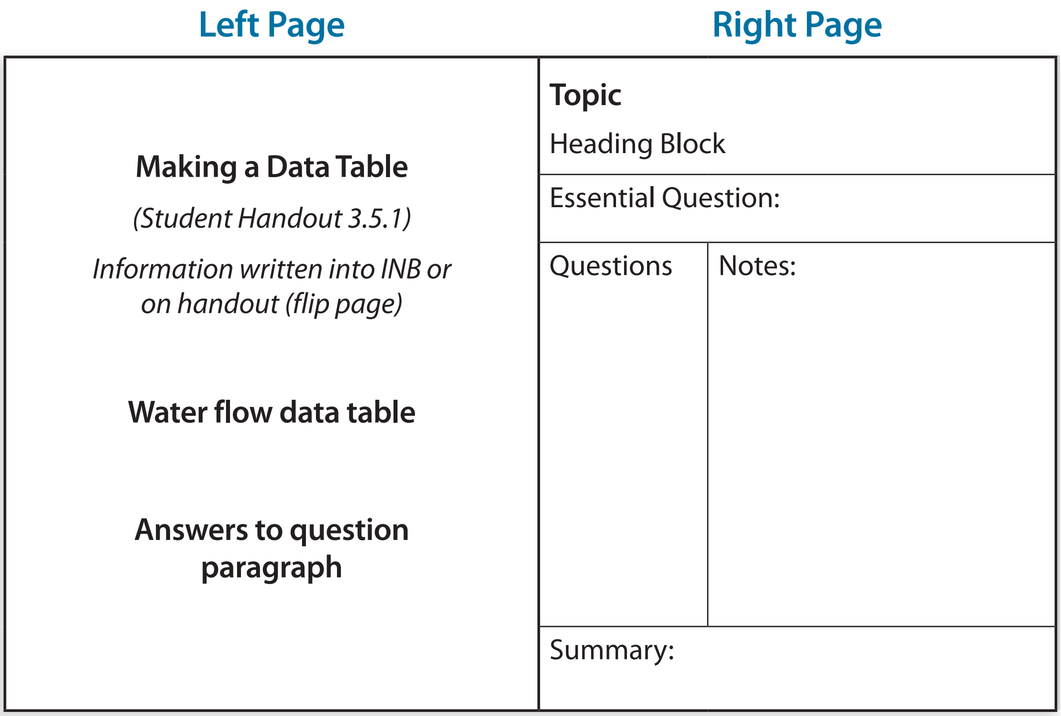
Handouts

Student Handout 3.5.1: *Making a Data Table*

Teacher Directions

- Have students set up a right page in their INBs for taking notes on the discussion on gathering data and preparing data tables for an experiment. Either develop your own essential question or have students create the essential question.

Suggested INB Set-Up



- If the class has not reviewed independent variables, dependent variables, and controls, begin the instruction at that point. It is especially important when reviewing the vocabulary terms to also address how they might appear on tests, including such variations as "variable parameters" and "controlled parameters."
- A good way to quickly review independent and dependent variables after describing them is to display some advertisements and discuss the claim of the advertisement with the class. Have the class members identify what variable they would "manipulate" (independent variable) and what variable would "respond" (dependent variable) within an experiment that tests that claim. (This preliminary discussion is also a good way to prepare students for the *Magazine Ad: Experimental Design* lesson.)
- Deliver the notes in ten-minute portions, pausing to allow students to process each portion of the lecture. A simple way to process every ten minutes can be a quick pair-share of vocabulary, whiteboard responses, a one-sentence summary, writing a question about the notes, etc.
- Guide students through a discussion of preparing data tables. Be sure to make the following points:

  Data tables should have the independent ("manipulated") variable as the first column and the dependent ("responding") variable in the second column, with units listed at the top of each column. The example below is for the lab data in this lesson.

Independent Variable & Units	Dependent Variable & Units
Example: Time heated (min)	*Example: Temperature (°C)*

  Show students a simple data table with just the independent variable and dependent variable, then show tables with increasing complexity such as data tables that have multiple dependent variables (i.e., plants in sunlight for a variable number of hours might have color, height, number of leaves, stalk diameter, etc., as the dependent variables).

Hours Plant in Sun	Leaf Color	Plant Height	Number Leaves	Stalk Diameter (mm)

- Distribute the *Making a Data Table* handout to students. It may be helpful to some students to see samples or pictures of each substance.
- Make sure that students create the data table prior to peer sharing and comparing their tables. This step allows them to work individually first, then work with a partner to discuss the table prior to a class discussion.
- The writing portions of the activity (answering questions, paragraph explanation, and summary) can be done in class or as homework, depending on the amount of class time you want to dedicate to the activity.

Sample Data Table for This Experiment

Tube	Material	Speed	Rank
1			
2			
3			
4			

- The paragraph explanation of the data should focus on the need to record each piece of data in an organized fashion with the independent variable first, then the dependent variable, followed by other data to be considered. Without recording the tube number, a person might mistake which tube contained which material.
- Recording the ranking of the water flow speeds is not required for data points, but it enables students to quickly answer one of the questions in the activity.

Answers to Questions Within the Activity

1. How many tubes are used in the experiment? *Three*
2. Is the material the same in each one? *No*
3. Through which one of the tubes do you think the water will move most rapidly? Which will be the second fastest? In which tube will water movement be the slowest?

   Gravel is the most rapid because it has more open spaces to allow the water to flow through. Sand is second. Clay soil has the slowest flow rate because the particles of clay are very small and stick together when wet, which slows the flow of water.
4. How can you determine the tube through which the water flowed most rapidly?

   Answers will vary. Students may suggest timing how long it takes for a specified amount or all of the water to flow through the tubes.

Differentiation Strategies

- For younger students or as an initial graphing exercise, prepare the data tables and have them complete the data table during an experiment, then graph the data. Allow students already proficient with data tables and graphs to be teachers in small groups or to model each step of the graph formation.
- Offer more sophisticated or longer lab investigations as practice for creating data tables and collecting data.

Making A Data Table

Making a proper data table is an important skill for scientists and science students. Making your first data table "from scratch" is an important skill to master, particularly when you are designing your own laboratory procedures. All data tables have the same basic format, listing the independent variable first followed by the dependent variables, providing places to record data collected during an experiment.

The experimental set up below is for an experiment that some students want to conduct on water flow through different types of soil. Their task is to observe the water movement through material in three different tubes. To record their observations and results, they need to make a data table. Your job is to help them design a data table for their experiment.

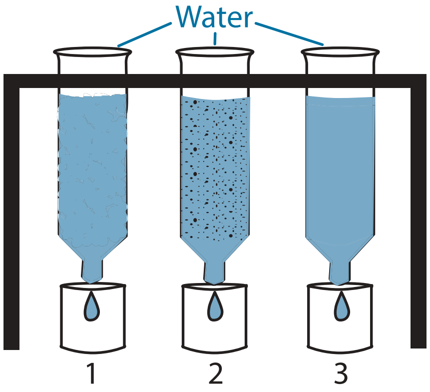
Experimental Set-Up

- Tube 1 contains gravel; tube 2 contains sand; tube 3 contains clay.
- Water is poured into each tube. The screen covering the bottom of each tube prevents the material from escaping, but allows water to flow freely.

Questions

Answer the following questions on a left page facing your notes on collecting data in your INB.

1. How many tubes are used in the experiment?
2. Is the material the same in each one?
3. Through which one of the tubes do you think the water will move most rapidly? Which will be the second fastest? In which tube will water movement be the slowest?
4. How can students determine the tube in which the water moved most rapidly?



Each piece of information asked for in these four questions must have a place to be recorded on the data table for this exercise. In other words, you will need some space to indicate the following:

- The number of the tube
- The contents of each tube
- The "speed rank" of the water moving through the tube
- The time it took for the water to go through each of the tubes

Make a table of your own on the left page of your INB and label it "Water Flow Data Table." When you have your table completed, ask your teacher for a sample to which you can compare your table. Make any adjustments necessary to make your table accurate.

Every experiment requires recording data of some kind. The process of designing a data table is similar to the process you used here for all experiments:

- Determine what you need to record, identifying your independent and dependent variable.
- Identify the title for each variable or piece of data.
- Count the number of experimental set-ups or trials you will run.
- Organize this information into a data table.

Below your data table and questions in your INB or below on this sheet, write a paragraph explaining why each piece of information from the experiment described above is necessary to have in the data table for this experiment.

Section 3.6

Graphing Data

Introduction

Graphs are used in many different subject areas as a way to represent data visually, making their interpretation clearer and easier. In science, graphs are an essential tool in making quantitative statements about the relationships that exist between variables. Creating and interpreting graphs must be taught at each grade level and in each science content area. Students who can skillfully identify, interpret, and describe the relationship between two variables in a graph will be well prepared for the rigors of the science classroom. This lesson can be used at all grade levels to instruct students in the preparation and dissection of graphs.

Timeline

Two class periods, one for discussion and one for graph preparation and analysis

Objectives: The Students Will . . .

- Become proficient at presenting data graphically
- Develop questioning skills that increase the interpretation and explanation of graphs
- Synthesize summaries of graphs and diagrams
- Create graphs for two variables
- Identify a graphical trends or patterns between two variables and accurately describe the relationship between them

WICOR Strategies

Writing:	Explain information from a graph
Inquiry:	Develop questions on the content of graphs
Collaboration:	Collaborate in peer revision of graphs
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read data and graphs to process and summarize the information

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.
- Understandings about scientific inquiry

Materials

- Graph paper

Handouts

Student Handout: 3.6.1: *How to Graph Data*

Teacher Directions

- Distribute the *How to Graph Data* handout to students. They will glue/tape this as a flip page onto a right page in their INB over the discussion on graphing. The student-prepared graph will be glued or taped onto the left page.

Suggested INB Set-Up

Left Page	Right Page
Student-prepared graph *(Tape in as a flip page.)* **Answers to questions** **Summary**	**How to Graph Data** *(Student Handout 3.6.1)* *(Tape in as a flip page.)*

- It is very important to review vocabulary terms with your students in the direct instruction on graphing. Include in the introductory discussion a review of the independent and dependent variables, axes, range, scale, and labeling (including axes, titles, and units). Other vocabulary to cover should be: linear, nonlinear, direct, and indirect/inverse relationships.
- Using the information on the *How to Graph Data* handout, discuss with students the steps in creating graphs. Reinforce the concept that graphs show trends and patterns for two variables to more easily identify the relationship between them. Quantitative statements about the relationship between the variables can be made by describing slope of the line, averages, and line or curve of best fit.
- The mnemonic "DRY MIX" is a simple way for students to remember the variables and how they are placed into a graph.

  D = dependent variable
  R = responding variable
  Y = y axis
  M = manipulated variable
  I = independent variable
  X = x axis

- Use a sample graph to explain range and scale. It is a tough concept for students, but may be easier if the graph starts at (0,0).
- Have students work in pairs or small collaborative groups to create the graph of the average daily humidity and answer the questions. The assignment can also be done for homework, followed by collaborative sharing the following day.

Answers to Questions on the Graphing Procedure

1. How many different combinations of the three variables above could you graph for Table 1?

   Three: humidity vs. temp; humidity vs. date; temp vs. date

2. a. What is the range for the average air temperature? *11 (42–31)*

   b. What is the range for the average humidity? *16 (31–15)*

3. a. If you have 15 squares on the graph for your x axis, what would a good scale for the temperature be? *Answers will vary. 1 square = 1° C is reasonable.*

   b. If you have 20 squares on the graph for your y axis, what would be a good scale for the humidity be? *Answers will vary. 1 cm = 1% is reasonable.*

4. a. If you were going to graph air temperature vs. humidity, which would be the independent variable? *Air temperature, as it is first in the data table. Humidity is measured as a result of temperature.*

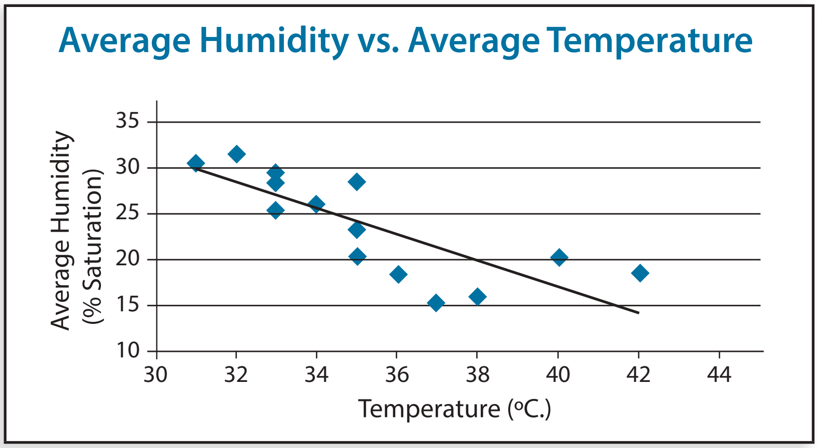
   b. If you were going to graph air temperature vs. time of month, which would be the independent variable? *Time of month, as it is first in the data table. Air temperature is measured as the month progresses. Time is always on the x axis.*

   c. If your answers to 4a and 4b were the same, explain why. If those answers were different explain why. *In (a), the amount of water air can hold depends on the temperature of the air. In (b), days will be the same, regardless of temperature.*

5. Write titles for the graphs from questions 4a and 4b. *Answers will vary. "Humidity vs. Temperature" and "Temperature vs. Date" are reasonable.*
6. Define the term "line of best fit" and when it applies to a graph. *An "average" line drawn so half of the data points are above it and half are below it.*
7. Why are the dates listed on the temperature-humidity table but not included on the graph? *Answers will vary. The point here is that when the data is collected it may not always be critical.*

8. Write a one- to two-sentence conclusion about the trends, significance, or relationship between the two variables used in the graph.

Here is what the student graph generated from the temperature-humidity data in Table 1 should look like:



Differentiation Strategies

- For younger students or those who require accommodations to help with processing information, provide guided instruction and use choral responses for creating data tables and graphs. It might also be helpful to these students to use a graph that has a range beginning at (0,0) rather than ones that start at a higher number.
- Use sentence frames for the summary of the graph.
- For some students the larger 1 cm graph paper is better for plotting coordinate points than paper with a smaller grid.
- Have students answer the questions as a class, using different colors to fill in those questions they were unsure of and extend the learning with a different graph but the same questions.
- Allow students already proficient with data tables and graphs to be teachers in small groups or to model each step of the graph formation.
- Offer more sophisticated or longer lab investigations to practice creating data tables, collecting data, and using graphs to analyze trends between variables.
- Invite students to add visuals, color-coding, and other kinds of personalization to their graphs.

Higher-Level Questions

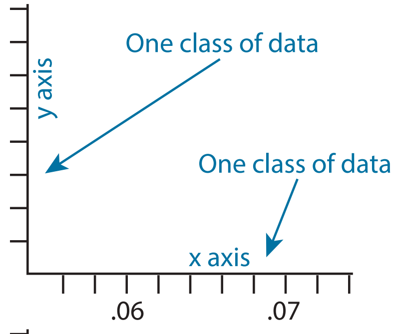
- What are the differences between direct and inverse graphs?
- Create a processing symbol/picture to represent and help someone remember the requirements for creating data tables and/or graphs.
- How might the graph look when you extrapolate the data?

How To Graph Data

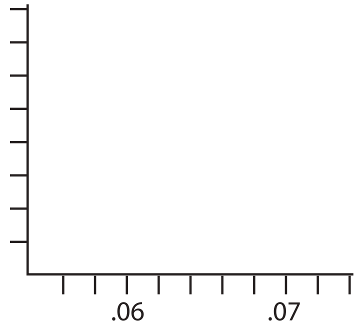
Presenting data in a graphic format is an important skill for science students to master. Use this set of instructions to guide you in creating any line graph. You will also learn about other form of charts and graphs and their uses.

Each lettered step is an instruction for graph creation.

A. **Draw the axes** for the variables. Look carefully at the data. A graph can only show the relationship between two different types of data. If you plan to have a multi-line graph showing multiple trials, be sure to include a key or legend. Use the mnemonic "DRY MIX" to set up the axes for each variable shown.



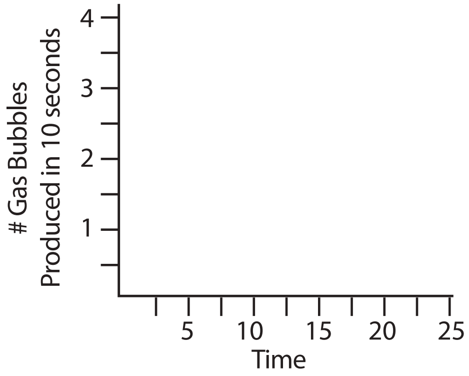
B. **Choose the range** for each variable by taking the largest number in the data set and subtracting it from the lowest number. This is your range for each axis.



C. **Determine the scale** for each axis. Divide the range for an axis by the number of graph squares available on the axis to help determine what scale to use for that data (e.g., by 2s, by 5s, by 100s, etc.).

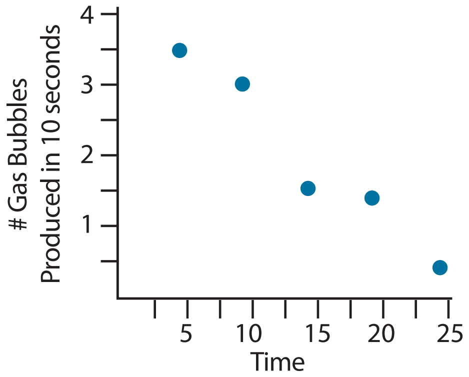
D. **Label each axis** with the quantity and unit being graphed. The x axis always contains the independent variable. The independent variable is data that is manipulated by the experimenter, and will be the variable used to compare the values of the responding variable measured in the experiment.

For example, if you collect data at five-minute intervals on the number of times gas bubbles are produced in ten seconds, the time is independent. The five minutes between measurements will pass whether gas bubbles are produced or not. The y axis contains the dependent variable, which depends on the independent variable (i.e., the time).

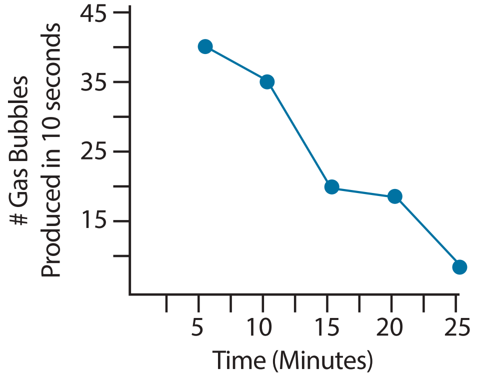


E. **Title your graph.** Remember the title can be a clue as to what is shown by the slope of the line. The titles are usually written as "y versus x." For example a graph of distance on the y axis and time on the x axis can be titled "Graph of Distance vs. Time." In this case, it could also be called "Graph of Speed," since the slope of a distance vs. time graph represents speed.

Number of Gas Bubbles Produced in the Reaction vs. Time

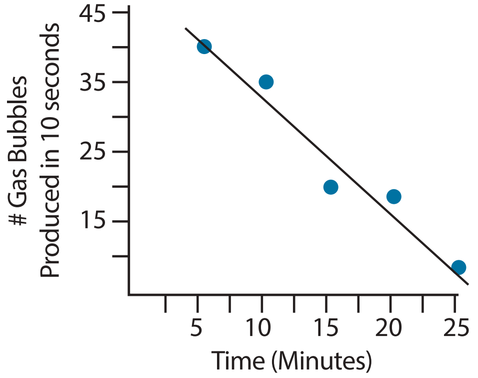


F. **Plot each data point** by finding where the x axis and y axis values intersect on the graph. Remember, in graphing multiple sets of data it is best to use a different color pencil or different symbol for each experimental trial.


Number of Gas Bubbles Produced in the Reaction vs. Time

G. **Draw the "line or curve of best fit"** showing the average of the graph points—draw a smooth line or curve passing through as many points as possible, with approximately equal numbers of data points above and below the line. Many scientific graphs differ from graphs that illustrate mathematical relationships. Usually in math, the dots are connected on the graph after plotting the points because the mathematical relationship between the points is continuous. For a science experiment, there may be a continuous relationship between the points, but it is more likely that the data will be an average of possible relationships.

H. **Identify trends in the data.** The trends in the data are not always readily visible by just reviewing the data in a table format, so think about what each graph you produce illustrates. After completing any graph, write a few sentences of conclusion about the trends and patterns within the graph, the significance, and/or important findings from the graph.


Number of Gas Bubbles Produced in the Reaction vs. Time

Graphing Exercise

- Follow the information on preparing graphs and plot the average daily humidity vs. the average air temperature. (See the table below.) Label the x axis as temperature, the independent variable. Label the y axis as the humidity, the dependent variable.
- Answer the questions in complete sentences.

Date	Average Air Temperature (°C)	Average Humidity (% Saturation)
September 1	33	28
September 3	34	26
September 5	33	29
September 7	32	31
September 9	35	28
September 11	40	20
September 13	42	18
September 15	38	16
September 17	36	18
September 19	37	15
September 21	35	20
September 23	35	23
September 25	33	25
September 27	35	23
September 29	31	30

Questions

1. How many different combinations of the three variables above could you graph from the data in the table?
2. a. What is the range for the average air temperature?
   b. What is the range for the average humidity?
3. a. If you have 15 squares on the graph for your x axis, what is a good0 scale for the temperature?
   b. If you have 20 squares on the graph for your y axis, what is a good scale for the humidity?
4. a. If you were going to graph air temperature vs. humidity, which would be the independent variable?
   b. If you were going to graph air temperature vs. time of month, which would be the independent variable?
   c. If your answers to 4a and 4b were the same, explain why. If those answers were different, explain why.
5. Write titles for the graphs from questions 4a and 4b.
6. Define the term "line of best fit" as it applies to a graph.
7. Why are the dates listed on the temperature-humidity table but not included on the graph?
8. Write a one- to two-sentence conclusion about the trends, significance, or relationship between the two variables used in the graph.

Section 3.7

Lab Reports

Introduction

Scientists communicate their experimental results through journal articles that are peer reviewed for scientific content and reasoning. Lab reports are one way in which students can practice communicating their experimental results to others. This can be a short write-up in the Interactive Notebook for each lab or an intensive assignment that includes several labs. It is important to settle on a format in which all results will be consistently reported. When students repeat the same process for different experiments, the quality of the lab report increases as they learn how to explain their thoughts and present their findings. Writing helps students to develop an understanding about scientific processes and ideas. As students try to explain their findings by evaluating their data (evidence), they create mental links from the information they know (prior knowledge) to what they are learning. Communicating and explaining scientific information are valuable skills for students.

This lesson on lab reports is designed to be used with an inquiry lab as the basis for writing a lab report in the INB. However, the report format information and the peer review components of the lesson can easily be applied to lab investigations for which the procedures are given. If students are asked to write a formal lab report, it can be written and taped wholly or partially into the INB, according to the teacher's preference.

Timeline

- 50–100 minutes: 40–60 minutes for writing and 30 minutes for peer reviewing
- Actual data collection time varies.

Objectives: The Students Will . . .

- Design and conduct an inquiry-based lab activity
- Present and analyze data in a formal written lab report
- Peer review and edit each component of the lab report

WICOR Strategies

Writing:	Write lab procedures and a lab report
Inquiry:	Develop a procedure for an experiment, analyze data and graphs
Collaboration:	Collaborate with a lab group to peer review, and edit procedures and reports
Organization:	Plan an investigation and use Interactive Notebooks
Reading:	Peer review lab procedures and reports

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Design and conduct scientific investigations.
- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Materials

- Materials and supplies as needed for the inquiry lab to be investigated

Handouts

Student Handout 3.3.2:	*Experiment Graphic Organizer (from Magazine Ad: Experimental Design)*
Student Handout 2.6.1:	*Components of Good Procedure Writing*
Student Handout 3.7.1:	*Lab Report Format*
Student Handout 3.7.2:	*Lab Report Peer Review*
Student Handout 3.7.3:	*Lab Report Evaluation Sheet*

Teacher Directions

Experimental Design Development

- Choose a lab activity for this investigation that develops a simple relationship between an independent variable and a dependent variable so that graphing and analysis of the data can be included in the lab report. Examples of inquiry lab investigations include:

Life Science	The effect of cell size (IV) on diffusion rates (DV)
Physical Science	The effect of temperature (IV) on chemical solubility (DV)
Geosciences	The effect of sediment particles size (IV) on the rate of water percolation (DV)

- The size of the lab group is at your discretion. Developing a procedure and writing the lab report as a collaborative team of two to three students promotes sharing of ideas and team support. This is particularly important during the initial inquiry labs.
- Discuss the investigation and refer students to the *Experiment Graphic Organizer (EGO)* handout from the *Magazine Ad: Experimental Design* lesson as a format for organizing the basic components of experimental design (IV, DV, control, hypothesis). Have students complete a graphic organizer for the lab activity on a left page in their INBs.
- Review the information in the graphic organizer before proceeding with the investigation.

Suggested INB Set-Up

Left Page	Right Page
Experiment Graphic Organizer *(Student Handout 3.32 or student-prepared)*	**Title of lab** **Introduction and hypothesis** **Materials** **Procedure**
Data tables **Graphs**	**Lab report analysis**

- Distribute the *Lab Report Forma*t handouts to students and review the introductory information on writing a lab report. Have the lab groups write the title of the lab in the INB (right page).
- Review the remaining information in the *Lab Report Format* page. If students have not previously used Student Handout 2.6.1: *Components of Good Procedure Writing* in the *Magazine Ad* lesson, discuss the components with them at this time.
- Instruct the lab groups to complete the following “pre-lab” sections beneath the title of the lab, writing the centered headings for each section.

  Introduction (This should answer the questions listed in the Introduction section of the lab report format and may include diagrams.)

  Hypothesis (written in an “if…then…because…” format)

  Materials (complete description of all items to be used)

  Procedure (a numbered list of discrete steps)

- As time allows, have the lab groups participate in peer reviews of the procedures.
- Direct the students to create data tables for recording data during the lab. (Refer to the *Making a Data Table* handout.)

Conducting the Investigation

- Remind students to observe all safety rules during the investigation and to record all data in the data table.

Writing the Report

- Review the "Results (Data Tables and Graphs)" section of the *Lab Report Format* handout with students. Instruct lab groups to set up the graphs, plot the data, and write the summary statements below the graphs.
- Allow lab partners to work together to write the first draft of the "Analysis" section in class so that they can ask questions while they are together. This first draft can be written on a separate piece of paper rather than in the INB. Students can complete the draft outside class.

Peer Review

- Have students or lab groups exchange papers and use the *Lab Report Peer Review* handout to look for the specific items that belong in each section of the lab report. They should also review and comment on the writing styles and the clarity of the writing.

Final Lab Report

- Students (or lab groups) should redraft their "Analysis" section based on peer review comments, writing it on a left page across from the data tables. The redraft can be done in class so both partners contribute to the final product.
- The first draft of the analysis can be attached to the INB as a flip page to show revisions in thinking and content.

Evaluation

- The *Lab Report Evaluation Sheet* provides a tool for evaluating the complete lab report.

Differentiation Strategies

- Student groups may peer review each section of the lab report before proceeding to the following section.
- Students can prepare their formal lab reports on tri-fold boards and make oral presentations to their classmates.
- Allow sufficient time to define the evaluation checklist requirements for all students, especially English language learners.

Lab Report Format

Your lab report is an opportunity to express what you learned during the lab experiment. It includes what you were going to do, what you did, what you discovered or verified, and what the results mean to the scientific community. Your reporting should be clear, objective, and to the point. Include all relevant information in the proper section of the lab report.

Each section of the lab report will be written neatly in ink or word-processed. Each section will begin with a centered section header such as, "Introduction and Hypothesis." All data will be reported and analyzed.

Title Page

The title page includes a title that indicates the subject of the report. It is concise (fewer than 15 words) and includes the important aspects of the experiment. The title is centered on the page. The student's name, class title, and date also appear on the title page.

Introduction and Hypothesis

The introduction first gives the research background of the experiment (from scientific sources). It should include an explanation of the general problem or area being investigated and why the problem is important to research. The introduction also includes the hypothesis, written as an "if…then…because…" statement. It is based on the known research, the expected outcome, and how this outcome supports or refutes the hypothesis.

The questions that are answered in the introduction include:

- What is the purpose of this experiment?
- Why is this experiment important? (Who cares about the results and why do/should they care about this topic?)
- What information is known about the science involved in the experiment?
- What new information will be learned from this experiment?
- What are the expected results?
- What is the hypothesis? (Written as an "if…then…because…" statement)

You may be required to read some articles, a textbook, or other materials to learn about this scientific topic. Ask your teacher what references are available for the lab.

Materials and Procedure

This section includes a list of the materials that were used in the experiment. It includes a description of the equipment and the amount of a reagent. The procedure should clearly describe the experiment so that another person could carry out the exact same experiment in all details. Brand names of equipment, concentrations and amounts, species, size, age, gender, and other information should be included. The procedure is a numbered list of discrete steps. Include a labeled sketch of the set-up after the procedure.

Results (Data Tables and Graphs)

Present your findings in labeled data tables and in a logical order. *Do not interpret your results in this section.* Give the results that you have found, not what you think you have found.

Graph your data in this section considering what type of graph should be used. You may have one or more graphs depending on the data that was collected. All graphs must be properly labeled and have a summary statement of the results below the graph. This summary is a written description of what the graph means.

Analysis

The analysis reviews the purpose for doing the experiment and the hypothesis. It also includes an interpretation of the results. Answers to the questions posed in the introduction are provided in this section. Questions that are answered in this section include:

- What was the purpose of the experiment?
- What were the results and how were they significant?
- Were there any trends in the graphs? What do these trends mean?
- What other predictions could you make from this data?
- Does the data support or reject your hypothesis?
- Is there an explanation for your data other than the *independent variable* affects the *dependent variable*?
- What is another experiment or study that could be an extension of this one?

WORKS CITED

This is the reference area for all sources used in your lab report. The citation must include the author's name, publication data, title of article and/or book, as well as other information used to locate this reference source. Use the appropriate citation format as instructed by your teacher.

Lab Report Peer Review

Purpose

This peer review is an opportunity to get help with your lab report and make sure everything is included in the report. You and a classmate will exchange lab reports. Read your partner's report and mark off the critical elements that he or she has done correctly in the lab report.

Instructions: Put a check in the box for items that the author of the lab report has completed well. Please add appropriate comments to the lab report to help the author to edit his or her work.

Format

- ☐ Work is neatly put together
- ☐ Sections appear in the correct order
- ☐ All sections have been attempted
- ☐ Report is word-processed or written neatly in ink
- ☐ Data tables are correctly labeled
- ☐ Graphs are correctly titled and labeled

Title Page

- ☐ Is first page of report
- ☐ Title appears centered vertically
- ☐ Describes experiment
- ☐ Title includes all important key words about experiment (fewer than 15 words)
- ☐ Student's name written below title
- ☐ Class title included on the line after student name
- ☐ Teacher's name written under class title
- ☐ Date appears under teacher's name

Experimental Design

- ☐ Title is appropriate
- ☐ Hypothesis is testable by this experiment
- ☐ Independent variable is correct
- ☐ Groups of independent variables are described
- ☐ Number of trials is accurate
- ☐ Dependent variable is correct
- ☐ Three or more constants are listed
- ☐ Listed constants are variables that need to be controlled

Introduction and Hypothesis

- ☐ "Introduction and Hypothesis" appears centered at top of page
- ☐ Discusses purpose of the experiment
- ☐ States why this experiment is significant
- ☐ Describes how this experiment will illustrate a scientific concept
- ☐ Defines the major terms related to this scientific topic
- ☐ Discusses the major information that relates to the scientific topic
- ☐ All material is directly relevant to the scientific content
- ☐ Hypothesis makes a statement about relationship expected in results
- ☐ Is well written in narrative style
- ☐ Includes citations (if applicable)
- ☐ Citations appear in the correct format (if applicable)
- ☐ Works Cited page included (if applicable)
- ☐ Well researched using quality sources

Materials and Procedure Section

☐ "Materials" section heading written
☐ Lists all materials
☐ Includes the quantities of equipment
☐ "Procedure" section heading written
☐ Uses expository style
☐ Is a numbered set of step-by-step instructions
☐ Is repeatable
☐ Is complete
☐ Explains how to control constants
☐ States how to collect measurements
☐ States when to collect measurements
☐ Describes how to set up equipment
☐ Contains neat, labeled sketch
☐ Procedure refers to sketch
☐ Procedure refers to all materials listed

Results Section

Data Table(s)

☐ Includes accurate, descriptive title
☐ Has row headings
☐ Has metric units in row headings
☐ Has column headings

Graph(s)

☐ Uses graph paper
☐ Is as large as possible
☐ Has accurate, descriptive title
☐ IV is plotted on x axis
☐ DV is plotted on y axis
☐ Has x axis and y axis labeled
☐ Has units on both axes
☐ Graph type is appropriate

☐ Has metric units in column heading
☐ Legible data
☐ Has summary sentence that explains what the results are
☐ Summary statement appears under table
☐ Uses data from data table
☐ Trend line (or line of best fit) drawn
☐ Uses color appropriately
☐ Has a key for graph
☐ Has summary statement that summarizes what the graphed data means
☐ Summary statement appears below x axis
☐ Graph is appropriate.
☐ Calculations or statistics are neat (if applicable)

Analysis Section

☐ "Analysis" section heading written
☐ Explains purpose of lab
☐ States whether hypothesis is rejected/accepted
☐ States interpretation of the data
☐ Refers to actual data
☐ Explains the results based on knowledge of topic
☐ States sources of error and variables out of your control
☐ Proposes new experiment based on the one investigated
☐ Proposes new hypothesis for a new experiment
☐ Provides answers to other analysis questions (if required)
☐ Is written in paragraph form
☐ Is well organized
☐ Is well written

Return the lab report to the authors with this peer review attached.

Review the peer review of your report. Read the comments. Ask the reviewers what they meant if you do not understand them. Redraft your report based on the comments and the items above that were not complete.

Lab Report Evaluation Sheet

Title Page

Required

☐ Title is appropriate
☐ Name, name of class, and date

Experimental Design

/20 points

☐ Title is appropriate
☐ Hypothesis is testable by this experiment
☐ Independent variable is correctly identified
☐ Groups of independent variables are described
☐ Number of trials is stated
☐ Dependent variable is correctly identified
☐ Lists several constants/controlled variables

Introduction & Hypothesis

/20 points

☐ Correctly states purpose of experiment
☐ Explains significance of experiment
☐ Provides information about scientific concept
☐ Discussion includes previous investigations that lead to this experiment
☐ Hypothesis about expected results is stated

Materials & Procedure

/10 points

☐ All materials are listed
☐ Quantities of materials are included
☐ Procedure is repeatable
☐ Procedure is numbered
☐ Procedure is exact
☐ Includes diagram of experimental set-up

Results

/20 points

☐ Data tables are titled, neatly constructed, and include units
☐ Graphs include labels, titles, keys, and summary statements
☐ Graph is appropriate type

Analysis

/20 points

☐ Explains purpose of experiment
☐ Restates hypothesis
☐ States the findings of the experiment using specific data
☐ Rejects/supports hypothesis
☐ Discusses errors in lab techniques and procedures
☐ Proposes new experiment

Format

/10 points

☐ Section headings given
☐ Each section free of mechanical errors
☐ Writing is clear and insightful

Total Points Earned__________/100 points

Section 3.8

Drops on a Penny: Simple Statistics for the Science Classroom

Introduction

Science is, above all, a process that requires experimentation. Students learn to refine and repeat investigations by being given the opportunity to do just that in a search for more accurate data. In order to develop better experimental designs, simple statistical analysis can be used at any grade level to provide students with evidence that a particular independent variable caused a change in the measured results. *Drops on a Penny* is a common physical science and chemistry activity that demonstrates the difference in intermolecular forces between molecules of different liquids. In this statistics activity, students will design an experiment procedure, collect data, and use the data to determine simple statistics for the data, including mean, median, stem and leaf plots, and box and whiskers graphs. To meet the needs of students in various grade levels or science content areas, segments of the *Drops on a Penny* investigations can be used independently or in conjunction with each other.

Timeline

60–90 minutes. The time will vary depending on whether reading and instruction is provided on the intermolecular forces and properties of water or if the activity is done simply as designing an experiment and presenting the statistics.

Objectives: The Students Will . . .

- Improve upon a scientific investigation to control variables that affect the outcome
- Calculate the mean and median of data
- Generate and analyze box and whisker plots

WICOR Strategies

Writing:	Create vocabulary cards, write cartoon to process learning
Inquiry:	Design an experimental procedure, determine statistics on data
Collaboration:	Collaborate with partner in lab investigation
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Mark the text in a scientific article

National Science Education Standards

Content Standard (Grades K–12): Unifying Concepts and Processes

- Evidence, models, and explanation

Content Standard A (Grades 5–8): Science as Inquiry

- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Content Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations.
- Design and conduct scientific investigations.
- Use technology and mathematics to improve investigations and communications.
- Communicate and defend a scientific argument.
- Understandings about scientific inquiry

Materials

- Red and blue colored pencils or pens
- Various types and sizes of droppers
- Wax paper
- Beaker or cup
- Small quantities of water
- Index cards, cut in half (or pieces of paper)
- Highlighters
- Pennies
- Ring stands and clamps
- Graph paper (optional)

Handouts

Student Handout 3.8.1:	*Drops on a Penny Investigation: Building Background Knowledge*
Student Handout 3.8.2:	*Drops on a Penny Investigation: Part 1: Design the Investigation*
Student Handout 3.8.3:	*Part 2: Collect the Data*
Student Handout 3.8.4:	*Part 3: Analyzing the Results: Finding the Medians*
Student Handout 3.8.5:	*Part 3: Analyzing the Results: Making the Box and Whiskers Plot*
Teacher Reference 3.8.6:	*Example Data Analysis*

Teacher Directions

Lab Preparation

- Prepare student stations with paper towels, a variety of droppers, a few pennies, and a beaker or cup labeled, “Water,” containing about 25 mL of tap water.
- Choose the key vocabulary words for this exercise that are appropriate to your lesson objectives or district standards (suggestions: intermolecular force, hydrogen bonding, cohesion, adhesion, specific heat, meniscus, and surface tension).
- Students will work together in teams of two during data collection.

Part 1: Building Background Knowledge

- ***Teacher Note:*** How to use the INBs with lab investigations is a matter of "what works for you." Some teachers are strict about use of left pages as "input" and right pages as "output." Other teachers prefer labs to be set up in the order they will be presented. The INB set-up diagrams in this lab are suggested formats, but it is an individual choice in how to use the INBs.
- Distribute copies of Student Handout 3.9.1: *Building Background Knowledge* to students or provide copies of a different reading that you have chosen and that contains the appropriate level of information on properties of water for the class you teach. Have students mark the text as indicated in the student directions. (Refer to the marking the text lesson in Unit 5.)

  Circle the key vocabulary about the properties of water in **blue**.

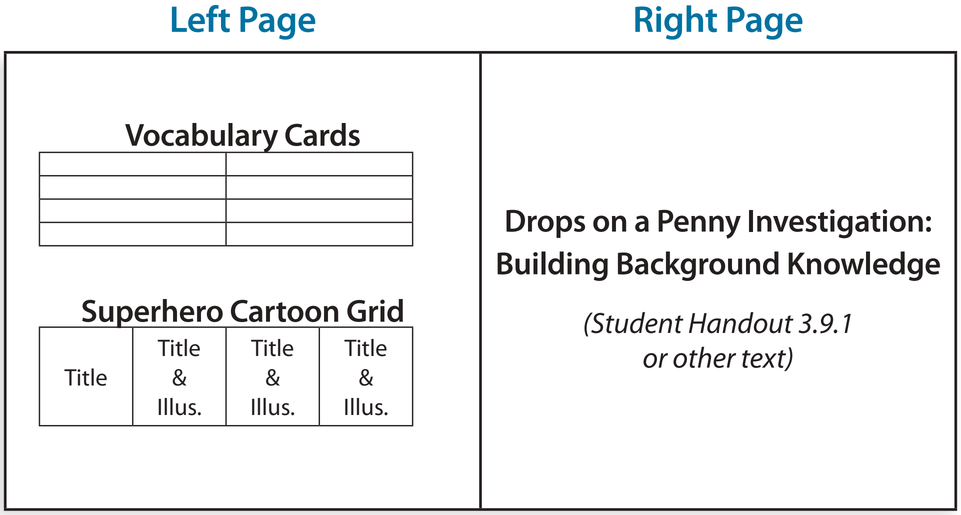
  Underline the vocabulary that they do not understand in **red**.

  Highlight the properties of water that are discussed in the reading.

- Discuss as a class the main concepts of the reading and any key vocabulary words from the reading that the students did not understand.
- Have students create vocabulary cards for the key terms in this lesson. The key term should be written on the front. The reverse side holds the definition and a diagram or sketch of the property the term describes. Students will then tape the cards onto the top half of a left page in their INBs so that they will be able to flip up the cards to see the definitions and diagrams. Make sure that they write appropriate definitions on the backs of the cards.
- Have students process the science words with left-side activities such as a cartoon that shows water as a superhero demonstrating its many properties. They should draw a four- to six-block grid beneath the vocabulary cards in the INB. The first block should be the title block. The other blocks should have illustrations that describe the properties and text that explains the properties.

  To help students begin their thinking process about the cartoon, ask them to think about the idea of the Superman descriptor: He is "faster than a speeding bullet, more powerful than a locomotive, and able to leap tall buildings in a single bound." What can water do?

Suggested INB Set-Up



Part 2: Designing the Experiment and Collecting the Data.

- Use Student Handout 3.8.2: *Drops on a Penny Investigation: Part 1: Design the Investigation* and Student Handout 3.8.3: *Part 2: Collect the Data* to guide your instruction on designing the experiment and collecting the data, using the materials indicated in the materials list.
- Instruct students to design their own procedures for determining the number of drops of water that will fit on a penny. Check each procedure and allow students to move forward at their own pace. Alternatively, you can control the pace by having class discussions about procedures and agreeing on the procedures in order to gather more data. As a possibility, student groups could individually do fewer trials and the data could be combined for the whole class.
- Discuss the controls to the procedures that students could institute as "improvements." The controls might include—*but are not limited to*—the following examples:

  Controlling the height of the dropper

  Using the same dropper or one with a more narrow opening

  Using the same angle of the dropper (set an angle number to measure)

  Using the same side of the penny

  Cleaning the penny
- Ensure students have stated clear "improvements" before they continue with the investigation.

Suggested INB Set-Up:

Left Page	Right Page
Collect the Data *(Student Handout 3.8.3 or student-prepared)*	**Design the Investigation** *(Student Handout 3.8.2 or student-prepared)*

Part 3: Analyzing the Data

- The teacher reference *Example Data Analysis* shows a data analysis sample for an investigation in pulse rate differences during movies. You can use this as background information for the statistical analysis of this lesson.
- You may want to model the data analysis process with the class using the data they collected. Student handouts on *Analyzing the Results: Finding the Median* and *Analyzing the Results: Making the Box* and Whiskers Plot will be used for analysis of the data.
- Provide graph paper for the box and whiskers analysis if that makes it easier for students to keep the data in vertical lines for comparison.

Suggested INB Set-Up

Left Page	Right Page
Analyzing the Results: Making the Box and Whiskers Plot *(Student Handout 3.8.5 or student-prepared)* **Paragraph summary**	**Analyzing the Results: Finding the Medians** *(Student Handout 3.8.4 or student-prepared)*

- Review with students how to do pair-sharing (see the Active Learning Strategies in the appendix) to ensure that everyone understands the process before allowing students to complete their investigations.
- Have students peer review the summaries of the box and whiskers by having the students switch papers and read the summaries. Also have them write the numbers of the prompt questions where they see them addressed in the writing. Have students return papers to the owners for revision as necessary. All prompts should be represented before you read the papers.

Answers to Statistical Analysis Questions

- Question 2: What does the size of the "box" indicate about the procedural controls?

  If the box is big that denotes a wide spread of data; whereas small boxes show smaller spread of data indicating better-controlled experiments.

- Question 3: What does the size of the "whisker" indicate?

  Longer lines show that the experimental procedure is less controlled.

Differentiation Strategies

- For an activity on the properties of water, use the reading on properties of water and the processing activities (vocabulary cards and superhero cartoon).
- Use the reading and the lab experiment, including improvements to the procedure, for an inquiry-based lab investigation on the properties of water.
- You can teach only the statistical analysis portion of the lesson by removing the reading and processing activities on the properties of water. When focusing only on the statistical analysis, be sure that students already have background knowledge about why the drops on a penny form or they will not understand that this is a scientific phenomenon. If you choose to focus on just the analysis, provide a procedure for students to follow to count drops on a penny. By doing this you will save time; however students will not refine the procedure, which will result in a small box on the box and whiskers. When students improve their own procedure, they start to understand the idea of experiment**al** error rather than experiment**er** error.

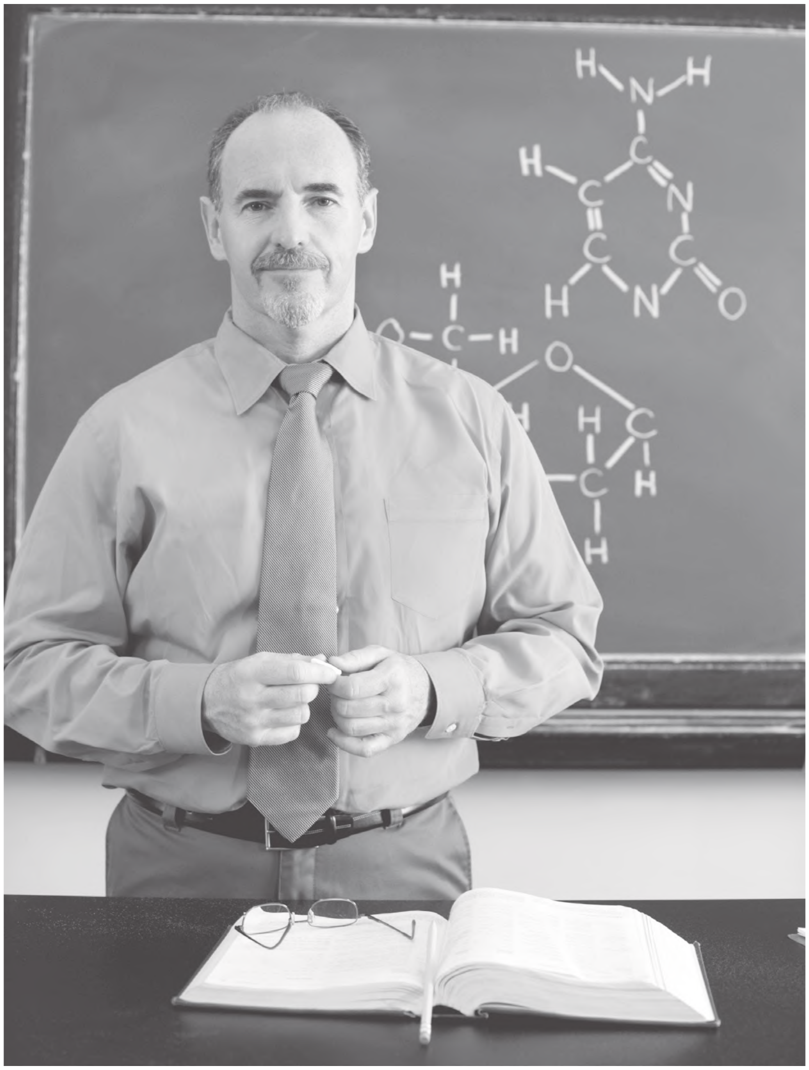
Higher-Level Questions

- Explain why can you put more drops of water on a penny than you can isopropyl (rubbing) alcohol?
- Would CCl4, carbon tetrachloride, behave more like water or more like rubbing alcohol if we used it in this experiment? Justify your answer.
- Design an experiment that tests the relationship between the boiling points of water and rubbing alcohol. Write a hypothesis that would frame your investigation.

ADDITIONAL RESOURCES

Gonick, L. & Smith, W. (1993). *The cartoon guide to statistics.* New York, NY: HarperCollins Publishers, Inc.

Kentchemistry. (2010). Hydrogen bonding – water drops on a penny [Video file]. Retrieved from http://youtu.be/tv4Jrc06yLA



Drops on a Penny Investigation
Building Background Knowledge

Instructions: Read the following passage about the properties of water. Mark the text as follows:

Circle the key vocabulary about the properties of water in **blue**.

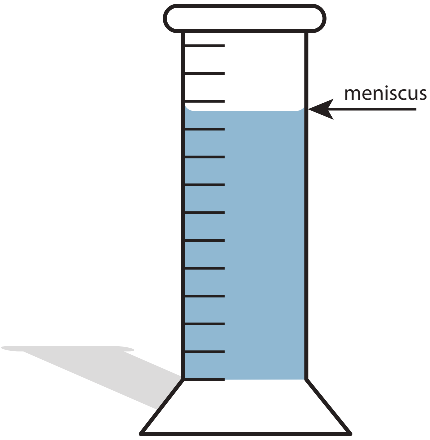
Underline the vocabulary that they do not understand in **red**.

Highlight the properties of water that are discussed in the reading.

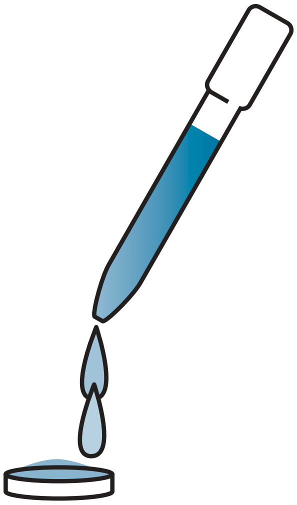
Water has several special properties due to its attraction to other water molecules. These attractions between molecules are called *intermolecular forces.* Because part of the water molecule is positively charged and part of the water molecule is negatively charged, the molecules will tend to stick together: positive end to negative end. Water molecules can also stick to other molecules that have partially positive and partially negative sides. These molecules are called *polar molecules*. When any molecule is attracted to another like molecule, the property is called *cohesion*.

Glass and plastic have polar surfaces to which water is attracted. When water molecules stick to other non-water molecules, it is called *adhesion*. Adhesion is responsible for the meniscus that water forms in a graduated cylinder. Cohesion and adhesion lead to different properties of water that make it a special molecule with unique features.

Cohesion is responsible for the *surface tension* of water because water molecules are attracted to each other and held together by hydrogen bonds, which are strong intermolecular forces. Surface tension is the property of water that binds the water molecules together to form a "skin." The cohesion between water molecules cause the molecules to stick together and contract on the surface, which allows water strider insects to move on top of it rather than fall into the water. This cohesion and surface tension also cause the pain of a belly flop because the hydrogen bonds provide resistance to the body's mass all at the same time.



Another unique property of water is its *high specific heat*, which means that it takes a large amount of energy to change the temperature of water one degree Celsius. In order to increase the temperature of the water, you have to break the hydrogen bonds between molecules to allow each water molecule to have a greater kinetic energy. Because water has strong hydrogen bonds, more energy is required to increase the kinetic energy than is required for a molecule that does not have (or has fewer) hydrogen bonds, such as alcohol.



Drops on a Penny Investigation

Part 1: Design the Investigation

In this section you will work with another student as a team.

Both partners need a record of the results.

With your lab partner, examine the equipment that you have been given. Discuss how many drops you think can be dropped onto a penny lying flat on the table. Make your prediction in the box.

Prediction	

Explain why you chose the number of drops that you wrote in your prediction.

Use your prediction and explanation to form your hypothesis.

Now design a procedure to test how many drops of water can fit on the flat side of a penny. Obtain approval of the procedure from your teacher.

Drops on a Penny Investigation

Part 2: Collect the Data

After you gain approval of the procedure from your teacher, execute the lab according to your design. Record your data in the data table below for the original procedure. Dry the penny after trial 1 and repeat the procedure ten more times exactly as you did it in the first trial. Record the number of drops.

Table 1:
The Number of Drops on a Penny for Each Refinement of Procedure

Number of Drops of Water on the Penny	Original Procedure	Improvement 1 Color Used:	Improvements 1 & 2 Color Used:
Trial 1			
Trial 2			
Trial 3			
Trial 4			
Trial 5			
Trial 6			
Trial 7			
Trial 8			
Trial 9			
Trial 10			

At this point you should be wondering how you could improve the number of drops that will fit on the penny. All experiments have experimental errors that affect the accuracy of the data. Many of these result from procedural steps. Identify two different steps in your procedure that you could control more carefully during your experiment. Be specific on what will be changed. If you choose to change the angle of the dropper, specify the specific angle that you will use and how you will measure it. If you choose height of the dropper as the step to change, specify the new height to be used.

Improvement 1)

Improvement 2)

Now use a pen or pencil of a different color to refine your original procedure with just improvement 1. Repeat the procedure above with just improvement 1. Record the number of drops on the penny.

Now use a pen or pencil of a third color to refine your original procedure with improvement 2. Repeat the procedure above with both improvements 1 and 2. Record the number of drops on the penny.

Drops on a Penny Investigation

Part 3: Analyzing the Results: Finding the Medians

List the data for the number of drops for each trial in order from least to greatest number. Determine the lower median, median, upper median, and range of the values.

Table 2:

Number of Drops From Least to Greatest

	Original Procedure	Improvement 1	Improvements 1 & 2
Lowest number of drops			
Lower median (the middle of the lower half of the data): 25% of the data is lower than this number.			
Median (the middle value of the data): In this case there is an even number of data points. Find the mean of two data points at the center.			
Upper median (the middle of the upper half of the data): 25% of the data is greater than this number.			
Greatest number of drops			

Range (subtract the lowest value from the greatest value):

STUDENT HANDOUT 3.8.5

Drops on a Penny Investigation

Part 3: Analyzing the Results: Making the Box and Whiskers Plot

Setting the Scale: Using your lowest and highest numbers of drops on the pennies, select a scale for the number lines below so that they are all identical and can house all data. Label the plots accordingly. If 100 drops is the maximum, an appropriate scale could begin at zero on the left and proceed by 5 for each line until you reach 100.

Table 3:
The Statistics for Number of Drops on a Penny

Original Procedure

Improvement 1

Improvement 1 & 2

Adding the Data:

- Put a dot above the "Original Procedure" number line for the median for that grouping. Draw a vertical line at that point. Label this, "M." (See the Example Data Analysis for a similar experiment on pulse rate while watching movies.)
- Add a dot for the lower and upper medians. Label them "LM" and "UM." Draw a vertical line for each and then make a box between these two values. This box includes 50% of the data that you collected.
- Add a dot for the lowest and greatest values. Extend a line from the LM dot to the lowest value. Extend a line from the UM dot to the greatest value. Each line represents 25% of your data.
- Repeat this process for Improvements 1 and 2.

Answer the following questions in complete sentences to form a paragraph that describes your data:

1. What data do the results show? What was the hypothesis for this lab?
2. What does the size of the "box" indicate about the procedural controls? What does the size of the "whisker" indicate?
3. Do any boxes overlap? What does this indicate? What does the lack of overlap indicate about the improvements to the procedures?
4. Based on this analysis of data, do you accept or reject your hypothesis? Explain why.

Example Data Analysis

Table 1: Ordered Data for Pulse Rate

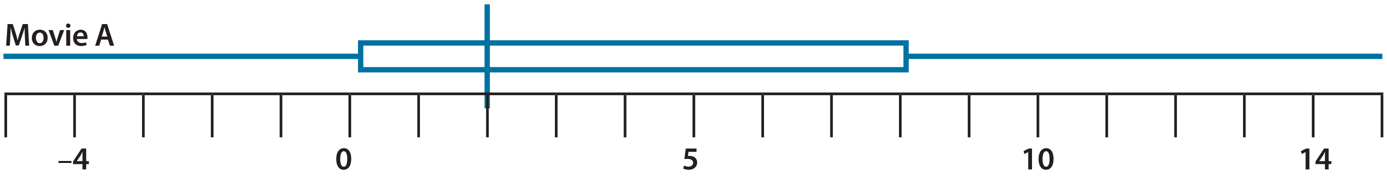
Difference During Movies Lab

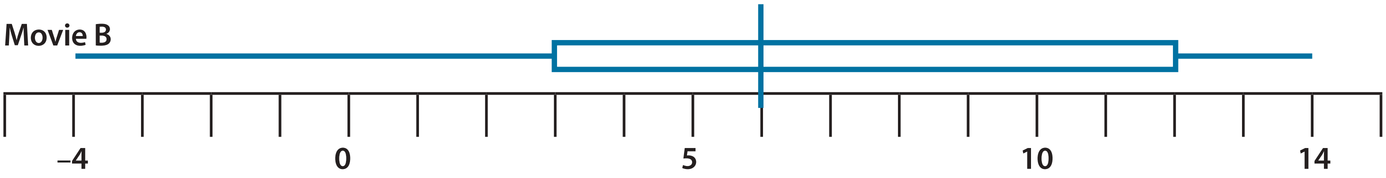
Movie A Action Thriller	Movie B Horror Film	Movie C Comedy
–5	–4	–4
–2	+3	–3
0	+3	0
0	+4	0
+2	+6	0
+3	+11	+2
+8	+12	+7
+10	+14	+9
+15	+14	+10

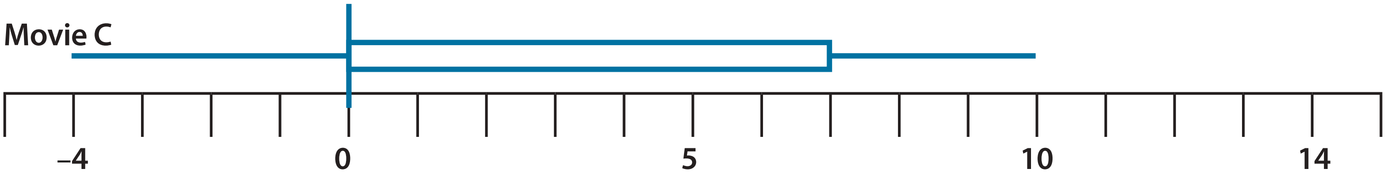
Table 2: The Statistics for Pulse Rate

During Movies Lab

	Movie A	Movie B	Movie C
Lower Median	0	+3	0
Median	+2	+6	0
Upper Median	+8	+12	+7
Range	20	18	14
Mean			







Summary for Box Plots: The data above represents pulse rates of human subjects in response to three different movie types. The hypothesis was that Movie B, the horror film, would cause an increase of pulse rates when compared to an action thriller and comedy. The boxes were all of similar sizes, suggesting that the variables were equally controlled. However, the whiskers have different lengths, indicating that Movie B, the horror film, had a wider range of pulse rate difference values. Movie B's data was the most inaccurate due to the –4 outlier. Apparently, subjects watching Movie B reacted either with boredom or excitement more than the other two movies. Movie C, the comedy, had the smallest whiskers extending to –5 and +10. Movie B, an action thriller, had outliers from –5 to +15, not significantly different from Movie A. Due to the fact that the boxes overlap so much, there does not to appear to be a significant difference between the experimental groups. The hypothesis is not supported by the experimental data.

Section 3.9

Accuracy and Precision

Introduction

In scientific inquiry measurements must be reported with certainty. Accuracy and precision are two terms used to describe the certainty. Accuracy refers to how close a measurement is to its accepted (true) value and is expressed in terms of absolute or relative error. Precision refers to how close repeated measurements are to each other and is expressed in terms of deviation from the mean. At the beginning of the year as scientific method is being taught and students begin to conduct experiments, they should learn how to evaluate the certainty of their laboratory data.

This lesson is used to help students understand the importance of measurements in scientific experimentation and the reliability of measuring instruments and processes, and the means to express data in absolute and relative terms. Incorporated in the lesson on are several ways to process the basic information on accuracy and precision: data collection and analysis, preparation of a Venn diagram, a collaborative processing strategy, and writing of a haiku. The introduction of significant figures is not part of the lesson, but it can be added as deemed appropriate for the students' grade level.

Timeline

60 minutes

Objectives: The Students Will . . .

- Learn the meanings of accuracy and precision and the equations that express these quantities
- Compare and contrast accuracy and precision
- Evaluate data in terms of accuracy and precision

WICOR Strategies

Writing:	Write a summary, Venn diagram and haiku poem
Inquiry:	Investigate and calculate error and deviation in measurements
Collaboration:	Brainstorm with group members
Organization:	Plan and organize using Interactive Notebooks
Reading:	Read and mark a text

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Use appropriate tools and techniques to gather, analyze and interpret data
- Communicate scientific procedures and explanations
- Use mathematics in all aspects of scientific inquiry

Content Standard A (Grades 9–12): Science as Inquiry

- Identify questions and concepts that guide scientific investigations
- Understandings about scientific inquiry

Materials

- Metric rulers or meter sticks

Handouts

Student Handout 3.9.1:	*Accuracy and Precision*
Teacher Reference 3.9.2:	*Accuracy and Precision Student Sample*

Teacher Directions

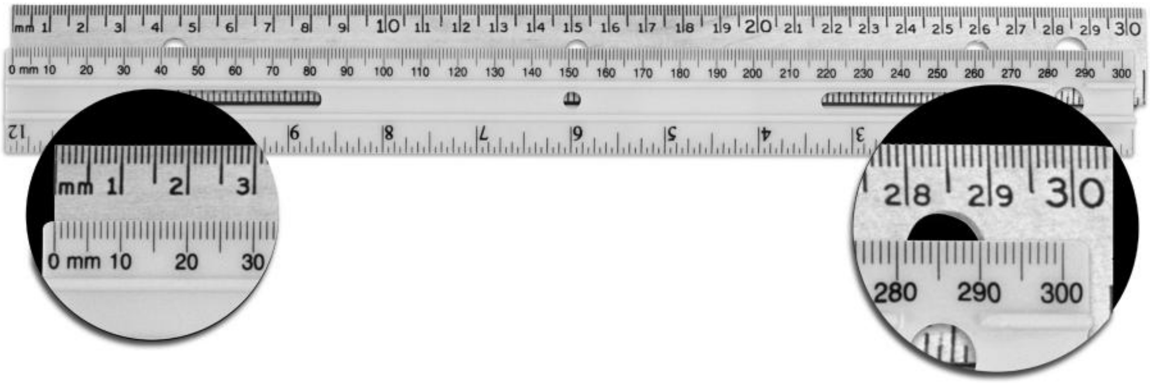
Introductory Discussion

- Solicit student responses on the meaning of the term "accuracy," and discuss the actual definition.
- Demonstrate how the accuracy of a measurement is dependent on the calibration of the instrument being used for the measurement.

  Show students two meter sticks or metric rulers that were made by different companies.

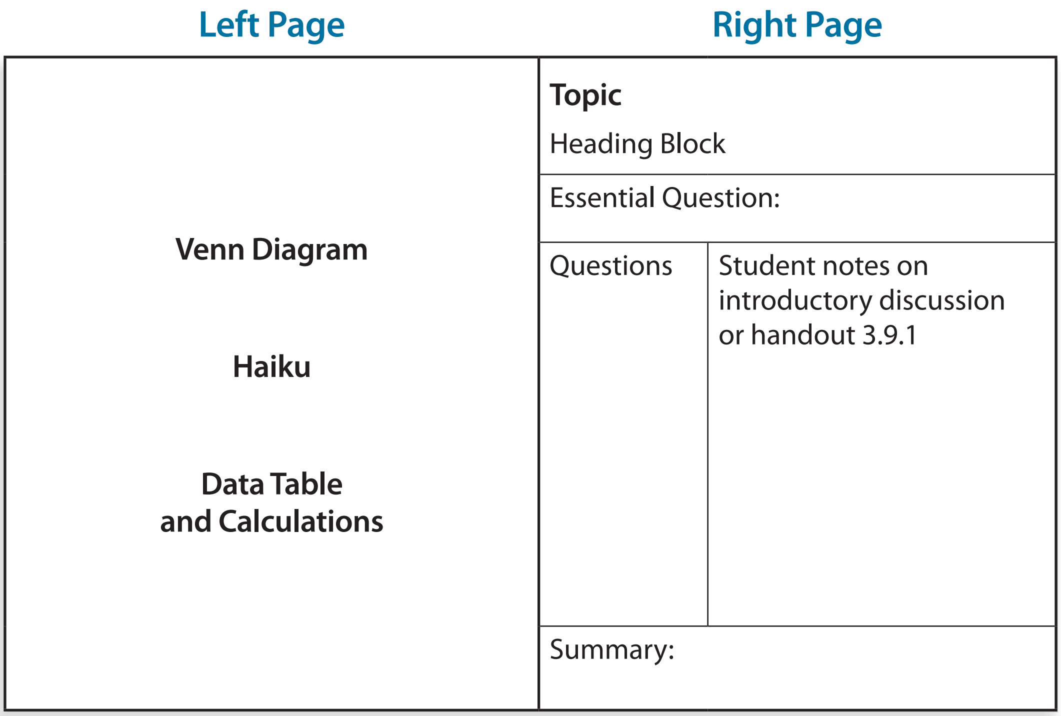
  Line up the rulers side by side at the 1.00 centimeter marks or at the end of the ruler. Have students view the calibration of each measuring device at the opposite end.

  In the diagrams below, the meter sticks were different by one millimeter at the 30 centimeter mark. This difference was due to the different calibration standard used by each company.



- This demonstration can be used to help students see that if they use an incorrectly calibrated measuring device, they cannot make an accurate measurement. Accuracy is dependent upon the instrument calibration. It also is dependent on the skill of the individual taking the measurement.
- If there are enough different types of rulers, students can also repeat lining up their rulers/meter sticks with a partner to view the differences between their markings.
- Discuss with students the information on the *Accuracy and Precision* handout. Students can either take Cornell notes on a right page in the INB and mark the key terms and important information, or mark the text of the handout during the discussion and glue it into the INB.
- Carefully review with students the processes of determining the absolute and relative errors and deviations, as shown on the handout.

Suggested INB Set-Up



Data Collection and Analysis

- Now that students have an understanding of the concepts of accuracy and precision, have them perform a simple activity of measuring the height of a page in their INBs.
- Ask students to take at least five measurements of the height of the page and record the values in a table on a left page in the INB.
- Direct students to evaluate the measurements by comparing their measurements to the accepted value and the mean or average value. The comparison should be done by making calculations of the absolute and relative error and deviation. The values can then be tabulated in the table. The determinations must show the formulas used for each calculation.

- If the notebook is 8.5 in. by 11.0 in., the accepted value for the height of the page is 27.94 centimeters.

Sample data table and calculations:

Accepted value 27.94 cm

Length (cm)	Absolute Error (cm)	Relative Error (%)	Absolute Deviation (cm)
28.11	0.17	0.62%	0.00
28.15	0.24	0.86%	0.04
28.12	0.18	0.65%	0.01
28.04	0.15	0.54%	0.02
28.08	0.14	0.50%	0.03
28.11 **Mean**			**0.02** **Mean**

Absolute Error $= E_a = |\text{Observed} - \text{Accepted}| = |O - A| = |28.11 - 27.94| = 0.17$

Relative Error $= E_r = \dfrac{\text{Absolute error}}{\text{Accepted Value}} \times 100\% = \dfrac{0.17}{27.94} \times 100\% = 0.61\%$

Absolute Deviation $= \text{Da} = |\text{Observed} - \text{Mean Value}| = O - M = 28.11 - 28.11 = 0$

Relative Deviation $= \text{Dr} = \dfrac{\text{Ave. absolute deviation}}{\text{Mean value}} = D_a/M \times 100\% = \dfrac{0.02}{28.11} \times 100\% = 0.07\%$

Processing the Activity

- Using the "Numbered Heads" strategy in the *Active Learning Strategies* in Unit 4, have students discuss and be prepared to respond to the following questions or other questions related to the topic.

  Can you make a measurement that is very precise but not accurate?

  Can a measurement be accurate but not precise?

  When you measured the length of the paper, the measurements were not the same. Explain why this was the case.

  Object 1 was measured as 15.2 cm long, but it had an accepted value of 15.4 cm. Object 2 was measured as 3.7 cm long, but it had an accepted value of 3.5 cml. Which determination of error (absolute or relative) is more informative in comparing the degrees of error in the two measurements?

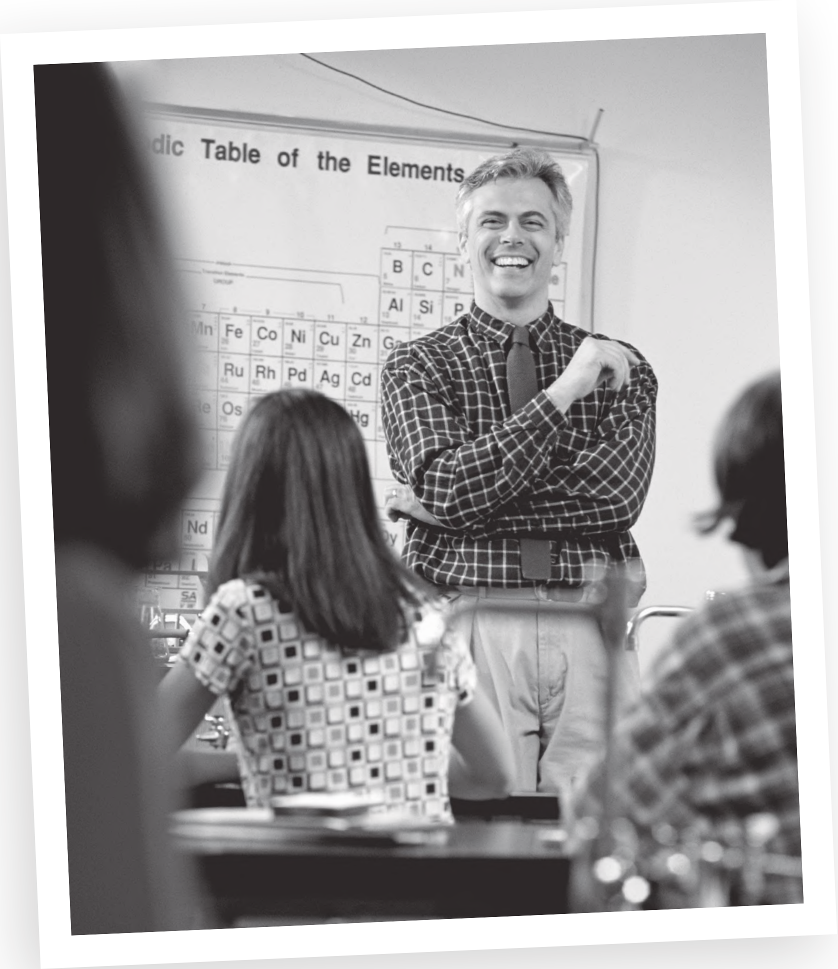
- Have the students illustrate their knowledge of uncertainties in measurements by comparing accuracy to precision using a Venn diagram or Bull's Eye comparison (see *Processing Activities* in the appendix) and writing a Haiku poem about the concepts. This is done on the left page of the INB (refer to *Accuracy and Precision* Student Handout).
- Have students write a summary of the lesson on the bottom of the right side note page in the INB.

Differentiation

- This lesson utilize a variety of instructional delivery methods including discussion, collaborative processing, hands-on activity, and writing a haiku and Venn diagram. You can substitute other methods or processing activities, as desired.
- The determination of absolute and relative errors can be deleted for students in lower grade levels.
- Small-group instruction may be used as the students measure the height of the INB and make the calculations for absolute and relative errors and deviations.

Higher Level Questions

- What might happen if scientists did not use accuracy and precision in their experiments?
- Predict how this is used in a real life situation such as in home construction.



Accuracy and Precision

Measurements are an important part in scientific investigations. It is important to show the certainty in the measurements. Data collected by scientists is evaluated in terms of its accuracy and precision. Accuracy refers to how close a measurement is to its accepted (true) value and is expressed in terms of absolute or relative error. Precision refers to how close repeated measurements are to each other (reliable reproducibility) and is expressed in terms of deviation from the mean value. Measurements may be precise without being accurate, yet if all measurements are accurate, they are also precise.

If the errors and deviation are large then the results may not be considered viable. The data from experiments should be scrutinized by the experimenter. If the data has great errors or deviation, then better methods of measurements should be pursued. This can refer to the instrument used for measurement and to the skill of the person making the measurement. As the scientist, you will use the forms of evaluation described below to judge the validity of experimental data. Data is evaluated in terms of accuracy and precision in analyzing data.

Accuracy can be evaluated in absolute or relative terms. The absolute error is the absolute value of the difference between the accepted value and the measurement. This can be written in equation form as shown below.

$$\text{Absolute error} = |\text{Observed} - \text{Accepted value}| \qquad E_a = |O - A|$$

This can be expressed as a percentage error also. The percentage error is the relative error. It is expressed in the following equation.

$$\text{Relative error} = \frac{\text{Absolute error}}{\text{Accepted value}} \times 100\% \qquad E_r = \frac{E_a}{A} \times 100$$

Accuracy is determined by how well a measuring instrument is calibrated. If an instrument is not made correctly then any measurement taken with that instrument will not be correct.

Data can also be evaluated in terms of the deviation from each other of measurements that are made in the same manner. This is known as precision and is evaluated in terms of absolute and relative deviation. Absolute deviation is the absolute value of the difference between the mean or average value and the measured value. This is expressed below in the equation.

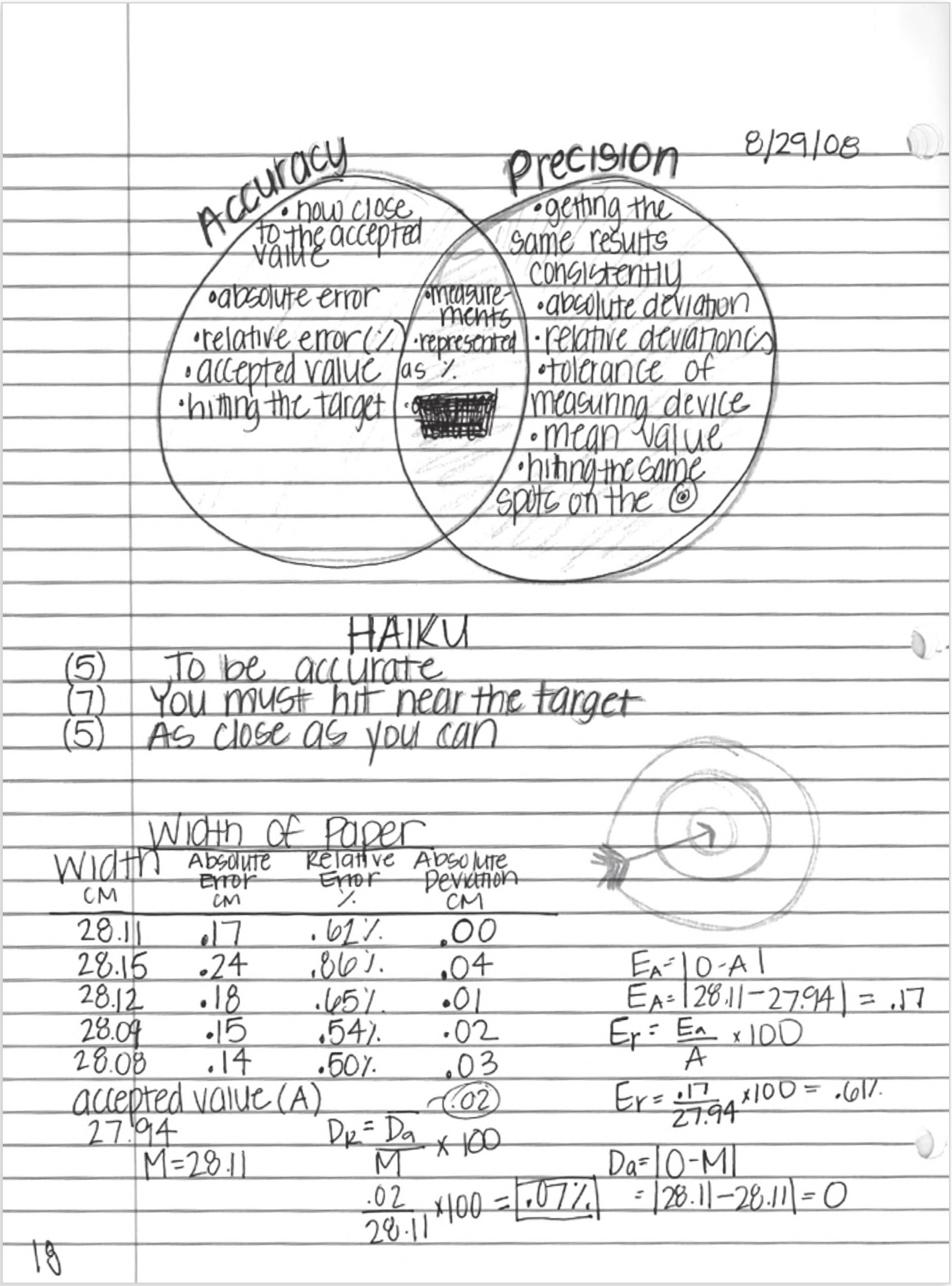
$$\text{Absolute deviation} = |\text{Observed} - \text{Mean value}| \qquad D_a = |O - M|$$

Another way to express the deviation or precision is as a percentage. This is the relative deviation and is expressed as follows.

$$\text{Relative deviation} = \frac{\text{Average absolute deviation}}{\text{Mean value}} \times 100\% \qquad D_r = \frac{D_a}{M} \times 100\%$$

Accuracy and Precision

Student Sample



8/29/08

Accuracy
- how close to the accepted value
- absolute error
- relative error (%)
- accepted value
- hitting the target

Accuracy and Precision
- measurements
- represented as %
- [redacted]

Precision
- getting the same results consistently
- absolute deviation
- relative deviation (%)
- tolerance of measuring device
- mean value
- hitting the same spots on the ◎

HAIKU

(5) To be accurate
(7) You must hit near the target
(5) As close as you can

Width of Paper

Width CM	Absolute Error CM	Relative Error %	Absolute Deviation CM
28.11	.17	.61%	.00
28.15	.24	.86%	.04
28.12	.18	.65%	.01
28.09	.15	.54%	.02
28.08	.14	.50%	.03

accepted value (A)
27.94

M=28.11

$\boxed{.02}$

$D_R = \frac{D_a}{M} \times 100$

$\frac{.02}{28.11} \times 100 = \boxed{.07\%}$

$E_A = |O - A|$

$E_A = |28.11 - 27.94| = .17$

$E_r = \frac{E_a}{A} \times 100$

$E_r = \frac{.17}{27.94} \times 100 = .61\%$

$D_a = |O - M|$

$= |28.11 - 28.11| = 0$

18

Unit 4

Collaboration

One of the most important things a scientist does is to work collaboratively in a team, tapping into the expertise of others, evaluating possible actions for a project, and making the best choices on how to proceed. A classroom incorporating AVID strategies is one that uses collaboration among students to promote their learning in the same way. The purpose of collaboration in the science classroom is to bring all students together to take responsibility for their learning through inquiry, exploration, and questioning. As they learn to collaborate more effectively, they become better listeners, thinkers, speakers, and writers; they discover ideas and remember them because they are actively involved.

Working together cooperatively promotes students' long-term retention of content material because they learn the "how" as well as the "what" of learning. High achievement for all students occurs in a science classroom environment in which they are discussing and refining the learning process. To develop an effective collaborative learning experience for students, the teacher must carefully guide and reinforce the process.

Collaborative group learning differs from cooperative learning in the focus on shared responsibility for each other's success and the active involvement of all group members.

Cooperative Learning	Collaborative Learning
• No interdependence	• Positive interdependence
• Homogeneous	• Heterogeneous
• One appointed leader	• Shared leadership
• Responsible for self	• Shared responsibility for one another
• Interaction not always necessary	• Interaction necessary for task completion
• Minimal group processing	• Groups process their effectiveness

Unit 4 includes a section of collaborative active learning strategies that are easy to implement in any classroom. These are the AVID collaboration staples and the hallmarks of AVID science classrooms. The strategies enable students to work together to produce better products and deeper learning than would be developed if they worked separately. The AVID tutorial model presented in this unit is another powerful collaborative learning tool that helps students explore and refine their thinking processes. This empowers students and develops their confidence in learning science through a collaborative team.

Donohue, J. & Gill, T. (2009). *The write path I: Mathematics teacher guide*. San Diego, CA: AVID Press.

Section 4.1

Processing Speeds Continuum

Introduction

The rate at which students process classroom content can vary widely within a class. While the pace of instruction cannot be altered significantly for some classes (e.g., Advanced Placement classes), the teacher should be aware of the information processing rate of the students since this can affect their perception of the content material and their classroom performance. The *Processing Speeds Continuum* activity is a tool for teachers to visually model the rate at which students are processing information. It is a quick activity that can be used as often as desired, even on a daily basis, to provide feedback to the teacher. The class data from the activity typically generates a bell curve. The teacher can use this information to explain to students that a certain amount of course content must be covered over a given period of time, but that he or she will try to meet individual needs of students by reviewing their processing rates and adjusting the pace of instruction as necessary.

Timeline

10 minutes when introduced; 5 minutes for each subsequent use

Objectives: The Students Will . . .

- Evaluate their rate of processing of information to inform their academic progress

WICOR Strategies

Inquiry:	Analyze and interpret histograms
Collaboration:	Use class data to create histograms

National Science Education Standards

- None

Materials

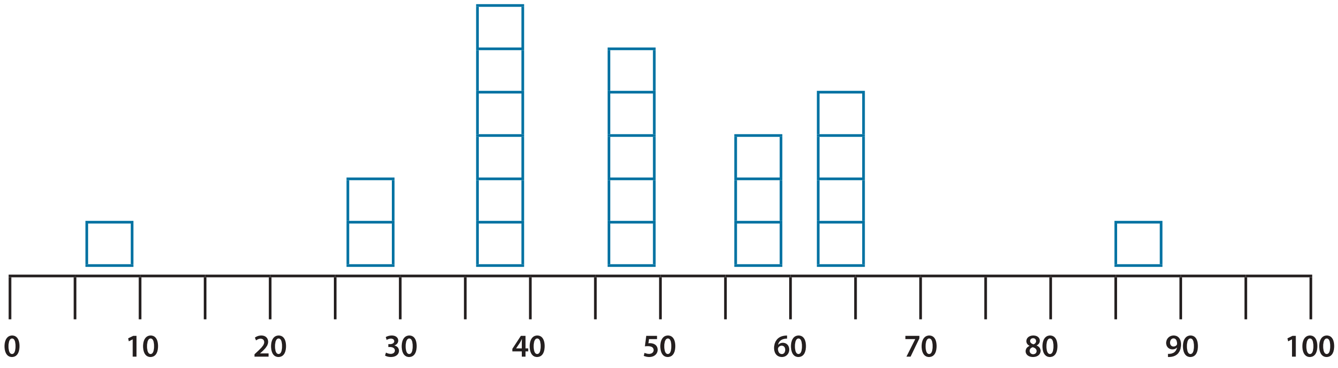
- Sticky notes or dots
- Long stretch of tape on the wall

Handouts

None

Teacher Directions

- Use tape to create a horizontal number line on the wall.
- Label the number line in increments of 10 starting with 0 on the left side and proceeding up to 100 on the right. This can be a large display or small display depending on what you use as the adhesive object for the students' processing speeds. Distribute to each student a sticky note, colored sticker dot, sticker, or some other adhesive object that is acceptable for them to stick on the wall.
- Direct students to compare their processing rates or speeds to the speed of cars: Low speeds indicate slow processing rates and high speeds indicate fast processing rates.
- Ask students to write their processing rates on the sticky notes/dots and post them on the number line. If you prefer, you can allow students to make the decision where their speed best falls in the levels you provide. Have students "stack" their responses so that you get a histogram effect.



- The sample above suggests that there is one student who needs additional help to get caught up, one student who needs enrichment, and the remainder of the class that is progressing to mastery.
- Examine the histogram with the whole class and make some observations about the processing speed of the class. Discuss ways that students can increase their processing speed such as building background knowledge, reading, doing homework, improving note-taking, following instructions, etc. Discuss the bell curve qualities of this visual and make instructional decisions for your class based on this data.
- This activity can be done after each lesson, in the middle of the unit, or any time you need student feedback on the pace of the lessons and how it affects their understanding. You can assign students personal reusable sticky notes that they move from time to time or start with fresh stickers each time.

Section 4.2

Philosophical Chairs

Introduction

Philosophical Chairs is a format for classroom discussion that can be used in any science classroom at any grade level. The activity focuses on a central statement or topic that is controversial. Students take a position on the issue and attempt to influence the opinions of others through logical arguments and facts. This activity uses a format similar to debate, but it is the dialogue that is most valuable. The constructive dialogue increases students' understanding of the topic being explored.

Philosophical Chairs exemplifies the use of WICOR strategies in lesson planning. Inquiry and collaboration are inherent in Philosophical Chairs, and writing and reading are easily incorporated into a plan that integrates the five components of WICOR. Additionally, this activity can be an excellent prewriting activity, since it allows students to gain and develop a variety of ideas about a topic. Philosophical Chairs is not dependent on a text, but the process is enhanced by using a text for information.

Timeline

- 50-minute class period to complete reading or inquiry activity
- 50-minute class period to complete Philosophical Chairs and extension activity

Objectives: The Students Will . . .

- Develop critical reading skills
- Become proficient with collaborative dialogue about scientific content and current events
- Develop oral and written language skills

WICOR Strategies

Writing:	Write and support a position statement Write higher-level questions to foster dialogue
Inquiry:	Develop a position statement and provide details to support the position and evaluate differing points of view
Collaboration:	Work as a team to develop arguments to support a position statement
Organization:	Plan and organize using Interactive Notebooks
Reading:	Read and analyze scientific literature; respond to a written prompt

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

Materials

- Reading selection with central statement or controversial topic

Handouts

Teacher Reference 4.2.1:	*Topics for Philosophical Chairs*
Teacher Reference 4.2.2:	*Guidelines for Philosophical Chairs*
Student Handout 4.2.3:	*Philosophical Chairs: Rules of Engagement*
Student Handout 4.2.4:	*Philosophical Chairs Written Evaluation Sheet*
Student Handout 4.2.5:	*Philosophical Chairs Reflection*

Teacher Directions

Preparing for the Activity:

- Choose a reading sample (article or text) on a controversial topic and formulate a central statement on which students can take a position. The statement should be one that will divide the class into those who agree with the statement and those who disagree. If you do not use a reading as the basis of the *Philosophical Chairs*, provide students with a statement on a controversial topic. (See *Topics for Philosophical Chairs* for a list of topics.)
- Become familiar with the guidelines for conducting Philosophical Chairs by referring to the *Guidelines for Philosophical Chairs*.
- Arrange the classroom for the activity by setting up chairs or desks facing each other to designate the "agree" and "disagree" positions. You can also have the students stand on opposite sides of the room.
- In the early stages of using *Philosophical Chairs*, you may want to begin with just two sides (agree and disagree). Later, you can add a third section for students who are "undecided." This group can participate during the discussion or may be required to take a position before participating.
- Post the central statement (prompt/thesis statement) for the students and have them write it in the INB.

Suggested INB Set-Up

Left Page	Right Page
Central statement for discussion **Opinion line** **Reflection or evaluation** *(Student-prepared or Student Handout 4.24 or 4.2.5 taped in as flip pages)*	**Article or text**

- Have students read the text and highlight at least three statements that support their personal opinions about the central statement or statements they might challenge on the topic. Ask students to formulate questions on the reading that need clarification and represent the key points that support or challenge their positions. They can write these questions in the margin.
- Have students place the article on a right page of the INB.
- Immediately below the central statement have the students draw the following line and mark it with "agree" and "disagree" on opposite ends of the line. They should then write and circle the number "1" at the position where they currently stand on the issue. Example below:

AGREE DISAGREE

①

- Have the students write a two- to three-sentence explanation of why they chose their positions on the opinion line.
- Review the *Philosophical Chairs Rules of Engagement* handout with the students.

Conducting the Activity

- Ask students to move to the chairs (or side of the room) that support their position on the central statement.
- Conduct the *Philosophical Chairs* activity according to the information on *Guidelines for Philosophical Chairs*.
- About every 5–6 minutes, stop the discussion for a couple of minutes and have students place a new number on the opinion line in their notebooks and write the justification of their decisions.

- You can bring the discussion to a close at any time. If time allows, each side (or each participant) may be given an opportunity to make a final statement on the issue.
- Leave time at the end of the period for students to reflect on the activity by responding to the questions on the *Philosophical Chairs Written Evaluation Sheet* or the *Philosophical Chairs Reflection* handout. These can be written into the INB or taped in as flip pages.
- Have students share their responses if sufficient time is available.

Differentiation Strategies

- The basic format for *Philosophical Chairs* remains the same for all grade levels; however you can differentiate by choosing central statements or topics with increased complexity and by decreasing the level of teacher involvement in the process.
- The lesson/activity categories listed below can also be used to create opportunities for student discussion of science phenomena and to differentiate the lesson for the *Philosophical Chairs* discussion:

  High-interest demonstration
  Discrepant event
  Formation of hypotheses for an inquiry activity

Higher-Level Questions

- What arguments and statements helped you determine your position for the activity?
- Predict how your standing on the issue would have changed if you were the only person on your side of the issue.

Topics for Philosophical Chairs

1. The United States should promote and fund the building of nuclear power plants to provide electrical energy.
2. Offshore drilling for oil should be discontinued.
3. Using unclaimed animals in animal shelters for medical research should be prohibited.
4. All chemicals that cause damage to the ozone layer should be prohibited from use or sale.
5. Do the benefits of burning hydrocarbons outweigh the harmful environmental effects?
6. The genetic selection of human embryos should be outlawed by the government.
7. The ultimate benefits of space exploration outweigh the huge costs of research and development of the space program.
8. Commercial products made with PCB (polychlorinatedbiphenyls) serve many useful purposes, but the health risks of PCB are greater than its usefulness.
9. There should be a ban of fast food commercials aimed at children.
10. All chemicals that cause damage to the ozone layer should be prohibited from use or sale.
11. Cities should enact ordinances to greatly decrease or ban the use of thin polyethylene bags.
12. The U.S. should send its radioactive waste from nuclear reactors and other sources into outer space.
13. The practice of fluorinating water should be discontinued.
14. The cutting of timber in the Amazon rainforests should be regulated by a council of nations since the rainforests play such a significant environmental role.
15. Consumers need to be informed if the food they purchase is genetically engineered.
16. The cost of protecting endangered species outweighs the benefit of maintaining the species.
17. States should require mandatory recycling of paper, glass, and plastics.
18. Global warming is hastened by the burning of fossil fuels.

Guidelines for Philosophical Chairs

Classroom Setup

Chairs/desks are set up facing each other with about half facing one way and half facing the opposite way.

Directions

1. A statement is presented to the students. This statement might be based on a reading or might be a stand-alone statement. Either way, the statement should be one that will divide the class into those who agree with the statement and those who disagree with the statement. Be sure that the statement is written on the board for reference during the activity. (Note: Allowing for a group of students who are undecided is addressed later in these guidelines.)
2. Those who agree with the central statement sit on one side and those who disagree sit on the other side.
3. A mediator, who will remain neutral and call on sides to speak, is positioned between the two sides. (This role is usually filled by the teacher in the beginning or middle school years. Eventually, students should take on this role.) In addition to facilitating the discussion, the mediator may at times paraphrase the arguments made by each side for clarification. It is important that the mediator always remains neutral.
4. The mediator recognizes someone from the side of the classroom that agrees with the central statement to begin the discussion with an argument in favor of the position stated. Next, the mediator will recognize someone from the other side to respond to the argument. This continues throughout the activity, and part of the job of the mediator is to ensure participation by as many students as possible and to keep just a few students from dominating the discussion. The mediator may also put a time limit on how long each side addresses the issue on each turn.
5. In addition to speaking in the discussion, students may express their opinions by moving from one side to other. Anyone may change seats at any time. Changing seats does not necessarily mean that a person's mind is changed, but rather that the argument made is compelling enough to sway opinions. Students may move back and forth throughout the discussion.
6. The discussion and movement go on for a designated period of time—usually one class period. The mediator may bring the discussion to a close at any time. Each side may be given an opportunity to make a final statement on the issue. If time allows, each participant states his/her final opinion and may also tell which arguments he/she found most convincing.
7. An additional piece to this activity can be to have a few students observe the process and take notes instead of participating. These students will debrief their observations to the class at the end of the activity. You may have students who were absent or unprepared to participate fulfill this role.

Evaluation

Leave time at the end of the period for students to reflect on the activity. Use one of the activities included in this unit. Students may begin the reflection in class and finish it for homework.

Modifications

It is recommended that you begin this activity with just two sides. If students have difficulty choosing a side to begin, encourage them to sit on the side that they agree with the most even if they do not completely agree. Once students are accustomed to this format, you may choose to add this additional component: You may add a third section of seats with a few chairs for students who are undecided. This section is placed between the two opposing sides. During the discussion, you may allow students from the undecided section to participate, or you may require that they take a position before participating. Students may move from the sides that agree or disagree with the statement to the undecided section if they wish. Before you end the discussion, require that all students still seated in the undecided zone move to one side or the other depending on which they believe made the most compelling arguments.

Philosophical Chairs
Rules of Engagement

1. Be sure you understand the central statement or topic before the discussion begins. Decide which section you will sit in.
2. Listen carefully when others speak and seek to understand their arguments even if you don't agree.
3. Wait for the mediator to recognize you before you speak; only one person speaks at a time.
4. You must first summarize briefly the previous speaker's argument before you make your response.
5. If you have spoken for your side, you must wait until three other people on your side speak before you speak again.
6. Be sure that when you speak, you address the ideas, not the person stating them.
7. Keep an open mind, and move to the other side or the undecided section if you feel that someone made a good argument or your opinion is swayed.
8. Support the mediator by maintaining order and helping the discussion to progress.

Philosophical Chairs Written Evaluation Sheet

Directions: Answer each of the following questions about today's Philosophical Chairs activity in a few sentences.

1. What was the most frustrating part of today's discussion?

2. What was the most successful part?

3. What statements led you to change your seat or to remain sitting in your original position?

4. What conclusions can you draw about how you form your beliefs based on today's discussion?

5. What would you change about your participation in today's activity? Do you wish you had said something that you did not? Did you think about changing seats but didn't? Explain.

Philosophical Chairs Reflection

Directions: Provide a written reflection of the philosophical discussion you heard in class. Be sure you include the following in your reflection points:

- the statement that was discussed
- the arguments for the statement
- the arguments against the statement
- your position and reasons for this position
- whether or not you changed your mind during the discussion, which arguments swayed your thinking, and why

Section 4.3

Tutorials in Science

Introduction

Many teachers do not have an opportunity within the class period to spend much time reviewing content. Some teachers have opportunities outside of the class in which students can ask questions on prior content covered within the science course. Tutorials in the science classroom are an effective way to help students progress to a deeper level of comprehension of subject matter or to review prior to an exam. Whether students are coming to a tutorial within a science class or outside of the classroom, students need to move beyond the "I don't get it" stage to a higher level of inquiry-based questioning skills.

In traditional study groups there is little or no interdependence and no accountability. They are typically led by one person. Often individuals only take responsibility for their own question and there is little group processing. The AVID tutorial model, using student presenters and Socratic questioning, leads to students taking responsibility for their own learning, as well as for the group's learning. Working in small, collaborative groups, students explore and answer questions using higher-level thinking. This type of tutorial group strengthens and enhances students' listening, thinking, speaking, and writing skills by keeping them actively involved in the process of learning.

Timeline

- 30–40 minutes to teach how to use the *Tutorial Request Form*
- One class period for tutorial process

Objectives: The Students Will . . .

- Become effective at identifying a "point of confusion" within science content
- Use the AVID tutorial model to take ownership of the problem-solving process
- Present and analyze questions in a tutorial group
- Develop questioning skills that enhance the thinking process
- Synthesize summaries and reflections of the learning in collaborative groups

WICOR Strategies

Writing:	Take three-column notes; write reflective summaries
Inquiry:	Develop questions that identify the "point of confusion" on problems
Collaboration:	Participate in collaborative tutorials
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read and analyze class notes to identify tutorial questions

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry

- Think critically and logically to make the relationships between evidence and
- explanations.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Understandings about scientific inquiry

Materials

- Whiteboard or chart paper
- Markers

Handouts

Student Handout 4.3.1:	*Steps in the Tutorial Process*
Student Handout 4.3.2:	*Using Tutorial Question Stems*
Teacher Reference 4.3.3:	*The Tutorial Learning Process*
Student Handout 4.3.4:	*Tutorial Request Form*
Teacher Reference 4.3.5:	*Tutorial Request Form (Reference)*
Teacher Reference 4.3.6:	*Tutorial Request Form Student Sample*
Student Handout 4.3.7:	*Tutorial Process Checklist*

Teacher Directions

Part 1: The Tutorial Request Form

- Introduce students to the AVID tutorial model through a discussion of the value of collaborative tutorials in strengthening students' listening, thinking, and questioning skills. Also address the college readiness skill of developing individual problem-solving skills.
- Preview the tutorial process by discussing the *Steps for Content Tutorials* handout with students. Emphasize the fact that the tutorial process begins with good Cornell notes on a topic and identification of a tutorial question based on the point of confusion. (Refer to *The Tutorial Learning Process* reference sheet.)
- Distribute the *Using Tutorial Question Stems* and the *Tutorial Request Form* handouts. Each of the handouts can be put into the INB as desired. The practice *Tutorial Request Form* can be inserted after it is completed at the end of the tutorial session.

Suggested INB Set-Up

Left Page	Right Page
Using Tutorial Question Stems *(Student Handout 4.3.2)* **and** **Steps in the Tutorial Process** *(Student Handout 4.3.1)*	**Tutorial Request Form** *(Student Handout 4.3.4)* *(Tape in as a flip page after completion.)*

- Display the *Tutorial Request Form* (TRF) and distribute copies to students.
- Model the process of completing the TRF, displaying the form with a document camera or overhead projector. Begin by asking students to review their recent Cornell notes and homework. (Refer to *Tutorial Request Form (Reference)* as a guide for completing the form.)
- Have students volunteer questions from their Cornell notes, or questions they may have missed on a homework to start the process. The handout *Using Tutorial Question Stems* can also be used to help them form questions.
- Write one of the questions on the displayed TRF form for the students. Ask them to identify an essential question for the volunteered topic. This is commonly a content standard or objective that is worded as a question. Also have students identify the source of the question, a homework title, date of notes, page in the text, etc.
- Have students volunteer some key vocabulary from the course content material that might be associated with the question, making sure to write the definitions down onto the TRF as they proceed.
- Have students identify what they already know about the problem in the second section of the form: how to start the problem, the steps in the solution, etc. If a student is having trouble starting the problem, ask him or her to refer to previous notes or homework for background information.
- Instruct students to identify the steps or ways they have tried to solve the problem or answer the question, what they can do to move forward on it, and the parts they understand. This should lead them to their point of confusion on the content or question. This is the point the students must reach when developing their tutorial questions.

Suggested INB Set-Up

<table>
<tr><th colspan="3">Left Page</th><th>Right Page</th></tr>
<tr><td colspan="3">Notes on Tutorials</td><td rowspan="3">Tutorial Request Form
<i>(Student Handout 4.3.4– flip page or student-prepared)</i>
<i>Note: No summary is done on the left page for the notes, as the TRF has a reflection.</i></td></tr>
<tr><td>Questions</td><td>Notes</td><td>Steps</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Part 2: The Tutorial

- The front page of the tutorial request form is done prior to coming to the tutorial study group. The students must complete the form to be able to participate effectively within the tutorial group.
- When students attend classroom tutorials, have them place the completed TRF template on a right page of the INB. They could also copy the TRF onto the page from a reference page. This reference page can be available in the front of their INB, within their classroom binders, or on the teacher website.
- As students enter the classroom, place them into groups according to the subject area of their tutorial questions, making sure groups are not larger than seven students. Have the students sit in a semi-circle (horseshoe shape), and give each group a large whiteboard to present their questions.
- Review the tutorial process steps and the tutorial question stems with students as a reminder of the processes they will use during a tutorial.
- Direct the students to share their tutorial questions within their groups and decide the order in which to address everyone's questions (as time allows).
- The student presenter should be at the whiteboard (or chart paper) and present his or her question, using the TRF as the guide to lead to the point of confusion. Have students in the tutorial group take three-column notes onto the left page of their Interactive Notebooks with the question in the first column and the notes on the group discussion in the center column. The final column is reserved for steps in the solution to the problem, developed by the group to help the student presenter determine the solution to the problem. Recording the steps will help solve similar problems in the future.
- After the tutorial, have students complete the reflection section on the TRF. The reflection is a mental process that asks students to consider their experiences. A reflection can occur orally and/or in writing. This process helps students learn independently and evaluate their own thinking processes.
- The *Tutorial Observation Form* provides a way for you and the students to debrief on the tutorial process. Use this form periodically to make sure the tutorial process is understood and working effectively.

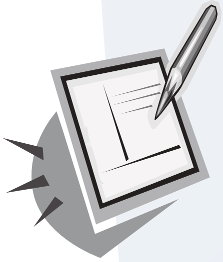
Differentiation Strategies

- The collaborative nature of the tutorial provides the environment for a broad level of differentiation among content areas or age groups. Be sure to remind students on the value of "coaching" their peers rather than dismissing questions which are "too easy."

Higher-Level Questions

- Evaluate traditional and collaborative study groups to compare the most effective features of both models.
- Create a processing symbol/picture to represent and help someone remember the steps the group used to solve a particular question.
- How might a tutorial question be extended or expanded to a higher level of thinking?

Steps in the Tutorial Process



Before the Tutorial

1

Students take Cornell notes in their academic classes.

2

Students complete the pre-work inquiry on the Tutorial Request Form (TRF) while reviewing Cornell notes, completing homework or studying for a quiz/test.

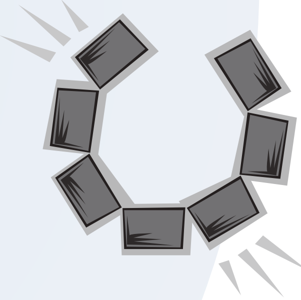
3

As students enter the room, the teacher/tutor checks the TRF pre-work and Cornell note resources.

During the Tutorial

4

Students are divided into tutorial groups to meet the 7:1 student/tutor ratio.

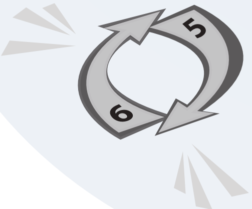


5

The student presenter begins the tutorial by giving a 30-Second Speech about his/her pre-work. Tutor and group members ask questions to guide the student presenter through the critical thinking process. All tutorial members take three-column notes.

6

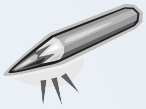
The group members/tutors check for understanding as the student presenter reviews the work and articulates the steps/process used to clarify the point of confusion.



7

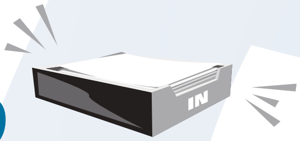
Steps 5 and 6 are repeated for as many group members as time allows.

After the Tutorial



8

Students complete a written reflection on the learning that occurred from clarifying the point of confusion.



9

Students turn in their TRFs to teacher/tutor for grading and feedback.

10

Teacher/tutors/students debrief the tutorial process. Students verify their learning in their academic classes.

Using Tutorial Question Stems

Directions: Use these stems throughout the tutorial process to assist in working through the levels of inquiry. The notes generated from the inquiry process should be recorded in a three-column note format. See three-column note format on the next page.

1. How are ____________________ and ____________________ similar?
2. What is the difference between ____________________ and ____________________?
3. How could ____________________ be used to ____________________?
4. What do you think would happen if ____________________?
5. How does ____________________ connect to what we've learned before?
6. What is a new example of ____________________?
7. What are the strengths and weaknesses of ____________________?
8. In your own words, what is ____________________?
9. Why is ____________________ important?
10. How would you explain ____________________?
11. What is another way to explain why ____________________?
12. How do you think ____________________?
13. How does ____________________ compare to ____________________?
14. How are ____________________ and ____________________ different?
15. Imagine that ____________________; how would you react?
16. What will happen to ____________________ if ____________________?
17. What speculation can we make about ____________________?
18. Considering ____________________, what conclusion can be made about ____________________?
19. How would you summarize ____________________ in your own words?
20. What are the real life applications of ____________________?

The Tutorial Learning Process

1. For homework the night before tutorials, each student will identify a problem or topic from Cornell notes, a textbook, workbooks, quizzes, or tests he or she does not understand.

2. Students will complete the first page of the *Tutorial Request Form (TRF)*.
    - Initial question: This can be a simple question about content problem.
    - Key academic vocabulary: Terms associated with the topic or question
    - What is known about the initial question
    - Critical thinking about the initial question
    - Identification of general process or steps
    - Tutorial question on the "Point of Confusion"

3. The teacher/tutors or peer tutors collect the TRFs and form tutorial groups based on the content of the questions, age group, or ability levels. These groups should have 4–7 students in them. The seating configuration should be a semi-circle (horseshoe shape) in order to facilitate communication with the student presenting the problem. The teacher/tutor or peer tutor should be positioned with the seated group members and will facilitate the process of selecting a student presenter.

4. The student presenter will write his or her question on the board and explain to the group members his or her knowledge and understanding of the question. The group members ask questions that check for understanding and probe deeper into possible approaches to solving the problem.

    The seated group members are responsible for helping the presenter think about the problem by asking questions to clarify understanding and pushing the thinking of the presenter. They are not responsible for finding the solution.

5. The teacher/tutor or peer tutor takes notes for the student presenter during the time the presenter is at the board. The tutor facilitates the inquiry aspect of this tutorial process by guiding the seated members of the group by modeling questions that they might ask the student presenter.

6. The group members help the presenter clarify the solution process by asking questions such as:
    - Is your solution or answer reasonable?
    - How could you check your answer?
    - Can the solution or answer be explained in another way?

7. The above presentation-questioning process is repeated for each remaining group member, as time allows. ***Teacher Note:*** The greatest value of the tutorials is the *process*, not the solution to the problem.

8. At the end of the tutorial session, all members of the tutorial group should write a reflection of their learning (content and/or process).

Donohue, J. & Gill, T. (2009). *The write path I: Mathematics teacher guide*. San Diego, CA: AVID Press.

Tutorial Request Form (TRF)
Pre-work Inquiry (Before the Tutorial)

Subject:	Name:
Standard Essential Question:	AVID Period:
	Date:

Pre-Work Inquiry	Resources	Collaborative Inquiry	Cornell Note-Taking	Reflection	Total
_____ **/12**	_____ **/1**	_____ **/2**	_____ **/3**	_____ **/7**	_____ **/25**

Initial/Original Question:

Source, Page # and Problem #: ____

/1

Key Academic Vocabulary/Definition Associated With Topic/Question:

1.

2.

/2

What I Know About My Question:

1.

2.

/2

Critical Thinking About Initial Question:	Identify General Process and Steps:
/3	**/2**

Question From Point of Confusion:

/2

Two-Column Note-Taking (In Class—During the Tutorial)

Take two-column notes (question/notes/steps or process) during the tutorial on notebook paper. Keep your notes in your binder to study.

Reflection (In Class—After the Tutorial)

My point of confusion is based on a focus area from myGrade/Tutorial Analysis: ☐ Yes ☐ No
I was a student presenter during tutorial today: ☐ Yes ☐ No

My point of confusion was . . . ____________________
____
____
____________________ **/1**

What I learned about my point of confusion is . . . ____________________
____
____
____________________ **/1**

I gained a new/greater understanding of my point of confusion by/when . . . ____________________
____
____
____________________ **/2**

This learning is important because it connects to my previous learning/experience, myself and/or my world

(circle one) in the following way . . . ____________________
____
____
____________________ **/2**

What I found meaningful about today's tutorial session is . . . ____________________
____
____
____________________ **/1**

REFERENCE

Tutorial Request Form (TRF)
Pre-work Inquiry (Before the Tutorial)

AVID
Proven Achievement.
Lifelong Advantage.

Subject: Standard Essential Question:	Name: AVID Period: Date:

Pre-Work Inquiry	Resources	Collaborative Inquiry	Cornell Note-Taking	Reflection	Total
_____ /12	_____ /1	_____ /2	_____ /3	_____ /7	_____ /25

Initial/Original Question:

Source, Page # and Problem #: ______________________________

- "As I review my resources (Cornell Notes, textbook, workbooks, quizzes/tests), what is something that I don't understand?"
- "How can I simplify and explain this question in my own words?"

/1

Key Academic Vocabulary/Definition Associated With Topic/Question:

- What are the key academic vocabulary words I need to understand?"
- "What is the definition from my book or notes?"
- "Can I define them in my own words?"

/2

What I Know About My Question:

- "What concept does this remind me of?"
- "How can I organize the information?"
- "Can I connect this concept to prior knowledge from this content area or another subject?"
- "Can I make a prediction about a reasonable answer?"

/2

Critical Thinking About Initial Question:

- "What can I show about my question?"
- "What does the textbook or notes say about this topic?"
- "How do I plan to approach this question? What strategies should I use?"
- "Can I work backwards?"
- "From my initial question, what do I know and what can I show?"
- "Have a done a similar problem/question and what steps did I take to solve it?"
- "Can I break down the question to smaller parts, and if so, what would they be?"
- "Can I call someone from my class to assist me?"
- "Is there a reliable website that can support me in my learning?"

/3

Identify General Process and Steps:

- "What are the steps to what I know?"
- "What can I show that I can apply to a similar problem?"

/2

Question From Point of Confusion:

- (This is the tutorial question. Using academic vocabulary, create a tutorial question based on your point of confusion.)

/2

TEACHER REFERENCE 4.3.6 (1 of 2)

Student Sample

Tutorial Request Form (TRF)
Pre-work Inquiry (Before the Tutorial)

Subject: Chemistry

Standard Essential Question:
How are molecular and structural formula used?

Name:

AVID Period:

Date:

Pre-Work Inquiry	Resources	Collaborative Inquiry	Cornell Note-Taking	Reflection	Total
12 /12	1 /1	2 /2	3 /3	7 /7	25 /25

Initial/Original Question:

Source, Page # and Problem #: Notes, pg 53

In what ways are molecular and structural formulas alike and different? /1

Key Academic Vocabulary/Definition Associated With Topic/Question:

1. Molecular formula: A chemical formula that shows the number and kinds of atoms in a molecule, but not the arrangement
2. Structural formula: A formula that indicates the location of the atoms relative to one another in a molecule and that indicates the number and locations of chemical bonds /2

What I Know About My Question:

1. Molecular formulas tell the number and kinds of atoms.
2. Both formulas are used for covalent compounds. /2

Critical Thinking About Initial Question:

Both have to do with atoms and formulas and molecules.

The kinds of atoms and number of valence electrons are important.

A structure has to do with the way something is built.

Lewis dot formulas are used for molecules.

/3

Identify General Process and Steps:

Find how they are similar by analyzing the definitions. Review how to write and draw kinds of bonds.

Review molecular shapes.

Use the number and kind of atoms and the number of bonds each one can make to find out.

/2

Question From Point of Confusion:

How can the molecular formula be used to determine the structural formula? /2

Student Sample

Two-Column Note-Taking (In Class—During the Tutorial)

Take two-column notes (question/notes/steps or process) during the tutorial on notebook paper. Keep your notes in your binder to study.

Reflection (In Class—After the Tutorial)

My point of confusion is based on a focus area from myGrade/Tutorial Analysis: ☐ Yes ☐ No

I was a student presenter during tutorial today: ☐ Yes ☐ No

My point of confusion was . . . How can the molecular formula be used to determine the structural formula. /1

What I learned about my point of confusion is . . . I learned that the number of atoms and the total number of valence electrons for the atoms in the molecular formula will guide me to the number of bonds to be made and the number of bonds determine the shape and the structural formula. /1

I gained a new/greater understanding of my point of confusion by/when . . . I realized that the total number of valence electrons for the atoms in the molecule will lead me to know how many bonds to make. /2

This learning is important because it connects to my previous learning/experience, myself and/or my world (circle one) in the following way . . . Finding out how to write structural formulas is just a matter of using the information I already know. /2

What I found meaningful about today's tutorial session is . . . that the process of changing molecular formulas to structural formulas is fairly simple if I really think about what I already know about atoms and valence electrons and bonds. /1

Tutorial Process Checklist

	Student-Centered	Collaborative
Teacher	☐ Monitors tutorials ☐ Coaches students to monitor their own behavior ☐ Stays with 1–2 groups the entire tutorial time ☐ Models higher-level questioning	☐ Coaches students and tutors in the tutorial process ☐ Coaches students/tutors to share responsibility for monitoring their own/each other's behavior ☐ Rotates to observe each group during the tutorial time ☐ Models higher-level questioning; validates students who ask higher-level questions
Tutor	☐ Works with 1–2 groups in a period ☐ Works with student presenter at board; discusses possible solutions with the group ☐ Asks questions and promotes discussion toward a solution ☐ Encourages students to take Cornell notes on all student questions	☐ Coaches and works with one group the entire period ☐ Sits with the tutorial group and away from the student presenter ☐ Facilitates the group and pushes the thinking of all students to a higher level ☐ Takes Cornell notes for the student presenter and models Cornell note-taking for the group members
Student Presenter	☐ Works at board presenting his or her own question to group; tutor occasionally is at board with student ☐ Listens and records notes at board while group members discuss questions ☐ May present higher-level questions from subject area ☐ Records group thinking at the board	☐ Works at board presenting his or her question to group as tutor takes Cornell notes ☐ Shares prior knowledge with group and uses group member questions to assist in working toward a solution ☐ Presents higher-level question based on problem in subject area ☐ Records own and group thinking on board
Group Members	☐ Discuss questions being presented ☐ Take Cornell notes on each student presenter's question ☐ Engage in discussion ☐ Seating arrangements promote collaboration and discussion among some individuals in the group	☐ Take responsibility for pushing the thinking of all students through the use of inquiry, promoting shared leadership ☐ Take detailed Cornell notes on each student's question ☐ All engage in discussion ☐ Engage in a reflection about the learning process used to arrive at solution ☐ Seating arrangements promote collaboration and discussion among all members

Section 4.4

Active Learning Strategies

Introduction

Collaboration is a key construct when students learn. It provides the social structure that many students require and practice in articulating understanding. By involving others in our learning, we have the opportunity to revise our thinking and check our understanding in a safe environment. These strategies have many names but the steps and concepts remain the same.

You will notice that these activities only give you the instructions for the strategy. There is no set-up or follow-up to the learning done in the activity. Be vigilant to include these critical learning pieces into your lesson so that students have an introduction and closure to the active learning part of the lesson.

Keys to Success When Implementing

- Active Learning Strategies
- Start small!
- Plan an active learning strategy, try it out, collect feedback, then modify and try it again.
- Start on the first day of class.
- Explain to students why you are doing this and how it will aid them in the learning process.
- Develop classroom routines for transitions.
- Work collaboratively with a colleague while you are implementing active learning methodologies.

Think-Pair-Share

Used as a quick processing activity and/or check for understanding; the think/write steps are crucial for giving students time to process their understanding in preparation for sharing

1. Instruct students to think carefully about a specific topic or a question. This may be facilitated by a quickwrite.
2. Instruct students to find a partner near to them.
3. When you give a signal, one partner should share his or her answer to the question and the reasons that support it, while the other partner listens.
4. The partners exchange roles.
5. The partners prepare to share their answers/responses with the large group.

Think-Pair-Share Squared

Used as a quick processing activity and/or check for understanding; the think/write steps are crucial for giving students time to process their understanding in preparation for sharing

1. Participants listen to a question, concern, or scenario.
2. Individuals think and make notes about the questions, concern, or scenario.
3. Individuals pair and discuss their responses.
4. Pairs join into groups of four and discuss responses.
5. Foursomes prepare to share their answers/responses with the large group.

KWL

When done collaboratively, used to elicit collective background knowledge, to build purpose for a learning task, and to chronicle learning; allows students to build on each other's learning

1. Draw three columns on chart paper. Label the columns of the KWL chart: "What We Know," "What We Want/ Need to Know," and "What We Learned."
2. Identify a text selection or topic for students to consider during the activity.
3. Ask students to brainstorm and enter information in the columns indicating what they know and want/need to know.
4. Provide students with frequent practice.

Carousel Brainstorming

Used to elicit and build background knowledge, or to gather opinions; allows students to build on one another's ideas in a very structured manner

1. Assign each student to a group and prepare a wall chart for each group.
2. Have groups go to their respective posters. Give each group a different color marker so you can track which group added what concept to the poster. Groups will carry their marker with them from poster to poster.
3. Starting at its assigned poster, the group records as many ideas as it can to that poster. There are no wrong answers; all responses should be added. When the signal occurs, groups move to the chart to their right.
4. At the second poster, groups review what the previous group wrote and generate additional ideas which they add to the chart paper.
5. On the second signal, groups rotate clockwise to the third chart and continue the process until they return to their own poster. To ensure that this activity is successful, limit the amount of time the groups spend in front of each poster as there will be a natural reduction in ideas generated by the sixth poster.
6. When groups return to their poster, instruct them to take a "gallery walk" of all charts to see all of the ideas.

Jigsaw—Home Group/Expert Group

Used when discussion of new information is desired but time is limited or the target text/content material is especially dense; provides scaffolded inquiry with accountability

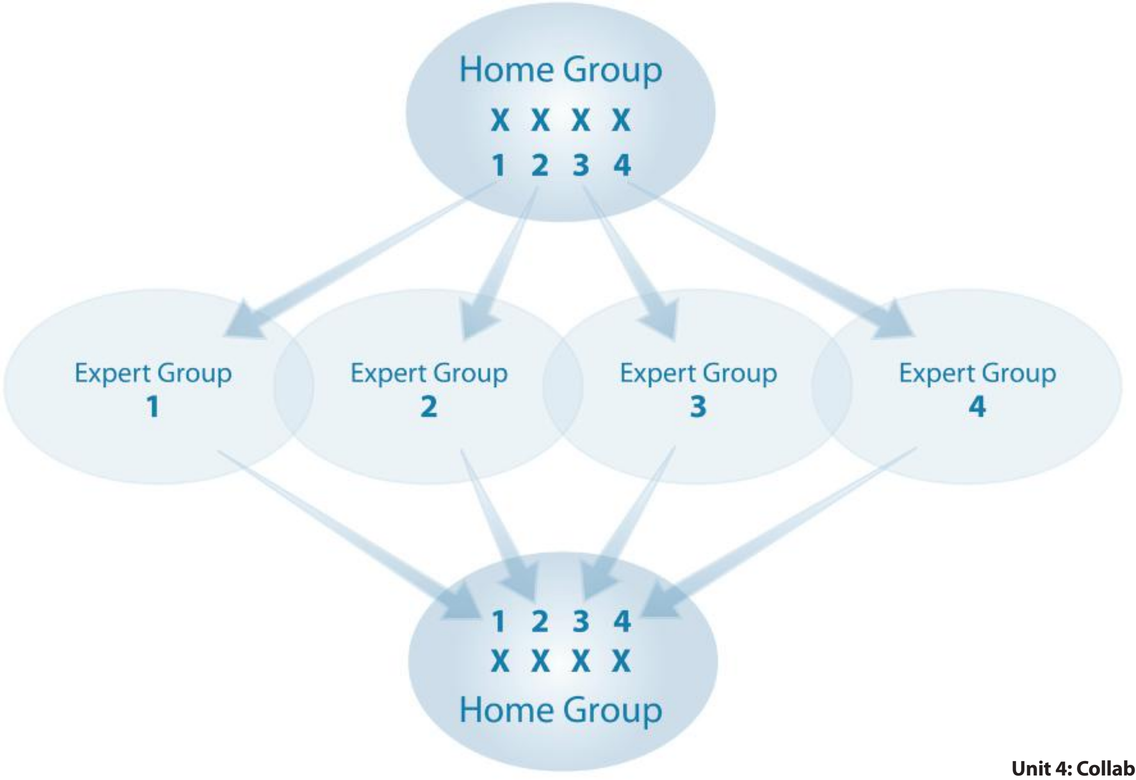
1. Divide the class into groups. The number of sections of the reading or the number of concepts being reviewed or introduced will determine the number and size of the groups.

2. Assign each member of the group a number that corresponds to the section of the text to be read or the concept to be mastered. Each member reads the section he or she is responsible for while taking notes.
3. Students should leave their "home" groups and form "expert" groups with other students with the same number. Each "expert" group works on its part of the assignment; members assist each other with questions, clarifications, and summaries. In preparation for going back to his or her "home" group as an "expert," each student rehearses and teaches the lesson to the other members.
4. Students return to their "home" groups and share, discuss information, and teach their part of the assignment.
5. Students reassemble as a whole class and share their thoughts and responses.

Jigsaw Sequencing Groups

Used to structure a group for negotiation and problem solving

1. Cut sections of a scientific process, experiment, solution to a problem, or reading into individual parts. Each part should have a complete meaning and show a type of transition at the beginning or end of that section.
2. Form groups of students that correspond to the number of "jigsaw" pieces.
3. Each group member receives a different piece of the scientific process, experiment, solution to a problem, or reading.
4. One student at a time, each member of the group decides where their piece fits in the sequence.
5. If a student thinks he or she has the first section of the sequence, the student must give the reasons why without letting the group read the section. That student tells the group, "I think I have the first piece because…"
6. If the group agrees that it is the first section, the student reads the section aloud to the group and then places it on the table.
7. The group then proceeds to look for the next section following the same rules as above.



Numbered Heads Together

Used for quick collaborative discussion with group and individual accountability

1. Place students in groups of four.
2. Have students in each group number off from one to four.
3. Pose a question for students to discuss or review.
4. Have students discuss the question in their groups, making sure that each member of the group can answer the question if called upon.
5. Select a random number corresponding to a number of a group member.
6. Select one or two students to respond to the question. Additional students with the same number can respond to the question by adding new information to the previous response(s).

Fishbowl

Used as a structure for modeling a process and for giving groups of students the opportunity to have structured talk while others have structured listening

1. Set up a small inner circle of students (i.e., the fishbowl group) to demonstrate an activity for the class. Have all other students form a larger outer circle around the inner circle of students.
2. The inner circle should listen carefully to teacher directions and then demonstrate the activity to the rest of the class.
3. As necessary, clarify and correct the activity steps with the fishbowl group.
4. Debrief with the entire class.

Note: The fishbowl can also be used as a type of Socratic Seminar, where the inner circle of students participates in a discussion and the outer circle of students listens and takes notes. Later, the outer circle of students can comment on the discussion, using their notes. They can also exchange places with the fishbowl students.

Novel Ideas Only

Used for eliciting collective background information, reviewing recently taught information, and for practicing academic talk, careful listening, and public speaking

1. Place students in groups and assign groups a topic about which they are to list ideas. Set a time limit for the task.
2. Have all members of the groups stand up. Have a spokesperson from each group share one "novel" idea from the group's list. As students hear an item shared by another group, they check it off their own group's list.
3. Move to another group for another new idea. Students in each group must listen attentively to ensure that no group repeats information already provided by another group. (Each group spokesperson can only give information not previously mentioned.)
4. When all of a group's ideas have been shared out, the entire group will sit down.
5. The activity continues until all "novel" ideas about the topic have been shared and all students are again sitting down.

Novel Ideas—Four Corners

Used to check for comprehension and to build student accountability for articulating their understanding; also helps build cohesion among classmates as they discover they can help each other

1. Allow students to divide themselves into four groups based on their perceived level of understanding or mastery of a question or concept (1 = lowest level of understanding; 4 = highest level of understanding).
2. Ask the groups to brainstorm all that they know about the question or concept and to generate questions that would help them gain more understanding.
3. Ask a representative from the level one group to share all that was on the group's brainstorm list, saving questions until all groups have shared.
4. Proceed in turn with each sequential group, allowing them to share new information not previously mentioned.
5. Finish with the group that perceived themselves as having mastered the material.
6. Revisit groups' questions to see if any have been answered by the other groups' sharing, and then invite students to answer the questions still pending.
7. Clarify misconceptions and misstatements.

Inside/Outside Circles or Parrallel Lineups ("Conga Line")

Used to review key concepts and to build academic talk

1. Divide students into two equal groups.
2. Place half the group in the inner circle directly facing a member of the second half of the group in an outer circle. (Alternatively, form parallel lines.)
3. Provide a limited amount of time for the partners to quiz each other on vocabulary or review questions, or to discuss another teacher-designated topic.
4. Have the outer circle move to the left (or right) two or three partners down.
5. Repeat step 3.

Give One/Get One

Used as an interactive method to review content, elicit background knowledge, or process newly taught information

1. Have students divide a sheet of paper or the left side of their INBs into two columns. Label the left column "Give One" and label the right column "Get One."
2. Ask each student to make a list of ideas that they have learned about a topic or write their answers to a specific prompt on the "Give One" side.
3. Give students two to three minutes to create as long a list as possible.
4. Have students mingle with their peers. Students must give an idea from their list to each student they meet; they must also write down one new idea from each partner's list. Have them list the ideas that they get under the "Get One" column.
5. As a whole class, create a list of ideas/answers from the individual lists of students.

Note: You can play music while students mingle. When the music stops, students will partner with another person. Repeat this process as many times as you can in three to five minutes. If you do not use music, announce when to change partners.

Talking Chips

Used for accountable and equitable talk in small group discussions and to promote academic talk

1. Have students each create three cards with their name on each card—Talking Chips.
2. During discussion groups, have students take out their talking chips. Tell them that when they are ready to contribute to the discussion they must place one of their chips in the center of the table. When they do this, all other students at the table must stop talking and listen attentively.
3. When students have used up all of their talking chips, they must wait for others to use theirs up, too, before they can contribute to the discussion again.
4. Once all chips are in the center of the table, they can be redistributed and all participants can join in the discussion again.

Note: An alternative is to give each student two pennies so they can "add their two cents" over the course of the discussion. The drawback is that there are no names on the pennies. The benefit is that you can request that all students must contribute one penny/one idea before other students get a second chance. This method helps students to warm up to asking questions. Since they have to participate, they might as well ask a question.

Take Five

Used to gain consensus decision-making; an effective way to assess group needs and gather information for problem-solving

1. Divide the group into smaller groups of four or five students each.
2. Provide quiet time for each student to complete a five- to ten-minute quickwrite.
3. Provide time for groups to collaborate and brainstorm.
   a. Each student should share his or her writing one at a time.
   b. Groups should look for common themes and record consensus.
   c. Each group should then discuss its list and identify priorities by numbering 1, 2, 3, etc. Each small group shares its top agreements or priorities with the larger group.
4. The larger group records common themes/priorities.

Parking Lot

Used to encourage students to communicate their concerns and questions in a non-threatening, "safe" place

1. Provide students with sticky notes on which they can record questions and concerns.
2. Designate a location (the "parking lot") in the room for students to post their questions and concerns.
3. Encourage students to add to the parking lot at any time.
4. Check the parking lot frequently and address any notes that have been posted.

Whip Around

Used to provide every group member an opportunity to comment or discuss a concept or question

1. Divide students into small groups of four to five students.
2. Present a question or discussion prompt.
3. Give a time limit, usually two to three minutes.
4. Each student should be provided an opportunity to comment by going around the group sequentially.
5. A student may pass one time, but must comment the next time it is his or her turn.

Popcorn

Used to give students an informal opportunity to quickly share ideas and comments with the whole group

1. Allow students to share their ideas with the whole group without having to raise their hands.
2. Students can stand to share their ideas. This resembles the popcorn title because students sit while they listen and "pop up" when they have an idea to share.
3. Standing improves thinking by including movement to change physiological state as well as keeping comments short.
4. Record the ideas/comments on chart paper.

Note-Checking Pairs

Used to foster the 10-2 instructional model (10 minutes of "input"; 2 minutes of "processing") and to check for comprehension

At the end of a class segment (after 10–15 minutes), ask students to find a "shoulder partner" to review their notes through a quick pair activity such as one below:

1. Summarize three important points.
2. Choose the most important idea that will appear on the exam.
3. Check the completeness and accuracy of your partner's notes.
4. Use the notes to solve an example problem.
5. Write questions in the left column of your partner's Cornell notes.
6. Use the notes to work on a teacher-generated question.

Note: These notes and the processing that has been done can be collected as a formative assessment.

Games

Used to introduce or review concepts or topics in an engaging manner

Games such as Buzz!®, counting games, Jeopardy®, matching, mysteries, group competitions, puzzles, charades, Scrabble®, Pictionary®, etc., can be designed to introduce or review specific vocabulary and concepts.

Unit 5

Reading to Learn

Students across all disciplines need strong reading skills and strategies. College-bound students will be expected to analyze lengthy and complex texts methodically, efficiently, and critically. Science is particularly difficult for many students because of its complexity and rigor. Teachers must intentionally *teach* and *use* critical reading strategies to increase academic literacy within the science classroom.

The *Reading to Learn* unit provides effective strategies that develop students' critical reading skills, focusing on prereading, during-reading, and after-reading activities. Students will incorporate content vocabulary and concepts from their reading into writing products. The strategies move from development of background knowledge and vocabulary, to interacting directly with the text while reading, making connections, and finally, to synthesizing readings into new understanding. Each step in this process deepens and extends the learning of the students.

Prereading

Building background knowledge prepares students to comprehend reading passages at a higher level of understanding. In the vocabulary-rich sciences, developing understanding of terminology is of particular importance in developing critical reading skills. This is addressed through building a definition, vocabulary bookmarks, total physical response (TPR), and the use of three-column Cornell notes. The *Processing Activities* in the appendix present additional strategies for vocabulary development.

During Reading

During the reading process, students should use active strategies to access information and make connections. Students interact with the reading by marking the text to identify the key ideas and asking questions about the concepts to broaden their understanding and make connections. Learning to annotate a selection helps students be involved and actively question what they are reading. Using a graphic organizer to sort, categorize, order, and connect ideas during the reading process structures the information that the student is taking from the reading.

After Reading

After students have read the text and organized their thoughts, they further deepen their understanding through summarizing and synthesizing ideas. When students can articulate their learning in this way, they demonstrate what they truly understand. The One-Pager is a method to provide a graphic approach to summaries. *Get Curious and Ask Questions* pushes students to take their analysis even further by asking higher-level, critical questions.

Section 5.1

Vocabulary Development

Introduction

Science educators do more than teach content to students: Teachers ask students to learn and use more new vocabulary than is learned in the average world language class. It is vital to students' academic success that they learn and retain academic vocabulary. A robust vocabulary improves comprehension of content material as well as writing and reading skills. The vocabulary instruction can happen at any time within a lesson: the beginning of a unit, chapter, or lesson, or as the students experience the vocabulary within the content area.

Teaching vocabulary starts with identifying the words most important for the student to use or know to increase comprehension of the content being read. Vocabulary development is particularly important as a prereading strategy for improvement of students' comprehension of scientific texts heavily infused with content-specific terms.

The vocabulary development activities of this section are just a few of the many that could be used to help students incorporate the huge amount of scientific vocabulary into their knowledge of science. Additional strategies for development of vocabulary are described in the *Processing Activities* in the appendix. Examples of these activities include *Vocabulary Cards, Fold-It 1, Fold-It 2,* and *Bull's Eye Comparison*.

Timeline

Each strategy takes about 15–20 minutes to teach, but the students will need varying amounts of time on the completion of each depending on their ease with language and reading abilities.

Objectives: The Students Will . . .

- Use critical reading strategies to comprehend text information
- Use strategies to incorporate new science vocabulary into their language

WICOR Strategies

Writing: Write definitions of vocabulary words

Inquiry: Illustrate vocabulary words and phrases

Collaboration: Peer review definitions

Organization: Plan and organize using note-taking and Interactive Notebooks

Reading: Read scientific texts

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Communicate scientific procedures and explanations

Content Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Reading passage (text or article)

Handouts

Student Handout 5.1.1:	*Vocabulary Bookmark*

Teacher Directions

Build a Definition:

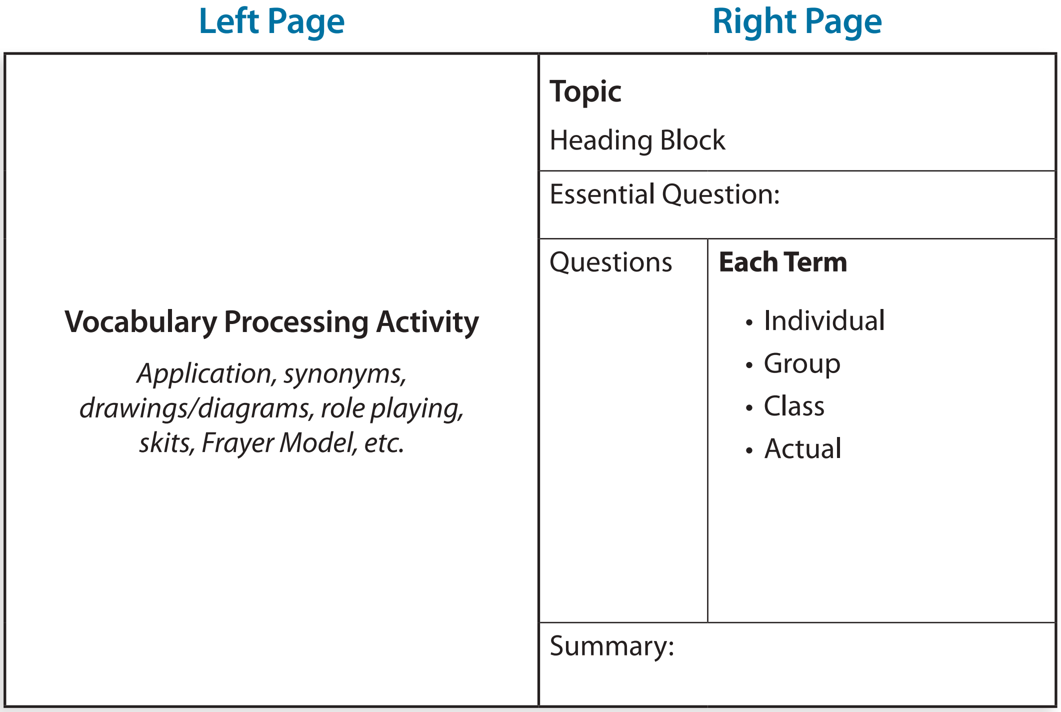
- Choose 4–6 words in a lesson to focus on during the vocabulary activity. The websites listed in the reference section can assist in selecting the words to focus on within a content area.
- Have students write the words on a right page of Cornell notes with at least three lines between each word. Assess their prior knowledge of the words by asking them to quietly reflect on what the word might mean and write three words that might be used in the definition. Encourage students to note any prefixes or suffixes on the words. If you have a reference book or list of prefixes and suffixes, students may want to use this information.

Example:

Vocabulary term:	abiotic (factor)
Words for definition:	not, without, biology, living, life

- In small groups, have each student share their three words individually. As a group they should decide on the three best words that would be included in the definition of the word.
- As a class share the top three words from each group and vote with a quick show of hands to select three words most likely to be found in the definition of the word. At this time, students can be asked to look up the word and share the definition with other students. Alternately, students can read the selected text and add to the definition after reading it in context.
- Have students process the vocabulary terms on the left page in the INB. Some suggestions are to have students use the word in sentences of their own, search for the word or its synonyms within the text or other course materials, draw pictures or diagrams to expand on the definition, or act out the word in a skit. Other processing ideas are in the *Processing Activities* section in the appendix.

Suggested INB Set-Up



Three-Column Cornell Notes

- The Cornell note format can be modified to have three columns: left column for questions, middle column for notes, and right column for vocabulary words and illustrations related to the words. Students' home language words can also be added to the right column.
- Model the use of three-column notes on an overhead projector or document camera during a class discussion. Identify key terms in the right column, and draw a diagram or picture that will help students understand and remember the terms.

Total Physical Response (TPR) Vocabulary

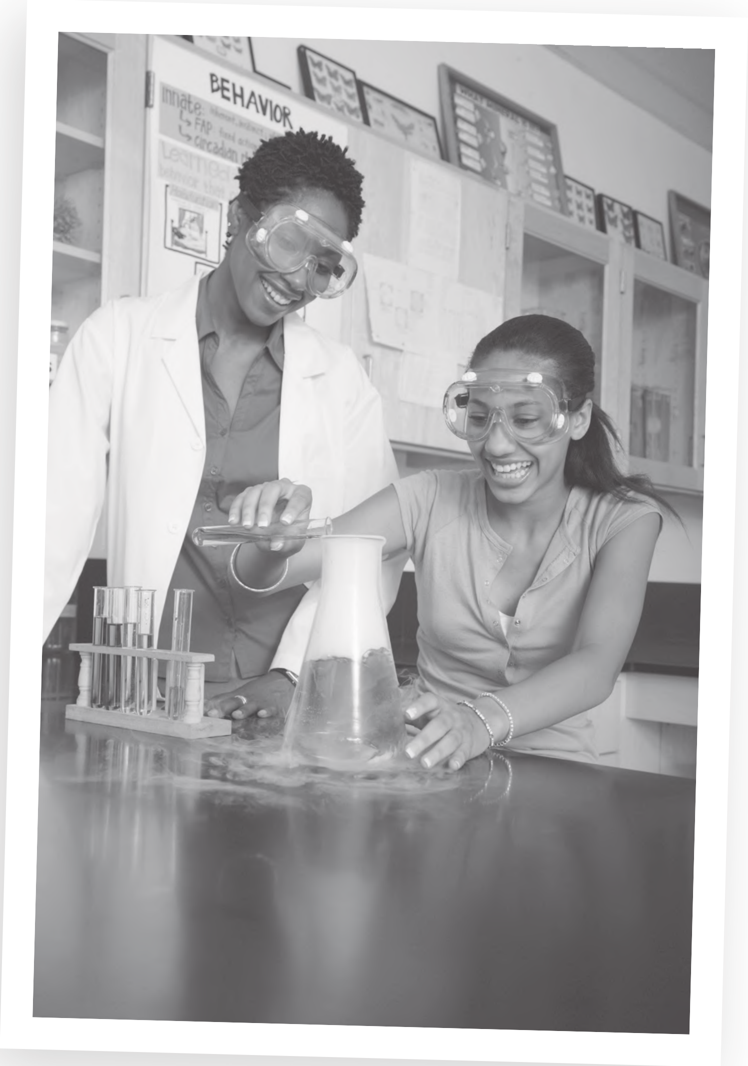
- Assign to each group of students a different vocabulary term or concept.
- Ask students to discuss and define the meaning of the term or concept to present with their performance.
- Have students work together to create a physical demonstration ("acting out") of the term or concept that may include an example.
- Have each group explain its definition of the word and present its physical demonstration of the term or concept.
- Conduct a class discussion about the performances and vocabulary words.

Vocabulary Bookmark

- Have students create vocabulary bookmarks to use to keep track of unfamiliar words before, during, or after they read a text or article. An alternative is to give students a list of words they should be familiar with as they read the text or article.
- You can print the *Vocabulary Bookmark* templates on cardstock paper so they will last longer. A suggested format for the bookmarks is to have students write their names, the name of reading passage, and the vocabulary words on the front of the bookmark and write the definition and draw an illustration of the word on the back of the bookmark.

Differentiation Strategies

- The vocabulary activities of this section are appropriate for all age groups and content areas.



STUDENT HANDOUT 5.1.1

Vocabulary Bookmark

Name:

Title of Article or Reading Passage:

Vocabulary Words:

Section 5.2

Marking the Text and Pausing to Connect

Introduction

“Marking the Text” is an active reading strategy that helps students determine the essential information in a reading passage. The strategy is characterized by numbering paragraphs, circling key terms, and underlining important information. Marking the text can be used with textbook readings, scientific articles, or classroom Cornell notes. Modeling the strategy and creating opportunities for students to practice and develop proficiency in using the strategy will provide them with a skill that will aide in their comprehension of difficult content material. Instructors should provide continued support to students as they become proficient in using this fundamental skill.

“Pausing to Connect” is another reading strategy to help students connect key terms and ideas within the text to create meaning from the text they are reading. During the reading process students will pause to reflect on what they read, visually mark connections among terms and ideas, and summarize the ideas presented.

Timeline

One class period

Objectives: The Students Will . . .

- Use critical reading strategies to comprehend text information
- Use strategies to incorporate new science vocabulary into their language
- Identify essential information and the supporting details within a text
- Develop questioning skills that increase the higher-order processing of the text

WICOR Strategies

Writing:	Construct notes and summaries
Inquiry:	Develop questions that synthesize the content of the reading and processing of content
Collaboration:	Peer review notes; work collaboratively on analyzing essential information from a text
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Read scientific texts to process and summarize the information

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Communicate scientific procedures and explanations

Content Standard A (Grades 9–12): Science as Inquiry

- Communicate and defend a scientific argument.

Materials

- Reading passage (text or article)

Handouts

Student Handout 5.2.1:	*Marking the Text: Science*
Teacher Reference 5.2.2:	*Marking the Text: Numbering Paragraphs, Circling Key Terms, and Underlining Author's Claims*
Teacher Reference 5.2.3:	*Marking the Text: Additional Ways to Isolate Key Information*
Teacher Reference 5.2.4:	*Pausing to Connect Essential Words*

Teacher Directions

- Select a reading passage to introduce students to the marking the text strategy. The reading can be a newspaper or magazine article, textbook, novel, or other consumable for which you have an intentional purpose within your content area. (You can also use the students' Cornell notes.) Make copies when appropriate so that each student will be able to write directly on the text.

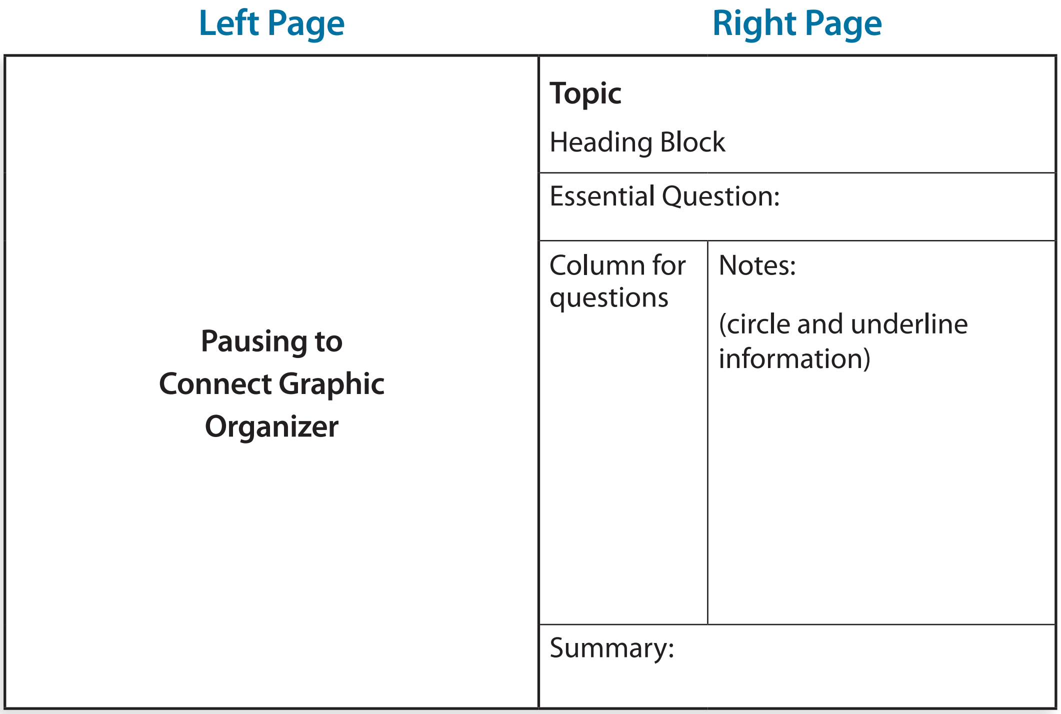
  Note: A technique for marking text copies you want to reuse with other students is to use overhead transparency sheets or sheet protectors that are split down a second side to slide over a page in a book. Students can use dry erase markers or overhead projector markers to mark the text.

- Distribute Student Handout 5.2.1: *Marking the Text: Science* to students. Discuss the three main components of marking the text.
- Distribute copies of the reading passage. If desired, you may want to have students read the text once before beginning the process of marking the text.
- Explicitly teach students how to number the paragraphs, even though this may seem to be a simple process. One way to involve the class in the numbering process is to ask them to call out the first word of paragraph one, then paragraph two, etc. Students could also work in partners or table groups to number the paragraphs.
- Use a document camera or overhead projector to display the text as you number the paragraphs, circle the key terms, and underline important information. As you take each step, solicit input from the students and explain why each step is marked.
- Additional ways to use the marking the text strategy:

  Students can also use the marking the text strategy with their Cornell notes by numbering paragraphs, circling key terms, and underlining important information. Using pens or pencils of different colors will give prominence to the marked items. Students can pair-share their notes, then add to their original markings using input from their pair-share partners.

  For lengthy or difficult texts, students can record the key terms and underlined information in the right column of the Cornell notes and create questions in the left column.

Suggested INB Set-Up



- Model how to pause and connect information from the text. (Refer to Teacher Reference 5.2.4.) Show how readers make sense of ideas by rereading sections of text or by connecting words or sentences to surrounding information. Explanations of the connections can be written in the margins of the text or on the left side of the INB.
- Once the connections have been made, allow students to discuss the connections they made in pairs or small groups.
- Have the student groups create a graphic organizer that shows the connection of information within the text. They can use a sample graphic organizer from Section 5.3 or create their own organizer.

Differentiation Strategies

- For younger students or those who require additional time for processing information, provide guided instruction, and use choral responses for marking the text and pausing to connect.
- Provide a word bank for students to use while taking Cornell notes and for marking the key terms. Students can also use sentence stems and the word bank for writing the summary.
- For students with low fine motor skills, use large-tip highlighters for the circling and underlining to avoid their drawing lines through the text with a pen or pencil.
- Encourage students to add visuals, color-coding, and other kinds of personalization to their text markings.
- Have students use different colored pens or pencils to differentiate between specific content vocabulary and academic vocabulary (e.g., predict, generalize, correlate, etc.).

- Allow students already proficient with techniques to be teachers in small groups or be the models to demonstrate each step of marking the text.
- Offer more sophisticated or longer texts to practice the techniques of connecting the ideas between paragraphs as well as between essential words.

Higher-Level Questions

- Create a symbol/picture to represent and help someone remember the definitions for each word.
- Do the vocabulary words or concepts have multiple meanings or uses outside of the science classroom?
- What are synonyms and antonyms for each of the vocabulary words?

ADDITIONAL RESOURCES

(n.d.). The university word list. Retrieved from http://auburn.edu/~nunnath/engl6240/wlistuni.html

Haywood, S. (n.d.). Academic vocabulary. Retrieved from http://nottingham.ac.uk/~alzsh3/acvocab/wordlists.htm

Marking the Text: Science

This Strategy has three distinct marks:

1. Number the paragraphs.

① Before you read, take a moment and number the paragraphs in the section you are planning to read. Start with the number one and continue numbering sequentially until you reach the end of the text or reading assignment. Write the number near the paragraph indention and circle the number; write it small enough so that you have room to write in the margin.

② As with page numbers, paragraph numbers will act as a reference so you can easily refer to specific sections of the text.

2. Circle key terms, cited authors, and other essential words or numbers.

You might circle…

• key concepts • content-based vocabulary • lesson-based vocabulary • names of people, theories, and/or experiments • properties • elements • formulas • units of measure • variables • values • percentages	• ____________________ • ____________________ • ____________________

3. Underline the author's claims and other information relevant to the reading purpose.

While reading informational texts (i.e. textbooks, reference books, articles, or journals), read carefully to identify information that is relevant to the reading task. Relevant information might include:

• concerns • claims • data • definitions • descriptions • evidence • examples • explanations	• guiding language • hypotheses • "if-then" statements • main ideas • methods • processes	• ____________________ • ____________________ • ____________________

Here are some strategies to help students identify essential information in the reading:

- Read the introduction to the chapter, lab, or article.
- Scan the text for visuals, vocabulary, comprehension questions, or other reading aids..
- Review your notes for key concepts.
- Preview chapter or unit reviews.

Marking the Text:
Numbering Paragraphs, Circling Key Terms, and Underlining Author's Claims

The following excerpt offers sample markings and brief descriptions of those markings. Notice the reading purpose for the excerpt. Without a reading purpose, young readers—especially those new to this strategy—will not know what to circle.

READING PURPOSE:

Number the paragraphs, circle key terms, and underline the author's claims.

"Watts Up" with Electric Vehicles?

① Public discussion and political debate about how to respond to the issues of climate change and a dwindling supply of non-renewable energies such as Mid-East fossil fuel are increasingly commonplace, and increasingly contentious. The current buzz about electric vehicles as a potential, clean energy solution is no exception.

② As people and politicians prepare to make consumer choices and policy decisions, it is crucial that both parties sift through exaggerated promises and look at the facts. If 10% of all vehicles on the road in the United States were electric vehicles (about 25 million of them), we would consume about 1 million fewer barrels of oil every day, or about 400 million fewer barrels per year. These new vehicles, however, would require as much electrical power as is used by about 75 million households. Because most electricity in the U.S. is generated by burning oil, natural gas, or coal—which is a dirty process that results in a large carbon footprint—this actually results in an increase in the number of barrels of oil consumed—and burned—per year, by about 80 million. And that doesn't even touch on the problems of what to do with 25 million dead lithium-ion batteries, or what to do about electrical grids that collapse when too many air conditioners get used on a hot day.

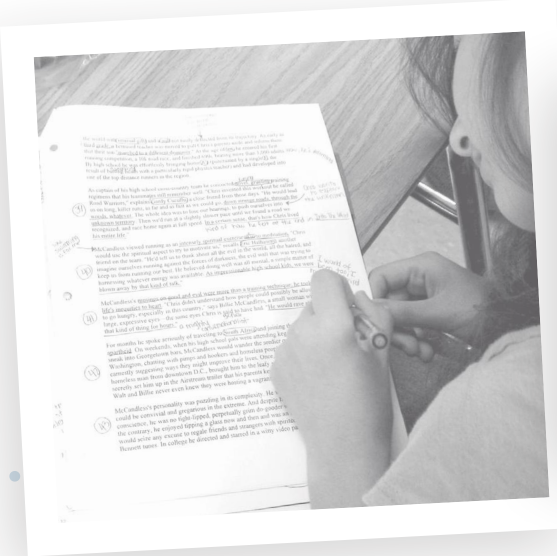
③ Before the federal government steers this country on the road to a $10,000 subsidy for anyone who wants to purchase an electric vehicle, we need to ease up on the electron pedal and think about whether this current "solution" to our energy and climate crises is a road to a cleaner, more sustainable world, or just a detour toward large profits for some, and even larger environmental issues for all.

Although words and phrases like "fossil fuel," "carbon footprint" and "subsidy" are not repeated, they are key terms because they directly relate to public policy and energy and climate concerns. In addition to the key terms, the author makes a claim in the second paragraph.

Marking the Text:
Additional Ways to Isolate Key Information

As students learn how to read and mark texts with greater proficiency, they will develop the need to expand their thinking about what to mark and how to mark it. As reading and writing assignments become more sophisticated, they will need to read a text for various purposes. The three original marks—numbering, circling, and underlining—may not offer enough flexibility for students who are reading for various purposes. For this reason, students should learn a few additional markings that will help them differentiate between one type of information and another. There are three new marks to consider:

[Bracket] information when underlining has been used for another purpose.	Students should use brackets to isolate relevant information that has not already been underlined. In fictional texts, students might underline descriptions of characters and bracket figurative language. While reading arguments, students might underline claims and bracket evidence. And in science, students might underline definitions and bracket data.
Write labels in the margins | claim	Writing labels in the margins is a strategy used by readers who mark the text and write in the margins. Labels are often double underlined so that they stand out from other marginalia (i.e. notes, comments, analysis, or drawings). When writing labels in the margins, draw a vertical line along the edge of the text in order to isolate the section of text being labeled. Readers will also use labels when charting the macrostructure of the text or when keeping track of shifts—places in the text where the author takes readers in a new direction or presents a new focus.
Box words when circling has been used for another purpose.	Sometimes readers need to keep track of two different types of words or ideas. For example, a reader might choose to circle key terms and keep track of an author's use of descriptive language. Having two distinct marks will make it easier to reference the material later.



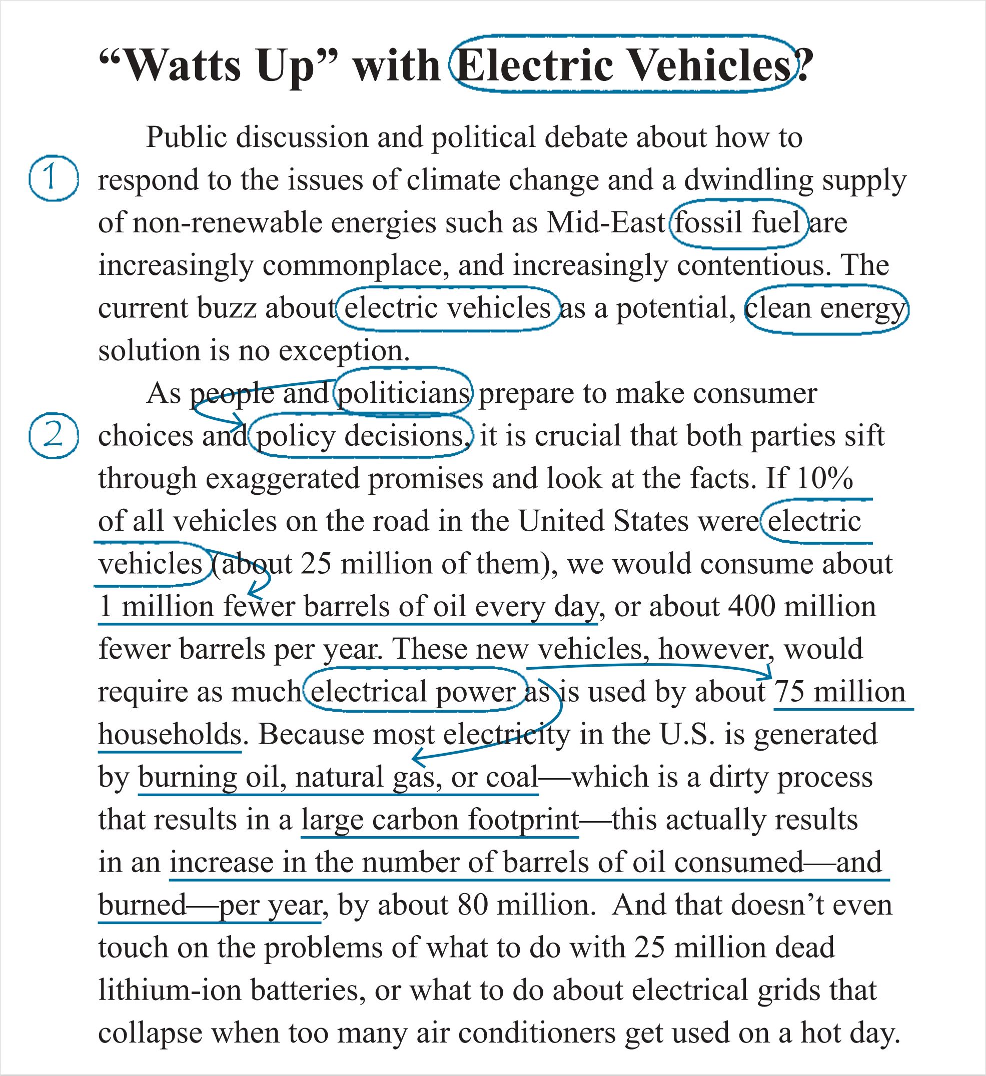
TEACHER REFERENCE 5.2.4

Pausing to Connect Essential Words

In this excerpt, the author discusses public policy and electric vehicle subsidies. The reader response at the bottom of the page offers one way a reader might pause to connect ideas within a text.

READING PURPOSE:

What is the author saying in paragraph two?



"Watts Up" with Electric Vehicles?

① Public discussion and political debate about how to respond to the issues of climate change and a dwindling supply of non-renewable energies such as Mid-East fossil fuel are increasingly commonplace, and increasingly contentious. The current buzz about electric vehicles as a potential, clean energy solution is no exception.

② As people and politicians prepare to make consumer choices and policy decisions, it is crucial that both parties sift through exaggerated promises and look at the facts. If 10% of all vehicles on the road in the United States were electric vehicles (about 25 million of them), we would consume about 1 million fewer barrels of oil every day, or about 400 million fewer barrels per year. These new vehicles, however, would require as much electrical power as is used by about 75 million households. Because most electricity in the U.S. is generated by burning oil, natural gas, or coal—which is a dirty process that results in a large carbon footprint—this actually results in an increase in the number of barrels of oil consumed—and burned—per year, by about 80 million. And that doesn't even touch on the problems of what to do with 25 million dead lithium-ion batteries, or what to do about electrical grids that collapse when too many air conditioners get used on a hot day.

Reader Response (Example of "Pausing to Connect")

What is the relationship between "electric vehicles," "fossil fuel," and "carbon footprint"? I think I understand the relationship. "Fossil fuels" like oil, natural gas, and coal are burned to create "electric power." Electric vehicles run on electric power, which doesn't directly produce pollution. So why does the author say that politicians need to think carefully before making "policy decisions" that will result in more electric vehicles? Maybe it is the actual impact of putting a lot more electric vehicles on the road that the author wants his or her readers to think about. Even though electric vehicles run on electric power, the U.S. burns fossil fuels to create electric power. Burning fossil fuels "results in a large carbon footprint," so an increase in electric vehicles would result in an increase in demand for electric power, and possibly an "increase in the number of barrels of oil consumed—and burned—per year." It makes sense to think about this. The policy decisions that politicians make should be based on facts, not just ideas that sound good.

Section 5.3

Critical Reading in Science: Graphic Organizers

Introduction

Reading in science requires a critical eye with a healthy skepticism to determine the bias, evidence, and impact of the claims in a reading sample. While reading, students can make sense of the information by using a graphic organizer to help organize information in a visual representation of the topic or concept. The visual of a graphic organizer can also help students organize their thought processes as they write about a topic.

There are many types and formats of graphic organizers. The ones presented in this unit support student processing of information while reading an article or text with science content. It is important to consider the type of reading selection so that students learn to select an appropriate graphic organizer to present the information that they gather.

Timeline

10–30 minutes depending on length of the reading assignment

Objectives: The Students Will . . .

- Organize information from scientific readings
- Summarize information using graphic organizers

WICOR Strategies

Writing:	Summarize with graphic organizers
Inquiry:	Select appropriate graphic organizers
Collaboration:	Group work on graphic organizers
Organization:	Plan and organize using Interactive Notebooks
Reading:	Read a text and create a graphic organizer

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Develop descriptions, explanations, predictions, and models using evidence.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

Handouts

Teacher Reference 5.3.1: *Graphic Organizer Synopsis*
Student Handout 5.3.2: *NEWS*
Teacher Reference 5.3.3: *NEWS Student Sample*
Student Handout 5.3.4: *R&R: Read and Recall*
Teacher Reference 5.3.5: *R&R Student Sample: Read and Recall*
Student Handout 5.3.6: *DDEE*
Teacher Reference 5.3.7: *DDEE Student Sample*
Student Handout 5.3.8: *Describing an Experiment*
Teacher Reference 5.3.9: *Describing an Experiment Student Sample*
Student Handout 5.3.10 *Descriptive Organizer*
Teacher Reference 5.3.11: *Descriptive Organizer Student Sample*
Student Handout 5.3.12: *Compare and Contrast Organizer*
Teacher Reference 5.3.13: *Compare and Contrast Organizer Student Sample*
Student Handout 5.3.14: *Sequence Organizer*
Teacher Reference 5.3.15: *Sequence Organizer Student Sample*
Student Handout 5.3.16: *Classification Organizer*
Teacher Reference 5.3.17: *Classification Organizer Student Sample*
Student Handout 5.3.18: *Analogy Graphic Organizer*
Teacher Reference 5.3.19: *Analogy Graphic Organizer Student Sample*

Teacher Directions

- Select a reading source to use as an example for creating a graphic organizer.
- Use a prereading strategy such as marking the text to develop the background knowledge of your students.
- Discuss the type of information presented in the article to guide students in selecting an appropriate graphic organizer. (See *Graphic Organizer Synopsis* for description of each type of graphic organizer.) Modeling the selection process will support student learning so that they can eventually select an appropriate output themselves.
- To add the graphic organizers to the Interactive Notebook, students should complete the graphic organizer on the left side with the text source or notes on the right side of the spiral.
- The graphic organizers should always be accompanied by a summary statement to convey the concept presented through the organizer.

Differentiation Strategies

- In addition to the summary statement at the bottom of the graphic organizers, an area for critical vocabulary for ELLs or others who struggle with the vocabulary input can also be added.

Graphic Organizer Synopsis

NEWS

NEWS helps students make personal connections to newspaper articles that make scientific claims. Students will determine the main newsworthy ideas in an article and the evidence supporting the claims presented. This organizer provides limited details and works well for short articles.

R & R: Read and Recall

This organizer is a variation of Cornell notes with Costa's Levels of Thinking. Students will number the paragraphs of a text, pause after reading each paragraph, and determine the question(s) that the author answered in the paragraph. The questions should be Level 1 and 2, and are written under the "read" column. On the "recall" side, students will make a bulleted list of the ideas that are important to answer each question. More rows can be added as needed. When the organizer is finished, students can study by asking themselves the questions in the read column and verifying their answer with the points in the recall column.

DDEE

The DDEE organizer requires students to **D**efine, **D**escribe, **E**xplain, and give **E**xamples of scientific concepts or terms. It helps to develop those skills for students in all content areas and grade levels. The organizer works well in helping students answer free-response or short-answer questions from a reading on a single concept, especially in preparing responses to prompts on Advanced Placement and International Baccalaureate exams. The organizer does not apply as easily to longer readings that have multiple themes or concepts discussed.

Describe an experiment

This organizer works for the critical components of classic science experiments (e.g., Rutherford's "scattering" experiment) that students are often expected to know. Understanding experimental design is taken to a higher level than naming variables and controls. Students are asked to describe the set-up/equipment and conclusions. They will also create a summary and add an illustration that describes the observations and conclusions of the experiment.

Descriptive Organizer

Science often requires students to describe a concept, process, or event. This organizer helps students to associate the appropriate words with the concept on the organizer.

Compare Contrast Organizer

Many science concepts require comparing and contrasting at deeper levels. This organizer helps students see the similarities and differences in concepts in a more organized manner than in a Venn diagram. The middle column of circles contains the common characteristics of the concepts being considered. The outer circles contain characteristics that are different between the two concepts. The teacher may need to help students determine the important ideas to include in the organizer. Graphics should be included with the organizer to enhance the ideas presented.

Sequence Organizer

Science is replete with processes that students must remember in specific orders. This graphic organizer focuses on the order and the details that support that order. The large rectangles represent the main events, and the smaller rectangles describe details of the process. Illustrations and a summary are required for this graphic organizer.

Classification Organizer

This organizer provides structure to information that requires classification. The general name of the group of items is written at the top of the organizer. On the next level are written the different groups that make up the general group. On the third level, the specific details of each group are written. Illustrations, diagrams, and pictures are required components of this graphic organizer.

Analogy

By creating analogies, students determine relationships between ideas by comparing them to other concepts that hold the same relationships. When students can compare one idea to something more concrete or accessible to them, they are processing at Costa's Level 2. This is an important step for students in science because it provides a connection to common aspects and makes students think about the concept more deeply. In this example, the summary is replaced with direct questions to guide student thought.

STUDENT HANDOUT 5.3.2

NEWS

Title of Article: ____________________

Date of Publication: ____________________

Author's Qualifications: ____________________

Noteworthy	
Evidence	
What does this have to do with me?	
Science connection	

Summary of Article:

Student Sample

NEWS

Title of Article: "NASA Mission Finds Water, Methane, Mercury on Moon"

Date of Publication: 10-21-2010

Author's Qualifications: Marc Kaufman is a Washington Post Staff Writer

Noteworthy	Scientists found water, mercury, silver, and gold at the moon's southern pole. They originally thought the moon had a few resources, but after the LCROSS (Lunar Crater Observation and Sensing Satellite) mission there are many more questions raised about the history of the Earth, the moon, and the universe that can be answered through studies of the frozen craters of the moon.
Evidence	Six investigators have written about the mission, so Schultz isn't the only one who wrote about this mission. The article described the way the information was gathered by saying, a "data-collecting shepherding spacecraft that followed the rocket [that crashed into the moon]...passed through the plum of debris created by the crash." This spacecraft examined the debris using spectroscopy to search for water and other compounds. We will only really learn more about the moon's resources after additional missions.
What does this have to do with me?	Since I'm interested in space travel, water found on the moon could power or help to create fuel for space rockets that I may ride in, or I could help build the technology that will use those resources. The information and clues hidden in the frozen poles of the moon could help me understand more about the history of the world and universe.
Science connection	This whole article is about science. The article talks about the compounds and elements found on the moon's south pole, how scientists' views of the moon changed because of this mission, how the percentages of water vapor and other elements were found, what spectroscopy is and one of its uses, future research that could be performed, and how using science could help us understand more about the history of the universe and world.

Summary of Article:

NASA crashed a rocket into the south pole of the moon so they could collect data on the contents of the soil. The findings changed scientists' views on the moon. New theories are emerging, and new research and innovations are starting.

R&R: Read and Recall

Number the paragraphs of a text, pausing after reading each paragraph to determine the Level 1 and 2 question(s) that the author answered in each paragraph. Write the questions in the "Read" column. On the "Recall" side, make a bulleted list of the ideas that are important to answer each question. More rows can be added as needed. Write a summary of the information in the text. You can use this organizer as a study tool by asking yourself the questions in the "Read" column and verifying your responses with the answers in the "Recall" column.

Paragraph Number	Read	Recall

Summary of Reading:

Student Sample

R&R: Read and Recall

Number the paragraphs of a text, pausing after reading each paragraph to determine the Level 1 and 2 question(s) that the author answered in each paragraph. Write the questions in the "Read" column. On the "Recall" side, make a bulleted list of the ideas that are important to answer each question. More rows can be added as needed. Write a summary of the information in the text. You can use this organizer as a study tool by asking yourself the questions in the "Read" column and verifying your responses with the answers in the "Recall" column.

Paragraph Number	Read	Recall
1-2	What is the study called? How did the researchers monitor the bears?	• "Big Brother" black bear • They watched the movements, metabolism, heart rate, and breathing of 5 black bears.
3	How does a bear's hibernation compare to other animals'? What is the scientific name for a black bear?	• Bears maintain a high body temperature unlike squirrels, chipmunks, raccoons, and skunks. • The bears stay groggy for two to three weeks after waking up. • Ursus americanus is the scientific name for a black bear.
4	How can the study of bear hibernation be applied to humans? How were these bears chosen?	• It can be used by putting injured or sick people in hibernation-like states. • Another use is to keep human muscle tone and bone mass from deteriorating in space and in beds without activity. • The bears were accustomed to people and too potentially dangerous to release.
5	Who is another researcher who has studied hibernating black bears?	• Lynn Rogers

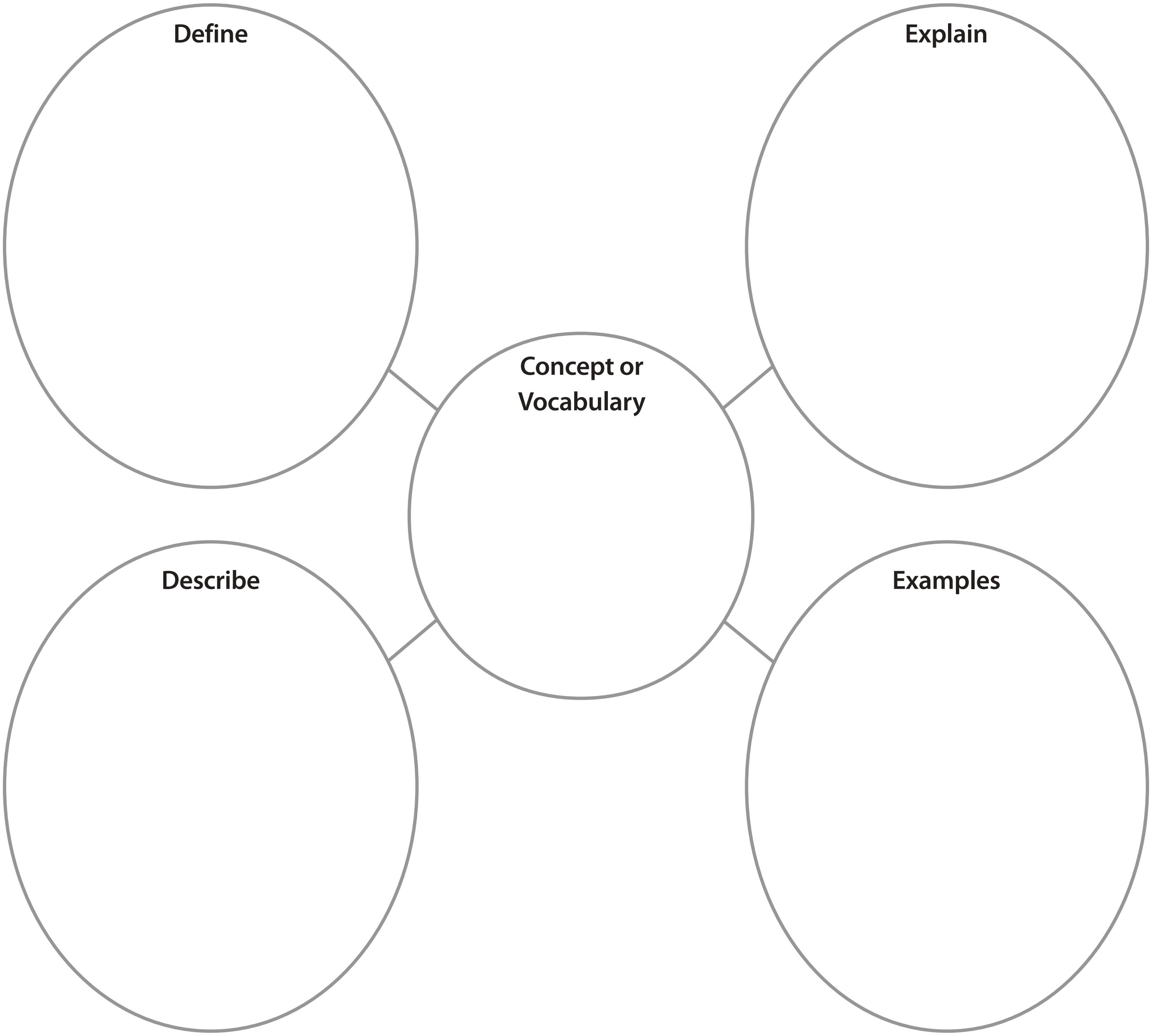
Summary of Reading:

This article describes a study that scientists carried out on hibernating bears in order to learn information that could be used in medical practices. It also describes new findings about bear hibernation, what possible uses their findings could have, and past ways researchers have collected data.

STUDENT HANDOUT 5.3.6

DDEE

Use the DDEE organizer to **D**efine, **D**escribe, **E**xplain, and give **E**xamples of a scientific concept or term. Beneath the organizer, write a paragraph description of the concept or term you used.



Written description of concept or term:

Student Sample

DDEE

Use the DDEE organizer to **D**efine, **D**escribe, **E**xplain, and give **E**xamples of a scientific concept or term. Beneath the organizer, write a paragraph description of the concept or term you used.

Define

A molecule (often a protein) that serves as a catalyst (lowers the activation energy) for a reaction

Explain

Bind to substance via induced fit

Lower activation energy

Work in own optimum environment

Change shape of substrate with help of cofactors

Concept or Vocabulary

Enzymes

Describe

Globular proteins

Have specific substrates to bind to

Continue to be used after reaction

Regulated by inhibitors

Examples

DNA helicase, DNA polymerase, Amylase, Pepsin, Peroxidase, Topoisomerase, Lactase

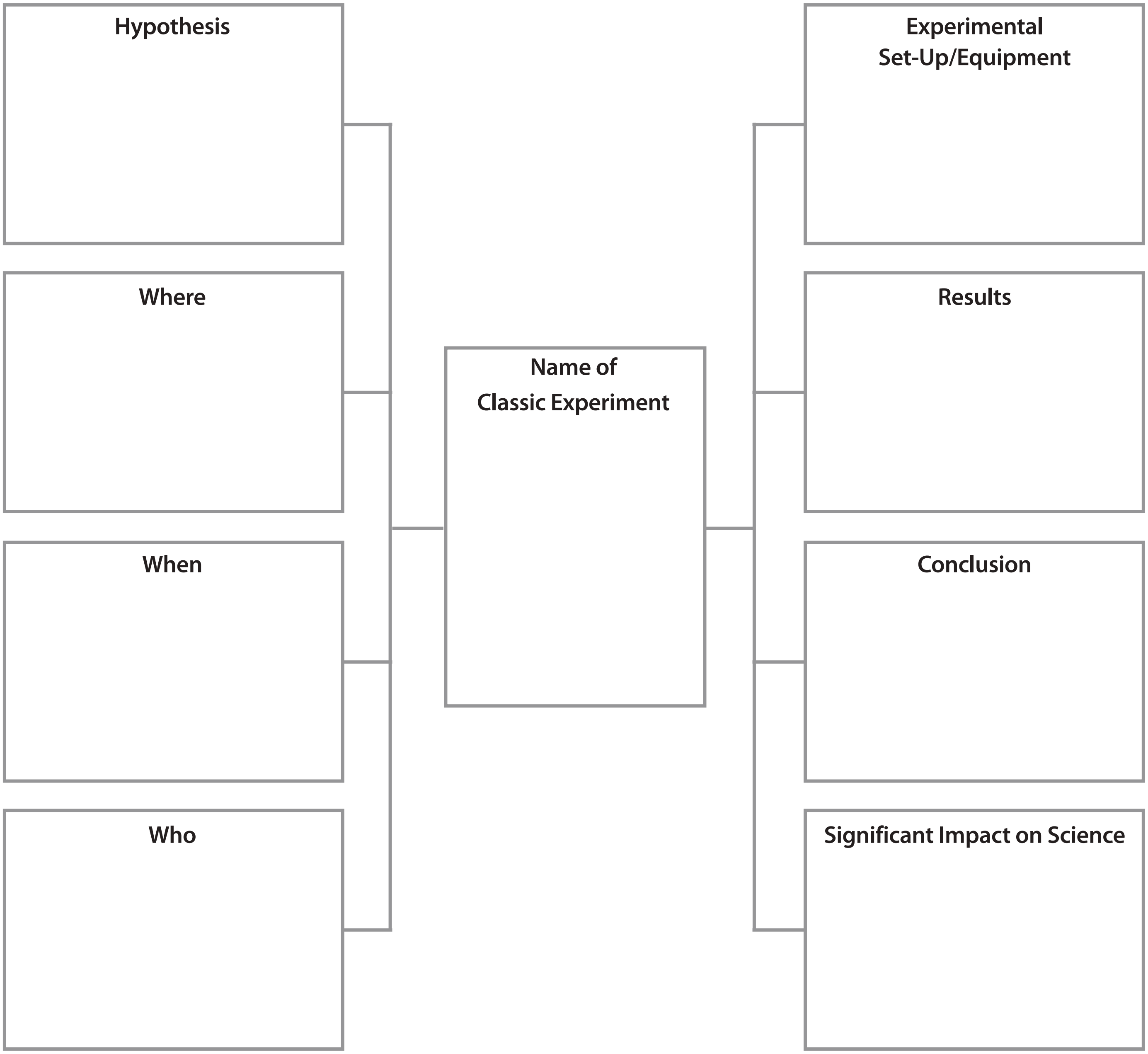
Written description of concept or term:

Enzymes are proteins that catalyze chemical reactions. Almost all chemical reactions in a biological cell need enzymes in order to occur at the rate necessary in the human body. Enzymes lower the activation energy of the reaction and cause the rate of reaction to increase. The substrates are converted into different molecules.

STUDENT HANDOUT 5.3.8

Describing An Experiment

Use this graphic organizer to think critically about a classic scientific experiment and its conclusions. Provide the stated information in each block, being sure to include sufficient information to help you understand and remember the components of the experiments. Write a paragraph summary of the experiment, and add an illustration that describes the observations and conclusions of the experiment.



Summary and illustration of experiment:

Student Sample

Describing An Experiment

Use this graphic organizer to think critically about a classic scientific experiment and its conclusions. Provide the stated information in each block, being sure to include sufficient information to help you understand and remember the components of the experiments. Write a paragraph summary of the experiment, and add an illustration that describes the observations and conclusions of the experiment.

Hypothesis

It was widely believed that bacteria were unchanging organisms throughout their lifetime. Even with the additional heat-killed pathogenic S cells, living nonpathogenic R cells will remain nonpathogenic.

Where

Britain

When

1928

Who

Frederick Griffith

Name of Classic Experiment

Griffith's Experiment

Experimental Set-Up/Equipment

Living R (nonpathogenic) cells were mixed with heat-killed S (pathogenic) cells and then injected into a mouse. Controls were living S cells, living R cells, and heat-killed S cells.

Results

Even though the mouse lived after being injected with only the living R and only the heat-killed cells, it died upon being injected with the mixture of the two just as it did after being injected by living S cells.

Conclusion

Griffith concluded that there must be an unknown substance in the heat- killed S cells that had transferred to the living R cells that had changed the phenotype of the R cells. He named that process transformation.

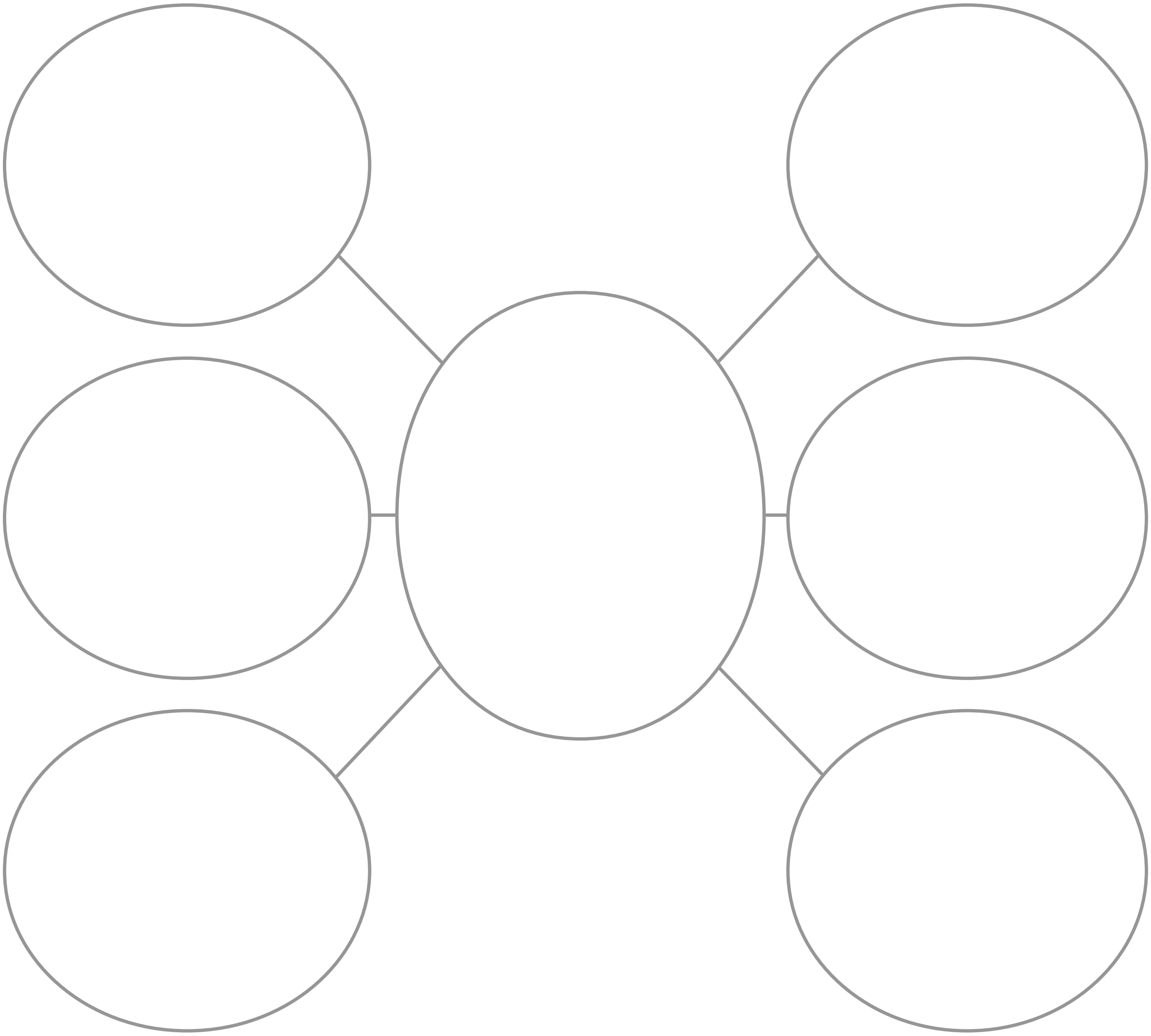
Significant Impact on Science

Griffith's findings were among the first to push away from the widely prevailing dogma of monomorphism revealing that there is something that could be transferred from bacteria to bacteria that dictates their phenotype. Oswald Avery later showed that the substance is DNA.

STUDENT HANDOUT 5.3.10

Descriptive Organizer

The descriptive organizer is used to describe an event, concept, topic, or theme. Describe the main idea in the center circle. In the surrounding circles, add information on the characteristics that describe the central concept. Write a summary and include an illustration of the concept, topic, or theme.



Written description and illustration of concept, idea, or object:

Student Sample

Descriptive Organizer

The descriptive organizer is used to describe an event, concept, topic, or theme. Describe the main idea in the center circle. In the surrounding circles, add information on the characteristics that describe the central concept. Write a summary and include an illustration of the concept, topic, or theme.

TOPOGRAPHICAL MAPS

Topo means place.
Graph means writing or picture.

Relief: difference in elevation between two points
Low relief means flat; high relief means steep.

Show surface shapes and features of Earth, both natural and manmade

Show surface shapes and features of Earth, both natural and Contour lines: imaginary lines on Earth's surface, connecting points of elevation; widely spaced on gentle slopes, close on steep

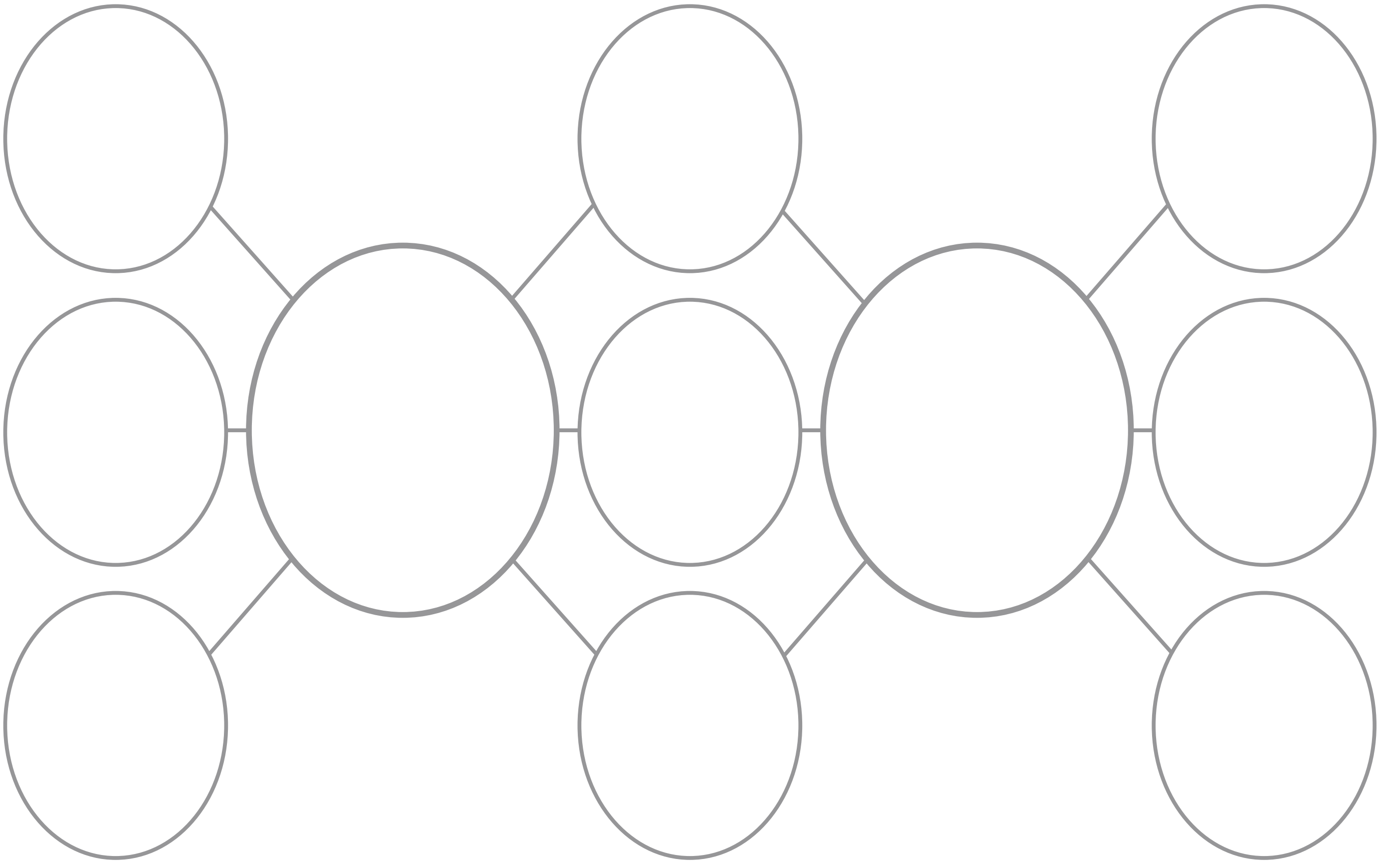
Scale: relationship between distance on the map and true distance on Earth's surface; usually expressed as fraction or ratio

Contour intervals: difference in elevation between adjacent contour lines; marked with elevation above sea level

Written description and illustration of concept, idea, or object:

Compare and Contrast Organizer

This organizer compares and contrasts two concepts. The middle column of circles contains the common characteristics of the concepts being considered. The outer circles contain characteristics that are different between the two concepts. Write a summary of the concepts and include an illustration of the summary.

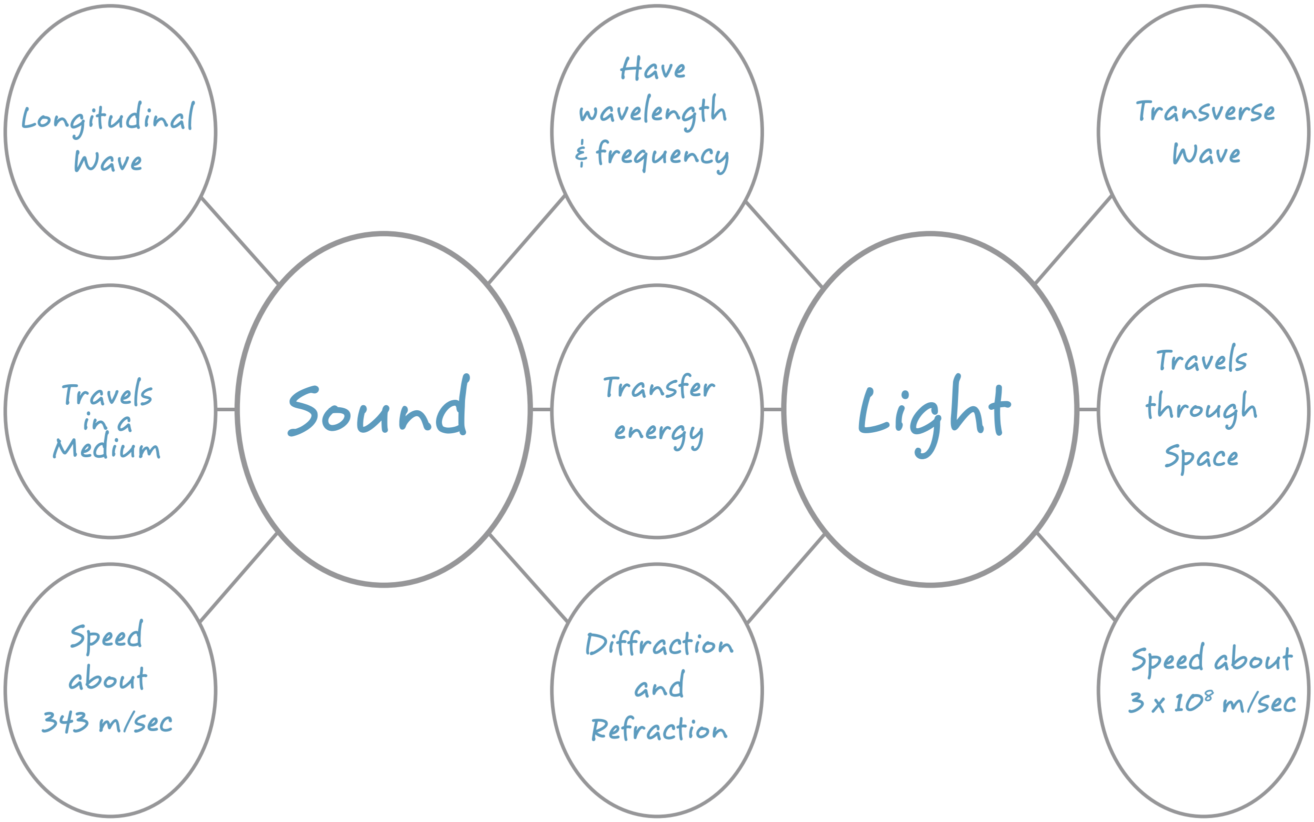


Summary and illustration of the concepts:

Student Sample

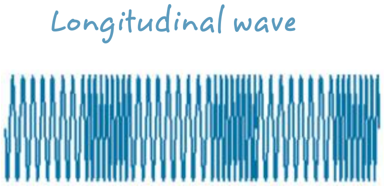
Compare and Contrast Organizer

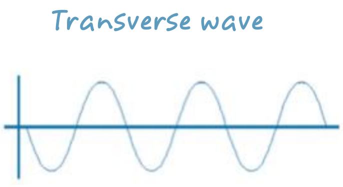
This organizer compares and contrasts two concepts. The middle column of circles contains the common characteristics of the concepts being considered. The outer circles contain characteristics that are different between the two concepts. Write a summary of the concepts and include an illustration of the summary.



Summary and illustration of the concepts:

Sound waves are longitudinal waves that travel through particles of matter. Their speed is about 343 m/second, which is much slower than that of light. Earthquakes also produce longitudinal waves. Both sound and light waves have wavelengths and frequency, and they have the properties of diffraction and refraction. Light is a transverse wave and can travel through a vacuum since it does not have to have particles of matter through which it travels. The speed of light is about 3×10^8 m/sec or about 186,000 miles per second.





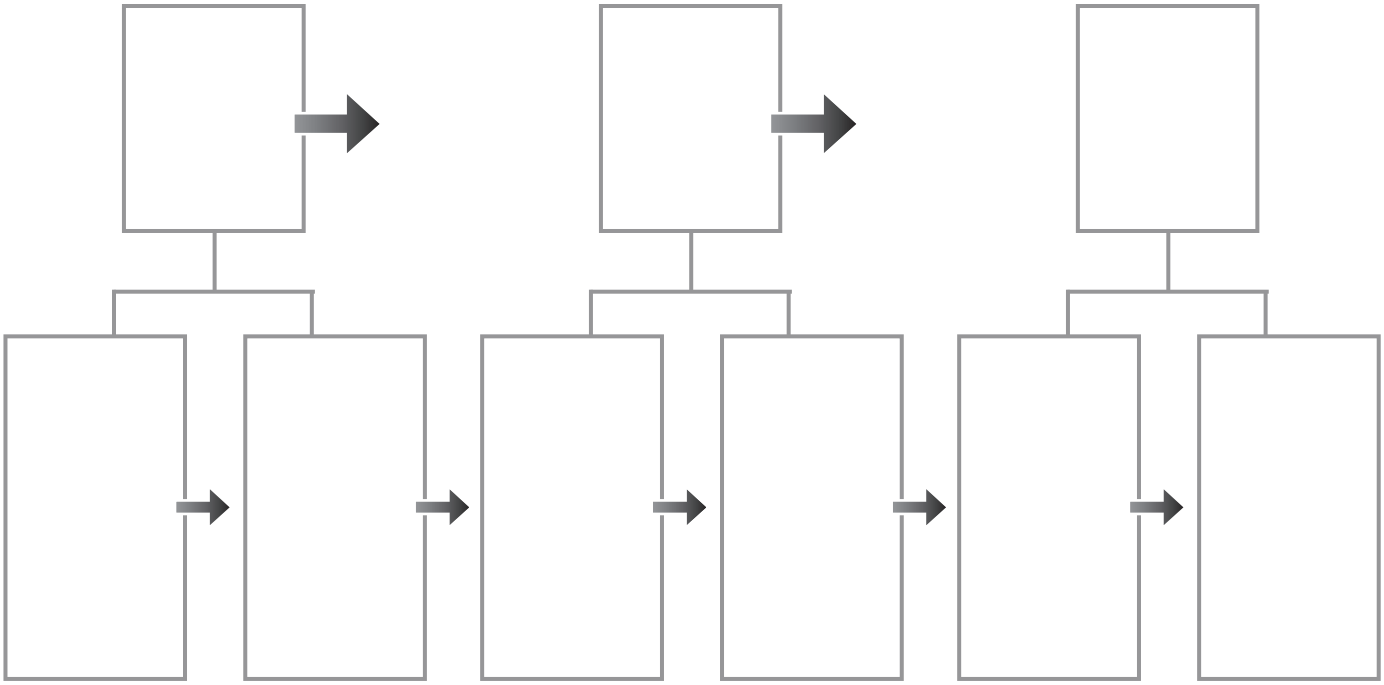
STUDENT HANDOUT 5.3.14

Sequence Organizer

In examining the processes of science, students must be able to describe items in order. This graphic organizer focuses on the order and the details that support that order. The large rectangles represent the main events, and the smaller rectangles describe details of the process. Illustrations and a summary are required for this graphic organizer.

Process:____

Purpose of Process: ____



Summary of Process:

Sequence Organizer

In examining the processes of science, students must be able to describe items in order. This graphic organizer focuses on the order and the details that support that order. The large rectangles represent the main events, and the smaller rectangles describe details of the process. Illustrations and a summary are required for this graphic organizer.

Process: Angiosperm Reproduction

Purpose of Process: Ensure continuation of plant's genetic line

Sporophyte → Gametophyte → Sporophyte (And Repeat) (Alternation of Generation)

2n → n	n	2n	2n	2n	2n
Meiosis	→ Pollination	→ Fertilization	→ Seed Development	→ Germination	→ Growth
Production of male and female gametophytes	Pollen finds Stigma and pollen tube begins growing	Male and female gametophytes fuse to form zygote,	Embryo, endosperm, and seed coat develop so that the seed can survive until it germinates. Possible dormancy, depending on environment.	Growth begins, root and shoot break through seed coat	Meristematic growth as the plant matures and lives, eventually develops flower

Summary of Process:

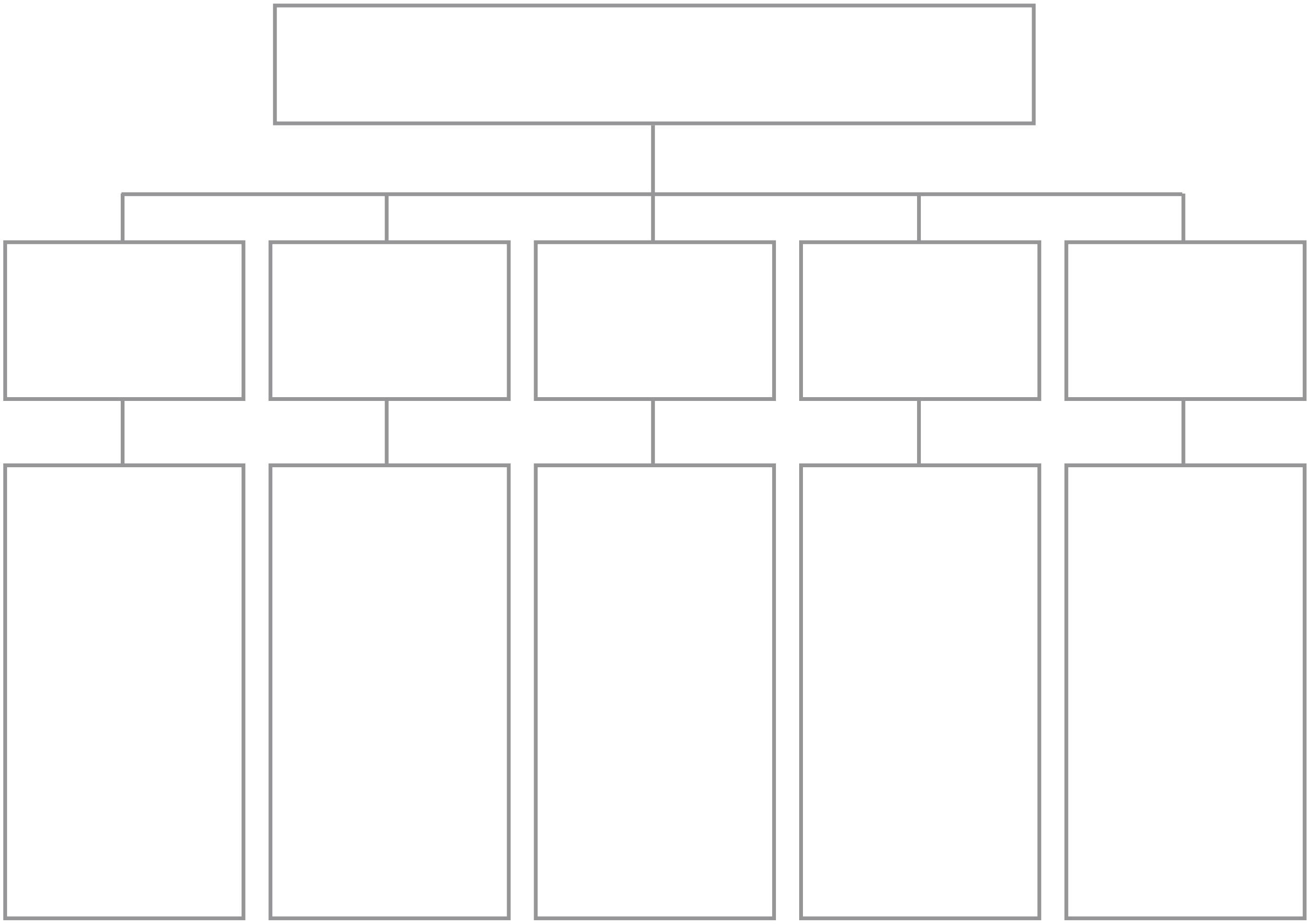
In the mature flower of a 2n angiosperm plant, meiosis occurs in 2 locations. In the anthers, 2n microsporocytes give rise to n male gametophytes through meiosis, as the 2n megasporocytes in the ovules of the ovary, The male gametophyte travels to the stigma of another angiosperm (to ensure genetic variability) encased in a pollen grain, and the tube cell works to push the generative cell to the overy with a pollen tube. The Male and female gametophytes fuse to form a zygote, which is supplied with nutrition by the endosperm as the seed develops. When the seed is properly imbibed, the root and stem breach the seed coat and grow in opposite directions, as the plant grows into an adult angiosperm

Classification Organizer

This organizer provides structure to information that requires classification. The general name of the group of items is written at the top of the organizer. On the next level are written the different groups that make up the general group. On the third level, the specific details of each group are written. Illustrations, diagrams, and pictures are required components of this graphic organizer.

Guiding questions:

- What are the specific members of the group?
- Are there things that might go into multiple groups?
- Is there another way to classify this information?

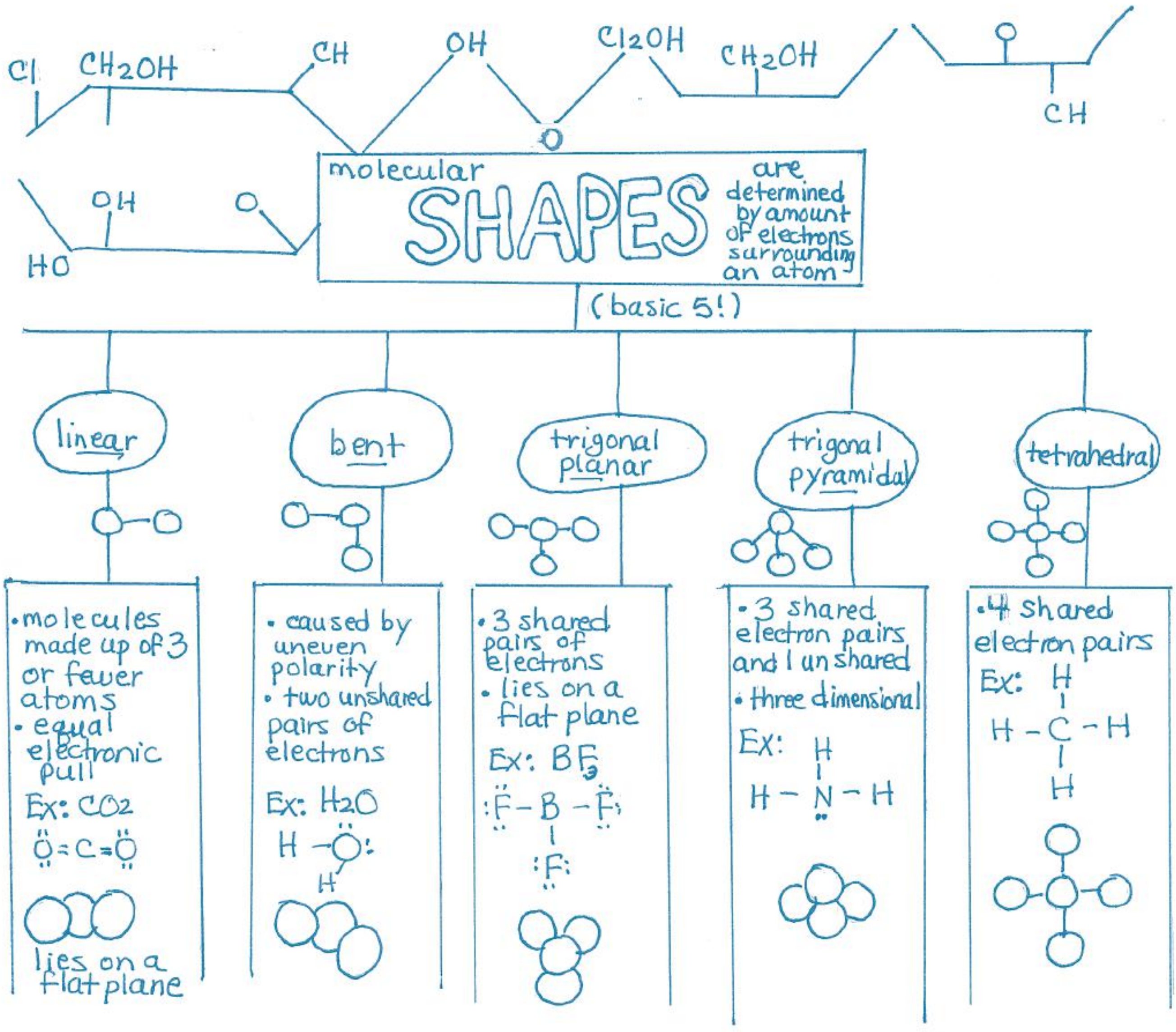


Summary of Classification:

Student Sample

Classification Organizer

This organizer provides structure to information that requires classification. The general name of the group of items is written at the top of the organizer. On the next level are written the different groups that make up the general group. On the third level, the specific details of each group are written. Illustrations, diagrams, and pictures are required components of this graphic organizer.



molecular SHAPES are determined by amount of electrons surrounding an atom

(basic 5!)

linear
- molecules made up of 3 or fewer atoms
- equal electronic pull

Ex: CO_2

Ö=C=Ö

lies on a flat plane

bent
- caused by uneven polarity
- two unshared pairs of electrons

Ex: H_2O

H–Ö:
H

trigonal planar
- 3 shared pairs of electrons
- lies on a flat plane

Ex: BF_3

:F̈–B–F̈:
:F:

trigonal pyramidal
- 3 shared electron pairs and 1 unshared
- three dimensional

Ex: H
H–N–H

tetrahedral
- 4 shared electron pairs

Ex: H
H–C–H
H

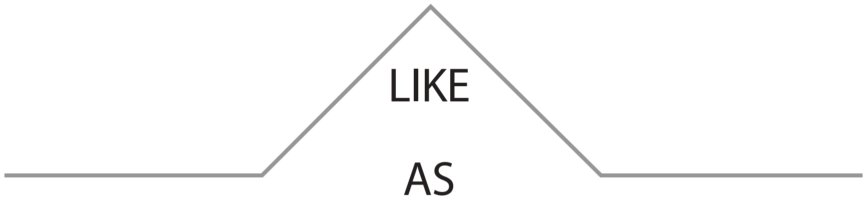
STUDENT HANDOUT 5.3.18

Analogy Graphic Organizer

An analogy shows a relationship between concepts, events, or ideas by comparing them to other concepts, events, or ideas that hold similar relationships. In words the relationship is expressed as "A is to B as C is to D." The summary for the analogy graphic organizer is replaced with questions to guide your thought.

Instructions

1. Choose two concepts, people, or ideas that are related in some way, and place them on the left side of the analogy chart.
2. Explain the relationship between these two events.
3. Choose two other concepts that are related to one another in the same ways as the first two, and place them on the right side of the analogy chart.



Guiding Questions

- What is the common relationship between these two concepts or ideas?
- Because relationships are never exactly the same, explain how the relationship for both pairs of things are the same and different.
- What other pairs of relationships can be seen?

Student Sample

Analogy Graphic Organizer

An analogy shows a relationship between concepts, events, or ideas by comparing them to other concepts, events, or ideas that hold similar relationships. In words the relationship is expressed as "A is to B as C is to D." The summary for the analogy graphic organizer is replaced with questions to guide your thought.

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1. Choose two concepts, people, or ideas that are related in some way, and place them on the left side of the analogy chart.
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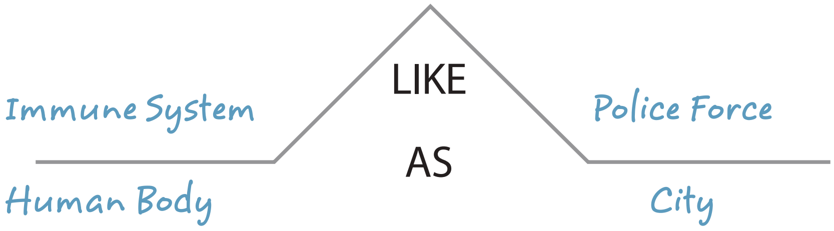


Guiding Questions

- What is the common relationship between these two concepts or ideas?

  Both the immune system and the police force serve as active protection for the human body and the city, respectively.

- Because relationships are never exactly the same, explain how the relationship for both pairs of things are the same and different.

  They are the same because both the immune system and the police force are "patrolling" for elements that would cause harm for their city/human body. The immune system attacks anything it thinks could be harmful, but the police force must have probable cause to act. The immune system is constantly alert everywhere in the body, but the police force is on only in certain locations at any given time.

- What other pairs of relationships can be seen?

  An army for its country

  A shell for a hermit crab (more of a passive relationship)

Section 5.4

One-Pager

Introduction

The One-Pager is a strategy for responding to a wide variety of learning experiences such as a reading, demonstration, video, field trip, or essential question from a unit of study. It can be described as a collage combining visual and textual elements that represent the student's processing and thoughtful response to the learning experience.

On a single piece of paper or poster board, students design an original graphic interpretation of the learning experience, which includes a personal response to the experience as a whole. The response can be a summary, answer to an essential question, or an interpretation. Additionally, the One-Pager must include quotes relating to the topic, higher-level questions to provoke further thoughts, essential vocabulary, and a symbolic border that encompasses all components.

Timeline

60 minutes

Objectives: The Students Will . . .

- Create a visual and textual interpretation of the learning experience
- Respond and make creative connections to the learning experience

WICOR Strategies

Writing:	Write questions, summaries, and personal responses
Inquiry:	Analyze a text and write questions according to Costa's Levels of Thinking
Collaboration:	Work in groups to create interpretations of a learning experience; perform a gallery walk of student products
Organization:	Plan and organize using an Interactive Notebook
Reading:	Read and analyze a content-area text or article

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Think critically and logically to make the relationships between evidence and explanations.
- Communicate scientific procedures and explanations.

Content Standard A (Grades 9–12): Science as Inquiry

- Recognize and analyze alternative explanations and models.
- Communicate and defend a scientific argument.

Materials

- Reading passage
- White paper, colored pencils, highlighters (optional: computer graphics)

Handouts

Student Handout 5.4.1:	*One-Pager*
Teacher Reference 5.4.2:	*One-Pager Student Sample*
Teacher Reference 5.4.3:	*One-Pager Score Card*

Teacher Directions

- Provide students with a content-rich reading assignment. Ask students to mark the text by numbering the paragraphs and reading and highlighting the main idea, key vocabulary, and significant quotes or statements. Students should also create a Costa's Level 2 or 3 question based on the main idea from each paragraph.
- After students have read the assignment, distribute (or display) and review the requirements on the *One-Pager* handout.

  Title (based on the content). Encourage the use of color and make the title reflect the concept using creative fonts.

  Symbolic border to represent the theme of the reading. The border may repeat the same pattern or use a variety of symbols and visuals.

  Main idea of the reading

  Three images to create a central focus of the One-Pager. The images can be drawings, computer graphics, symbols, or magazine pictures.

  Five essential vocabulary words/phrases. The words or phrases should express the main ideas, or students' impressions, feelings, or thoughts about what was read.

  Two significant quotations from the reading. The quotations must be in proper format.

  Two questions, Costa's Level 2 and 3, and their answers. The questions should be based on the underlined important content.

  Personal response. The response should summarize the information on the One-Pager or make real-life connections to the information.

- If the One-Pager is an INB assignment used to process a reading assignment, it should be placed on the left side corresponding to the article on the right page.

Suggested INB Set-Up

Left Page	Right Page
One-Pager	Reading selection

- Display the One-Pagers throughout the room and have students complete a gallery walk as a learning experience and to see how others represented the reading.
- Use the *One-Pager Score Card* to assess the completed One-Pagers.

Differentiation Strategies

- The One-Pager naturally provides all the essential components needed for differentiation. Although students will follow the same instructions, the individual response and creativeness will be evident in the final product.
- The One-Pager can also be used to respond to a variety of learning experiences, such as a discrepant event, teacher demonstration, video clip, guest speaker, or as an answer to an essential question posed during a unit of study.

Higher-Level Questions

- How does the One-Pager help to compare and contrast essential information in a reading selection?
- Explain how the quotations capture the essence of the reading passage.

One-Pager

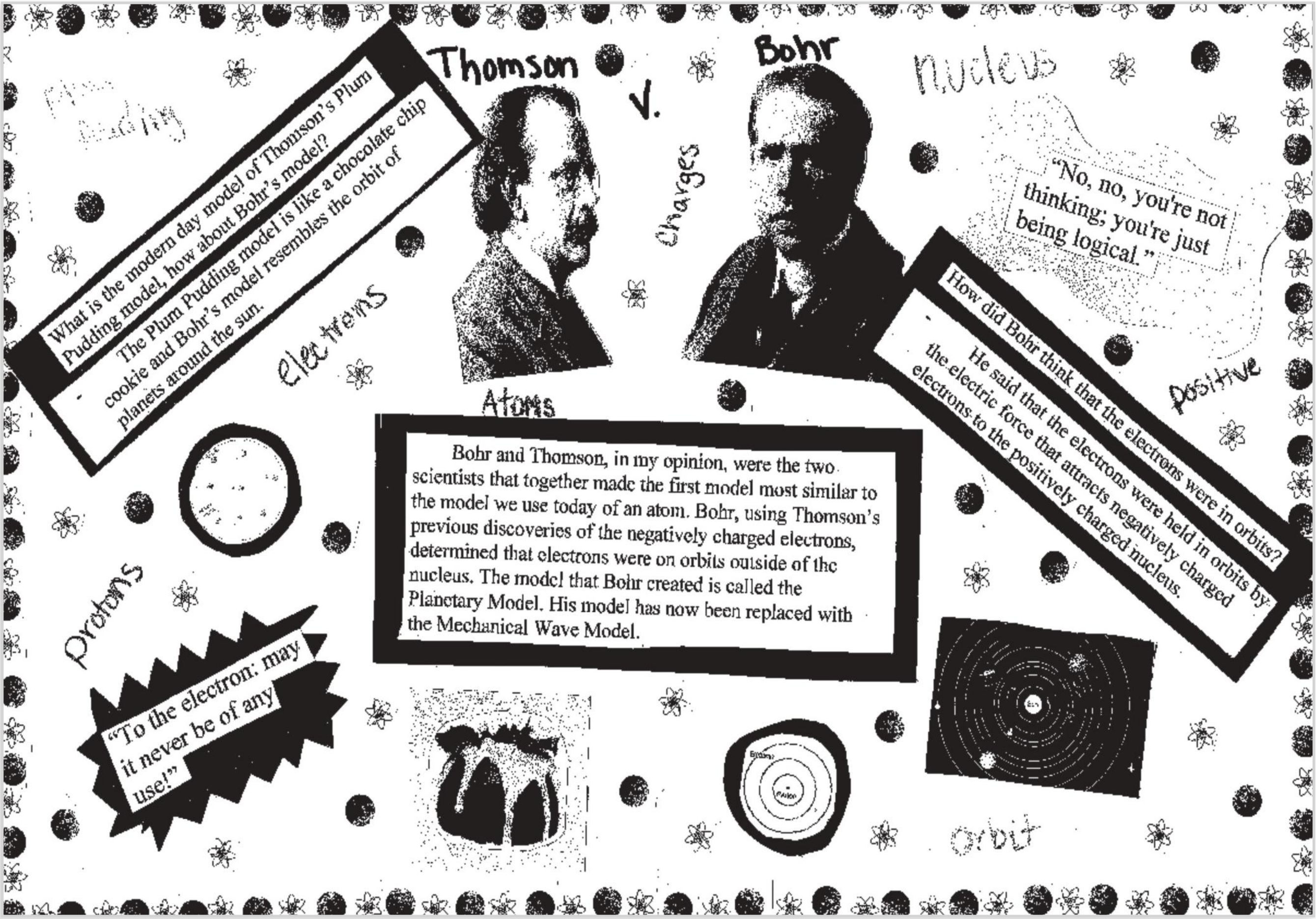
A One-Pager is a creative response to your learning experience. It allows you to respond imaginatively while being brief and concise in making connections between words and images. We think about what we see and read differently when we are asked to do something with what we have seen or read. We learn best when we create our own ideas. Your personal thinking about what you have experienced should be understood by the audience that views the One-Pager.

Follow this format for your One-Pager.

- ☐ Use unlined white paper.
- ☐ Title the One-Pager appropriately to reflect the content.
- ☐ Use colored pens, pencils, or markers. The more visually appealing it is the more your peers will learn.
- ☐ Fill the entire page.
- ☐ Be purposeful about the arrangement of your One-Pager. For example, have a reason for using a certain color or for placing an object in a certain place.
- ☐ Write two quotations from the reading or activity. Use the proper grammatical format.
- ☐ Use three visual images, either drawn or cut out from magazines, to create a central focus to your page. If you use a computer image, personalize it to make it your own.
- ☐ Place five essential vocabulary words/phrases around the images. These terms/words/phrases should express the main ideas, your impressions, feelings, or thoughts about what you have seen or read.
- ☐ Write the main idea of the reading.
- ☐ Write two Costa’s Level 2 or 3 questions and answer them.
- ☐ Put a symbolic colored border around the edges of the page.
- ☐ Write your name on the back.

Student Sample

One-Pager



What is the modern day model of Thomson's Plum Pudding model, how about Bohr's model?

The Plum Pudding model is like a chocolate chip cookie and Bohr's model resembles the orbit of planets around the sun.

"No, no, you're not thinking; you're just being logical."

How did Bohr think that the electrons were in orbits?

He said that the electrons were held in orbits by the electric force that attracts negatively charged electrons to the positively charged nucleus.

Bohr and Thomson, in my opinion, were the two scientists that together made the first model most similar to the model we use today of an atom. Bohr, using Thomson's previous discoveries of the negatively charged electrons, determined that electrons were on orbits outside of the nucleus. The model that Bohr created is called the Planetary Model. His model has now been replaced with the Mechanical Wave Model.

"To the electron: may it never be of any use!"

One-Pager Score Card

	Points
Title and symbolic border represents theme of content	/2
Two quotes that represent the concept	/5
Three graphics tied to the quotes and/or the information as a whole	/5
Five key vocabulary terms	/3
Two higher-level questions and answers	/5
Thoughtful personal response	/5
Total	/25

Section 5.5

Comparative Analysis

Introduction

When a scientist finds a plant, animal, or chemical reaction that is not recognized, he or she turns to reference materials that provide descriptions of the characteristics of the "new discovery." These characteristics are grouped by similarities. The scientist tries to classify the organism or reaction by finding the group that the new discovery most resembles. This process involves being able to identify similarities and differences between two or more objects or phenomena. Determining differences between similar objects is often the basis for new discovery in science. Geology, comparative anatomy, and forensic science use comparative analysis frequently to identify new specimens and phenomena in nature.

Identifying similarities and differences is a powerful instructional strategy, which Marzano et al. describes as the "core" of all learning. He also states that, "It enhances students' understanding of and ability to use knowledge" (Marzano, 2004, p. 155). This instructional skill represents Costa's Level 2 thinking because it allows students to process and analyze as they identify common and dissimilar characteristics.

A Venn diagram continues to be one of the most popular graphic organizers used to help students identify similarities and differences, but there are several other organizers that encourage this level of student thinking as well. A compare and contrast organizer and comparison matrix require students to list more similarities and differences and require them to process the content at a higher level. Using a variety of organizers can help to provide differentiation to ensure the success of all students working with all content.

Timeline

60 minutes

Objectives: The Students Will . . .

- Write qualitative and quantitative observations and inferences
- Use a Venn diagram to examine similarities and differences
- Analyze similarities and differences to classify and identify items
- Synthesize similarities and differences to create an original diamante poem

WICOR Strategies

Writing:	Write a quickwrite description
Inquiry:	Apply Costa's Levels of Thinking in processing activities
Collaboration:	Work with a partner in peer reviews
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Complete peer review summaries

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Develop descriptions, explanations, predictions, and models using evidence.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Materials

- Objects, specimen, diagrams, or models for analysis

Handouts

Teacher Reference 5.5.1:	*Venn Diagram Rubric*
Student Handout 5.5.2:	*Diamante Poem*
Teacher Reference 5.5.3:	*Diamante Poem Student Sample*

Teacher Directions

- There are two variations on this lesson design.

  The students can be given actual objects, diagrams, or models to observe and interpret for the quickwrite. (See Section 2.1.) This variation is more kinesthetic and allows students to actually practice recording high-quality quantitative and qualitative observations and inferences.

  The second variation allows students to think, reflect, and compare various concepts learned during a unit of study.

- Provided below in Figure 1 is a sample of objects, models, and diagrams that can be used in the observation lesson. Figure 2 provides a brief list of concepts that can be used during or after a unit for comparison of two things.

Figure 1: Objects/Diagrams/Models for Comparison

Biology/Life	Physical/Chemistry	Earth/Environmental	Physics
• Plants (leaves, flowers) • Animal specimens • Cells (animal, plant), insects, invertebrates, vertebrates	• Chemicals (ionic and covalent) • Elements (metals, nonmetals, metalloids) • Tools (beaker, graduated cylinder) • Periodic table	• Rocks • Minerals • Planets • Moon phases	• Circuits (parallel, series) • Machines • Motion (velocity and speed)

Figure 2: Specific Concepts for Comparison

Biology/Life	Physical/Chemistry	Earth/Environmental	Physics
• Prokaryotic vs. eukaryotic • Abiotic vs. biotic • Gymnosperm vs. angiosperm • Vertebrates • Kingdoms • Types of reproduction • Body systems	• Physical vs. chemical changes • Matter (elements, compounds, and mixtures) • Phases of matter • Acids and bases • Types of chemical reactions • Periodic table • Types of bonds	• Layers of Earth • Clouds • Landforms • Geological time periods • Physical vs. chemical weathering • Rocks • Minerals • Types of precipitation	• Parallel vs. perpendicular • Potential vs. kinetic energy • Conductors vs. insulators • Newton's 3 Laws • Motion (displacement, velocity, and acceleration) • Mirrors and lenses

- Distribute to each student an object, diagram, or concept to be analyzed. Have students complete a three-minute quickwrite on a right page in which they describe in detail all of the physical/chemical properties, characteristics, uses, and functions of the object or concept. Stress the importance of including as many descriptors as possible. Encourage students to include a sketch, color picture, or diagram of the object/concept.

Suggested INB Set-Up

Left Page	Right Page
Venn diagram Summary statements Diamante poem	Quickwrite and picture of object/concept New information

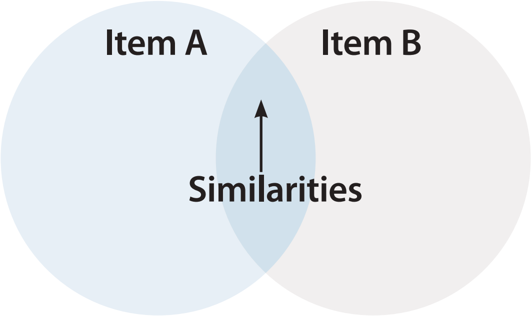
Pair-Share

- Instruct students to find the partner who has an "opposite" object or concept (e.g., *physical and chemical* properties). Students will switch papers and read the other partner's quickwrite. The partners will edit and add any new information to their partner's quickwrite. The pair will then discuss the edits and addition of any new information.

Venn Diagram

- The partners will use a Venn diagram (see Figure 3) to compare the characteristics of the objects/concepts. Students will list the characteristics that are unique to each sample in the circle that represents only the object/concept it describes. Have them write all the similarities between the two objects/concepts in the center where the circles overlap. (You may assign students a certain number of characteristics to list in each circle to make sure that they thoroughly analyze the similarities and differences.)

Figure 3: Venn Diagram



Summary

After students have completed the Venn diagram, they should write summary statements to demonstrate clear understanding of the relationships that exist between the objects being compared. The following questions can be used as prompts to help them express how the objects compare.

What categories of characteristics or attributes are used to compare and contrast these objects?
What are the most important qualities or attributes that make them different?
What can we conclude about these objects or concepts?
What did you learn by comparing the objects or concepts?

Pair-Share Squared

The partners will now find a second set of partners who have the same objects or concepts. The pair-share squared teams will work together to create a **diamante poem**. (See *Diamante Poem Template*.) The diamante poem is a style of poetry that requires students to create a product using the similarities and differences identified in the Venn diagram. The student teams will share their poems with the class by sharing their INBs through use of a document camera.

The students can also create the diamante poems on chart paper. The class can then view each poem during a gallery walk. (See *Active Learning Strategies* in Unit 4.) This will allow students to review each set of concepts discussed in the unit multiple times.

Differentiation Strategies

- Students may work with one or two partners to compare three objects, models, or concepts. A sample Venn diagram is included that can be used to compare and contrast three objects/concepts.
- The following graphic organizers can also be used to distinguish similarities and differences and differentiate the lesson for various students.

A Bull's Eye Diagram (See *Processing Activities* in appendix.)

Comparison Matrix: The comparison matrix, an effective analytic tool, serves to determine the essential characteristics of objects and concepts. The comparison matrix uses an aggregation method to outline the most typical features and properties of a set of items without drawing a conclusion directly. The matrix simplifies the process of analysis and can be used for a multitude of objects, complex concepts, or to challenge more advanced students. (See Figure 4.)

Figure 4: Comparison Matrix—Atomic Particles

Atomic Particles	Location	Charge	Purpose
Proton	Nucleus	Positive (+)	Identity
Electron	Electron Cloud	Negative (–)	Chemical Reatcivity
Neutron	Nucleus	Neutral (o)	Nuclear Glue

Higher-Level Questions

- What physical and chemical properties helped you determine similarities and differences for the object, model, or concept?
- Predict how comparing three objects would affect determination of the differences among the objects, models, and concepts.

Venn Diagram Rubric

Objects being compared in the Venn diagram:

______________________________________ and ______________________________________

The following rubric should give you ideas about evaluating the Venn diagram.

Criteria	Not Evident	Adequate Progress	Excellent Mastery
Accuracy of comparison statements	Few or none of the statements are supported by the text.	Most statements are supported by the text.	All statements are supported by the text.
Structure and relationships within the Venn diagram	Few statements are placed in the correct circle.	Most statements are placed in the correct circle, but students mixed up a few statements.	All statements noting similarities are placed in the center circle and all statements that note differences are placed in the correct outer circle.
Number of quality statements	Students make two or fewer comparison statements in each circle.	Students are able to make three to four comparison statements in each circle.	Students are able to make five or more comparison statements in each circle.
Collaboration	One partner always relied on partner to do the work.	Both partners worked, but one needed to be reminded to contribute.	Both partners shared the work equally.

STUDENT HANDOUT 5.5.2

Diamante Poem

A diamante poem follows a very specific format. There are seven lines, and each line must have a specific number and type of words. The topic noun in line 1 is opposite to the ending noun in line 7. When finished, the poem will be in the shape of a diamond!

Line 1: Topic **(noun 1)**

Line 2: **Two** describing words **(adjectives for noun 1)**

Line 3: **Three** action words ("-ing" **verbs for noun 1**)

Line 4: **Four** words: Two words about the topic and two words opposite to those in line 2

Line 5: **Three** action words for the ending noun ("-ing" **verbs for noun 2**)

Line 6: **Two** words to describe the ending **noun 2**

Line 7: Ending **noun 2** (opposite of Line 1)

Topic 1

Topic 1 Diagram

Topic 1 Explanation

________ (noun)

________ (adjective) ________ (adjective)

________ (-ing verb) ________ (-ing verb) ________ (-ing verb)

________ (word describing noun 1) ________ (word describing noun 1) ________ (word describing noun 2) ________ (word describing noun 2)

________ (-ing verb) ________ (-ing verb) ________ (-ing verb)

________ (adjective) ________ (adjective)

________ (noun)

Topic 2 Explanation

Topic 2 Diagram

Topic 2

Student Sample

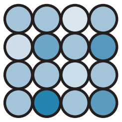
Diamante Poem

A diamante poem follows a very specific format. There are seven lines, and each line must have a specific number and type of words. The topic noun in line 1 is opposite to the ending noun in line 7. When finished, the poem will be in the shape of a diamond!

Line 1: Topic **(noun 1)**
Line 2: **Two** describing words **(adjectives for noun 1)**
Line 3: **Three** action words ("-ing" **verbs for noun 1**)
Line 4: **Four** words: Two words about the topic and two words opposite to those in line 2
Line 5: **Three** action words for the ending noun ("-ing" **verbs for noun 2**)
Line 6: **Two** words to describe the ending **noun 2**
Line 7: Ending **noun 2** (opposite of Line 1)

MATTER

Matter is anything that has mass and volume. It has three phases and is made up of atoms and molecules.



Matter
(noun)

Observable Substantive
(adjective) (adjective)

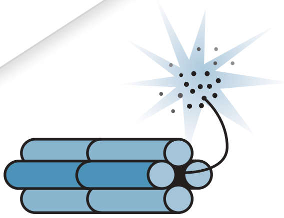
Existing Rearranging Weighing
(-ing verb) (-ing verb) (-ing verb)

Mass Particles Dynamic Potent
(word describing noun 1) (word describing noun 1) (word describing noun 2) (word describing noun 2)

Transforming Causing Transferring
(-ing verb) (-ing verb) (-ing verb)

Potential Kinetic
(adjective) (adjective)

Energy
(noun)



Energy causes something to happen. It can be potential (stored) or kinetic (dynamic). There are several types of energy that transform into different types.

ENERGY

Section 5.6

Get Curious and Ask Questions

Introduction

One goal most science teachers have is directing students to be inquisitive and inquiry-oriented. This activity helps students ask analytical questions about the text that they are reading. It is excellent support for journal articles, science fairs, and other independent research activities.

Timeline

30 minutes

Objectives: The Students Will . . .

- Analyze a scientific article
- Connect scientific ideas to previous knowledge
- Determine the validity and potential bias of scientific arguments

WICOR Strategies

Writing:	Summarize an article
Inquiry:	Develop questions and make connections between ideas
Collaboration:	Edit with peer groups
Organization:	Plan and organize using note-taking and Interactive Notebooks
Reading:	Prepare a graphic organizer during the reading process

National Science Education Standards

Content Standard A (Grades 5–8): Science as Inquiry.

- Develop descriptions, explanations, predictions, and models using evidence.

Content Standard A (Grades 9–12): Science as Inquiry

- Formulate and revise scientific explanations and models using logic and evidence.
- Communicate and defend a scientific argument.

Materials

- Peer-reviewed journal article or other scientific article

Handouts

Student Handout 5.6.1: *Get Curious & Ask Questions*

Teacher Directions

- Provide students with a journal article that relates to class material and is at or just above their reading/content levels. The articles can be varied in the classroom so that each student can select one that is appropriate for him or her.
- Assign reading and explain the graphic organizer format.
- Have students complete the four square chart as they read.
- Stop students after five minutes to pair-share with a partner or triad and then add to their graphic organizer.
- Continue reading and debriefing throughout the article.
- Conclude the activity with a paragraph summary of the article.

Suggested INB Set-Up

Left Page

So what?	Says who?
What if...?	What does this remind me of?

Right Page

Journal article:

Journal:

Author(s) with qualifications:

Date of publication:

(Article taped in as a flip page)

Differentiation Strategies

- In preparing this lesson, consider the variety of student readiness levels for scientific journals. Provide options for students to select from a variety of sources. These can include a scientific journal article you chose, a related article from *Science* magazine or another technical publication that is more popular science than peer-reviewed journal, or a source that discusses scientific studies as source information such as a newspaper or other magazine. Help students make appropriate selections based on their learning level and preparation.
- For students completing background research in advanced academic settings, select a variety of journal articles to pique interest and cover some applications that students could use to extend their studies.

STUDENT HANDOUT 5.6.1

Get Curious and Ask Questions

Four questions that you should always be asking in science are: “So what?” “Says who?” “What if…?” and “What does this remind me of?” Each of these questions helps you to determine the real meaning of text, connect ideas to what you already know, and determine the presence of any bias. The four questions can be powerful in analyzing scientific articles as well as many other aspects of the world around us.

So what?	How is this significant? What does this tell me? What can I infer from the observations and data presented? *Example:* What does the fact that all life is made of cells tell us?
Says who?	Is this a fact or someone’s opinion? How can this be verified? Does this depend on someone’s point of view? *Example:* How do we know that cells replicate their DNA? What experiments have been done? Who did them?
What if?	What would happen if…? What if I did _____ to _____? *Example:* What would happen if cells stopped dividing?
What does this remind me of?	Where have I seen this content before? What does it make me think about in science? *Example:* What does the cell cycle remind me of?

Write the following headings and corresponding information on a right page in your INB about the article that you are reading.

Journal article:

Journal:

Author(s) with qualifications:

Date of publication:

Complete the four-square grid below on the left page of the INB facing the information above.

So what?	**Says who?**
What if...?	**What does this remind me of?**

Appendix

Writing to Learn
Processing Activities

In order to use the INB effectively, students must process and analyze the concepts, vocabulary, and information they are supposed to learn. There are many activities you can use for left-side INB processing of the content. The following activities highlight writing-to-learn strategies that can be used as output for the INB. All levels of students have used these strategies to learn, including students from the upper elementary to Advanced Placement and International Baccalaureate classes, as well as English language learners and students with learning disabilities.

The processing activities can be used for topics, concepts, events, vocabulary, figures, and equations. In the activity descriptions these will be generically referred to as concepts. Each activity requires writing, a nonlinguistic representation, and an explanation. ("Do it, draw it, describe it.") The level of these products will depend on the skills, background, and sophistication of the students in the class. The length of the writing portion should be at least one paragraph, but can be varied depending on the teacher's directions.

The purpose of each activity is stated with the instructions. When students demonstrate understanding in a different form than they have learned it, they truly show what they understand. Limiting a student's word count or providing a strict format increases the rigor of the assignment because they need to understand the material and then express themselves articulately within the limits provided.

Non-Linguistic Graphic Representation (Illustration)

Purpose: *Use different parts of the brain to demonstrate content mastery.*

1. On the left side of the INB, develop a non-linguistic graphic representation or illustration to represent one of the assigned concepts.
2. Create a slogan or phrase that captures the essence of the concept.
3. Demonstrate the concept in a real-life situation.
4. The illustration must use multiple colors and be suitable for all ages and all situations.
5. A two- to three-paragraph explanation should be written underneath the artwork.

Variations

- *Lost or Found:* Make a lost or found poster about the assigned concept.
- *Band Buzz:* Design a logo for a band named after the assigned concept.
- *Protest Sign:* Create a protest sign emphasizing the assigned concept.

Question Cards

Purpose: *Create study cards that summarize concepts.*

Question cards are written to reflect and review information. The question is placed on the front of the card. A summarized answer is placed on the back of the card. Cards should be placed in the INB in an attached envelope or pocket. An alternative is not to include these in the INB but to have students purchase a ring to hold all questions cards throughout the year.

Vocabulary Card Instructions: Visual Writing

Purpose: *Create study cards for major vocabulary terms and concepts.*

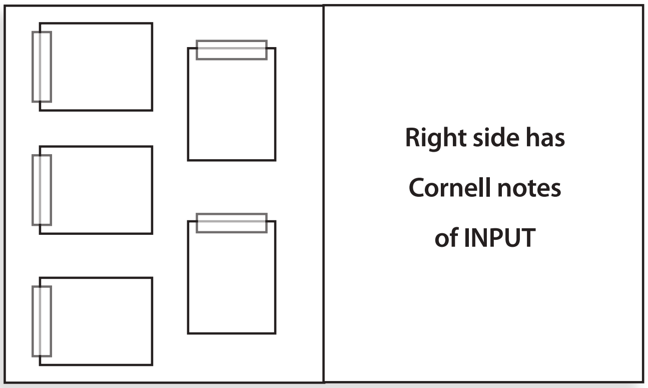
Made on 1/8 of a sheet of paper, the cartoon or diagram side is taped facing up on the page (see illustration). Use the vocabulary cards to review information by looking at the diagram and making the connection between the diagrams or pictures and the figure, term, or event.

Front Side—Cartoon or Diagram

1. Diagram or cartoon in multiple colors
2. Minimal writing on this side of the card

Back Side—Explanation

1. Word (spelled correctly)
2. Link—a word useful in remembering the word. The meaning should be known and can be a word related to or rhyming with the vocabulary word.



3. Definition—meaning of word using terms the student understands (one sentence)
4. Usage sentences—two sentences explaining the meaning of the vocabulary word
5. Attach cards to left side of INB or attach on ring for studying.

Riddle Cards: Poetry

Purpose: *Limit student writing length to select most powerful words.*

The purpose of a riddle card is to assist students in learning and understanding concepts covered in class that are necessary for understanding. The riddle and diagram are placed on the front of a card. The riddle and diagram side is taped facing up. The answer and explanation are placed on the back of the card.

Front Side

1. Riddle—the riddle should contain one or more clues. The clues might or might not rhyme, but must refer to aspects of the answer.
2. Artwork—the multicolored artwork should reflect the topic of the riddle with a clue that might help solve the riddle.

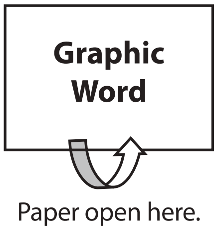
Back Side

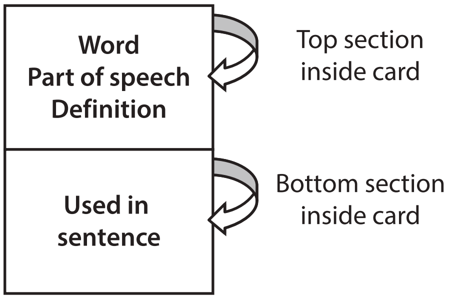
1. Answer to the riddle—the answer must be clearly and cleanly written across the top of the card.
2. Explanation—the explanation must be below the answer and explain how the clues and artwork lead to the answer. The explanation should be two to three sentences in length.

Fold-It 1: Explain One Term—Visual Writing

Purpose: *Process single vocabulary terms.*

1. Fold a piece of paper in half.
2. On the front of the "tent," write the word and create a multicolored illustration representing the term.
3. On the top section of the inside when unfolded, write the word on the top "line," part of speech on the second "line," and then write the definition of the word in your own words on the third "line."
4. On the bottom section of the inside when unfolded, write a sentence with the word to clarify its meaning.
5. Glue into INB on the left side as OUTPUT.

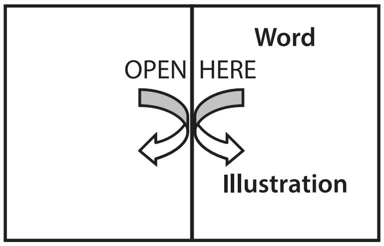


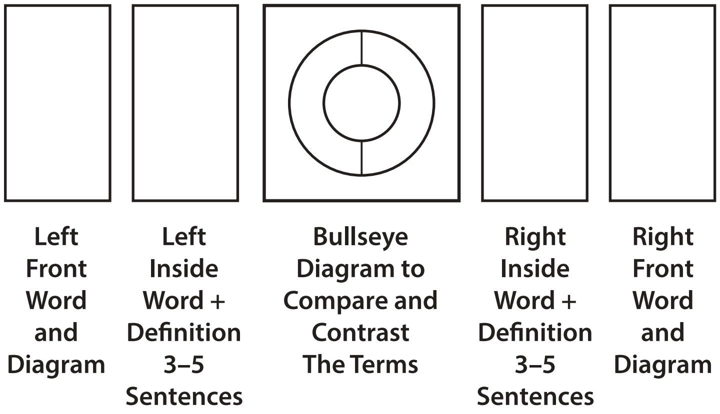


Fold-It 2: Compare and Contrast Two Terms—Visual Writing

Purpose: *Compare and contrast two related vocabulary terms.*

1. Hold the paper landscape in front of you. Fold the two side edges (the shorter of the edges) inward until they meet in the center. Crease the sides.
2. With the edges still folded, meeting at the center, write one term on the left fold and create a multicolored illustration. Repeat this process on the right side for the second word.
3. Open the flaps. On the left flap from the edge to the fold, write the word and definition in your own words using three to five sentences. Repeat this process for the right-side flap.
4. Create a bulls-eye diagram in the center section to compare and contrast the two terms.

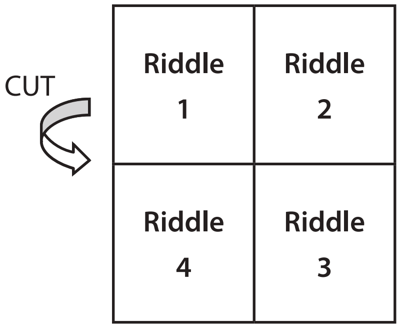


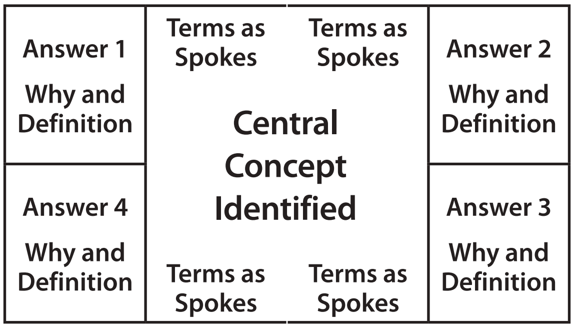


Fold-It 4: Concept Map—Visual Writing

Purpose: *Differentiate among four different vocabulary terms.*

1. Hold the paper landscape in front of you. Fold the two side edges (the shorter of the edges) inward until they meet in the center. Crease the sides.
2. Cut each flap in two (to form two 'doors').
3. Outer flaps—place a riddle and a multicolored illustration on each flap.
4. Inside each flap—write the riddle answer and the reason why the riddle and diagram show this.
5. Central area—construct a concept map with the terms as spokes. Be sure to have the reason connecting the term to the central concept.

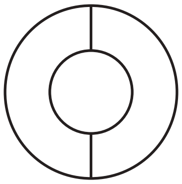




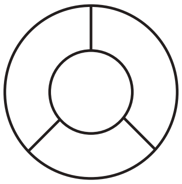
Bull's-Eye Comparison: Visual Writing

Purpose: *Compare and contrast two or three concepts using a bull's-eye diagram.*

1. Draw the bull's-eye diagram for the number of terms that you are comparing.
2. Label each area with one of the terms.
3. Make a comprehensive list of the differences between the two topics on the outside sections. List unique characteristics for the appropriately labeled section.
4. Make a comprehensive list of similarities between the topics in the center of the bull's-eye.
5. To the right of the bull's-eye, create a multicolored illustration that shows how the topics are related.
6. Below the bull's-eye, write a paragraph that explains how the illustration and similarities are connected.



2 Topic

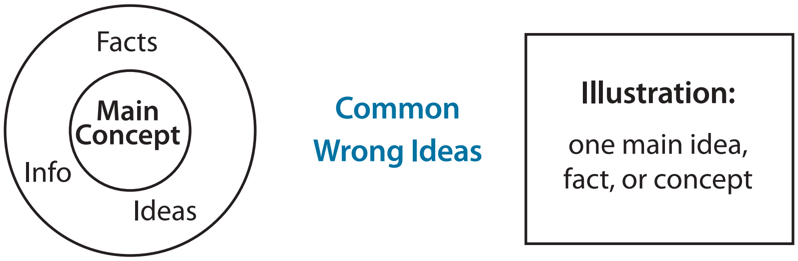


3 Topic

The Ring of Truth: Visual Writing:

Purpose: *Identify misconceptions about science concepts.*

1. Draw the Ring of Truth diagram on the left side of the INB.
2. In the inner circle, write the term or concept being reviewed.
3. In the outer circle, list specific facts, ideas, and information about the term or concept.
4. Outside the Ring of Truth, write down common wrong or incorrect ideas or information that the Person On The Street (POTS) might have about the term or concept.
5. To the right, include a multicolored diagram showing one main idea, fact, or concept about the main term or concept.
6. Underneath the Ring of Truth, write at least two paragraphs explaining why the wrong ideas are incorrect and why people might have these misconceptions.



addressing misconceptions

Single Frame Cartoon Project: Genre Writing

Purpose: *Visualize a concept in a different way.*

The Top Half of the Left Side of the INB

1. Create a multicolored, single-frame cartoon (like *The Far Side)* representing the assigned concept.
2. The only text allowed is a maximum of two lines for a caption. Speaking bubbles are okay, but not encouraged.

The Bottom Half of the Left Side of the INB

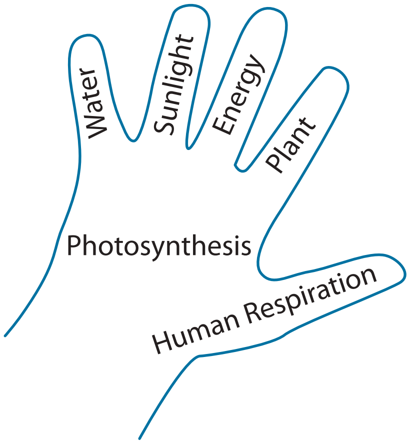
1. State the concept, event, or figure being shown. Center under the cartoon.
2. Write a paragraph explaining how the cartoon shows or addresses the assigned concept, event, or figure.
3. Write a paragraph explaining how the caption represents and reflects the assigned concept, event, or figure.

Grasping a Concept: Analogy

Purpose: *Identify key ideas related to a concept studied in class and explain the connections.*

Imagine a hand with five digits around a palm. The palm holds the main concept. Each digit is one aspect of the concept.

1. Trace your non-writing hand.
2. In the palm area, write the concept and make a simple multicolored sketch representing it.
3. On each digit, write a vocabulary term, minor concept, figure, event, or equation related to the topic on the palm.
4. At the end of each digit include a simple multicolored sketch representing what is on the digit.
5. The thumb opposes the other digits, so the thumb should have a related but somewhat opposite or different slant than the other digits.
6. Below the hand, write a three-paragraph explanation. The first paragraph explains the sketch in the palm of the hand. The second paragraph explains how the information on the digits relates to the topic on the palm. The final paragraph must explain how the thumb information is related but is opposed to the other digits' information.

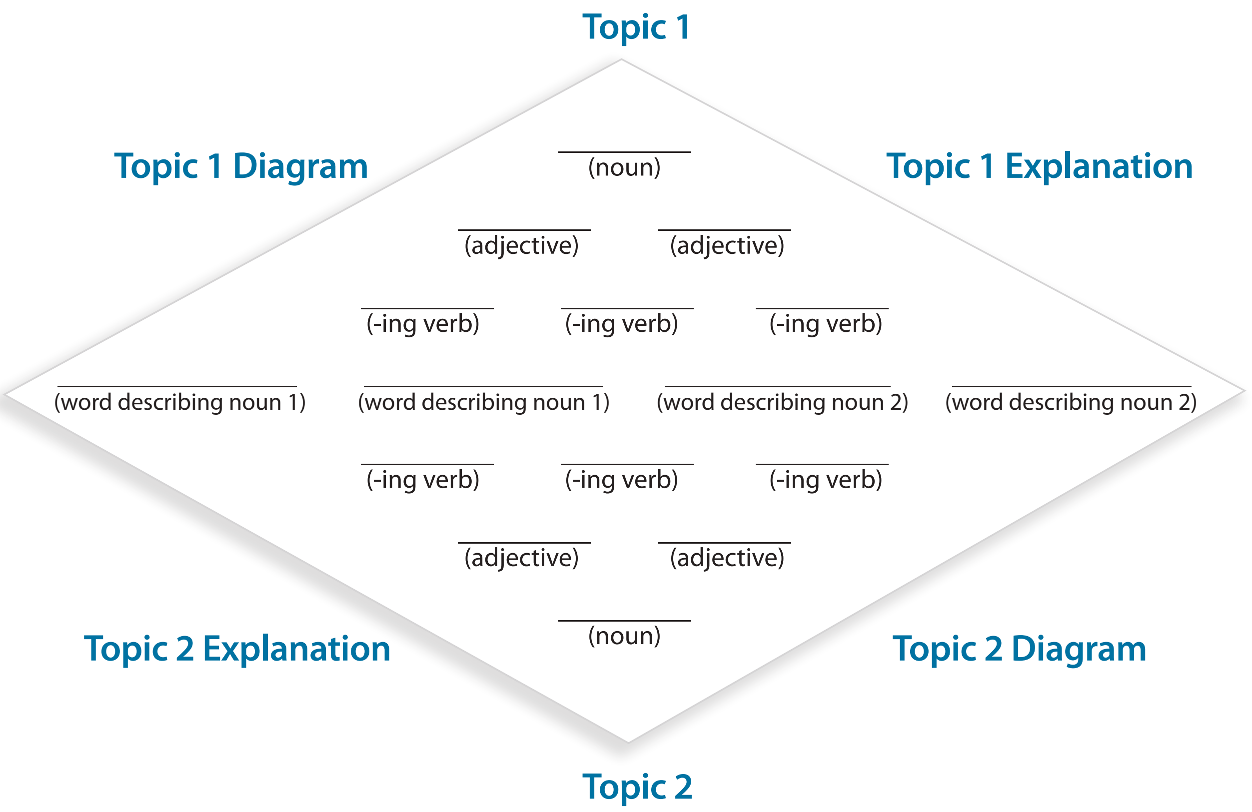


Diamante (Diamond): Poetry

Purpose: *Compare and contrast two science terms or concepts.*

A diamante poem compares and contrasts two terms using the format shown in the diagram. The top three lines describe topic 1 while the bottom three lines describe topic 2. The middle line has two words for topic 1 and two for topic 2. Be sure to make the poem make sense and convey a clear thought even though you have a limited number of words. *Poetry does not just list words!* (See *Comparative Analysis* lesson in Unit 5 for a larger diamante diagram.)

1. Write topic 1 on the top line and topic 2 on the bottom line.
2. Create a multicolored diagram that helps to visualize topic 1 outside the diamond shape on the top left. Do the same for topic 2, but place the multicolored diagram outside the diamond on the lower right side.
3. Think of two adjectives that describe topic 1 and write them on the second line.
4. Think of three "-ing" words that relate to and describe topic 1.
5. Think of two more words that describe topic 1 and write them on the first two lines of the middle line (line 4).
6. Repeat this process using the template for topic 2. Start at the bottom and work your way to the middle line on the right side of the poem.
7. Write an explanation of how the terms and diagrams relate for each topic. Place it outside the diamond on the top right for topic 1 and the lower left for topic 2.



Haiku: Poetry

Purpose: *Limit student writing length to select most powerful words.*

Haiku is a minimalist, contemplative poetry style from Japan that emphasizes nature, color, season, contrasts, and surprises. Usually it has three lines and 17 syllables distributed in a 5-7-5 syllable pattern. It should show a sensation, impression, or drama of a specific fact or concept. It may require several haikus to illustrate a complete concept. Be sure to make the poem make sense and convey a clear thought even though you have a limited numbers of words. *Poetry does not just list words!*

1. Follow the strict pattern to demonstrate understanding of the assigned concept, vocabulary, event, or figure.
2. Create a border for the poem or include multicolored artwork reflecting the topic.
3. There must be a short three- to five-sentence explanation telling how the haiku shows an understanding of the assigned topic.

Cinquain: Poetry

Purpose: *Limit student writing length to select the most powerful words.*

A cinquain is a five-line poem written about a single concept, object, or idea. The format is a short, unrhymed poem of 22 syllables and five lines. The five lines contain 2, 4, 6, 8, and 2 syllables. Each line is supposed to deal with a specific aspect of the cinquian's topic. Be sure the poem makes sense and conveys a clear thought even though you have a limited number of words. *Poetry does not just list words!*

1. Write a cinquain on the assigned concept.

    The first line consists of two syllables/one word (the title).

    The second line consists of four syllables/two words (describes the title).

    The third line consists of six syllables/three words (states an action).

    The fourth line consists of eight syllables/four words (expresses a feeling).

    The last line consists of two syllables/one word (another word for the title).

2. Create a multicolored illustration of the concept to the right of the cinquain.
3. Write a one-paragraph explanation of how the cinquain and illustration relate to the assigned topic below the cinquain.

Raindrop

Moisture, Falling

Sustain, Nourish, Cleansing

Teardrop, Diamond, Dropping, Earthward

Dewdrop

Limerick Assignment: Poetry

Purpose: *Limit student writing length to select most powerful words.*

A limerick is a five-line poem with a strict sound pattern as follows: Da DUM da da DUM da da DUM. The last words of the first, second, and fifth lines rhyme with each other. The first, second, and fifth lines are longer than the third and fourth lines. The last words of the third and fourth lines rhyme with each other. Your limerick must be school appropriate and G or PG rated. Be sure that the poem makes sense and conveys a clear thought even though you have a limited number of words. *Poetry does not just list words!*

1. Write a limerick to address the assigned concept, vocabulary, event, or figure.
2. Create a multicolored illustration about the topic following the limerick.
3. Write a one-paragraph explanation of how the limerick and illustration relate to the assigned topic below the limerick.

Fables: Genre Writing

Purpose: *Create a short story with a moral to illustrate a concept.*

A fable is a short story with animals as main characters. There is a moral or point to this story of two to three paragraphs.

1. Write a fable that highlights the assigned concept.
2. Include and underline the moral or point to the story in the last paragraph.
3. Create a multicolored illustration showing the key concept following the fable.
4. Write a one-paragraph explanation of how the fable and illustration relate to the assigned topic to the right of the illustration.

Acrostic Poem: Poetry

Purpose: *Limit student writing length to select the most powerful words.*

An acrostic poem uses a word for its subject. This type of poetry does not have to rhyme, but it does need to make sense. *Poetry does not just list words!*

1. Write the assigned concept vertically (up and down).
2. Write words, terms, and concepts related to the term horizontally (back and forth) off the letter in the vertical term. The letter may be the start of a word or in the center of a word—*teacher's choice!*
3. Create an illustration representing the term or word following the acrostic poem.
4. Write two paragraphs of three to five sentences explaining how the horizontal words and terms AND the illustration fit the vertical term.

Rhyming Poem: Poetry

Purpose: *Demonstrate concept mastery in restricted format.*

The poem must use the assigned vocabulary terms or concepts. This poem includes a title reflecting the major concept, vocabulary, event, or figure of the poem. The poem includes a minimum of five couplets (two lines which rhyme with each other) and five vocabulary terms. Be sure that the poem makes sense and conveys a clear thought even though you have a limited numbers of words. *Poetry does not just list words!*

1. Write a rhyming poem using at least five vocabulary terms.
2. Highlight vocabulary terms.
3. To the right of the poem, create a multicolored diagram with at least one vehicle, one animal, and one vegetable.
4. Below the poem and illustration, write a minimum of two paragraphs which explain how the poem and illustration demonstrate the assigned topic.

Letter to the Editor: Genre Writing

Purpose: *Write a letter to the editor expressing an opinion about a scientific concept, event, or figure.*

Letters to the editor have a definite point of view and express an opinion about the topic. This letter will be two to four paragraphs long and addresses an assigned concept, vocabulary word, event, or figure. It includes a minimum of five vocabulary terms and five scientific facts to support your opinion.

1. Write a letter to the editor about the assigned concept, vocabulary, event, or figure. Use formal letter writing formats.
2. Create a multicolored illustration showing the concept.
3. Write a minimum of two paragraphs which explain how the letter and illustration demonstrate the assigned topic.

Newspaper Article: Genre Writing

Purpose: *Write a newspaper article about a scientific concept, event, or figure.*

Newspaper articles focus on facts such as the five Ws: who, what, when, where, and why about the topic. These articles include interesting facts that people can use in everyday conversation and are written for the everyday person. New vocabulary must be explained so that the reader understands the information. The format includes the article title, the byline, and the story. Make sure all ideas are expressed in your words. Give credit for ideas that are not yours in MLA or APA style.

1. Write a two- to three-paragraph article suitable for the school newspaper about the assigned concept, vocabulary, event, or figure. Include at least two interesting facts people could use in common everyday conversations and a minimum of five vocabulary terms underlined in the text.
2. Create a multicolored graphic or diagram to support the article that represents the concept or equation being applied or shares interesting data. Include a caption of two to three sentences explaining the graphic.

Box of Colors: Analogy Writing

Purpose: *Demonstrate content mastery in a strict format.*

As part of a campaign to make learning more color-conscious, colored markers are given names describing both the color and concept, vocabulary, event, or figure.

1. Sketch a crayon or marker box with a minimum of six colors of crayon sticking out of the box: blue, red, green, yellow, and two of your choosing.
2. Name each color as seen on the crayon wrappers using scientific concepts and color words. Examples are "Revolution Red" or "Photosynthesis Purple."
3. Select crayon colors that relate to the scientific concept.
4. Draw the outside of the box with a slogan to entice people to purchase this mix of colors.
5. Create a safety warning label across the bottom of the box.
6. Write a one-paragraph explanation of the reasons that the colors naturally fit together and are related to each other.

Clothing Line: Analogy Writing

Purpose: *Create an analogy for a scientific concept.*

Your love of learning and fashion has led you to the owner of a company offering a clothing line named after an assigned concept.

1. Describe one item from the clothing line and how it represents the concept.
2. Create a multicolored illustration of the article of clothing with the logo advertising the concept. One portion of the logo must use or apply the concept as part of the illustration.
3. Write two to three paragraphs which describe how the name of the clothing line will help it sell, how the illustration shows the concept, and how wearing the clothing would help a student learn the information behind the concept.

Toy Design: Analogy Writing

Purpose: *Create an analogy for a scientific concept.*

Apply your knowledge of fun and learning to design the hottest and bestselling toy of the season. It must be able to fit into a standard backpack. The toy must apply an assigned concept and not cause serious bodily injury as part of normal use. As part of the campaign to promote sales the following information must be provided:

1. What is the name of the toy?
2. What is the basic concept used when playing with the toy?
3. What are the most fun features of the toy?
4. What age group is the toy designed to reach?
5. How will playing with the toy help teach the concept?
6. Make a multicolored illustration of the toy being used by a happy consumer.
7. Use at least two paragraphs to describe the slogan to sell the toy. Part of the slogan must contain an everyday application applying the toy's concept.

Public Service Announcement (PSA): Genre Writing

Purpose: *Demonstrate concept mastery through a public service announcement.*

You are charged with writing a public service announcement on an assigned concept. The PSA must be no longer than 30 seconds when read aloud. The concept, event, or figure must be identified at least twice during the PSA and include a minimum of five vocabulary terms or phrases from the current unit.

1. Write the PSA so it is no longer than 30 seconds when read aloud. Include a minimum of five vocabulary terms. Underline each vocabulary term.
2. Write a one-sentence declaration of the organization responsible for developing the PSA following the PSA.
3. Create a multicolored billboard or sign for the side of a bus advertising the PSA. The science concept must be addressed here.
4. Write a two-paragraph explanation of how and why the PSA would influence people to better understand the main concept, event, or figure.

T-Shirt Design: Visual Writing

Purpose: *Demonstrate concept mastery in visual format.*

Design a slogan and artwork for a T-shirt representing one of the assigned concepts, events, figures, variables, or terms. Include artwork and slogan for T-shirt.

1. Design the front and back of a T-shirt with multicolored artwork showing the concept, event, figure, variable, or term on at least one side.
2. The back of the shirt must have a one- or two-line "cute or clever (but clean)" saying/slogan using the concept, event, figure, variable, or term.
3. Write two paragraphs explaining how the artwork and saying explain the concept.

Radio Commercial or Thirty Seconds of Fame and Glory: Audio Writing

Purpose: *Demonstrate mastery of homework concept in limited format.*

Write a 30-second (maximum) radio commercial advertising the assigned concepts. The main message must reflect the assigned content.

1. Write a radio commercial that does not exceed 30 seconds in length and focuses on the main idea of the assignment. Include five vocabulary terms and underline each.
2. Include three sound effects (PG rated) in your commercial by describing the sound effect or music that would accompany the commercial. List these in parentheses.
3. Create a multicolored illustration showing a print advertisement to accompany the radio campaign.
4. In a paragraph, explain how both the radio commercial and the print advertisement meet the key points of the assignment.

Song or Rap: Poetry

Purpose: *Demonstrate concept mastery in strict format.*

Write a song that explains the assigned concepts. Underline key vocabulary words. Include a minimum of five terms.

1. Use a song, tune, or nursery rhyme familiar to you.
2. Create a multicolored illustration of the cover art for the CD or computer icon for the song showing an understanding of the assigned concepts.
3. Write a two- to three-paragraph explanation that clarifies how the art and the song support each other and demonstrate the scientific concept.
4. Present the song to the class in person.

Designing a Magazine Ad: Visual Writing

Purpose: *Demonstrate mastery of a concept in limited format.*

Design a magazine advertisement on one of the assigned concepts for a favorite magazine of teenagers or young adults.

1. At the top of the page, write the magazine title.
2. On the top half of the left side of the INB, create the multicolored advertisement. It must be no more than a half page in length. The ad is limited to 15 words of copy (text).
3. Below the advertisement, write at least two paragraphs that explain why the magazine was selected, how the artwork gets across the concept or equation used, and why the claims or selling points help explain the importance or develop the understanding of the concepts.

Don't Break the Bank: Summary Writing

Purpose: *Demonstrate concept mastery using limited word count.*

Words are at a premium these days, and messages are capped even on tweets and cell phone text messages. At ten cents per word, you have three dollars to spend on a message to explain the concept, event, figure, or variable.

1. Explain the assigned concept in 30 words or fewer.
2. Create a multicolored illustration that shows the key points of the assigned concept.
3. Write no more than two paragraphs explaining how the illustration and message are related to the assigned concept, event, figure, or variable.

Equation Bookmark: Visual Writing

Purpose: *Demonstrate concept mastery in visual format.*

Design a bookmark that is no more than 5 cm wide and 20 cm long.

On the Front

1. Draw a multicolored picture or illustration representing the main concept.
2. Write the assigned equation.

On the Back

1. Write the assigned equation.
2. Describe each variable in the equation.
3. Identify the correct units for each variable in the equation.
4. Write a paragraph to explain how the front illustration shows the equation in use. Highlight key vocabulary terms in the explanation.

A Fibonacci Sequence Poem: Poetry

Purpose: *Demonstrate concept mastery in limited format.*

Write a poem following the beginning of the Fibonacci sequence (1, 1, 2, 3, 5, and 8). The numbers represent the number of words to be used in each line of the poem. The poem must use at least five vocabulary terms and reflect a major concept. Be sure to make the poem make sense and convey a clear thought even though you have a limited number of words. Poetry does not just list words!

1. Write a title reflecting the major concept of the poem on the top of the left side of the INB.
2. Write the Fibonacci sequence poem:

   Line 1: One word

   Line 2: One word

   Line 3: Two words

   Line 4: Three words

   Line 5: Five words

   Line 6: Eight words

3. At least five vocabulary terms must be used. Underline them!
4. Create a multicolored diagram reflecting the assigned concept, event, figure, or variable with at least one plant, one historical figure, and one piece of sports equipment. In the diagram, some aspect of the Fibonacci sequence must be represented.
5. Write at least three paragraphs explaining how the poem and diagram demonstrate the assigned topic and how the Fibonacci sequence is represented in the diagram.

Portmanteau Words: Blending Words

Purpose: *Develop vocabulary by creating new words.*

Lewis Carroll coined the word *portmanteau* in *Through the Looking Glass*. Portmanteau is now used to describe the process of combining words to create a new one. Many words used in today's language are portmanteau words.

Sample portmanteau words:

because	by + cause	**fortnight**	fourteen + nights
breathalyzer	breath + analyzer	**ginormous**	giant + enormous
brunch	breakfast + lunch	**goodbye**	God + be (with) + ye
motel	motor + hotel	**guesstimate**	guess + estimate
Muppet	marionette + puppet	**hassle**	haggle + tussle

Create a portmanteau term using two of the assignment vocabulary terms.

1. Write the created portmanteau term at the top of the page with the words it blends underneath.
2. Write a one- or two-sentence definition of the created portmanteau underneath the blended terms.
3. Write a series of sentences allowing a person to figure out what the created portmanteau term means from the context clues in the sentence.
4. Make an illustration showing the portmanteau in action.
5. Write at least two paragraphs explaining how the sentences and diagram explain what the created portmanteau means. Be sure to highlight vocabulary terms used in the explanations.
6. Write a paragraph explaining why the created portmanteau should be adopted and used and what *major concept* with which it would be most appropriately associated.

Vehicle Name

Purpose: *Demonstrate concept mastery in limited format.*

As part of the design team for a new model vehicle, you must select a name for the model. The name must reflect the vehicle's abilities and an assigned concept. Include the following:

1. What is the model name of the vehicle?
2. Explain how the model name of the vehicle fits its abilities.
3. Write the advertising slogan to be used to represent and show the vehicle. At least two related vocabulary terms must be used in the slogan.
4. Create a multicolored magazine advertisement showing the vehicle and emphasizing its abilities and name.
5. Explain in at least two paragraphs how the slogan and magazine advertisement represent the concept.

Free Fall Sporting Event

Purpose: *Demonstrate concept mastery in limited format.*

Newtonia is a new, non-injurious sporting event that requires a team of players to work together to win. The sporting event will take place in free fall (no apparent gravity) inside a large air filled bubble.

Players are *not* allowed to use any electrical devices or electronic enhancements. The sporting event must apply at least five different concepts, events, figures, or variables during play.

1. Write the rule or rules to win.
2. Describe and illustrate the uniform or equipment needed to play.
3. Write each of the concepts or principles to be applied during the game and describe how applying each will help a team win the game.
4. Describe any special problems that would have to be solved due to the game being played in free fall (no apparent gravity).

Tree Timeline

Purpose: *Demonstrate understanding of a sequence of events.*

Create a timeline showing the development, major figures, technological and social developments, and consequences of a major event. The event is the "trunk" of the tree. The ground needs to list the major and minor conditions leading to the major event. An illustration of each condition must be made around the term.

1. Each of the major figures, technological and social developments, or consequences is a "branch" off the trunk.
2. Each branch has leaves or fruit developed from the major event. Diagrams, sketches, and representations of the figures, technological or social developments, or consequences are the "fruit" hanging off the branches.
3. Write a short advertisement describing what was made or developed from the "wood" and "fruits" of the tree.
4. Write a minimum of three paragraphs about the tree, growing conditions, and fruit. At least one paragraph describes the growing conditions needed for the event. At least one paragraph describes the fruit of the tree. At least one paragraph must explain the claims and statements of the advertisement.

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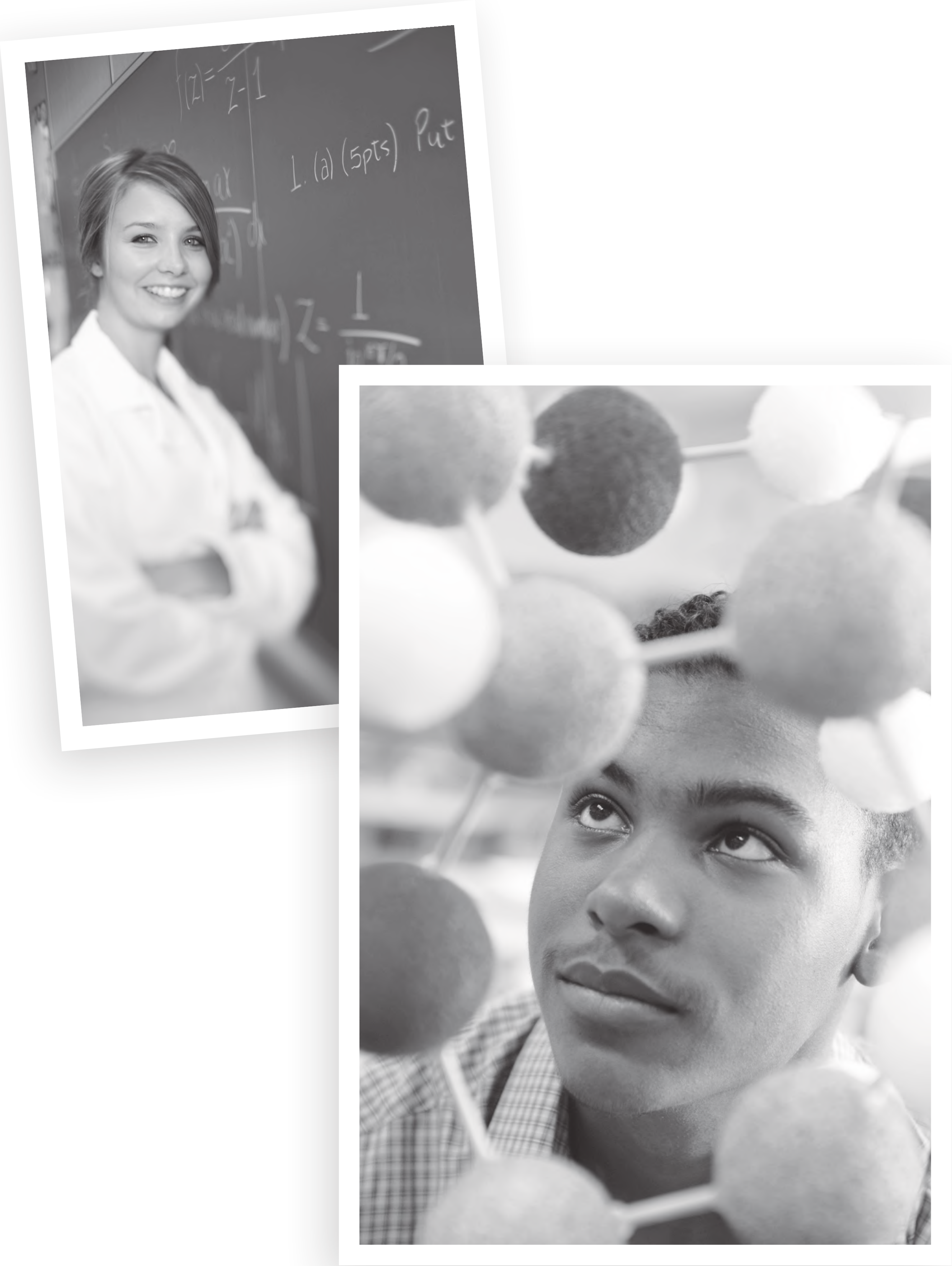
1. (a) (5pts) Put