Writing Across the Curriculum

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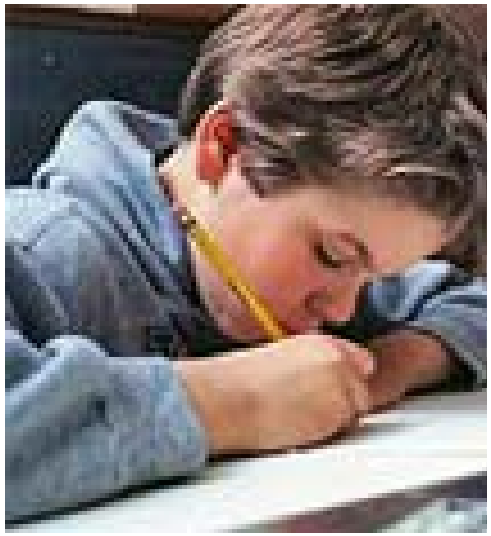
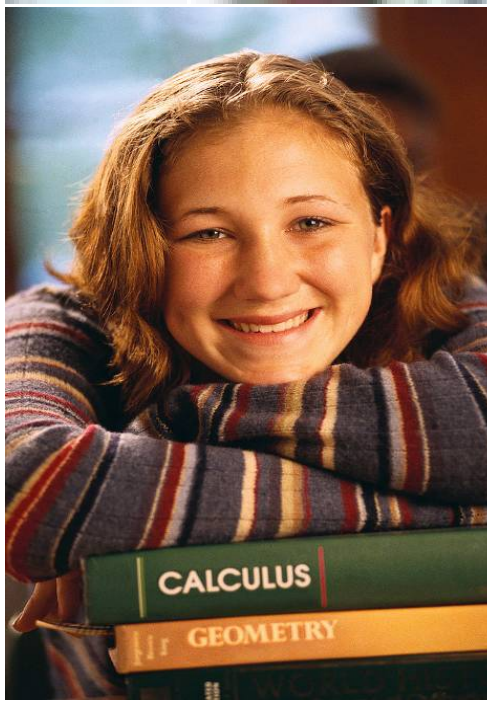
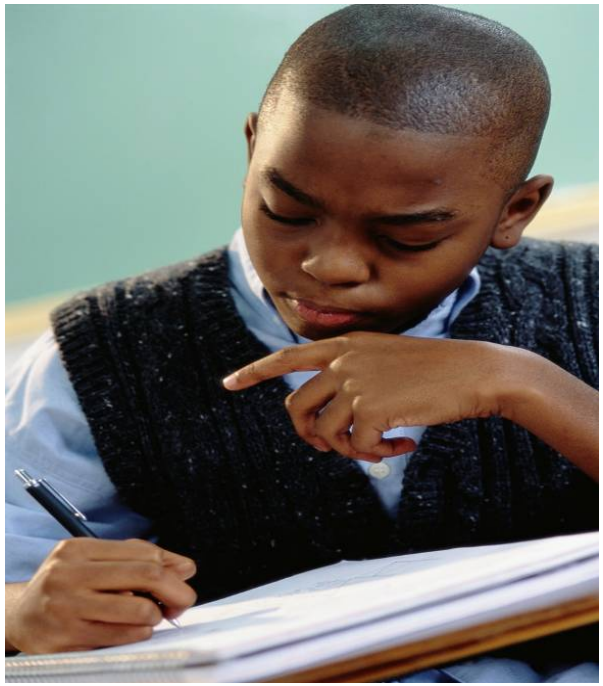






Introduction: Writing Across the Curriculum

What is it?

Teachers across the disciplines use writing-to-learn and writing-to–demonstrate-knowledge to enhance the learning of students in all disciplines.

Basic Principles Of Writing Across the Curriculum (WAC)

In response to the need of students to learn content using a variety of strategies and their need to practice writing in a variety of contexts, many teachers have adopted the strategies associated with WAC. The following principles underlie WAC:

- Writing promotes learning;
- Integration of writing and the writing process promotes student participation, a diversity of student voices, and engage students as critical thinkers while promoting their texts as important resources and thinking tools;
- Effective writing instruction integrates disciplines;
- The opportunity to write in every class develops good writers;
- Using writing as part of instruction can be used in every classroom; and
- Only by practicing the thinking and writing conventions of an academic discipline will students begin to communicate effectively within that discipline.

What's In It For Teachers and Students?

Including writing in instruction has short- and long-term benefits. In the short term, students and their teachers are better able to appraise how well they grasp information and where deeper elaboration of key concepts is needed. Students are able to take small pieces of content and analyze it looking for patterns and connections. In the long run, students who use writing as a technique to learn content have developed their skills as thinkers. Organization, summary, and analysis of content become easier for students, producing richer understandings. Students become more practiced at using writing to communicate their learning and thinking.

Writing is used to initiate discussion, reinforce content, and model the method of inquiry common to the field. Writing can help students discover new knowledge—to sort through previous understandings, draw connections, and uncover new ideas as they write.

Writing-to-learn activities encourage the kind of reflection on learning that improves students' meta-cognitive skills. The key to effectively using writing activities in every subject lies in matching the right activity to the learning situation. As you select writing strategies, ask yourself, "How well suited is this task for the objective the students are learning?" "Does this strategy fit my students' abilities and needs?" "Will this strategy complement the way my students will be assessed on content later?"

Assigned writing in all classes and courses helps students keep their writing skills sharp. Students become better readers, thinkers, and learners in a discipline by processing their ideas through writing. Writing assigned across the curriculum also helps students prepare for the day-in and day-out communicative tasks they'll face on the job, no matter what the job is. Equally important, students need to learn about how writing is used within a discipline; and utilizing many different kinds of writing assignments gives students practice with a variety of disciplinary forms and conventions.

So why assign writing in your classes? Students will learn more content, will clarify their thinking, and will leave your classroom better prepared to face thinking and communication challenges.

Definition: Writing-To-Learn

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Writing-to-learn fosters critical thinking, requiring analysis and application, and other higher level thinking skills. It is writing that uses impromptu, short or informal writing tasks designed by the teacher and included throughout the lesson to help students think through key concepts and ideas. Attention is focused on ideas rather than correctness of style, grammar or spelling. It is less structured than disciplinary writing.

This approach frequently uses journals, logs, micro-themes, responses to written or oral questions, summaries, free writing, notes and other writing assignments that align to learning ideas and concepts.

Definition: Writing-To-Demonstrate-Knowledge

A writing-to-demonstrate-knowledge assignment is one that teachers employ when they assign reports, essays, persuasive writing, and creative or expressive writing, as well as research papers.

When writing-to-demonstrate-knowledge, students show what they have learned by synthesizing information and explaining their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Examples include essays that deal with specific questions or problems, letters, projects, and more formal assignments or papers prepared over weeks or over a course. They adhere to format and style guidelines or standards typical of professional papers, such as reports, article reviews, and research papers and should be checked before submitted by the student for correctness of spelling, grammar, and transition word usage.

Preface: WAC In Science

Learning science is much more complex than memorizing sets of facts and examples. Research has shown that students come to classrooms with many naïve ideas about the natural world that often interfere with them learning science concepts (Duschl, 1990). Increasing student science literacy means that explanations harbored prior to instruction must be explored and often challenged. In order to develop new and/or improved conceptual frameworks, students must be given the opportunity to process their ideas – before, during and after new learning takes place. This can be done orally, meta-cognitively or in writing. This document will describe for teachers a number of writing strategies that students can use to surface their currently-held ideas, and then process them in relation to new science related experiences and information.

In addition, it is important for all scientists to be able to write clearly and effectively. Not only do they have to keep clean and complete records of their ideas and work, but they also have to communicate their findings to world-wide audiences. Sometimes they are also expected to write grant applications and share their findings with people outside the scientific community. Teaching students to write well must also be a part of any comprehensive science program. Strategies that require students to demonstrate their knowledge of science also provide opportunities to practice writing for authentic audiences. (Strategies and examples of this type of writing will also be provided on subsequent pages.)

In order for writing in science to impact student learning it must be more that just recording notes and/or data collected. Information must be personalized in some way. Students must be expected to include reflections, questions, predictions, claims linked to evidence and/or conclusions when they write. By making these personal connections, students begin to challenge prior misconceptions they may still harbor and start to develop a conceptual understanding of the scientific phenomena they are exploring in their studies.

Many science educators feel that students should already know how to write effectively when they come to their classrooms. This is not usually the case. Students have learned to write from their English teachers, but they usually do not know how to apply these skills to science. Science teachers will find that they may have to explicitly teach and provide scaffolding for each of these strategies before their students will be able to implement writing either for learning science or to demonstrate scientific knowledge.

Teachers should implement steps from the writing process to help students use writing strategies effectively in science:

- Explain the strategy and its purpose. If appropriate, describe the real-world application and audience for the product.
- Model how to do a sample of the expected writing. While modeling, talk aloud about the thinking that goes on while preparing to write and during writing.
- Have students practice the strategy. This might be done in small groups with the teacher or with partners.
- Provide feedback on the work, encouraging students to use the feedback in their next efforts.
- Encourage students to become more independent in their practice as they build their skills.

When students have demonstrated that they have mastered the strategy, it can then be used for a variety of classroom purposes. A few examples are:

- Keeping a personal record of ideas and experiences
- Providing formative assessment data for teachers
- Providing summative data for evaluation
- Communicating learning with parents and other interested parties

Each of the following strategies will include a specific scientific example. Please note that teachers are encouraged to modify these as needed.

Table Of Contents: WAC In Science

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Cause - Effect

Students observe or read about the interaction(s) between components of a natural or technological system. They record cause and effect relationships within that system on a graphic organizer. For more on cause and effect organizers please go to: http://www.educationoasis.com/curriculum/GO/cause_effect.htm.

What does it do?

- Promotes the analysis of how components of systems interact.
- Helps students identify variables in systems.
- Helps identify scientific questions for possible investigation.
- Supports the development of scientific predictions and/or hypothesis.

How to implement:

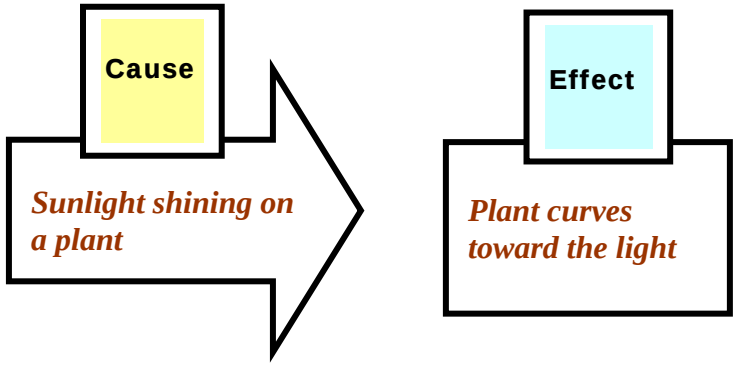
Teacher models the following steps and then scaffolds practice as needed until students are able to process independently.

- Study the targeted system(s) and identify the interacting components.
- Record any cause and effect relationships observed.
- Write questions that the graphic organizer helps answer.
- Write questions that the organizer raises that can be investigated scientifically or by reading.

Example 1: Simple Cause-Effect Organizer

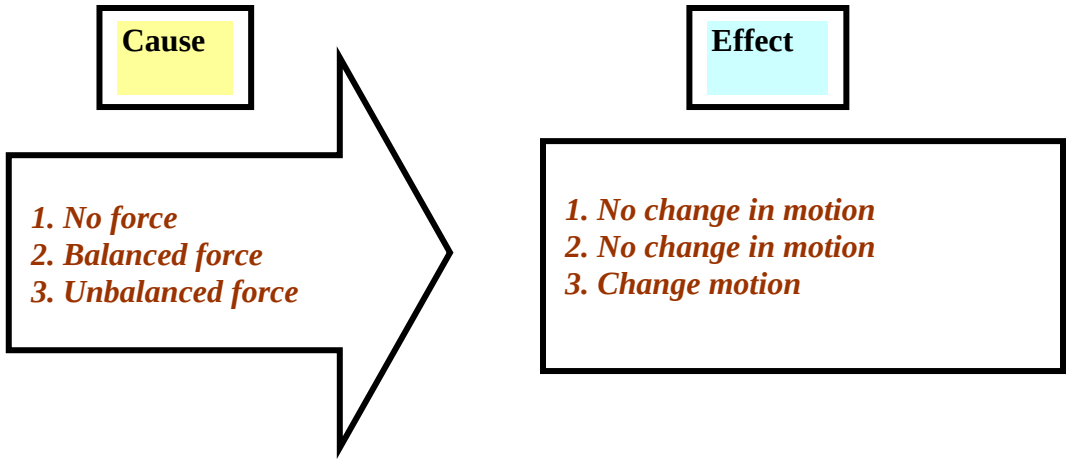
Investigations are often triggered by observing systems in the world. Students can record the changes they observe and how these changes were caused on a graphic organizer. This visual representation leads to questions for further investigation.

Questions: "*How does light affect a plant's growth?*"
"*How does colored light affect plants' growth?*"



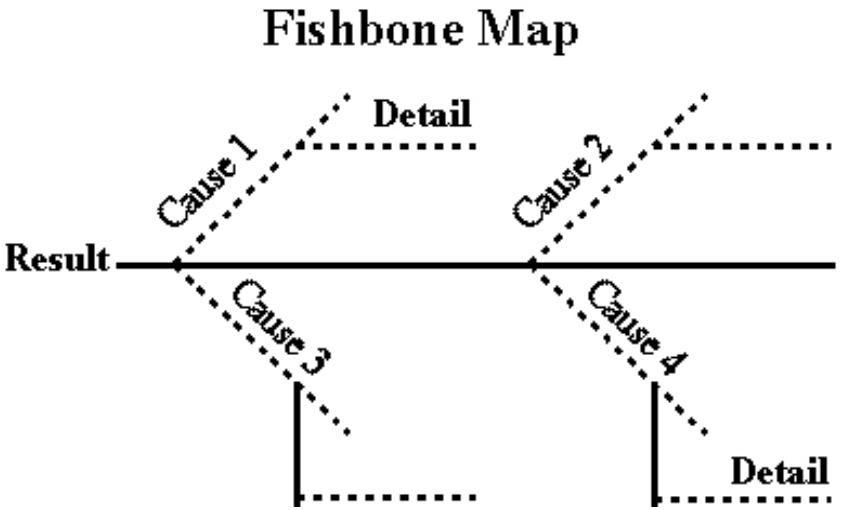
Example 2: Multiple Interactions
Changing one variable can have different effects on a system. Sometimes these changes are unexpected. The different ways a variable can impact a system can also be represented on a Cause-Effect Graphic Organizer.

Question: "How does changing a force affect the motion of an object?"



Example 3: Fishbone Map
This graphic organizer provides a tool for analysis of systems when multiple causes are responsible for a given effect. For example, when looking at *Global Warming,* this map would record many different causes: *coal burning power plants, automobile use, etc.*

Adapted from: http://www.sdcoe.k12.ca.us/score/actbank/sfish.htm



Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Column Notes

The double-entry journal is a two column graphic organizer. Students record important factual information from text and/or lecture in the left hand column. The right hand column is used by students to process and record personal responses to the information. A third column can be added if needed. For more on column notes go to: http://forpd.ucf.edu/strategies/stratCol.html.

What does it do?

- Helps students recall information.
- Provides students with an opportunity to clarify information.
- Helps students make personal connections with new information.
- Encourages students to analyze and question information presented.
- Informs teacher on extent to which students have understood the new information (formative assessment).

How to implement:

- Teacher either assigns a text reading or announces a lecture topic.
- Teacher describes how to identify important information and models how to take notes on a sample graphic organizer.
- Teacher explains the purpose of the right side of the organizer and models how to add a personal response.
- Teacher lectures for 10 minutes while students take notes on the left side of the organizer (or directs students to read and take notes for a specified segment of text).
- Students write and/or sketch reactions to their notes on the right side of the organizer.
- Students share reactions with a partner and then repeat the steps.
- At end of lesson, students write a summary paragraph about what they learned and compare it with their partner.
- Students may also be asked to write one sentence about the lesson on a note card as a “ticket out the door” (See Quick Write Strategy).

Example 1: T-Chart (Two Column Notes)

States of Matter

Note Taking	Note Making
States of matter--physical forms for substances. Solid, liquid, gas.	***If water vapor is a gas, and I cannot see gases, then why can I see steam???***
Atoms: tiny moving particles	***I remember when we pretended to be atoms by bumping into each other in class. We moved faster when we pretended to be a gas.***

Laboratory Investigation Log

Observations Made	Questions/Predictions
One plant in our room grew 3 centimeters more than the others this week and looks less green in color.	***What might have caused this plant to grow differently than the others? I wonder if it was getting less light.***

Example 2: Glossary of Important Terms and Concepts

Vocabulary Term	Explanation (In Own Words)	Examples And/Or Diagram
Photosynthesis	***How plants use sunlight to change carbon dioxide and water into food that plants use and store. We use this stored food for energy.***	***The starch in a potato The stored energy in seeds and grains***

Additional Ideas For Column Headings:

- What I Know/What I Wonder
- Topic/Details/Response
- Facts/Questions/Response
- Question/Answer

Modification:

- In lower grades teachers can use this same strategy with a class chart and/or class notebook. The teacher would record notes on the chart and then have students discuss with a partner. The teacher could then randomly select one person for reactions to record.
- Students can also record the notes that the teacher wrote on the chart/overhead on the left of their personal paper and then draw a description or reaction on the right.

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Compare and Contrast

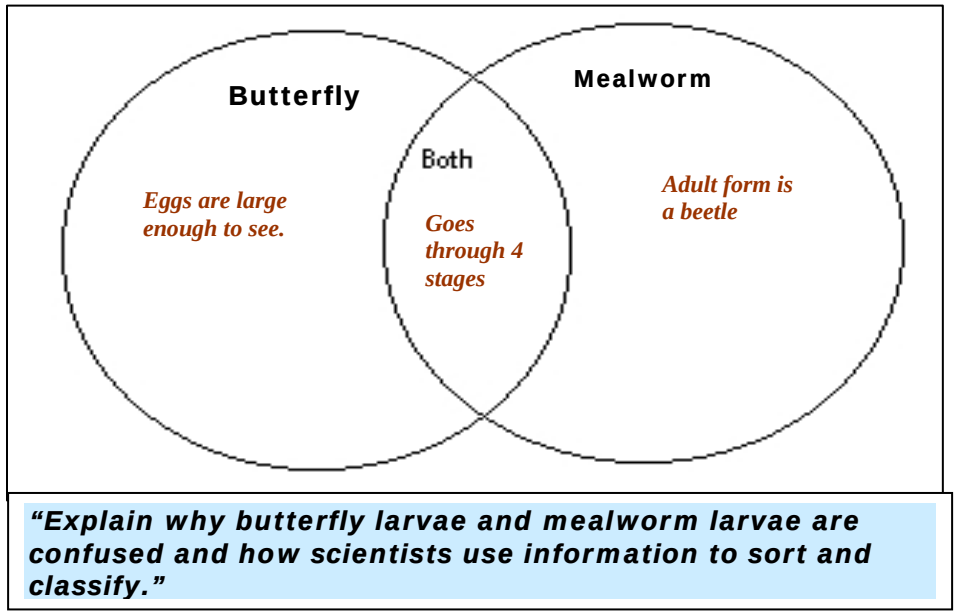
Students collect information about two or more scientific concepts, systems and/or examples. The key attributes are recorded on a graphic organizer in order to clarify similarities and differences.

What does it do?

- Encourages students to examine systems being compared analytically (break each down into component parts).
- Helps students organize/classify scientific information.
- Provides structure for remembering characteristics for scientific examples.

How to implement:

- Students collect information about the systems or concepts in question.
- Students carefully study and analyze information collected.
- Students record key attributes on appropriate graphic organizer (see examples below).
- Students summarize similarities and differences and make generalizations about what they have learned.



"Explain why butterfly larvae and mealworm larvae are confused and how scientists use information to sort and classify."

Example 1: Venn Diagram

The Venn is made of two or more overlapping circles. Similarities are recorded in the overlap area and unique characteristics on the two sides. For example, after observing the development of butterflies and mealworms, students can compare the two life cycles (see example). Follow up with writing prompt: Explain why _____ and _____ are confused and how scientists use information to sort and classify.

For more on Venn Diagrams please see: http://images.google.com/images?sourceid=navclient&ie=UTF- 8&rlz=1T4ADBR_enUS274US274&q=venn+diagram&um=1&sa=X&oi=image_result_group&resnum=1&ct=title.

Example 2: Compare and Contrast Matrix
Students carefully observe two or more items carefully and complete a matrix of characteristics observed.

CELL TYPE	CELL WALL	CELL MEMBRANE	CHLOROPLASTS	LARGE VACUOLE	SMALL VACUOLES
Plant	*X*	*X*	*X*	*X*	
Animal		*X*			*X*

Follow-up: Explain how structure is related to function in the cells observed (see Essay Writing).

Example 3: Compare/Contrast Retrieval Chart
Students research and record attributes of a number of examples on a matrix. For example, students may use this strategy to compare the attributes of different energy resources and then use that information to make a recommendation (see Persuasive Writing).

Energy Source	Description	Advantages	Disadvantages
Wind Power	*Windmill farms are placed in areas with high wind and are used to create electricity.*	*Clean and renewable form of energy. Does not cause global warming.*	*Many people object to having windmill farms in their area because they do not like the way they look.*
Coal	*Fossil fuel that is mined from strip and/or deep mines.*	*Very plentiful and can be burned in a clean manner.*	*Clean coal is more expensive and so many users cannot afford this technology. Not renewable and can cause pollution and global warming.*
Other			
Similarities	*Many different sources of energy can be used to make electricity.*		
Differences	*Some forms are cleaner than others and some are more expensive.*		
Generalizations	*Cleaner forms of energy are either more difficult to implement or more expensive.*		

Writing-To-Learn: Science

What is it?
A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

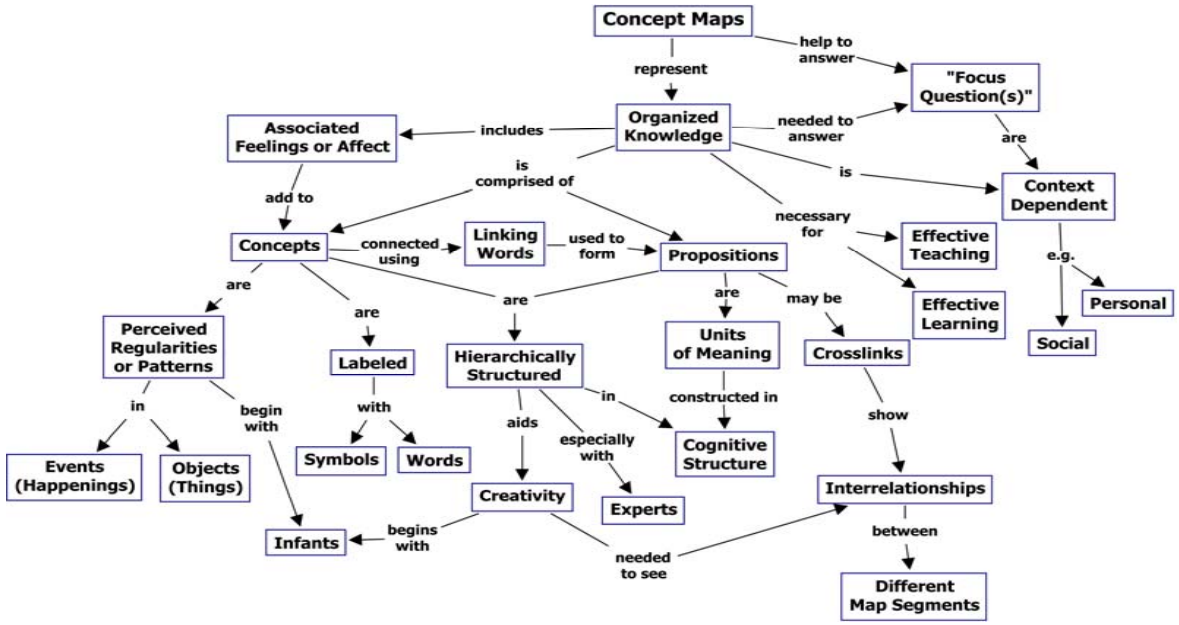
Strategy: Concept Definition Map
Students graphically represent how sub-concepts, vocabulary terms and examples are related to a main topic or central concept.

What does it do?
- Helps students make connections between ideas.
- Provides opportunity for review.
- Provides opportunity to access prior knowledge.
- Provides tool for reflection on changes in understanding.
- Provides a framework for formal writing projects (see Writing to Demonstrate Knowledge: Science).

How to implement:
- Teacher models how to create a concept map using everyday examples (e.g., health, travel).
- Class creates a concept map together on a topic previously studied.
- Teacher provides a list of terms related to the upcoming topic of study and any scaffolding needed for using this strategy.
- Students independently create a concept map that includes the terms provided, additional terms of their choosing and connecting phases (represents prior knowledge; pre-assessment tool).
- Students revisit their map periodically during the unit, adding and changing pieces as needed.
- Students write a paragraph reflecting on how their thinking has grown or changed during the unit.

Example 1: Electronic Mapping
Joseph Novak developed the process science education uses for concept mapping. This diagram is a Concept Map on Concept Mapping. (Joseph D. Novak. IHMC Senior Research Scientist)

See http://cmap.ihmc.us/ for additional information and free software for developing maps.



Example 2: Concept Map

- For Unit Review: Students can use their notes to develop a concept map to review a unit of study--Plate Tectonics. Source: Middle School Science and Technology, BSCS; Kendal Hunt Publishing

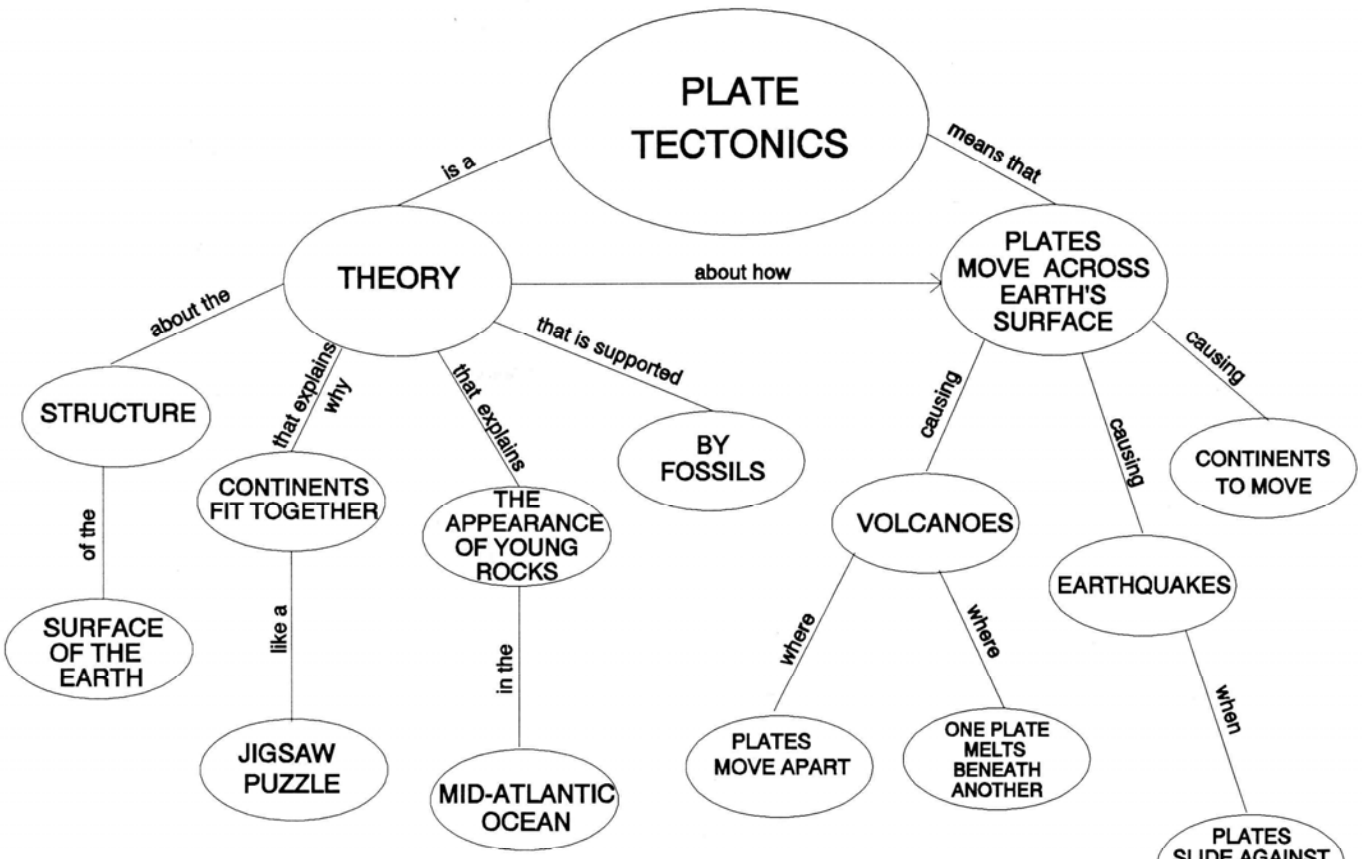


Figure CMA.5 This concept map is an example of how the students might display their understanding of plate tectonics.

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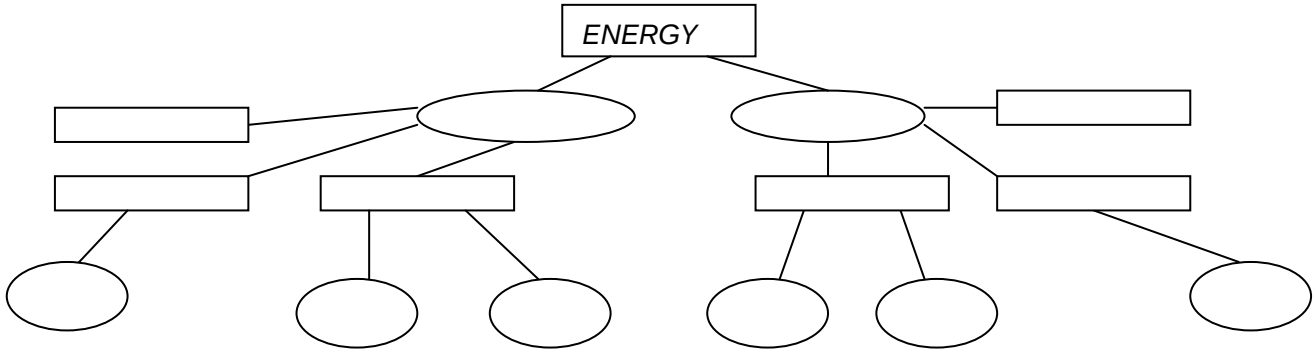
Concept Mapping

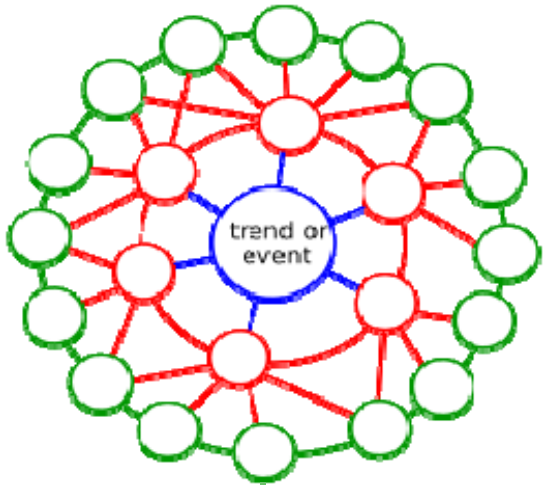
- For Unit Assessment:

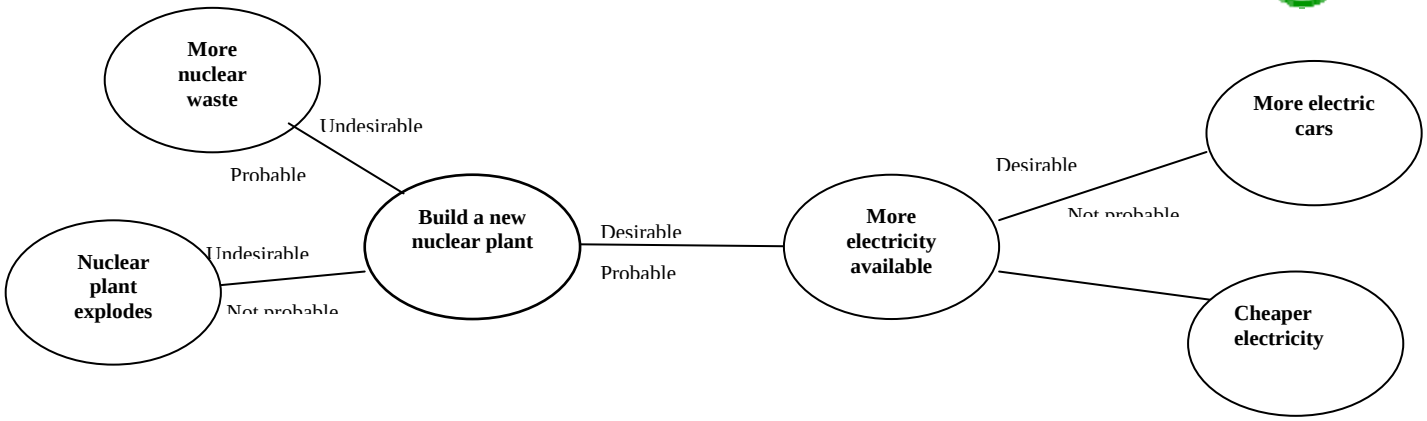
Test item: *"Use the following terms to complete the concept map below: potential; kinetic; electromagnetic; mechanical; heat; nuclear; chemical; gravitational potential (positional); solar; fuel; food; light; sound; electricity."*



Example 3: Futures Wheel

The Futures Wheel is an instrument for graphical visualization of direct and indirect future consequences of a particular change or development (i.e. environment impact). The central term describing the change to evaluate is positioned in the center of the page (or drawing area). Then, events or consequences following directly from that development are positioned around it. Next, the indirect consequences of the direct consequences are positioned around the first level consequences. After brainstorming is completed, the connecting lines are labeled as "desirable or undesirable" and as "probable or not probable." Based on this map the students take a position on the event or choice and support the position with examples from the map. (See: Glenn, Jerome C. "Futurizing Teaching vs. Futures Course," Social Science Record, Syracuse University, Volume IX, No. 3 Spring 1972.)





Writing-To-Learn: Science

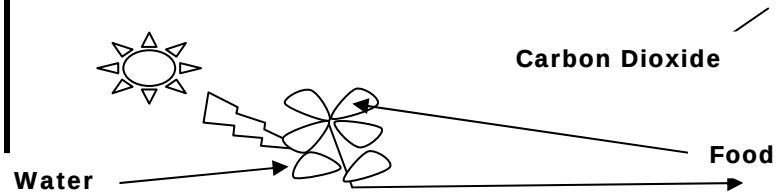
What is it?
A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Concept/Vocabulary Development
Students use a variety of methods and modes (oral, visual, written) to develop a personal, in-depth understanding of key scientific concepts and terms.

What does it do?
- Moves vocabulary development from rote memorization to conceptualization.
- Helps students remember critical concepts.
- Builds connections to new learning.
- Builds background knowledge needed for reading comprehension.

How to implement:
- Teacher provides description, explanation and/or example (i.e. direct experience, visual examples).
- Students restate concept/term in own words.
- Students make a picture, symbol or graphic representation.
- Revisit periodically using a variety of engaging activities (role play, games, compare/contrast, analogies, metaphors).
- Monitor student understanding (self and formative assessment).
- Teacher provides additional explanation and modeling, as needed (Marzano & Pickering, 2005).

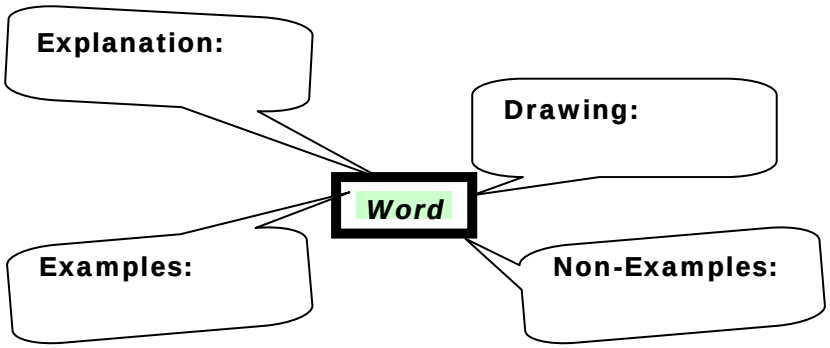
Example 1: Personal Dictionary
Students set aside a section of their Science Notebook as a dictionary. Each entry includes the term/concept, personal definition/description and a representative drawing. Teacher can provide a template for these entries.

Term: *Photosynthesis*	**Topic**: *Plants*
Description: *How plants use sunlight to change carbon dioxide and water into food that plants use and store. We use this stored food for energy.*	
Drawing: 	

Example 2: Examples and Non-Examples

Students describe term in own words and graphically.
Then they list as many examples and non-examples as possible.
Students compare their graphic organizer with a partner and add examples or missing non-examples.

Frayer (1999) adapted by Allen, J. (2007). *Inside words: Tools for teaching academic vocabulary, grades 4-12.*Portland, ME: Stenhouse Publishers.



Example 3: Interviewing Vocabulary

Write term on left side of matrix. Imagine the term is a living person and interview the word or phrase using 2-3 questions. Write the questions in the middle column. Write answers to questions in the right hand column. This can be done as a pre-reading or post-reading activity (or as a combination).

Vocabulary	Questions	Answers
Chloroplast	*What are you?* *Where do you exist?* *Why are you needed?*	*I am a small structure that is part of a plant cell. I exist in the cytoplasm of that cell and you can find me with a microscope. I look green because I am where light energy is converted into energy that plants use to live.*

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: CRAFTS – Context, Role, Audience, Format, Topic, and Strong Verb

CRAFTS (Bellamy, 2005) is a strategy that extends the RAFT model (Buehl, D. 2001) to include context. Students demonstrate their understanding of the targeted content by writing to an authentic audience and purpose.

What does it do?

- Demonstrates students' depth of knowledge (pre-assessment or summative assessment).
- Encourages students to focus on audience and voice in their science writing.
- Helps students apply content in an authentic context and for a purpose.
- Promotes creative and critical thinking.

How to implement:

Teachers model the strategy and then have students use the acronym to plan a writing scenario for developing a writing piece:

C = Context: "What is the context for the piece to be developed?"
R = Role: "Who or what are you?"
A = Audience: "Who are you addressing? Who is this writing for?"
F = Format: "What form will the writing take: letter, editorial, diary, memo, etc.?"
T = Topic: **"**What is the purpose and topic of the piece? Why?"
S = **Strong Verbs: "**What verb defines the purpose of the assignment?"

Template:	***Example:***
You are a (insert role), in (insert context) writing to (insert your audience) in (insert format of the communication) to (insert writing purpose using a strong verb).	***You are a journalist (role) working for a magazine (context) that targets non-scientists as readers (audience.) You will write an article (format) that will explain the difference between foods containing saturated and unsaturated fats (topic) so readers can make informed (purpose) decisions about their diets.***

CRAFTS Roles and Audiences

advocate	concerned citizen	geologist	nutritionist	scout
archeologist	critic	grant writer	NATO staff	speech writer software
astronaut	customer	grass roots leadership	an observer	engineer
author	detective	hospital patient	oceanographer	student
award winner	developer	inventor	parent	talk show host
builder	doctor	investigative reporter	park ranger	teacher
biographer	ecologists	journalist	patient pen pal	test writer
cartoonist	economists	lawyer	photographer	Third World Country
chairperson	editor	lobbyist	professor	tour guide
chambers of commerce	environmentalist	lab technician	publisher	travel agent
chemist	family members	medical staff	radio station	TV character
commentator	farmer	museum curator	research scientist	TV station
community leader	forensic scientist	naturalist	researcher	veterinarian
consumer	friend	neighbor	school board member	weather forecaster
		news anchor	scientist	zoo keeper

Examples Of CRAFTS Formats

abstract	digital story	letter to the editor	picture book	science notes
advertisement	diorama	letter	play	scripts
advice	display	magazine article	position statement	skits
autobiography	eulogy	message to the future	PowerPoint presentation	slogans
biography	dramatic monologues	model mystery	procedural text	song
book review	editorial	myth	promotional brochure	storyboard
book jacket	encyclopedia entry	news story	proposal public statements	tall tale
brochure	epitaph	news broadcast	radio play	technical advice
cartoon	essay	speech	radio script	technical manual
collection	feature article	obituary	realistic fiction	test
commercial	fiction	pamphlet	report	text book
complaint	how-to book	personal correspondence	requests research report	travelogue
concept book	human interest story	persuasive essay	science fiction story/series	TV script
contest entry	legend	photo essay		videotape

Examples Of Strong Verbs Relating To the Purpose For Writing

adapt	clarify	demonstrate	formulate	produce
analyze	collect	design	inform	persuade
argue	compare	develop	inspire	revise
articulate	convince	disprove	investigate	review
apply	criticize	devise	invent	show
appraise	construct	discuss	modify	solve
assess	create	display	organize	structure
categorize	critique	entertain	perform	support
challenge	debate	evaluate	plan	synthesize
classify	defend		present	teach
	define			test

Example 1: Technical Paper

- Designing a Scientific Exhibit:

As a team of museum curators, you will develop and present an exhibit for a class museum about an assigned geologic time period. Parents and students in other classes will be invited to visit your exhibit in order to learn more about evolution and geologic time. Each team's exhibit and presentation will include:

- Where the assigned time period fits on a geologic timeline.
- A description of organisms that are representative of the time period (e.g., aquatic and/or terrestrial).
- Evidence to support connections between representative organisms and organisms of other periods.

- Patterns and Sound:

You are a composer who has been asked by a publishing company to produce a teaching product that will describe creatively how sound can be produced and changed. Your goal is to create a product that receives good reviews from a panel of critics. Your product will be in the form of a book, poem and/or a piece of music which includes a repeating and/or cumulative pattern. Your product will use a pattern consistently throughout the piece and will provide a sophisticated model of how sound is created and changed. The product will be supported with appropriate text and/or illustrations which will describe the pattern used and how the selected pattern will help others learn about sound energy.

Example 2: Creative Advertising

As a team or individual animal advocate, you will create an infomercial to inform and make recommendations to peers, family members, and zoo administrators about how technology does and/or could affect the lives of one type of animal in the zoo. Your infomercial may take the form of a:

- Puppet show
- Play
- Song
- Speech with visual props
- Other (teacher approved)

The infomercial should include the following:

- A description of the technology currently used to meet the needs of this animal.
- Is the effect of the technology positive, negative, or both?
- What is your recommendation for your animal's future at the Detroit Zoo (or other local zoo?)

Individual task:

You will keep a reflection log that shows your growth or understanding of the issues of how technology affects the lives of various animal groups.

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: GIST (Generating Interactions Between Schemata and Text)

GIST is a step-by-step process for summarizing text material. It is particularly valuable with students who have difficultly putting what they have read into their own words. Students restate main ideas from scientific text omitting specific examples and/or evidence used to support or illustrate the concept(s) (Cunningham, 1982).

What does it do?

- Improves student comprehension of scientific text.
- Helps students process new information and make connections with own ideas/experiences.
- Provides a structure for identifying and remembering key ideas.
- Helps students surface questions about what they have read.

How to implement:

Teacher models the following steps and then scaffolds practice as needed until students are able to use them independently.

- Read first portion of text and reword the main idea into a short statement (less than 15 words).
- Read the second portion and restate the main idea for segments 1 and 2 in one short statement.
- Continue portion by portion until assigned text is completed.
- Write a one sentence summary of the text selection in own words.

Example: Textbook GIST

Use the process with scientific textbooks, restating main ideas one paragraph at a time. Summarize the section assigned with one or two sentences in your own words. Share the summary with a partner and discuss similarities, differences and questions raised.

Text Sample (Source: www.Wikipedia.org)

> *In biology, **evolution** is the process of change in the inherited traits of a population of organisms from one generation to the next. Genes that are passed on to an organism's offspring produce the inherited traits that are the basis of evolution. Mutations in genes can produce new or altered traits in individuals, resulting in the appearance of heritable differences between organisms. New traits may also arise from the transfer of genes between populations, as in migration, or between species, in horizontal gene transfer. In species that reproduce sexually, new combinations of genes are produced by genetic recombination, which can increase the variation in traits between organisms.*

There are two major mechanisms that drive evolution. The first is natural selection, a process causing heritable traits that are helpful for survival and reproduction to become more common in a population, and harmful traits to become more rare. This occurs because individuals with advantageous traits are more likely to reproduce, so that more individuals in the next generation inherit these traits. Over many generations, adaptations occur through a combination of successive, small, random changes in traits, and natural selection of those variants best-suited for their environment. The second is genetic drift, an independent process that produces random changes in the frequency of traits in a population.

IMPORTANT IDEA	IMPORTANT IDEA	IMPORTANT IDEA	IMPORTANT IDEA
Evolution happens when new traits appear in a population.	***Natural selection favors traits that help organisms survive.***		

Summary

Population traits can change over time through a variety of genetic processes.

Graphic from: http://www.michigan.gov/documents/mde/UnderstandingbyDesign_219619_7.pdf

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Journaling (Science Notebooks)

A Science Notebook is a record of student inquiry learning experiences over a period of time. The notebook can be used exclusively for inquiry investigations or it can be used to include reflections from reading or class discussions. It is more than a collection of observations, data collected, facts learned and procedures conducted. The notebook also documents student reflections, questions, predictions, and conclusions.

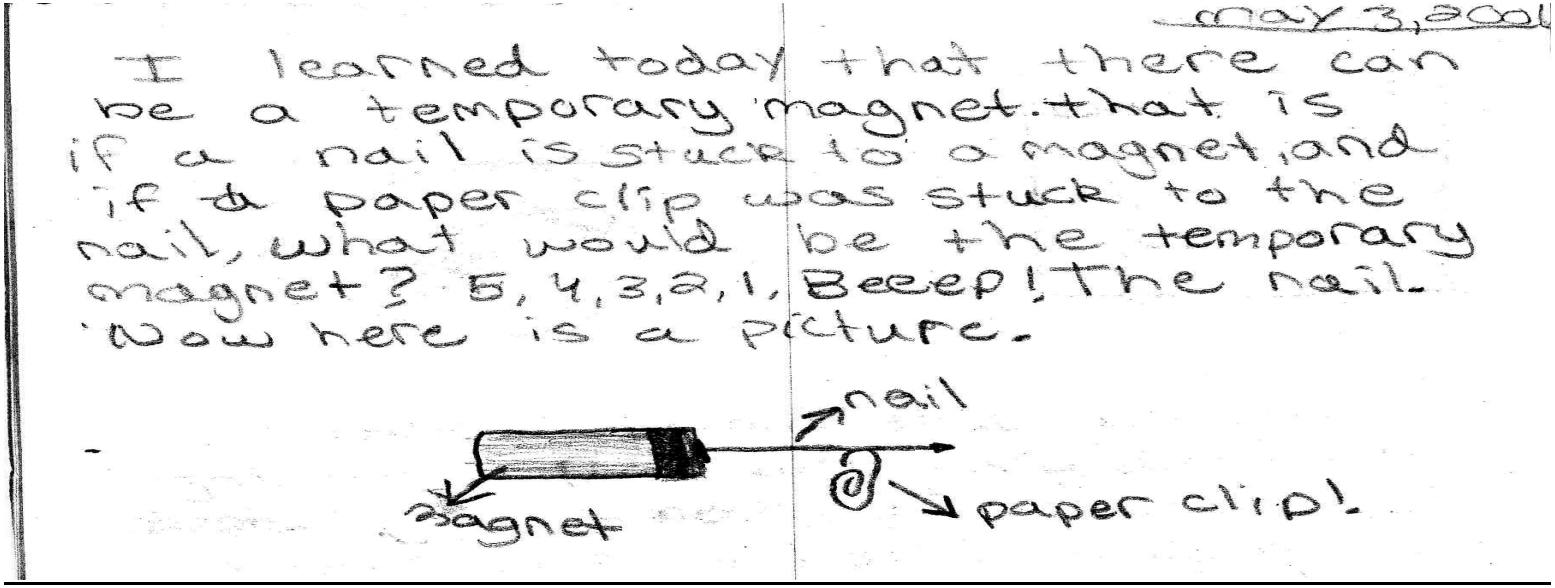
What does it do?

- Provides permanence and stability for student investigation results, reflections and questions.
- Provides a resource for writing Science Investigation Reports, i.e., published product.
- Provides a resource for reviewing information learned during science lessons.
- Provides feedback about students' investigatory skills: measuring, recording data, graphing, etc. (i.e., both self and formative assessment).

How to implement:

- Teacher explains purpose and provides specific format for science notebook. (Audience is student, but format is still important.)
- Students use notebook prior to investigations to record their thinking (including questions and predictions) and planning.
- Teacher models how to record data appropriately, as labeled drawings, charts and/or graphs.
- During investigation students record procedures used, observations and data collected. Students should not be expected to copy information from a handout of directions or from the text. This can be either pasted into the notebook or referenced.
- After the investigation students record conclusions, reflections and any scientific understandings they gained as a result of their experience. In addition, they record questions they still have or any new questions stimulated by the investigation. Sample prompts: *What claims should I make? What new ideas do I have after today's activity? How can I use what I have learned in my everyday life? What other questions can be investigated?*
- During class discussions students record new information and reflect on their learning.
- Teacher provides feedback on entries and encourages student to continue to process ideas. *What evidence do you have to support your claims? Is there another explanation for what happened? How does what you learned today compare to what you originally thought? Learned earlier this year?*

Sample Student Journal Entry (Grade 4)



Variation: Learning Log
Students write regularly in their notebook. This can be done the first five minutes of class to review or raise questions, in the middle of a lesson to process ideas, or during the last five minutes of class to summarize the day's learning. These responses can be integrated with investigations according to date or set up as a separate section of the notebook. The student might also have a section of the notebook set aside for lecture notes and reading notes (see Column Notes). Sample prompts: *Which part of your homework assignment was most difficult? What are two questions you would like answered during today's lesson? Summarize what you learned about this* topic *today/yesterday. What is one thing that is still puzzling you?*

Modifications:
At upper grades students should be expected to create their own charts and graphs in their notebooks. Teachers might want to provide paper with grids to make this easier. At the lower grades and for special needs, students' teachers can scaffold the tasks by providing templates with charts, graphs pre-labeled and ready for data entry, and starting-sentence stems for reflections. Primary grade students can record their ideas through drawings, labeled as much as possible and by using sentence stems that can be completed by adding only one or two key words.

Writing-To-Learn: Science

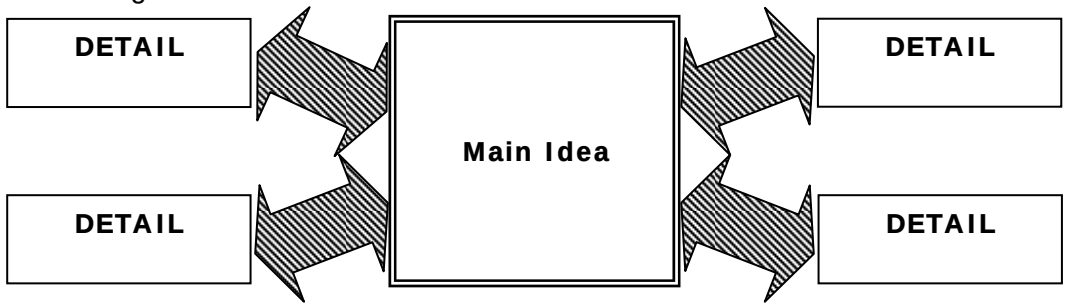
What is it?
A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Main Idea
Students organize by relative importance. Main idea(s) and supporting examples and/or evidence are identified and represented on an appropriate graphic organizer.

What does it do?
- Increase comprehension of targeted text.
- Helps move detailed scientific facts into long term memory.
- Provides a structure for reviewing and analyzing notes.
- Provides an organizational structure for follow-up essays (see Writing to Demonstrate Knowledge: Science).

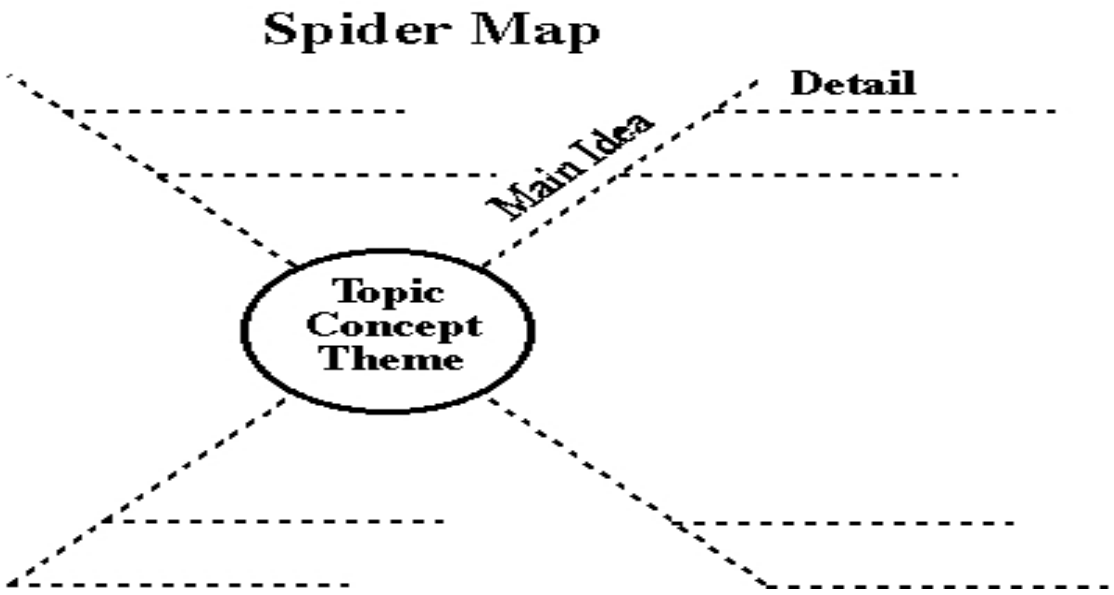
How to implement:
- Teacher models how to use appropriate graphic organizer and provides students with any scaffolding needed.
- Students review notes taken earlier from lecture, video, and/or text and classify information into main idea or support (Two color highlighters or pens can be used.).
- Students record information onto a graphic organizer (see examples).
- Students share their completed graphic organizer with a partner and discuss similarities and differences.
- Students write a reflection paragraph on how or why the main ideas identified are important in science.

Example 1: Main Idea and Supporting Details Graphic
This graphic shows the two-way interaction between main idea and details. Teachers model how to analyze the information, thinking aloud and recording each main idea from the text. Details supporting the main idea are recorded in the connecting boxes.



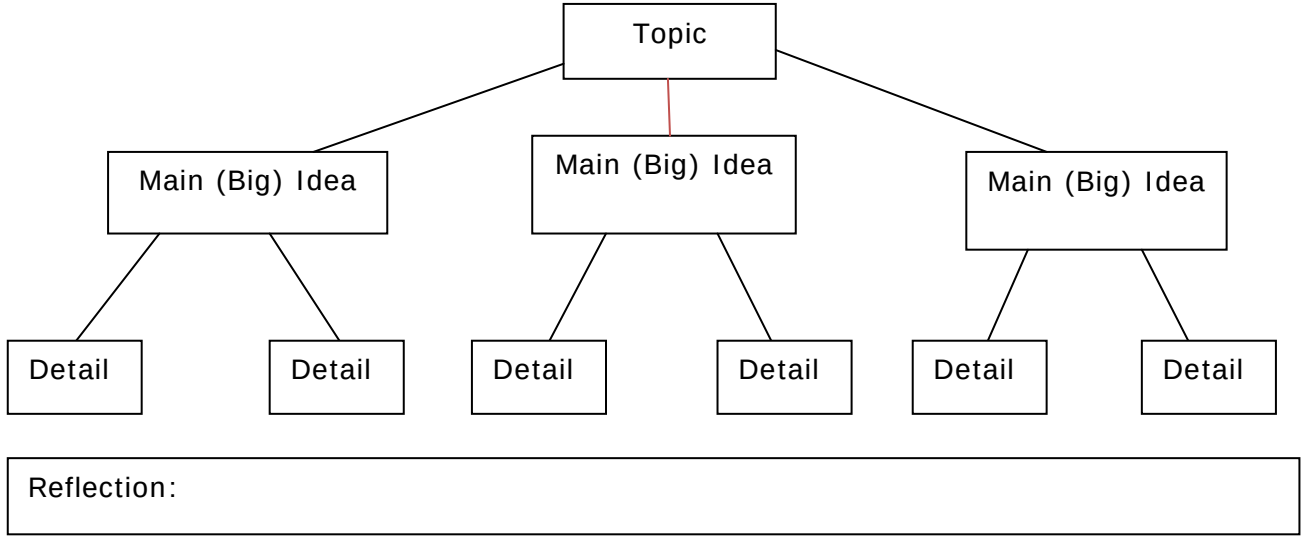
Read more about finding main idea at
http://vclass.mtsac.edu/amla-51/Main%20Idea/Mainidea.htm

Example 2: Spider Map Graphic Organizer:
Students discuss and record main ideas and details that lead to the central concept. The graphic can be drawn in log books and used to plan (as a prewriting activity) or for taking notes to help understand a lecture, video or other medium.



http://www.sdcoe.k12.ca.us/score/actbank/sspider.htm

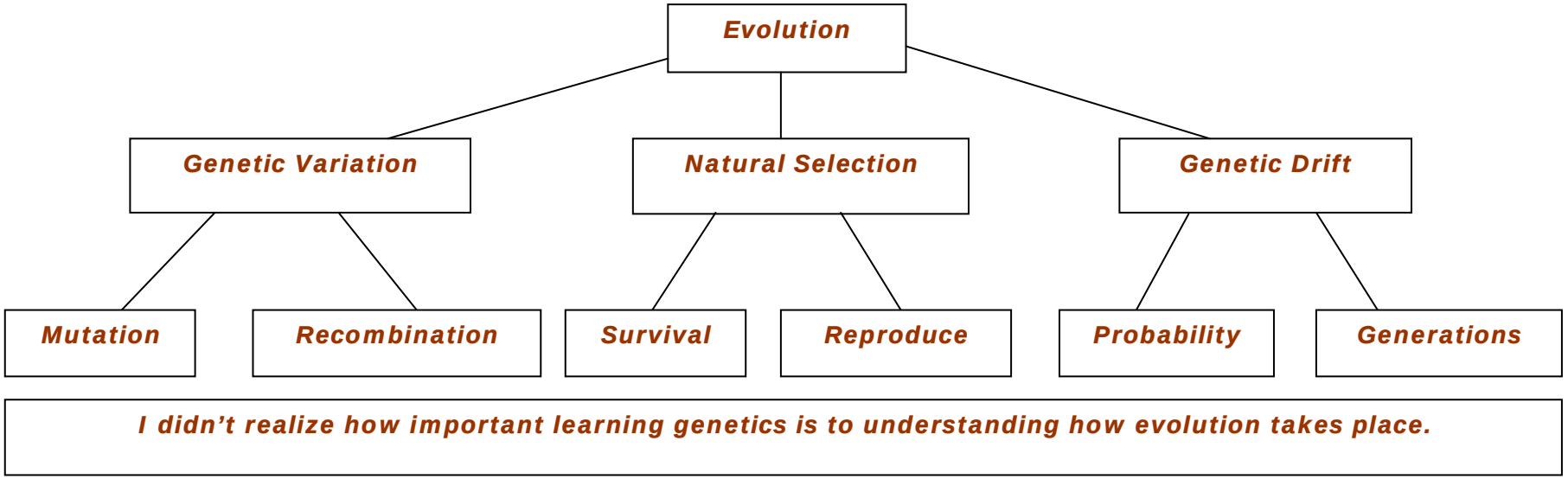
Example 3: Scientific Big Ideas Mapping
After completing a unit or portion of a unit, students review the information they have learned and organize it according to the "big ideas" included.



Text Sample (Wikipedia at http://en.wikipedia.org/wiki/Evolution)

*In biology, **evolution** is the process of change in the inherited traits of a population of organisms from one generation to the next. Genes that are passed on to an organism's offspring produce the inherited traits that are the basis of evolution. Mutations in genes can produce new or altered traits in individuals, resulting in the appearance of heritable differences between organisms. New traits may also arise from the transfer of genes between populations, as in migration, or between species, in horizontal gene transfer. In species that reproduce sexually, new combinations of genes are produced by genetic recombination, which can increase the variation in traits between organisms. Evolution occurs when these heritable differences become more common or rare in a population.*

There are two major mechanisms that drive evolution. The first is natural selection, a process causing heritable traits that are helpful for survival and reproduction to become more common in a population, and harmful traits to become more rare. This occurs because individuals with advantageous traits are more likely to reproduce, so that more individuals in the next generation inherit these traits.[1][2] Over many generations, adaptations occur through a combination of successive, small, random changes in traits, and natural selection of those variants best-suited for their environment.[3] The second is genetic drift, an independent process that produces random changes in the frequency of traits in a population. Genetic drift results from the role probability plays in whether a given trait will be passed on as individuals survive and reproduce. Though the changes produced in any one generation by drift and selection are small, differences accumulate with each subsequent generation and can, over time, cause substantial changes in the organisms.



Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Marginal Notes

Marginal notes are short written statements in which students record their interactions with text in the margins while they are reading.

What does it do?

- Activates students' background knowledge.
- Helps students monitor their comprehension of text.
- Stimulates questioning and analysis of text.
- Helps students become aware of connection between text and their thinking (meta-cognition).

How to implement:

- Teacher explains purpose for reading and taking marginal notes.
- Teacher uses "think aloud" while modeling how to record responses to text.
- Students read all of text segment before making notes (students highlight or underline key points when possible).
- Students record short notes in margins of text as the re-read text segment (directly or on sticky notes).
- Students discuss notes with partner and/or class.

Example:

Text Sample: Source: Wikipedia(http://en.wikipedia.org/wiki/Evolution)	**Reader Annotations (Go on sticky notes or in margins)**
*In biology, **evolution** is the process of change in the inherited traits of a population of organisms from one generation to the next. Genes that are passed on to an organism's offspring produce the inherited traits that are the basis of evolution. Mutations in genes can produce new or altered traits in individuals, resulting in the appearance of heritable differences between organisms. New traits may also arise from the transfer of genes between populations, as in migration, or between species, in horizontal gene transfer. In species that reproduce sexually, new combinations of genes are produced by genetic recombination, which can increase the variation in traits between organisms. Evolution occurs when these heritable differences become more common or rare in a population. There are two major mechanisms that drive evolution. The first is natural selection, a process causing heritable traits that are helpful for survival and reproduction to become more common in a population, and harmful traits to become more rare. This occurs because individuals with advantageous traits are more likely to reproduce, so that more individuals in the next generation inherit these traits.[1][2] Over many generations, adaptations occur through a combination of successive, small, random changes in traits, and natural selection of those variants best-suited for their environment.[3] The second is genetic drift, an independent process that produces random changes in the frequency of traits in a population. Genetic drift results from the role probability plays in whether a given trait will be passed on as individuals survive and reproduce. Though the changes produced in any one generation by drift and selection are small, differences accumulate with each subsequent generation and can, over time, cause substantial changes in the organisms.*	• A change process - over time. • Causes mutations? What? • Horizontal transfer? How? • What about asexual? • Survival of best traits • Need to reproduce • Random change possible • Drift changes – small • Evidence? Proof?

Writing-To-Learn: Science

What is it?
A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Metaphorical Thinking

Metaphorical thinking is an associative process that makes connections between scientific concepts and things that, on the surface, seem dissimilar.

What does it do?

- Accesses prior knowledge.
- Helps gain deeper insight into material by seeing content in a new and different way.
- Explores links between disciplines, ideas and personal experience.
- Promotes creativity and deep critical thinking.
- Provides feedback on depth of understanding (formative and self assessment).

How to implement:

- Teacher explains what metaphors are and gives a number of common examples from students' everyday lives *(That tennis player is a diamond in the rough; Virginia voting is a Litmus Test for election results.*).
- Collect and organize targeted science content information onto a graphic organizer.
- Develop metaphorical connections between the target and an unrelated idea or object.
- Write a summary paragraph that explains the science content targeted and why the connections were made.

Example 1: Direct Analogy--Cell Structure and Function *(Metaphorical Expression, Silver, Strong and Perini, 1997)* Students complete a graphic organizer on the parts of the cell and their functions. Teacher then provides a drawing of a city and asks students to make as many connections as they can between the cell and the city. When they are finished the students prepare a summary of their connections and comparisons and an explanation of why each connection was made. The summary should include a labeled drawing of a cell.

Example 2: Personal Analogy

Students develop empathy by giving personal feelings and emotions to objects. *"You are a polluted river. What is it like? How does it feel?"*

	Cell	City
Parts	*Cell membrane*	*City limits*
Location	*Around outside*	*Surrounds city*
Function	*Encloses the cell*	*Defines jurisdiction*

Example 3: Simile Review (*How to Write in Science, B. Tierney, 2004)*
Students write a paragraph completing a comparison between a scientific term and another unrelated, but familiar object. The teacher can provide the comparison or ask students to come up with one of their own. "*Mitochondria are like Wheaties because they give the cell energy. Both contain fat and proteins……"*

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Quick Write

Quick Writing asks students to independently record everything they can think of in 3-5 minutes. The prompt students are given can be open ended or specific, depending on the teacher's purpose. This strategy can be used before, during or after learning. It should not be a high risk, "graded" activity.

What does it do?

- Surfaces student thinking, making it visible and transparent.
- Provides information for teacher on lingering naïve conceptions, i.e., formative assessment.
- Helps students monitor their own learning.
- Raises questions for future inquiry.
- Provides direction for follow-up instruction, i.e., formative assessment.

How to implement:

- Teacher explains the purpose of the activity and that their products will be read but not graded.
- Teacher explains and models how s/he would respond to a given prompt.
- Students are told that they should write what first comes to mind on the topic and that they should not consult their notes or partners.
- Teacher then assigns a topic, which can be open ended or very specific.

Example 1: Explanation

Provide students with a visual prompt and ask them to respond with a description or explanation. The prompt can be a quote, demonstration, photograph or drawing.

- Students are shown a cartoon of a girl looking at a crescent-shaped moon and they are asked to write the text for the cartoon.
- Teacher adds clear water to an "empty" container and the color changes. Students are asked to explain what caused the change.

Example 2: Exit Slip

- At the end of a lesson students summarize in one sentence what they think was the main point of the lesson. Select 3 -5 cards randomly and read aloud or post at beginning of next class. Discuss how well statements reflected the lesson.
- Formative Assessment: At the beginning of the lesson explain the Quick Write Prompt. It can be general or specific.
  - o "*Class, today we will be learning about photosynthesis. At the end of class I will ask you to list three facts about this process."*
  - o *"Class, today we will be learning about photosynthesis. At the end of class I will be asking you to tell me either the reactants or products for this process."*

At the end of the lesson, repeat the prompt and use student responses for planning. Separate cards into groups. If most students respond appropriately, meet individually with those who are still having problems. If the responses are varied, set up differentiated instruction for the next lesson: enrichment, review and small group tutoring.

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Synthesizing

Students identify main idea from information presented (text, lecture and/or experience). They then combine this information with their prior knowledge to create a new or revised personal understanding (schema) *(See: Harvey & Goudvis, 2007).*

What does it do?

- Provides opportunity for students to make personal connections with information.
- Helps students accommodate prior knowledge and new information.
- Takes thinking required for summarization a step further.

How to implement:

- Students record their prior ideas and predictions.
- Students collect facts and/or data from a variety of sources.
- Students review and summarize new information.
- Students compare current ideas with ideas initially recorded.
- Students reflect on how their thinking has changed and make personal connections to their learning.

Example 1: Prompting and Recording

- Investigating Sound:

Students record everything they think they know about a science topic (sound). After a hands-on investigation, they revisit the graphic organizer and record how their thinking has changed. They then read informational text about how sound is formed and revisit the organizer again.

What is Sound?
I am thinking:
Now I am thinking:
Finally, I am thinking:
How this relates to me:

- Synthesizing Text

Students use an informational trade book or textbook to find facts about a topic in both the text and illustrations. After recording these facts, students summarize main points and reflect on how their thinking has changed on the topic (comparing ideas to prior thinking).

SYNTHESIS THROUGH INFORMATIONAL TEXT		
Important Facts from Pictures and Captions	**Important Facts from Text**	**Summary of Main Points**
Reflections:		

Example 2: Drawing and Describing

Students make a labeled drawing of a "scientist" (most students draw white males in lab coats with test tubes). Teacher then presents text, photos and video information about different types of people who work as scientists. Students draw a scientist again and compare their two illustrations. They reflect on the differences and make a personal connection.

Note: Student begins here after accessing written and/or visual text on scientists.

Labeled Drawing of a Scientist (include tools your scientist uses)	**Scientist's Job Description**
Revised Drawing of a Scientist (include tools your scientist uses)	**Revised Scientist's Job Description**
Synthesis: At first I thought, but now I think:	
Personal Response: I am like a scientist because:	

Writing-To-Learn: Science

What is it?

A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Time-Sequence

Students use a graphic organizer to represent events in their natural world which happen in a specific order. The graphic organizer must be appropriate to the type of sequence (linear, cyclical, repetitive). Information represented can come from text, lecture and/or direct observation.

What does it do?

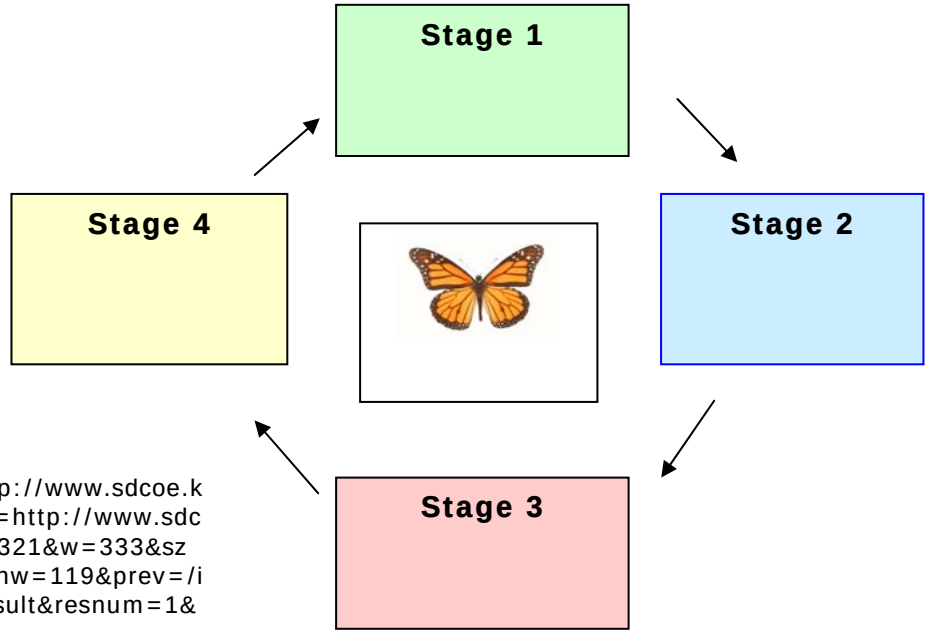
- Engages students in processing observations and/or information that was obtained over time into a sequence.
- Provides visual prompt for remembering stages or processes represented.
- Provides an organizing structure for future writin,g e.g., see *Story Writing* or *Essay Writing*.

How to implement:

- Teacher models how to use each type of sequence organizer.
- Class records steps from a class demonstration on a sequence chain.
- Class records natural cycle described in a text selection (i.e. Rock Cycle) on an appropriate diagram.
- Teacher assigns a task (text reading, investigation observations, etc.) and students practice using assigned organizer.
- Students select appropriate organizer to process time-sequenced scientific examples and concepts (see Science Notebook).

Example 1: Cycle Note-Taking

Class reads about butterfly growth and development. Students observe butterfly larvae turn into mature adults.
They record drawings and notes on a cyclic graphic organizer, representing the repetitive nature of the life cycle.



Adapted from
http://www.google.com/imgres?imgurl=http://www.sdcoe.k12.ca.us/score/actbank/cycle.gif&imgrefurl=http://www.sdcoe.k12.ca.us/score/actbank/tcycle.htm&h=321&w=333&sz=3&tbnid=86ERwnesGM4J::&tbnh=115&tbnw=119&prev=/images%3Fq%3Dcycle&sa=X&oi=image_result&resnum=1&ct=image&cd=1

Example 2: Linear Planning

- Succession of an Abandoned Field: Students watch a movie that describes the succession of an ecosystem, such as a forest. Students describe the sequence of events through labeled drawings and/or descriptions on a sequence chain graphic organizer.

Annual plants, bare ground, changes fast	***Biennial plants, grasses, poor soil***	***Perennial herb, shrubs, improved soil***	***Soft wood trees, Pine, Sweetgum, forms canopy***	***Less light on floor, more humid, leaf litter on soil***	***Hard wood trees, Oak, Hickory***

See more at: http://www.google.com/imgres?imgurl=http://www.sdcoe.k12.ca.us/score/actbank/cycle.gif

- Seasonal Change Flip Book: Students observe seasonal changes over time and represent them as dated drawings on 3x5 cards or small pieces of card stock. Cards are stapled together in order to form a flip book that illustrates the changes observed as a movie. Students write a script to accompany their flip book story about the seasons. This can also be done as a class flipbook and story.

Modifications:
Older students can be expected to select the appropriate graphic organizer for the type of sequence they are depicting. Younger students and special needs students can be given organizers that fit the situation or a choice from a limited number of organizers.

Writing-To-Learn: Science

What is it?
A writing-to-learn strategy is one that teachers employ throughout and/or at the end of a lesson to engage students and develop big ideas and concepts.

Strategy: Visualizing and Recording Mental Images

Some students process ideas better visually than orally. This strategy encourages students to use images to describe complex scientific concepts and/or processes. Students may each have their own unique way of representing these ideas.

What does it do?

- Engages multiple dimensions of a student's thinking process (i.e., Gardner's Multiple Intelligences; Brain Hemisphericity).
- Accesses student's personal schema for the concept.
- Encourages students to synthesize information.
- Surfaces student questions and lingering misunderstanding, i.e., formative assessment.

How to implement:

- Students sit quietly with their eyes closed.
- Teacher reads or describes a place, object, or process using details/sensory terms (e.g.,smells, sounds, texture, etc.).
- Students draw a picture that represents their image of the teacher's description.
- Students compare their representations with a partner or team.
- Students write a reflection on the visualization experience.

Example1: Succession Visualization

Teacher reads a description of an ecosystem before and after a forest fire. Students draw before and after pictures and then write a prediction of what will happen to the area after the fire.

> Before: *Imagine that you have been hiking in a woodland forest all day. The smell of evergreen trees fills your head. The crisp, clean air surrounds you as a gentle breeze blows through your hair. You hear the crunch of the old, fallen leaves as you walk through the leaf litter…(continued)*
>
> After: *It is now one month later, and you return to your area to see what has happened. Black sticks and charred stumps that were once trees poke up from the ground. The air is heavy with the smell of burnt wood. The ghost forest is silent now. (Guided visualization story continued by teacher in this same manner.)*

Example 2: Sketching from Sensory Experience
Provide students with a "mystery bag" that contains an item that is part of a larger object or animal. Without looking, students use their senses to observe the item (smell, sound, feel). Students close their eyes and try to visualize the item and the object from which it came. They then draw a representation of what they have visualized and share it with their partner or team. Students then write a reflection on their experience ("I was sure I knew what was in the bag because…."; "I had trouble visualizing the animal, but I knew it had large teeth and therefore must have fur as well.").

Example 3: Comparing Graphic Representations
Students draw a labeled representation of a scientific concept and use it to explain the idea to a partner. Partner provides feedback on whether or not drawing matches their personal visualization of the concept. Follow up writing prompt: "What parts of this concept were you able to represent easily in your drawing?" "Which parts of the concept are not represented? Why not?"

Modifications:
Students imagine a place or object in their mind (ecosystem, animal, plant, planet, etc.). Each student writes a vivid description of his/her visualization, using sensory terms. Students then read their description to a partner who draws what s/he visualizes from the description provided. Students reflect on the similarities and differences between their partner's image and their own.

For primary grades, students can be asked to use only one sense and to only identify and draw the object (onion, ball, etc.). Reflections can be collected on a class chart.

Writing-To-Demonstrate-Knowledge: Science

What is it?

When writing-to–demonstrate-knowledge, students show what they have learned by synthesizing information and explaining or applying their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Form / Format: Argumentation

In argumentation a claim is developed and proven using logical reasoning and examples. The writer also rebuts arguments of the potential opposition to the claim. Adapted from Karbach, J. (1990). Using Toulmin's model of argumentation. *Journal of Teaching Writing*, 81-91.

What does it do?

- Deepens students' understanding of science content.
- Promotes critical thinking, analytical skills, and logical reasoning.
- Prepares students for the ACT and postsecondary writing expectations.

How to implement:

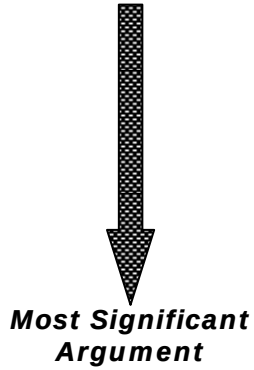
Teacher…

- Introduces students to the vocabulary and format appropriate for argumentation.
- Provides examples and non-examples of logical thinking and argumentation (i.e. trial lawyer movies).
- Provides opportunities for students to debate and/or argue positions in a systematic, logical format (Socratic Seminar, Formal Debate).
- Models how to use a template for planning the argumentation process.

Students…

- Research both positions of a controversial science related issue (i.e. use of nuclear power).
- Use a template to preplan their arguments, identifying both pro and con points.
- Prioritize their arguments according to importance.
- Organize their piece (Title, Introduction, Body, Conclusion) and develop a draft argumentation paper.
- Use criteria provided to self-evaluate and peer-evaluate draft. The following questions can be used as a guide:
    - *What was the position or claim?*
    - *What grounds were used to convince the reader to agree with the claim (*reasons why, data, evidence, and facts)?
    - *Is a tight argument established between the grounds and claim?*
    - *Is the information provided relevant and accurate? Is a rebuttal provided for potential counter arguments?*
    - *Is the case presented logically and is it adequately summarized?*
- Revise document, moving toward publication.

Prewriting Template



My Main Argument(s)	The Counter Argument(s)
Argument (claim): **Support (evidence):**	**Argument (claim):** **Support (evidence):**
Argument (claim): **Support (evidence):**	**Argument (claim):** **Support (evidence):**
Argument (claim): **Support (evidence):**	**Argument (claim):** **Support (evidence):**
Summary Argument	**Summary Argument**

Example: Position Paper

As a performance assessment task for a science unit, students take a position on a controversial societal issue related to the scientific concepts addressed in the unit.

Environmental Issue Advocacy Plan

As a member of an Environmental Advocacy Committee you have been asked to evaluate a situation that endangers a given ecosystem. Different solutions to the problem have been proposed. You will take a position on which solution is best and defend your position. You and your committee must convince the community that the solution you propose is not only the best option, but is also both workable and realistic.

Your position paper will include:

- *An analysis of the ecosystem in question (i.e. shoreline).*
- *A clear definition of the scenario problem (i.e. drilling offshore, construction of a new condominium complex on the shore).*
- *A workable/realistic solution to the problem with justification for the proposed solution (i.e. regulations that should be enforced).*
- *An alternative solution that may be proposed and why this option is less desirable.*

Writing-To-Demonstrate Knowledge: Science

What is it?

When writing-to–demonstrate-knowledge, students show what they have learned by synthesizing information and explaining or applying their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Form / Format: Essay Writing

An essay is a non-fiction piece of writing, usually written from an author's point of view. It includes writing that uses thesis statements and support for them. Essays conform to all rules of grammar and punctuation.

What does it do?

- Provides opportunities to organize and develop ideas on a topic.
- Encourages students to express their point of view on an issue.
- Requires students to support ideas/positions with facts and/or examples.
- Combines application of higher-order science and literacy skills (data collection, analysis, synthesis, summary, evaluation, etc.).
- Provides the teacher with feedback on student understanding and skill application (formative or summative assessment).

How to implement:

Teacher…

- Provides students with format for essay and assessment criteria (rubric).
- Provides samples of past products and criteria used to demonstrate desired traits.
- Models the development of a high quality essay.

Students …

- Develop a thesis for their essay.
- Organize information needed to support thesis (from research, science notebook, memory, peer discussions, etc.).
- Write essay based upon the given purpose and/or directions (see example).
- Self evaluate (and peer review, if appropriate) product using established criteria.
- Revise essay as needed.

Example 1: Written Response

Essay questions should be part of unit and term performance tasks. These questions may require a paragraph or a longer, more extensive response. They can be done in class as part of a test or can be given as at-home assessment tasks. Students need to make sure that the first sentence of their response answers the question clearly and concisely, without detail. This is followed by details and examples that support the answer. The last sentence of the essay should restate the answer and summarize the details/example provided.

Sample question, scoring guide and student response from 1999 Science MEAP:
http://www.michigan.gov/mde/0,1607,7-140-22709_31168_31355---,00.html

> ***Predict what would happen to the mass of a bean plant if one half of the leaves are covered with black construction paper for 45 days. Explain your prediction by using scientific evidence to support it.***

Scoring guide:

> ***2*** *= The response makes a prediction based on the mass, size, or weight of the plant AND explains the prediction using scientific evidence.*
>
> ***1*** *= The response makes a prediction based on the mass, size, or weight of the plant OR explains a prediction using scientific evidence.*
>
> ***0*** *= The response does not include an acceptable explanation. (The response may merely state that the whole plant would/might die, not be healthy, or not survive.)*

Sample student response (score = 2)

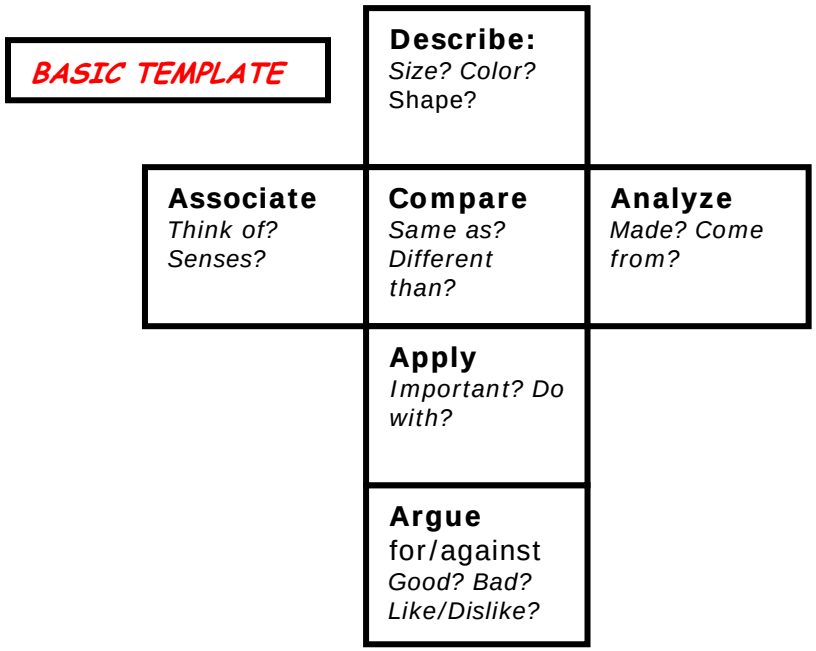
> ***If one half of the beans are covered with black construction paper for 45 days the mass of the bean plants would not be as much as 0.5 kg, it would be less. Plants need to make food by photosynthesis, which involves taking in the sunlight. If they covered some of the leaves, which are the ones responsible for taking in the sunlight, the process of photosynthesis would not produce so much food. Then the plant would not grow as much.***

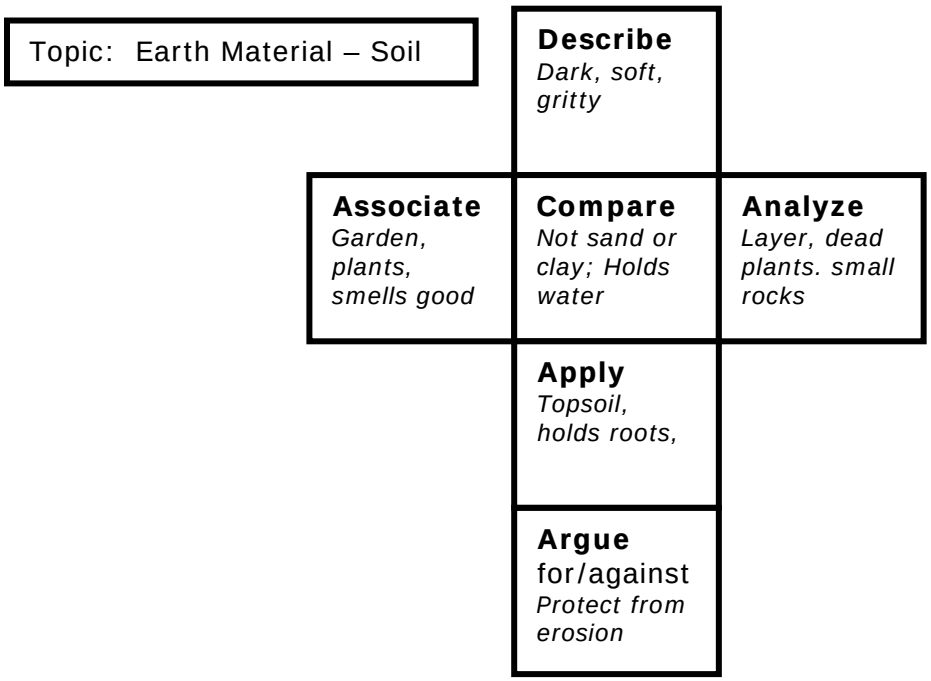
Example 2: Persuasive Stand

Students are given a problem related to a science topic or concept that has multiple appropriate answers. They are asked to chose a position and explain the reasons for their choice. Then they support/explain their point of view with facts/examples. The essay should conclude with a summary of their position. The scoring guide should include accuracy of information used for support.
Sample topics:

- Is Pluto a planet?
- What is the best way to control the deer population in Michigan?
- Should the U.S build more Nuclear Power Plants?

Cubing:
Cubing is a tool that can support the development of an in-depth essay on a given science topic. This strategy provides a structure for the essay and helps students look at the topic from a variety of perspectives. The template can be made of card stock and folded to form a cube. By rolling the cube, teachers can assign different parts of the project to members of a team (or class). Students can also roll the cube to decide which of the six facets they will use.





Writing-To-Demonstrate Knowledge: Science

What is it?

When writing-to–demonstrate-knowledge, students show what they have learned by synthesizing information and explaining or applying their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Format/Form: Informational Writing

Informational writing imparts scientific knowledge or tells the reader how to do something. The text is non-fiction and must be factually accurate.

What does it do?

- Requires students to organize and clearly communicate knowledge.
- Helps students clarify their own understanding of information.
- Provides performance-based format for student assessment.
- Provides applications for demonstrating knowledge through the construction of a variety of genre specific to the content area.
- Encourages student creativity.

How to implement:

Teacher …

- Provides students with formats for writing and assessment criteria (rubric).
- Reviews informational text patterns (e.g., compare/contrast, position/support, problem/solution, descriptive, sequential, enumerative, chronological sequence, cause/effect).
- Provides samples of past exemplary products and uses criteria to demonstrate desired traits.
- Models how the writing process (prewriting, drafting, revising, editing, publishing) can be used to develop a high quality product.

Students …

- Select a topic.
- Organize information needed (from research, science notebook, memory, peer discussions, etc.).
- Use a pre-writing technique to develop their ideas (graphic organizer, outline, etc.).
- Write first draft of informational text following conventions of the genre.
- Self evaluate (and peer review, if appropriate) product using established criteria.
- Revise text as needed.
- Prepare for publication.

Example 1: Create a Children's Trade Book

Students write an illustrated informational children's book on a scientific topic they recently studied. The goal is to inform a reader outside of the classroom. The writing can be conducted for their own age group or for another grade level. Copies of final products can be used in a variety of creative ways and can also be placed in the class library or given to another targeted audience for their library.

For example:

- Elementary book on plant parts: Students each write a pattern book using a repetitive format. On each page a plant part is described, drawn and labeled and then summarized in the final statement about the part's importance to the plant. The following stem can be provided for lower grades: "The most important thing about …….. is……."
- Review for MEAP test: Students write an informational book on material they have learned and pass these books along to teachers in Grades 5 or 8. These books serve as a resource library for students as they review for their upcoming science assessment.
- Children's Library: Students write an illustrated, informational book for students at a lower grade who will be studying the same topic, but at a simpler level. Grades 3 and 5 both study aspects of how objects move. Grade 5 students review what Grade 3 is expected to understand and use their knowledge to write a book for Grade 3 that can be added to their library of informational books. High school students can also write for a middle school audience.

Example 2: Write a Technical Manual

Students write "how to" manuals for skills needed to be successful in science investigations. These should include labeled illustrations and might include any of the following examples:

- "Safety in the Science Laboratory"
- "How to Use Measurement Instruments Accurately"
- "Directions for Activities Demonstrating Properties of Matter" (or any other science phenomena)
- "How to Design Circuits for Holiday Decorations"

Modifications:

Students in primary grades or with special needs can use more writing stems on their pages, or they might produce a class book instead of an individually composed manual.

Writing-To-Demonstrate-Knowledge: Science

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When writing-to–demonstrate-knowledge, students show what they have learned by synthesizing information and explaining or applying their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Format/Form: Investigation Report

In a Science Investigation Report, students are expected to take hands-on laboratory experiences and report on or process them through writing. Students report on and reflect on what they did in the lab activity to make sense of their results. Reports developed should be Type 5 Writing: publishable and for audiences outside the classroom (John Collins' *Five Types of Writing*).

What does it do?

- Provides an opportunity for important cognitive processing by offering opportunities for students to synthesize the information obtained from investigations.
- Requires students to communicate laboratory experiences and reflections clearly to an authentic audience.
- Provides formative, performance-based assessment information for teachers on science inquiry process skills attainment as well as students' clarity of scientific thought.

How to implement:

- Present students with the traditional format for an Investigation Report (Introduction, Methods, Results, Discussion).
- Explain how this format is used by scientists to structure scientific thinking: establishing a hypothesis, testing the hypothesis, reporting findings related to the hypothesis, and making a judgment as to the quality of support for the hypothesis.
- Discuss purpose, audience and implications for developing this type of report (other scientists, journals, public).
- Share examples of quality science reports with students (create or use from previous classes).
- Provide students with a rubric that describes the criteria and standards expected in a high quality report.
- Explicitly demonstrate places in sample reports that meet standards and illustrate strategies to use for those that need improvement.
- Model and practice each section of the report separately (during lab activities and/or demonstrations).
- Scaffold learning by writing sample reports as a class.
- Provide additional practice by having teams write reports on group investigations.
- Use partial lab reports where students write one or more parts of a full report, building up to where students are able to write a full report independently.
- Provide opportunities for students to critique reports written by others (from professional journals, from previous year students or by science teams).
- Provide a pre-lab template designed to help students prepare their thinking for the report. This might include:
    1. Scientific concept and what is already known about the concept.
    2. The purpose of the lab.
    3. A hypothesis and an explanation, based on what is known about the concept and the use of scientific reasoning conducted to reach the hypothesis, and the resources and procedures that will be used to test the hypothesis.

- Assign a report as an assessment at the end of each unit or term (not for every activity).
- Encourage students to get peer feedback on the first draft of their report and to use the provided rubric to self evaluate and revise.

Example 1: Topic-Based Investigations

- Introduce a system to investigate that is related to the topic of study.
- Generate a list of variables that can be manipulated in this system.
- Generate a list of what might be affected by changing one or more of these variables.
- Decide how the variables can be measured (qualitatively or quantitatively).
- Use the lists to develop a series of questions that can be investigated.
- Have students select one of the questions for investigation.
- Students present their Investigation Reports to other students who selected the same variables.
- Use the following template to plan the investigation prior to the formal results and write-up.

Science Investigation Planning Template			
The ***__plant___*** system we will investigate is***____radish seeds__.***			
What we already know about how this system works.	**Materials readily available for investigating this system…**	**Variables we can change…**	**How we could measure/describe how our system responds to changes?**
Radish seeds do not need light to germinate. They grow very quickly.	*Soil, Heat lamps, radish seeds, containers, Fertilizer*	*Temperature* *Number of seeds/ container* *Type of fertilizer* *Amount of fertilizer* *Amount of water*	*Time to germinate* *Height of plants* *Color of plant leaves*
How does_____ affect_____? *Manipulated **(Independent)** variable* *Responding (**Dependent**) variable*			
Questions to investigate: • *How does the type of soil affect the time it takes for radish seeds to germinate?* • *How does the temperature of the soil affect the time it takes for radish seeds to germinate?* • *How does the amount of water affect the time it takes for radish seeds to germinate?*			

Example 2: Independent Investigations

Teacher keeps an ongoing list of lingering questions generated by the class during all units and class labs. At the end of a unit or term, students select a question to investigate. With teacher support students conduct the investigation and then present their report in class or in other contexts:

- Science Conference:
  Students share reports with groups of students, parents and other members of the community in small groups. Participants ask questions and provide feedback to the reporting student(s).
- Poster Session:
  Students display their reports on posters. The audience can be other classes or parents during a learning fair.

Modifications:

For elementary level and primary students the report format would be modified. At lower grades the investigations are more descriptive than quantitative. Templates may include stems, charts and graphs that only need to be filled in (not developed). The following is a sample report template for primary grades.

Science Investigation Report Form: ***Upper Elementary***
Question for my investigation:
What I think the answer is to my question (Hypothesis):
Materials I will use to test my answer:
Procedure:
My observations (Tables and/or charts):
Summary of my results:
Possible errors in my investigation:
Additional questions I could investigate that are related to this question:

Science Investigation Report Form: ***Primary Grades***
I wonder what will happen if:
I think (Prediction):
How I will test what I think will happen:
Evidence I collected from my test:
Summary of what I learned:

Writing-To-Demonstrate-Knowledge: Science

What is it?
When writing-to–demonstrate-knowledge, students show what they have learned by synthesizing information and explaining or applying their understanding of concepts and ideas. Students write for an audience with a specific purpose. Products may apply knowledge in new ways or use academic structures for research and/or formal writing.

Form/Format: I-Search Paper (coined by Ken Macrorie in *The I-Search Paper*, 1988)
I-Search is an informal, inquiry genre for research. Students develop questions based upon their own interests or develop their own questions related to the topic under study. They utilize a variety of science resources to find answers to their questions.

What does it do?
- Stimulates student curiosity and interest.
- Provides an opportunity for students to delve deeply into an area of interest.
- Increases students' scientific content knowledge.
- Improves students' science inquiry skills.
- Provides opportunities to access information from multiple sources.
- Improves students' abilities to evaluate the scientific accuracy and significance of information accessed.

How to implement:
Teachers explain to students the Four Phases of the I-Search process and the criteria for product evaluation. Teachers provide modeling and scaffolding as needed for each phase of this process.

- **Phase 1: Immersion and Generation Of Question(s)**
  As a class, discuss science concept(s) from previously studied or upcoming units (prior knowledge). Brainstorm lists of questions that are related to ideas/concepts discussed (individually, in a team, as a class). Students select questions that best fits interests (individually or as a small team).
- **Phase 2: I-Search Plan Development**
  Students plan strategies for collecting information about their question/topic. They should be encouraged to use a variety of text/media: books, magazines, newspapers, internet resources, videos, pod casts, television documentaries, online newscasts, interviews, experimentation, field trips, etc.
- **Phase 3: Developing Knowledge—Gathering and Integrating Information**
  Students implement the search plan, taking careful notes on information collected and resources used. They integrate information from multiple sources using graphic organizers and other strategies to support their organization and analysis of the information collected.
- **Phase 4: Creatively and Skillfully Representing Knowledge**
  Students represent the knowledge they have constructed (written paper, exhibition, web site, video, skit, poster, or demonstration). Their products should communicate the following: Questions, Search Process, What I Learned, What This Means to Me, and References (see Macrorie, 1988 and Romano, 2000). Students reflect on what they learned and the skills they developed as a result of this process.

Example 1: Open-Ended

At the beginning of the year, term, or unit, ask students what area or topic in science they wish they knew more about. Evaluate the responses and have students select the most important area to focus on to develop the I-Search project. Some student examples follow:

- *"My father has diabetes and I would really like to know more about what causes this disease and ways it can be treated."*
- *"I love to cook and I would like to know more about the connection between chemistry and cooking."*
- *"I play baseball and want to understand more about how different types of pitches are thrown and why they move the way they do."*

Example 2: Unit-Related

Studying science raises new questions. During or after a unit of study have students generate new questions they would like to investigate.

- During a unit on "Animals and Their Needs" students select an animal they are interested in knowing more about for developing an I-Search project.
- After a class demonstration on scientific phenomena, students brainstorm questions they have about what they observed. Individuals or teams of students can select one of the questions generated for their research.

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Form / Format: Journalistic Reporting

Students write a newspaper/magazine article explaining a topic in science based on the results of their "investigation reporting."

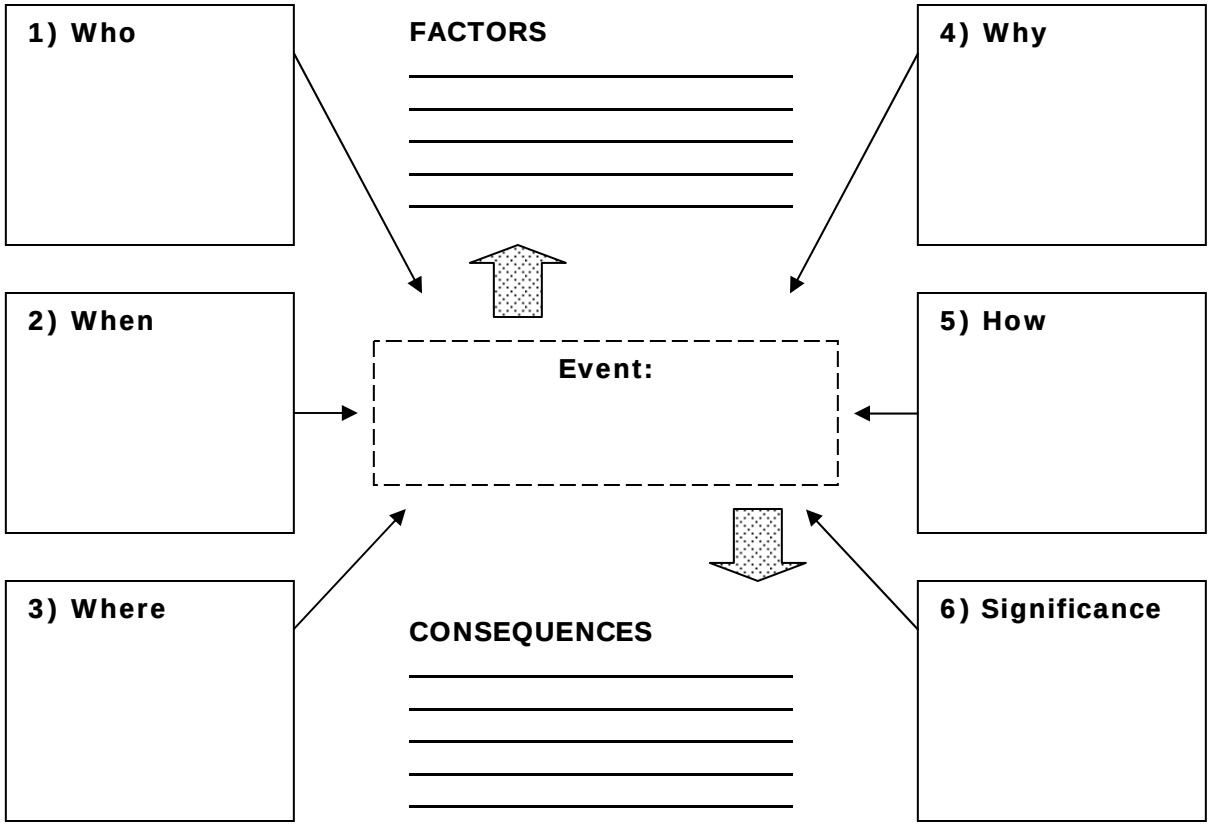
What does it do?

- Makes real world connections between scientific concepts and events in students' world.
- Encourages students to communicate information for non-scientific but authentic audiences.
- Provides an authentic purpose for application of science knowledge and writing skills.
- Increases student interest and motivation.
- Helps students understand and experience first-hand the genre of *Journalist Reporting*.

How to implement:

- As a class, analyze sample science-related articles in magazines and/or newspapers. Use a graphic organizer to determine importance and identify the significant information in the article.
- Model how to use the graphic organizer (below) as a prewriting tool.
- Review the following characteristics of a quality news article and develop a class rubric.
  - **Conciseness:** Short/direct sentences and paragraphs. Paragraphs are usually no more than three sentences.
  - **Clarity:** Clear statements about who did what to whom, when things happened, and in what sequence.
  - **Accuracy**: Includes verifiable facts.
  - **Detail:** Includes descriptions, exact quantities, complete names, addresses, classes and ages of people involved.
  - **Objectivity:** Facts speak for themselves. Personal feelings and opinions are not appropriate.
  - **Brevity:** To the point. Elimination of unnecessary words, phrases and information.
  - **Appropriate Quoting**: Alternates between direct (colorful) and indirect quotes.
  - **Attribution:** Identify all sources. Explain where information was found.
  - **Respect for Individuals**: Use full names and appropriate titles when a person is first mentioned.
  - **Titles**: Headlines are brief, informative, and use interesting word choices.
  - **Leads:** Pique the reader's interest and grab attention. Stress what is most important, unusual, or recent about the story. Avoid questions. The lead summarizes the substance of a story in one or two sentences.
  - **Body**: Answer questions anticipated from the reader. Important information should be included early. Offer facts and details according to their importance.
  - **Conclusion**: No real conclusion. The story usually ends after the least important details are reported.
- Students become investigative reporters in their school/community looking for science-related news events or situations. They use a graphic organizer (see below) to develop their article.

Adapted from NWP training handout, Cape Fear Writing Project, UNCW.


1) Who
FACTORS
4) Why
2) When
Event:
5) How
3) Where
CONSEQUENCES
6) Significance

Example 1: School-Related Articles

Students explore the school environment, observing and noting issues related to science. This could include watching school board meetings on television. Students return to class and discuss their observations as a team. The team decides which of the events or issues can be further investigated and developed into a news article. News articles are published in a class/school paper or read to the students and staff on a public address system (e.g., morning school video news update).

Sample issues include:

- "Cafeteria Becomes Green" – School decided to reduce the use of environmentally unfriendly products and/or to implement a recycling plan. The opposite would also make a good article – the cafeteria is not doing any of these things.
- "Windows in School Leak" – Students sitting next to the windows have noticed a cold draft and wonder how much energy is being lost and what it would cost to improve the facility.
- "Athletes Have Better Recovery Rates" – Students who are on a sports team can be excused from physical education classes. Students want to find out if being on a school team is better than or as good for your health as taking physical education classes.
- "Is Our Chemistry Lab Safe?" – Students have been practicing the safety guideline their teacher taught, but now they wonder if the physical plant and building guideline are also based on best safety practices.

Example 2: Community-Based Articles

Students listen to news reports, watch community council meetings, and observe their neighborhoods. They bring their observations to class for discussion. Ideas for investigative reporting are brainstormed and selected. Students can work as a class on this project and share information collected, or as individuals on different topics. Articles developed can be submitted to the local newspaper or to the school newspaper.

Samples include:

- "Fertilizers Used On Lake Property Endanger Fish"
- "More Black Squirrels Appearing"
- "Hazardous Materials Added To Curbside Recycling"

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Form/Format: Narrative Writing

Narrative writing tells a story. The basic format is beginning, middle, and end, using character, settings and plot. The goal of this type of writing in science is to apply and demonstrate knowledge learned about scientific concepts, science examples and/or famous scientists.

What does it do?

- Reveals student content knowledge and depth of understanding.
- Encourages student creativity.
- Provides alternative format for student assessment.
- Provides an alternative genre-related knowledge demonstration within the content area.

How to implement:

Teacher…

- Provides students with format for writing and assessment criteria (rubric).
- Provides samples of past products and uses criteria to demonstrate desired traits.
- Provides story map template for student planning of the narrative and models its use.
- Models the development of a high quality product.

Students …

- Determine a purpose and audience for their final product.
- Organize information needed (from research, science notebook, memory, peer discussions, etc.).
- Write story as per purpose and/or directions (see examples).
- Self evaluate/peer review product using established criteria.
- Revise story as needed.
- Publish the products.

Example 1: Travelogue

Student writes a fictional story (simulated) from the perspective of an inanimate object. The object takes a journey similar to what would happen in nature; however, the object travels this journey with human characteristics and reactions. The story includes accurate scientific facts and vocabulary. For example:

- A blood cell traveling through the circulatory system
- A raindrop traveling through the water cycle
- A pollen grain and its life cycle experiences

Example 2: Pourquois Story Telling

Pourquois stories are fictional explanations of natural phenomena, based on actual observations and descriptions. *How the Elephant Got its Trunk* by Rudyard Kipling is an example of this type of story. The teacher should read an example of this type of story to students. Have students analyze the characteristics of this genre and chart them on the board. Then students select a natural phenomenon they have personally observed or studied in class, and write their own story about it using their criteria. Stories should also include scientific facts. Steps for writing include:

- Select an animal trait, natural event, or people's custom to write about.
- Brainstorm ideas for characters, setting, and plot.
- Select actions that accurately illustrate the behavior of the natural phenomenon.
- Decide who will the main character(s) be--animals, natural forces, or other things found in nature?
- Decide when and where the story will take place?
- Give the "character(s)" an interesting personality.
- Develop the story's conflict and resolution.
- Illustrate the story.
- Have students tell their stories to an authentic audience.

Example 3: Story Book (Picture Book Or Chapter Book)

Students write a mystery, science fiction story or animal story, using what they know about the scientific context as they develop the plot, conflict and characters involved. The teacher can introduce this type of writing by reading an example to the class (*Who Really Killed Cock Robin* by Jean Craighead George: an eco-mystery scientifically based on food chains and environmental science).

The story should:

- Be told from a particular point of view.
- Make and support a point.
- Be filled with precise detail and description.
- Use vivid verbs and modifiers.
- Use conflict and sequence to resolve the main characters' problems, as any story does.
- Make use of dialogue if appropriate.

Conflict might involve nature, technology and/or society (population growth, energy use, etc.).

Example 4: Autobiography Of a Scientist

Students tell their own life story as a future scientist. They project themselves into the future using what they know given a scenario in which they apply science in their career, such as an engineer or as a research scientist. The story may include a future scientific discovery, travel to another planet, etc. This story should demonstrate that students understand the nature of science and how scientific contributions are made in society. The story plot should describe obstacles and conflicts they would face as future scientists.

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Form / Format: Research Report

A research report is an informational text produced to summarize a body of scientific work. The report must be based on documented, credible sources and should follow appropriate formats. Research reports use conventions of headings, subheadings, etc. (see Michigan's Genre Project at www.michigan.gov/glce for more information related to specific characteristics of genre).

What does it do?

- Helps students synthesize ideas and look at them more holistically.
- Raises questions for further scientific investigation.
- Encourages in-depth expertise on a topic.
- Provides experience with genres of writing expected within scientific professions.

How to implement:

The teacher should prepare a detailed timeline for this project that includes a number of checkpoints. Before beginning a research project with students, teachers should provide explicit instruction in the processes, steps, elements, and criteria involved. They include:

- Topic selection and development.
- Selection and citation of quality references.
- Comprehending, gathering and organizing information from traditional as well as web sources.
- Developing a first draft that includes thesis statement, introduction, supporting evidence/examples, summary/conclusion.
- Peer review and revision.
- Final draft.
- Proofing.
- Choosing from a variety of publication options.

Example 1: Developing Investigation Background

Before selecting scientific questions for their investigation, students need to have an in-depth understanding of the topic they are studying. Scientists begin their research reports with a literature search – a summary of the research that has already been done in their area and what other scientists have concluded from their work. This literature review can be a separate report, shared with the class to help everyone identify researchable questions for further investigation, or it can be integrated into the Science Investigation Report as an Introduction.

Example 2: Learning Stations
A team of students is assigned or selects one science sub-topic within an area of study. They conduct research and become the class experts on their area. In addition to creating a summary of what they have learned, they teach the most important points to the rest of the class through a "Learning Station." The station includes a variety of learning tools: visual display, labeled diagrams, activities for exploration or review, etc.

Example 3: Simulated Biography Of a Scientist
In order to better understand the nature of science, students research the life and accomplishments of a scientist (past or present). Students can be assigned someone who worked in an area related to the topic of study or they can select someone from a comprehensive list they are interested in learning more about (list must include minorities and women). Biographies should also describe how society reacted to the scientist and his/her contributions (i.e. conflict between Galileo and the church). See Michigan's Genre Project at www.michigan.gov/ela to reference the characteristics of a simulated biography. Take the composition through the stages of writing process.