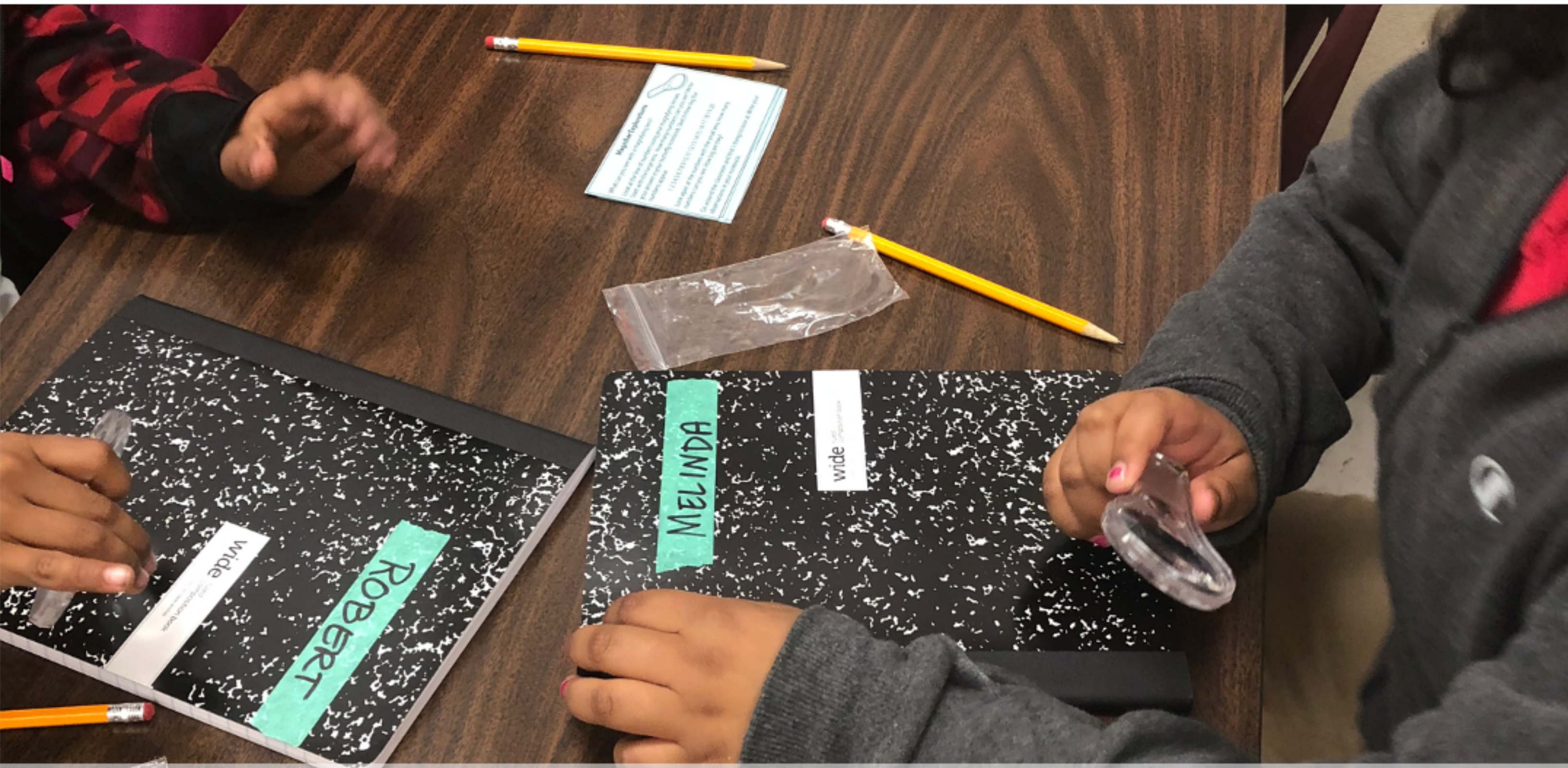
OVERVIEW GUIDE FOR TEACHERS

# Authentic Literacy and Language for Science




## Supporting Disciplinary Literacies for Science

BioEd

STEM Teacher Resources
from Baylor College of Medicine

# Overview Guide for Teachers

# Authentic Literacy and Language (ALL) for Science

Center for Educational Outreach
Baylor College of Medicine
Houston, Texas

College of Education
The University of North Texas
Denton, Texas

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STEM Teacher Resources from Baylor College of Medicine

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**STEM TEACHER RESOURCES FROM THE CENTER FOR EDUCATIONAL OUTREACH AT BAYLOR COLLEGE OF MEDICINE**

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Authors:
Nancy Moreno, Alana Newell, Dolores Garay, Gregory Vogt (Baylor College of Medicine)
Misty Sailors (University of North Texas)
Sarah Aguirre, Janine Garcia (University of Texas – San Antonio)



Center for Educational Outreach, Baylor College of Medicine One Baylor Plaza, BCM411, Houston, Texas 77030 713-798-8200 | 800-798-8244 | edoutreach@bcm.edu and bioedonline.org.

Baylor College of Medicine
CENTER FOR EDUCATIONAL OUTREACH

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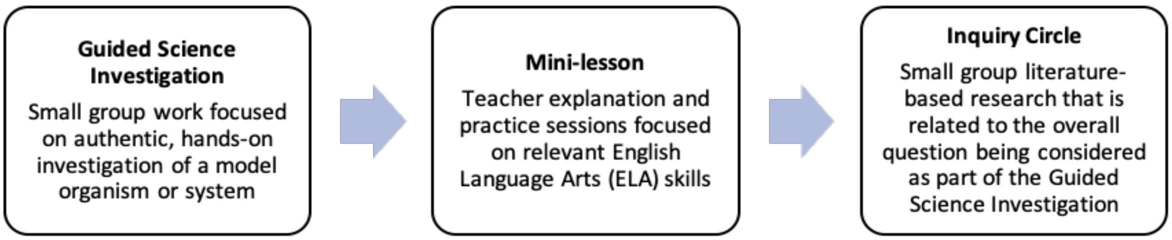
# 1. INTRODUCTION TO *ALL for Science*

## *1.1. What is* ALL for Science*?*

Authentic Literacy and Language (ALL) for Science is a curriculum framework designed to support students' learning of true-to-life language of science and scientists while participating in inquiry-based science activities. The framework is designed to promote both science sense-making and language sense-making through three aligned components, which are shown in the figure below.




Together, the three components are designed to authentically engage students in how scientists use language, while building students' science knowledge and skills. This guide will introduce you to the framework, its components and recommendations for its implementation.

## *1.2. STEM and Science Learning*

The acronym, STEM, stands for "science, technology, engineering and mathematics." It often refers to any educational program, teaching activity or curriculum that includes at least one of the four component subject areas. However, STEM also can be thought of as *an interdisciplinary approach to teaching and learning in which science and other skills are presented or taught holistically, without separating discipline-specific content, and make connections among individuals, school, community and the world through authentic problems or topics*.[1]

Early STEM experiences develop students' interest and knowledge, and contribute to later success in science-related careers.[2] Yet, many students to do not have access to authentic science learning practices that encourage them to persist in STEM-related coursework or to envision themselves in the roles of STEM professionals.

Being able to read, write, listen and speak using the language of science and the other STEM fields is key to students' success in these areas for several reasons. Language can help students develop their identities as a member of the science community. Identity development, in turn, may influence decisions to pursue science-related courses or careers.

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[1] Moreno N. 2018. Strengthening Environmental Health Literacy through Precollege STEM and Environmental Health Education. In Finn S, O'Fallon L (Eds.), *Environmental Health Literacy*. New York: Springer. pp 165-193.

[2] Maltese A, Tai R. 2010. Eyeballs in the Fridge: Sources of early interest in science. *International Journal of Science Education* 32(5): 669-685.

Along the same lines, students who are effective readers and writers in the context of science may be more likely to persist in science.[3] [4] This project weaves hands-on science learning with English language arts, so that students develop skills and habits of mind that reflect how scientists communicate and solve problems in the real world.

## 1.3. Language and Communities of Practice

In many ways, language can be the gateway to membership in a particular group. For example, scientists make new words to represent complex ideas, ask questions to guide their work and pay attention to details. By learning to use language as practicing scientists do, students become fluent with the discipline of science. In other words, they develop disciplinary literacy. Using language as a scientist is an important step toward becoming a member of the scientific community.

*ALL for Science* seeks to facilitate student participation in the community of scientists by embedding authentic use of language in lessons focused on both the "literacy" and "science" teaching aspects of a typical school day. The framework enables teachers to engage students seamlessly in science learning through authentic use of science language. At the same time, by empowering students to communicate as scientists, we hope to help them envision themselves in science or STEM-related career pathways.

## 1.4. Organization and How to Use This Approach

*ALL for Science* provides a bridge for teachers to connect English language arts (ELA) teaching and learning—with particular focus on use of expository texts and research—to science inquiry. In the process, we expect students to develop literacy skills related to science as a discipline. We have built the program around a daily schedule, with each day consisting of an ELA mini-lesson designed to support student group work on a text-based research question, followed by a hands-on guided inquiry experience on related science topics.

The model for each day has the following three sections.

- **Guided Science Investigation**. Science inquiry activity, in which the teacher facilitates and guides students, who work in small groups on a hands-on science exploration based on a model organism or system.
- **Reading Mini-lesson**. Whole group mini-lesson that focuses on a reading strategy relevant for use with science expository texts or media.
- **Inquiry Circle**. Small, guided Inquiry Circle groups in which learners apply and practice their reading strategies to their own text-based research.

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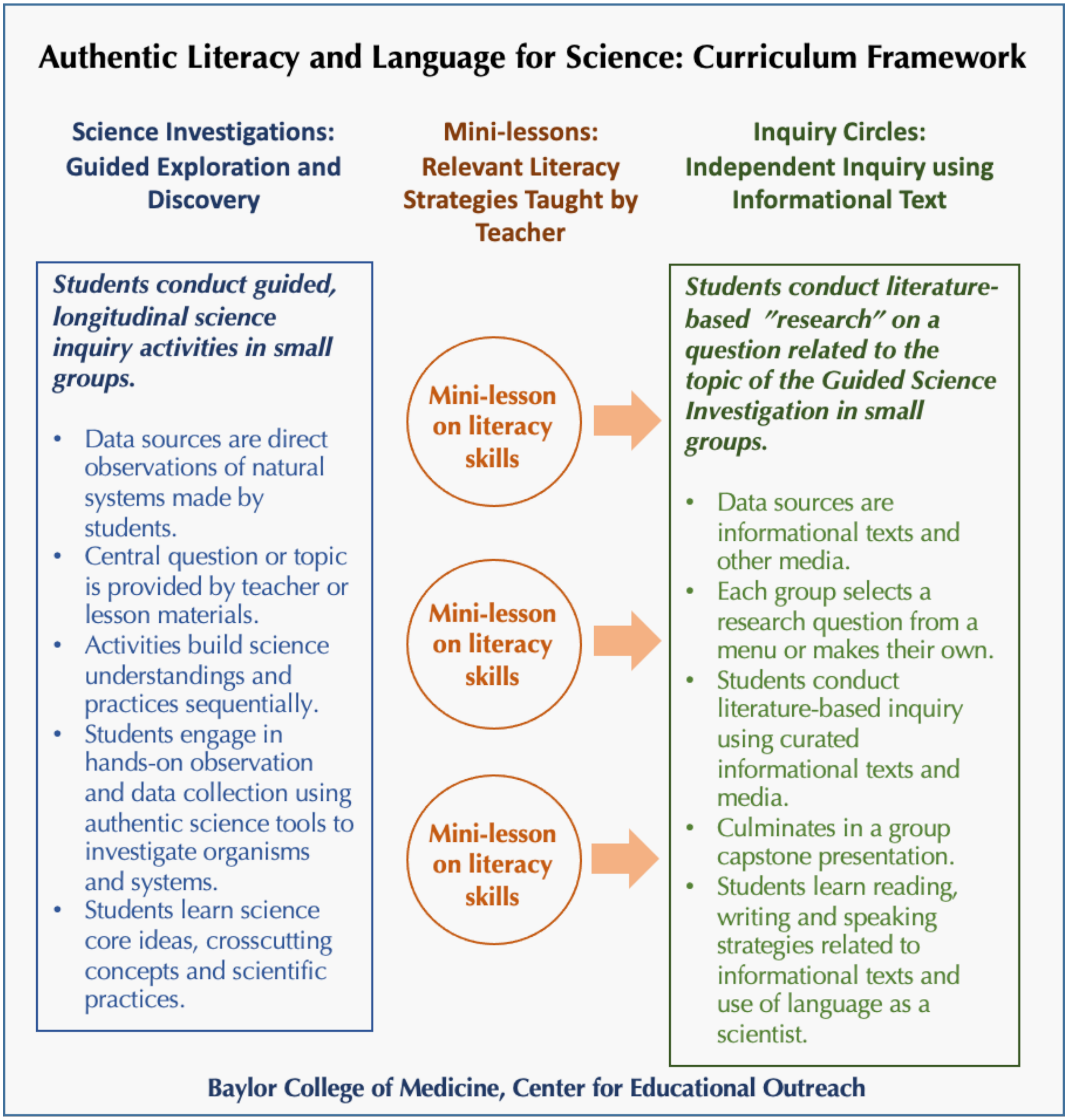
3 Zhai J, Jocz J, Tan AL. 2014. 'Am I Like a Scientist?': Primary children's images of doing science in school. *International Journal of Science Education* 36(4): 553-576

4 Shanahan T, Shanahan C, 2012. What is disciplinary literacy and why does it matter? *Topics in Language Disorders*, 32(1), 7-18.

The diagram below illustrates the various components of the model.




The three daily sections are connected by the unit's overarching topic. You may teach the literacy and science lessons separately throughout the day or back-to-back during a large block of time. For example, the mini lesson and Inquiry Circle groups can be conducted in the morning during the reading and language arts block, while the science inquiry activity can occur in the afternoon.

This guide is suggestive, not prescriptive. We believe teachers know their learners best and are experts in their fields. Therefore, while we provide phrases to suggest language you might use, we emphasize the freedom to employ language that works best in your classroom for your learners.  You will see the phrase, "Say something like ..." throughout the lessons as an invitation to adapt the language of the lesson to meet your needs.

Each Science Investigation activity contains a section entitled "Background Information," with details and guidance to aid in your understanding of the concepts covered. These sections are intended for teachers only, and should not be used as part of direct instruction with the learners

### *1.5. Additional Online Resources on BioEd Online*

All curricular units developed using the *ALL for Science* framework—and suggestions for resources to implement them—can be found on the project pages on www.BioEdOnline.org.

Within their Inquiry Circles, students select a topic or question to investigate using high quality informational text or media resources. Learners then choose the resources to collect information related to their question. You may use print materials in the classroom and make them available in a central place for students or have students access resources online.

For students who are working online, we provide links to a variety of media that will be valuable for their research. We include websites, videos, e-books, virtual tours, and interviews with experts. Please be advised that some of the websites have advertisements. Consider using websites like SafeShare.TV and ViewPure.com to remove the ads.

If you are using websites for students' research, we recommend checking in advance to ensure that the websites work within your school/district firewall. We also have included YouTube videos. You can find the suggested e-books on GetEpic.com, and sign up for a free account with learner access codes. Parents are eligible for free trial accounts, in case students are working from home or your district is not a subscriber. You can access links to virtual tours for some ecosystems or organisms, as well as the names of experts who can be interviewed via SkypeAScientist.com. Additionally, we encourage you to use resources already available through your district, such as Encyclopedia Britannica, Pebble Go, or Brain Pop.

# 2. THE CYCLE OF INQUIRY

## *2.1. Inquiry as a Process*

As noted in the National Science Education Standards, learning science is best accomplished by active participation in scientific inquiry.[5] Even very young children can build knowledge by asking and seeking answers to questions about the world around them. The Next Generation Science Standards (NGSS) explicitly acknowledge the curiosity of all children and the importance of leveraging that curiosity to promote science learning.[6] The guiding principles of the NGSS are listed below.

- **Children are born investigators**. Children naturally seek to understand and influence the world around them, and their early ideas about how things work can be used as foundation for teaching science.
- **Focusing on core ideas and practices**. A framework for science learning should focus on key (or, core) ideas, and on the basic practices and approaches used by scientists and engineers in the real world.
- **Understanding develops over time**. Core ideas should be developed over time through learning progressions, which provide instructional supports to help students progress toward mastery.
- **Science and engineering require both knowledge and practice**. Scientists use inquiry and problem-solving approaches to develop explanations and predict future outcomes. Engineers aim to solve problems related to a human problem or need.
- **Connecting to students' interest and experiences**. Science learning should connect to students' everyday lives, and link to future potential careers.
- **Promoting equity**. All students should have access to quality teaching, resources and time to learn science effectively, and engage in activities that inspire further participation in science.

Scientists use information from first-hand observations, experiments, and explanations and observations by other scientists. This information is contained in expository texts, graphs and tables, maps, photographs, video and other forms of media. *ALL for Science* enables students to use resources such as these to extend and deepen their understanding in ways similar to those used by practicing scientists.

## *2.2. Teacher as Facilitator of Active Learners*

The teacher's role in guided inquiry is to model and facilitate learner-driven exploration, research, and discovery. Once you have piqued your learners' interest, they must take an

[5] National Research Council. 1996. *National Science Education Standards*. Washington, DC: The National Academies Press.
[6] NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

active role in their own learning. Inquiry groups should explore and learn through investigation, while the teacher guides them by asking open-ended questions and encouraging further exploration. Once the learners have concluded their investigations, teachers may extend student learning by providing relevant information and encouraging students to share and justify their findings.

## *2.3. Using the 5E Approach for Science Inquiry*

We employ a learning cycle approach to develop students' science knowledge. This approach, referred to as the "5 E" model, has been refined and disseminated by BSCS.[7] Elements of the 5E learning cycle are listed below.

- **Engage**. Students are presented with a question, an interesting example or a problem. This phase connects students' past and present experiences, enables the teacher to estimate learners' prior knowledge, identify misconceptions and stimulate interest in the learning experiences that will follow.
- **Explore.** Students participate in actual experiences with physical materials, representations of data or media. Students may do experiments, collect data, make observations and connections, and ask questions. Students usually work in groups, with the teacher acting as a coach or facilitator to guide students as they conduct the investigations themselves.
- **Explain.** Students begin to make sense of their data, describe their observations, and develop their own explanations. Students listen to other learners' explanations and defend their own. The teacher's role in this phase is to ask appropriate questions, guide students (to include addressing misconceptions), and direct them to helpful resources.
- **Elaborate.** Students use the information they have gathered to propose solutions and apply what they have learned to new and different situations. The teacher's role is to help students extend their ideas to reach a much broader conclusion than the one they derived initially by conducting their investigation.
- **Evaluate.** Students judge their own learning progress. Teachers also may evaluate students' knowledge or skills development. If necessary, teachers may develop alternate assessment strategies to help students focus on new information and understand the lesson in greater depth.

For more information about applying the 5E learning cycle approach to teaching science inquiry, please watch the video at the link below.

http://www.bioedonline.org/videos/supplemental-videos/5e-model-for-teaching-inquiry-science/

[7] Bybee R. 2010. *The Teaching of Science: 21st Century Perspectives*. Arlington, VA: NSTA Press.

## *2.4. Texts that Support Science Learning*

As noted above, scientists use language in a variety of ways. Written language is especially important for recording and reporting findings, and for learning from the work of other scientists. Below are three important ways in which young students employ texts in science learning.

- **Science Notebooks.** Science notebooks are "thinking tools."[8] Students use their notebooks to record observations, notes, measurements, questions and information from additional sources. The notebooks encourage students to use writing to organize and document their ideas and reflections. As such, they also document student learning to the teacher. Classroom science notebooks replicate the work of scientists, who meticulously record their methods, data, observations and interpretations. Notebooks enable scientists to repeat their investigations and form the basis for communications about their findings. There are a number of ways to organize student science notebooks. Students will set up and use notebooks as part of their activities in this unit. More information can be found at the following links.

  *California Academy of Sciences*
  https://www.calacademy.org/educators/setting-up-your-science-notebooks
  https://www.youtube.com/watch?v=Ti3nUDNK8iA

- **Informational Texts.** Written materials, such as nonfiction trade books or science websites, support students' science learning and develop their language skills and vocabulary development. Scientists rely on informational texts to learn from the findings and experiences of other scientists. Similarly, informational texts provide background for the open-ended research projects that students will carry out in in their Inquiry Circles. The informational text resources available on the *ALL for Science* website have been evaluated favorably for accuracy and quality by our team.

- **Interdisciplinary Texts.** Scientists use a variety of visual strategies to make sense of their observations. Sometimes, it is sufficient to organize information in the form of a table. In other cases, a graph or a more complex diagram is needed to elucidate relationships among different kinds of variables. A bar graph, which uses columns to compare measurements or counts, can make it much easier to interpret information. The following NASA link provides basic information about using the information in graphs. https://climatekids.nasa.gov/graphs/

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[8] Gilbert, J, Koteman M. 2005. *Five Good Reasons to Use Science Notebooks*. https://www.nsta.org/publications/news/story.aspx?id=51160

## *2.5. Students Groups and Guided Science Investigations in the Classroom*

We recommend that students work together in groups of four for their guided science investigations. Usually, heterogeneous groups are most effective. However, working in groups does not necessarily imply that students will cooperate effectively to achieve their individual or collective goals. Even the process by which members are assigned to groups can affect many aspects of a team project. Here are some general factors to keep in mind when deciding how to configure groups.

- Students' shared interest in a topic
- Students' prior knowledge of, or experience with a topic
- Students' motivation to work independently
- The diversity of perspectives brought by students

Within their groups, students will have different defined roles. The four members of each group will rotate roles, so that they have a range of experiences. Consider having students rotate jobs once per week. Job badges and wall posters are included with unit materials. Establishing a cooperative model for learning in the classroom helps students conduct science explorations in an organized, effective manner.

You will notice that the "job" descriptions for each role differ from the typical cooperative group titles used for science teaching. The roles used in the *ALL for Science* framework are aligned with typical science positions in the real world.

Please watch the video below for more tips on setting up cooperative student groups.
http://www.bioedonline.org/videos/content-presentations/tools-and-techniques/cooperative-grouping-ideas-for-effective-classroom-practice

### Cooperative Group Roles for Science

| Lead Scientist | Lab Director | Data Scientist | Equipment Director |
|---|---|---|---|
| • Asks the questions and builds consensus related to the wording of the questions.<br>• Guides the work of the team by reading directions.<br>• Keeps the group focused on the investigation.<br>• Checks the work of the team. | • Gathers materials for the group.<br>• Reminds the team to follow safety rules.<br>• Leads the discussion about the observations and the results.<br>• Encourages the group members to participate in the research. | • Records observations and data gathered.<br>• Leads the team in making charts or posters.<br>• Tells teacher when the group is finished.<br>• Explains the results to the class. | • Picks up the materials.<br>• Operates or helps other team members use the equipment.<br>• Asks the teacher any questions of the team.<br>• Returns the materials and directs clean-up. |

## *2.6. Live Animals in the Classroom*

Studying living organisms in the classroom inspires students and allows them to develop skills related to stewardship, appreciation of the natural world and observation. Some *ALL for Science* units allow students to care for and observe producers, such as freshwater algae, or common invertebrate organisms, such as painted lady butterflies. Before beginning a unit, confirm whether your school or school district has specific guidelines about live invertebrate organisms in the classroom.

Painted lady butterfly pupa (*Vanessa cardui*).
Image: Harold Süpfle, Creative Commons, 2009.

Living organisms usually need to be ordered or colleged and grown a few days before beginning a unit. Directions for care of the specific live organisms are included in individual activities within each unit. Students should be instructed in the humane care of animals, and should observe care in making observations or transferring organisms. Classroom animals should not be released into the wild. They can be kept in the classroom, donated to a nature center or given to a responsible student with parental permission.

## *2.7. Products to Communicate and Celebrate Learning*

Scientists communicate their work and findings to peers and the general public through outlets such as written scientific articles or papers, articles for general audiences, letters, books, verbal presentations, 3–5 minute "lightning talks," video, posters, blogs and television, newspaper or radio interviews. Typically, the work of scientists goes through a process known as peer review. During peer review, other scientists read, discuss and provide feedback to the authors. Peer review guides the work of scientists and improves the overall quality of published scientific work.

Consider conducting a class scientific poster session to enable students to demonstrate their science learning and project findings. During the session, students from each group will explain their poster to other students, who circulate around the room. Allow half of the members of each team to stand with their posters, while the other members circulate. Then, have students switch roles so that all students are able to view the posters of other groups. Encourage students to ask questions and comment on the work of other groups.

## 3. READING AND WRITING STRATEGIES TO SUPPORT SCIENCE INQUIRY

### *3.1. Reading/writing Strategies to Support Science Inquiry*

Several reading and writing strategies are unique to reading and writing like a scientist. There also are generic reading and writing strategies that transcend various disciplines, including English Language Arts/Reading (ELA/R) and science. The model we describe in the this guide capitalizes on both types of strategies and addresses several ELA/R strategies that support science learning. The reading strategies presented in *ALL for Science* support word identification/knowledge strategies, ongoing comprehension strategies, and fix-up strategies. These strategies support the three cueing systems that readers use when they read.

### *3.2. Mini-lessons: Metacognition and Metalanguage toward Strategic Reading (Declarative, Conditional, Procedural)*

Research on improving reading comprehension has shown that children (even young children) can learn to be more strategic in their reading through intentional instruction[7]. Examples of intentional instruction include providing opportunities for readers to engage in reading strategies and "think alouds" of teachers' processing use of metalanguage to support the development metacognition.

The mini-lessons in *ALL for Science* units are written to teach children directly the three ways in which strategic readers learn and apply strategies for reading comprehension. All three are important in the processing of texts.

- **Declarative**. What the reading strategy is and the name for it.
- **Conditional.** When to employ the strategy and why the strategy is important to comprehension.
- **Procedural.** The cognitive processing behind the strategy.

### *3.3. Texts that Support Learning: Anchor Charts*

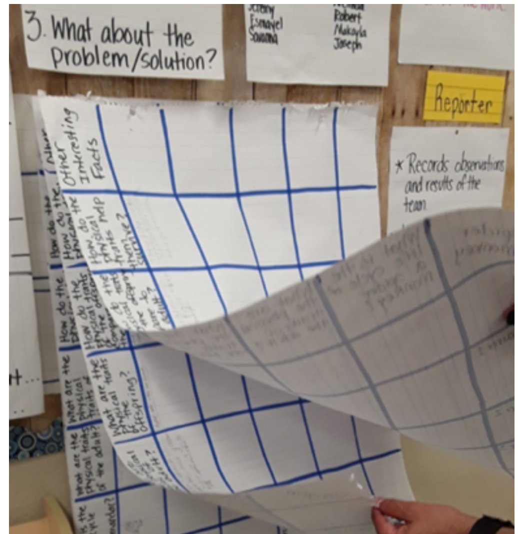
Teachers use anchor charts during the modeling of strategic reading Mini-lessons. We have provided sample anchor charts for each lesson that visually represent metacognitive learning. We encourage you to recreate these charts *with your learners* to anchor their learning. The more involved learners are in creating these anchor charts, the greater ownership they will take in using the strategy. We advise you to place anchor charts in a visible location within the classroom so learners can use them often. Each day's anchor chart should remain visible throughout the unit. We encourage you to model the strategy with

7 Sailors M, Price L. 2015. Support for Improvement of Practices through Intensive Coaching (SIPIC): A model of coaching for improving reading instruction and reading achievement. *Teaching and Teacher Education* 45: 115-127.

the anchor chart during the whole class activity so learners can then apply the same strategy(ies) within their Inquiry Circle groups.

### *3.4. Texts that Support Learning: Inquiry Charts*

Inquiry charts support text-based research and are a way to organize information. Each small group makes its own inquiry chart, organized around the research questions (see suggested questions at the top of the sample chart provided with each unit) and the sources that scientists use in their inquiry. As children find answers to their questions, they populate the inquiry chart. The information on the inquiry chart is summarized, synthesized and presented in the culminating project.




Example of Inquiry Charts posted to a bulletin board and retrieved when students break into their Inquiry Circle groups.

### *3.5. Texts that Support Learning: Portal Texts*

Portal texts are fictional texts designed to grab learners' attention and engage them in the subject matter. Learners can use the texts to build connections and generate research questions. We have provided sample portal texts, but you may choose others, based on needs and availability. Choose texts that will be engaging and spark the interest of your learners. We recommend that you choose one portal text per group, to be read by learners within the Inquiry Circle groups. Ideally, portal texts are used before starting the research, but some texts may be difficult for students to read without teacher assistance. Therefore, you may elect to read one portal text aloud each day during class read aloud time.

### *3.6. Selecting Appropriate Informational Texts*

We have provided a list of possible expository texts, websites and online books on each unit's landing page at www.BioEdOnline.org. You may choose to use other books, based on availability. We encourage you to provide each group with numerous and diverse sources. Look for expository texts with a variety of text features (e.g. table of contents, headings and subheadings, diagrams, captions, index, glossary, etc.); an appropriate reading level; current and accurate information; and colorful photos or scientific illustrations.

### *3.7. Assigning Small Groups in Inquiry Circles*

You may use a variety of methods to assign groups for the Inquiry Circles, which are the small groups that conduct text-based investigations related to their hands-on Science Investigations. Naturally occurring groups may already be in place in your classroom (e.g., table groups, reading groups, etc.), or groups may be formed based on learner interest in the organisms. You may choose to keep learners in the same groups during both the Science Investigation activites and Inquiry Circles, or may choose to reassign groups. We recommend forming heterogenous groups *while providing learners opportunities to choose* their topics of interest.

### *3.8. Products to Celebrate Learning in Inquiry Circles*

At the end of an inquiry project, scientists frequently make a product (e.g., scholarly paper or presentation) to share what they have learned. Similarly, you might allow your learners to share their findings by have having each Inquiry Circle group choose one product to create as a team.

The product should show what learners discovered about their topic. For instance, in the second grade *Heredity and Life Cycles* unit, students could display their organism's physical traits in adults and offspring. On the last day of the project, all groups should present their findings during a scientific symposium.

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**STEM TEACHER RESOURCES FROM CENTER FOR EDUCATIONAL OUTREACH AT BAYLOR COLLEGE OF MEDICINE**

Center for Educational Outreach
Baylor College of Medicine
One Baylor Plaza, BCM411
Houston, Texas 77030

713-798-8200 | 800-798-8244
edoutreach@bcm.edu
www.bioedonline.org

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