PROJECT READi

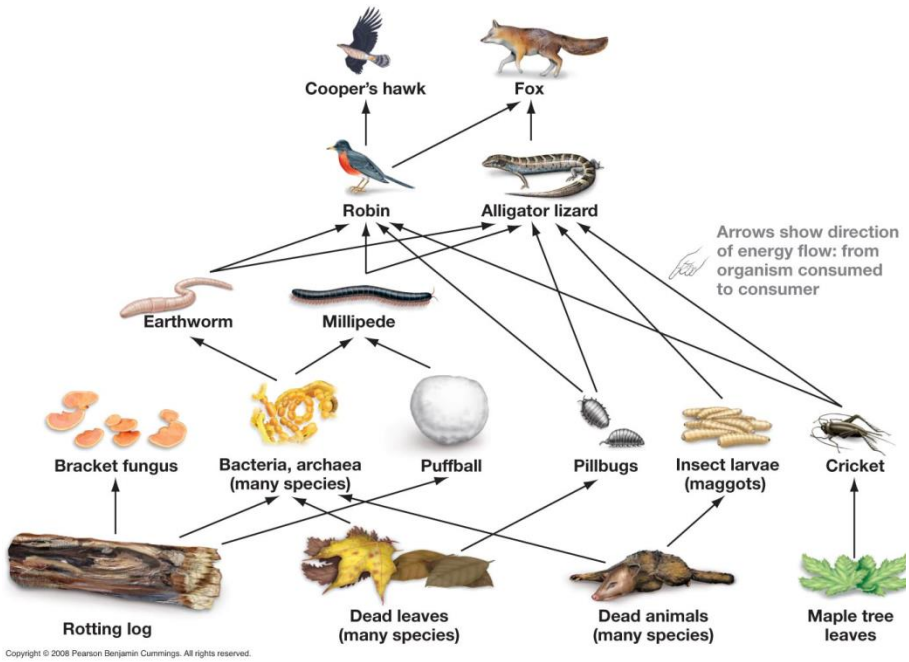
Reading Science Models
Interactive Notebook

Flow of energy in an ecosystem

Inquiry Questions

What are science models?

How do we read science models?



PROJECT READI

READI READING SCIENCE MODELS HIGH SCHOOL MODULE

STUDENT INTERACTIVE NOTEBOOK
Iteration 1, Fall 2013

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Image Sources:

Cover Image: http://jumbowallpaper.com/food-web-labeled.html

Text A: http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/environment/populationsandpyramidsrev5.shtml

Text B: http://coyotes-wolves-cougars.blogspot.com/2012/01/we-have-discussed-top-down-ripple.html

Text C: http://wwwrcamnl.wr.usgs.gov/isoig/projects/fingernails/images/bigFIG1-Foodwebillustration.gif

Model A: wikipedia.org

Model B: http://kvhs.nbed.nb.ca/gallant/biology/biology.html

Model C: http://www.phschool.com/iText/elife/site/text/chapter8/concept8.1.html

Model D: http://www.butler.edu/herbarium/treeid/treeparts.html

Model E: http://apbrwww5.apsu.edu/thompsonj/Anatomy%20&%20Physiology/2010/2010%20Exam%20Reviews/Exam%201%20Review/Ch03%20The%20Cell%20and%20Membrane%20Structure.htm

Model F: http://www.susanahalpine.com/anim/Life/memb.htm

The intended use of these materials is in tandem with ongoing professional development focused on supporting reading as scientific practice. This work is funded by the Reading for Understanding Initiative of the Institute for Education Sciences, U.S. Department of Education, through Grant R305F100007 to University of Illinois at Chicago. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Our Ideas About Models

Individual Think-Write

Silently read the three questions below. Then, write notes on this page about your thoughts, any connections you make to what you know, and any questions you have.

- What connections do you make with the word "model?"
- What are some examples of models?
- Are there different kinds of models?

- What is the purpose or purposes of models?

Teacher Notes: This think-write can be used as a warm-up and as a way of introducing the lessons to the students that puts/keeps their voices and ideas at the center of the class (in contrast to the teacher talking about models as an introduction which moves students' ideas and voices to the margins of the class). Also this approach supports early formative assessment of students' schema about models – scientific and otherwise.

Pairs

Talk about the word "model."

- Take turns sharing your thinking about models.
- Discuss what you notice about each other's ideas about models.
- Write notes about your ideas to share with the whole class.

Teacher Notes: If Think-Pair-Share is not yet routine in the class, teachers may need to invite student to reflect on what **norms are needed for everyone to participate in** pair talk.

One scaffold is a SOLAR listening poster, S=Square-up, O=Open mind and Open stance, L=Lean in (so everyone can talk quietly and everyone can hear their partners), A=Affirm (with nods or the like), R= Reflect (I heard you say … You thought about … Was interesting because …)

Looking ahead to the whole class discussion:

* During pair talks make "appointments" with students who haven't shared in class to be ready to share today.

* Identify groups that have interesting ideas and ask them to share in the whole group discussion (especially if they share rarely in the whole group.)

Share

Be ready to share something you wrote or heard with the class when the teacher asks for your ideas.

What is a Science Model?

Teacher Notes: Use routines to ensure anyone (and over time everyone) speaks and is heard in whole class discussion.

Supports for talking:

*Ask pairs to prepare something to share and to pick a spokesperson to say it, and/or model use of anonymous responses like, 'We wanted to say that …"

*Use equitable selection method (craft sticks/cards with student names on them).

*Ask for five volunteers before selecting any

Teacher Example

The intended use of these materials is in tandem with ongoing professional development focused on supporting reading as scientific practice. This work is funded by the Reading for Understanding Initiative of the Institute for Education Sciences, U.S. Department of Education, through Grant R305F100007 to University of Illinois at Chicago. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

Your teacher will briefly model scientific reading with the first paragraph of the text on the adjacent page. Pay close attention to the ways in which he/she makes sense of the text. Write down any reading strategies that help your teacher read more deeply here:

Teacher Notes: Verbally underscore/introduce that – as a routine - two inquiry questions frame our reading and metacognitive conversation about reading in science:

1) **How** did you/we make sense of the text and build new knowledge?

2) **What** knowledge did you/we build?

Use think-aloud to model science reading. If you want students to talk to the text or use double-entry notes, then combine those with a think-aloud. After your 1 minute model have a whole class discussion.

Ask students to reflect back what they saw you do in you model. This is a quick formative assessment that they are understanding the processes well enough to do it.

Individual/Pairs Read

Continue reading the text on the adjacent page. While reading make your thinking visible using either Think-Aloud with partner note-making, Talk to the text, or *I read / I thought* double-entry notes. Your teacher will say which to use.

Teacher Notes: Now is the time for formative assessment. Cruise the room and notice how students are reading, what challenges arise, what ah-has they make. Identify students who have interesting things to share about their reading processes. Again make appointments for students to share out, especially those who speak rarely in whole group.

Pair Share of Your Reading

With a partner, go through the text sentence by sentence (or paragraph by paragraph) discussing your reading. Take turns sharing and listening.

- Share comments, questions, understandings, roadblocks, reading processes – how you made sense of the text, how you built new understandings.
- Listen to your partners' thinking and elicit more thinking with questions such as: "What did you do?" or "How did that help you understand the reading?"
- Help each other clarify roadblocks.
- Add good ideas from your discussion to your notes

Teacher Notes: May need to insert a teacher (or teacher + student) model what this pair share would look like. It is an unusual (new) kind of talking for most students.

If students read it the first time using think-aloud, then, the pair share changes a bit. Ask students to give their partner a repost of the reading processes they heard their partner use, rather than sharing their own.

Explanatory Models in Science

A scientific model is an idea or set of ideas that explains what causes a particular phenomenon in nature.

Teacher Notes: Read this text (and all the other texts too) in advance of doing the lesson. Mark it up with your own authentic talk to the text. Identify the reading processes and schema that you used to read the text well. Your own read of the text will inform what you include in a one minute model that makes your thinking visible.

We are interested in models from the perspective of what practicing scientists actually do. The most important overall goal of scientists is the development of an understanding of how various parts of the natural world work. To do this, scientists make observations, identify patterns in data, then develop and test explanations for those patterns. Such ***explanations*** are called ***scientific models***.

It is important to note that scientists use drawings, graphs, equations, three dimensional structures, or words to communicate their **models** (which are ***ideas*** and ***not*** physical objects) to others. However, the drawings, replicas or other tools are distinct from the underlying models they purport to explain.

Explanatory models in science are continuously judged by a community of scientists. To evaluate a particular model, scientists ask:

1. Can the model ***explain all the observations***?
2. Can the model be used to ***predict*** the behavior of the system if it is manipulated in a specific way?
3. Is the model ***consistent with other ideas*** we have about how the world ***works and with other models*** in science?

In judging models, scientists don't ask whether a particular model is "right". ***They ask whether a model is "acceptable"***. And acceptability is based on a model's ability to do the three things outlined above: ***explain, predict, and be consistent with other knowledge***. Moreover, more than one model may be an acceptable explanation for the same phenomenon. ***It is not always possible to exclude all but one model*** – and also not always desirable. For example, physicists think about light as being wavelike or particle-like and each model of light's behavior is used to think about and account for phenomena differently.

Finally, we note that in practice, models are continuously revised as they are used to probe new phenomena and collect additional data.

This site was developed by the National Center for Mathematics and Science in the Wisconsin Center for Education Research at the University of Wisconsin-Madison.

Thinking and Talking about Science Models

Whole Class Discussion

Notes to Remember:

Teacher Notes: First elicit student reading processes and then shift to eliciting the content. Throughout the discussion probe students for more thinking when students' responses are 'thin' or suggest potentially richer thinking than verbalized. Also invite peers to build on or respond to prior comments. Some questions that could be used to elicit student thinking:

- What roadblocks or challenges arose when reading the article, "Explanatory Models in Science?" When some are noted ask the class if others had the same challenge/roadblock.
- How did you respond to or resolve the roadblocks?
- What was interesting or important in the article?
- What questions came to mind about models?
- What did you do with your questions? Did you try to answer them?
- What are some examples of scientific models?
- Are there any examples in our classroom or textbooks? (Flip through and look for some.)
- What examples of science models have you seen on TV, in a movie, on a web page, or elsewhere?
- Who can summarize this article? OR What are the characteristics or essential elements of a science model?

Make a poster of the students' summary or the characteristics/essential elements the students identify. You will refer back to this later in the class period. Resist correcting the students. If you see a gross misunderstanding, gently direct them to a portion of the article that addresses the misconception and have them discuss in pairs what the article means.

Remember those who do the reading, thinking and talking do the learning. Keep student voices at the center of the talk.

Therefore, use a routine for equitable participation so everyone gets to speak and be heard as well as listen and respond.

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Reading Science Modules – How and Why

Individual/Pairs Read

Read Text A, "Snowshoe Hare and Canadian Lynx Populations over Time." While reading make your thinking visible using either Think-Aloud with partner note-making, Talk to the text, or *I read / I thought* double-entry notes. Your teacher will say which to use.

Pair Discussion

Teacher Notes: Beginning a sequence of individual and pair work, depending on your students' stamina for reading, individual metacognition and metacognitive conversation, you may need to interleave whole class metacognitive conversations after some/each pair discussion. Ask yourself if this kind of sequence is a routine in your class already. If not take the first steps today with students to making it a routine.

Also, monitor and formatively assess whether the students are engaging in discussion of both HOW they are reading and WHAT they are reading. If they are not ALL doing both, then that is a reason to have a whole class metacognitive conversation that brings out exemplars of each kind of talk to underscore how both inquiry focuses are valuable. Again – try to keep the students' speaking and listening at the center throughout the discussion. See *Reading for Understanding*, Box 4.4, page 99 for questions to elicit student thinking – make yourself a crib sheet until these are rolling off your tongue naturally, as it were.

With a partner, go through Text A, "Snowshoe Hare and Canadian Lynx Populations over Time," discussing your reading *bit by bit*. Take turns sharing and listening.

- Share comments, questions, understandings, roadblocks, reading processes – how you made sense of the text, how you built new understandings.
- Listen to your partners' thinking and elicit more thinking with questions such as: "What did you do?" or "How did that help you understand the reading?"
- Help each other clarify roadblocks.
- Add good ideas from your discussion to your notes (i.e. your annotations or double-entry notes).
- Note commonalities or differences in your reading process between you and your partner and between the texts "Explanatory Models in Science" and Text A, "Snowshoe Hare and Canadian Lynx Populations over Time."

Teacher Notes: May need to have a brief discussion of how this process might be different because the text structure is different. May even need to model the process of sharing and turn-taking again, depending on how well they did that in the previous pair discussion.

The conversation now includes a comparison of how they read this text compared to the previous text. Listen in to the pair discussions. If the students are daggering to ALL parts of the discussion, then proceed directly to the next text. If not, then have a whole class discussion in which exemplars you've noted are shared. Perhaps send them back for focused discussion on any elements they did not discuss well already, followed by a second whole-class discussion.

Again, If students read it the first time using Think-Aloud, then, the pair-share changes a bit. Ask student to give their partner a repost of the reading processes they heard their partner use, rather than sharing their own

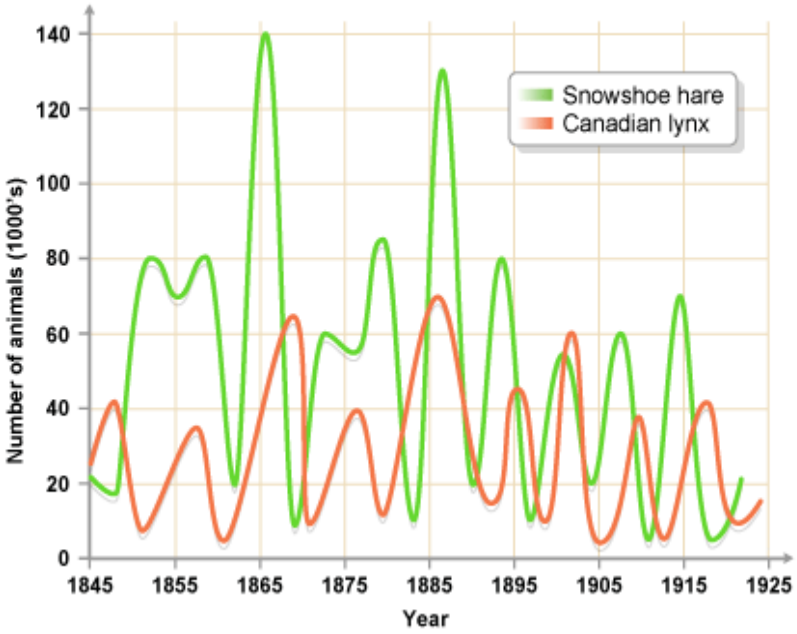
Individual/Pairs Read followed by Pair Discussion

Use the process described above (for reading and pair discussion of Text A) to read and discuss Text B. Expand the discussion of commonalities or differences in your reading process between each other and between texts to include the newly read texts.

After you have read and discussed Text C, discuss the following inquiry question: Which text or texts is (or might be) a scientific model? How do you know? What is your evidence?

Text A

Snowshoe Hare and Canadian Lynx Populations over Time



Text B

Text C

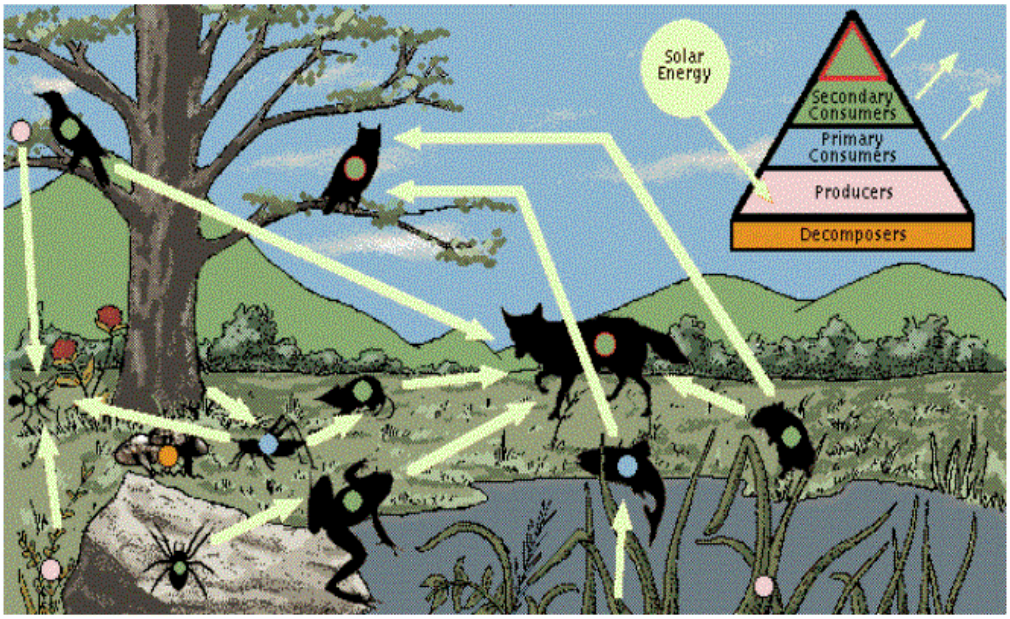


FIGURE 1: This diagram shows the relations between typical terrestrial organisms. The arrows connect the prey (diet) to the predator (consumer). The colored dots on the animals are coded to the colors in the triangular diagram at the upper right.

Reading Science Models – How and Why

Whole Class Discussion

Notes to Remember:

Teacher Notes: First discuss the reading process. Throughout the discussion refer to the texts by actual title as much as possible as a model for disciplinary discourse practices of citing texts/source in science. That said, in these notes for brevity I will use Text A, B, and C. Also, probe/elicit students for more thinking when students' responses are 'thin' or when there are indications that the student may have additional valuable thoughts to say about their reading processes. Also invite peers to build on or respond to peers' comments.
Possible prompts to elicit students' reading processes.

- What roadblocks or challenges arose when reading the texts?
- When some are noted ask the class if others had the same challenge/roadblock.
- How did you respond to or resolve the roadblocks?
- What was interesting or important in the texts?
- What questions came to mind about models?
- What did you do with your questions? Did you try to answer them?
- What is the big idea of Text A/B/C? Who can say what Text … is about? Is anything left out or extra in the summary? Does anyone have anything to add or refine in the summary? (Might need to put a think-pair-share process on this task, if reading to comprehend each text is not yet normative of student reading in this class.)

When you sense that students have solved critical roadblocks and can create a fairly accurate "this is about" statement, then shift the discussion to the second inquiry question – which of these texts (A, B and C) might be a scientific model.

- Elicit both evidence from the text (A, B and C) and warrants from the "Explanatory Texts in Science" or from the student's summary or the characteristics/essential elements poster.
- Elicit multiple interpretations of the same data: Did any else look at this evidence in Text …
- Elicit corroborating/conflicting evidence. In Text … did anyone find other evidence that corroborates with or conflicts with …

***You almost certainly will need to use a double-entry evidence/interpretation chart to record what the students share out to support them having a text-based and evidence-based conversation. While the arguments student are making here are about "genre" of science text, it is a kind of science argument writ large and a good place to underscore that in this class we uphold claims with evidence and we think critically about evidence to make sure the claims we make are sound.
May need to redirect students to the article, 'Explanatory Texts in Science" and to Texts A, B and C (and give them time to read and talk in pairs) to uphold the discussion as text-based and the argumentation as evidence-based.
Remember those who do the reading, thinking and talking do the learning. Keep student voices at the center of the talk.
Use a routine for equitable participation so everyone gets to speak and be heard as well as listen and respond.

What I Learned

Individual Think-Write

Silently read the three questions below. Then, write notes on this page about your thoughts, any connections you make to what you know, and any questions you have.

- What do you now know about science models that you didn't know before?
- What did you learn about your own reading process?
- What did you learn about reading science texts?

Teacher Notes: Designed to be an end of day wrap up. A chance for students to concretize their understandings. Could have a few students share one learning they accomplished.

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What Makes a Science Model Better?

Teacher Notes: The second day does not have any warm-up. If you want one, you could pose this question to students to brainstorm. Use a think-pair-share structure to hear some best ideas/predictions in the whole group discussion.

All this in anticipation of the students actually reading a scientific model and having a text-based exploration of the same question.

Individual/Pairs Read

Read Model A and Model B. While reading, make your thinking visible using either Think-Aloud with partner note-making, Talk to the text, or *I read / I thought* double-entry notes. Your teacher will say which to use.

Pair Discussion

With a partner, go through Model A and Model B, discussing your reading *bit by bit*. Take turns sharing and listening. Help each other clarify roadblocks. Add good ideas from your discussion to your notes (i.e. your annotations or double-entry notes).

Individual Think-Write

Silently read the question below. Circle the best response and write your reasons for choosing it.

Which model is better, Model A or Model B? Why?

- Model A is better.
- Model B is better.
- Models A and B are equally good.
- It is impossible to say which is better.

Pair Discussion

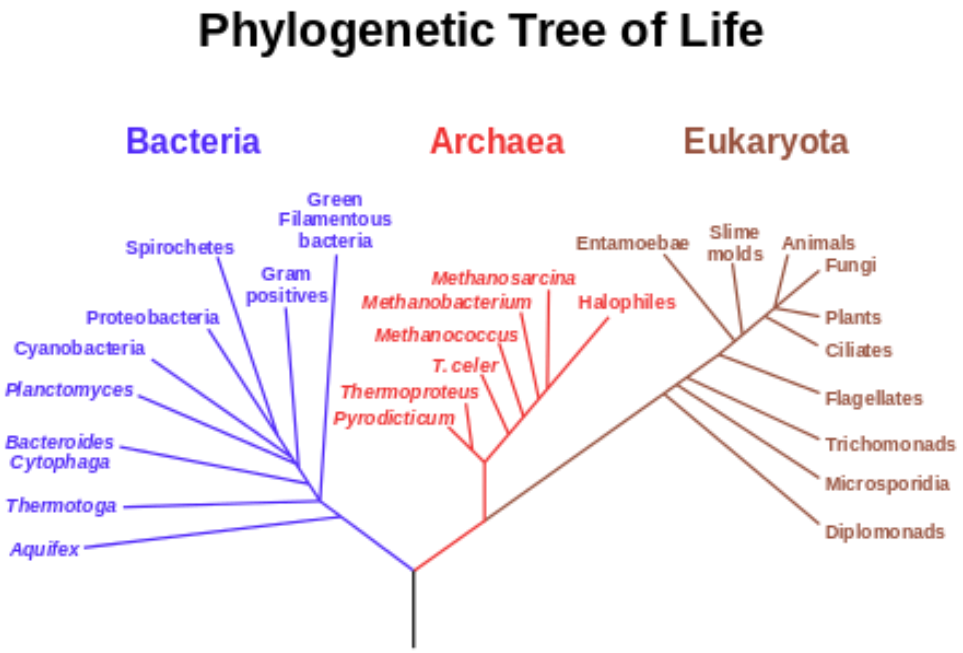
Share and discuss your responses. Be sure to give the reasons for your ideas.
As a pair choose the best response.
Be ready to share your pair's response and reasons.

Teacher Notes: Given just the model (but not the evidence), there is no way of assessing criteria 1 – the model explains all relevant evidence. I am referring here to the criterion offered in the article 'Explanatory Models in Science.' In contrast, given just the model students may be able to use Criterion 2, and perhaps 3, to guide the assessment of which model is better. More likely, the relevance of the model to the inquiry purpose/question is the principal that will arise in the discussion as how to determine if the model is better. One way to elicit a connection to criterion 1, is simply "are there any criterion we have not yet consider in our discussion?"

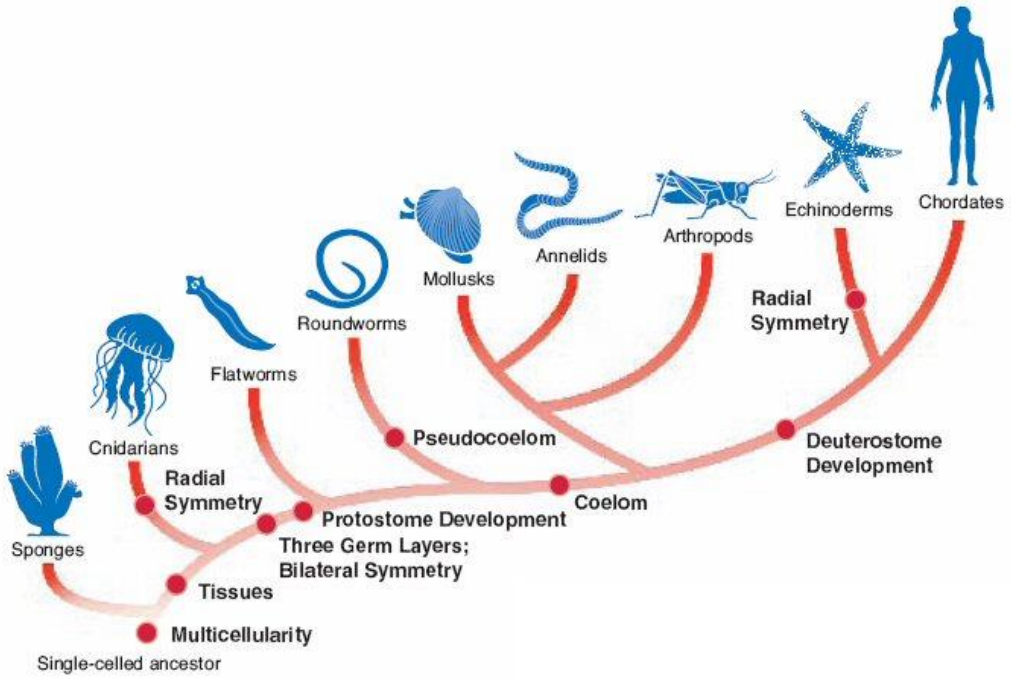
Whole Class Discussion

Notes to Remember:

Model A: Relatedness of Life



Model B: Relatedness of Life



Individual Think-Write

Silently read the question below and review Models A and B. Circle the best response and write your reasons for choosing it.

Which model is better if you want to explain the shared characteristics that certain life forms have in common? Why?

- Model A is better.
- Model B is better.
- Models A and B are equally good.
- It is impossible to say which is better.

Pair Discussion

Share and discuss your responses. Be sure to give the reasons for your ideas.

As a pair, choose the best response.

Be ready to share your pair's response and reasons.

Whole Class Discussion

Notes to Remember:

What Makes a Science Model Better?

Individual/Pairs Read

Read Model C and Model D. While reading make your thinking visible using either Think-Aloud with partner note-making, Talk to the text, or *I read / I thought* double-entry notes. Your teacher will say which to use.

Pair Discussion

With a partner, go through Model C and Model D discussing your reading *bit by bit*. Take turns sharing and listening. Help each other clarify roadblocks. Add good ideas from your discussion to your notes (i.e. your annotations or double-entry notes).

Individual Think-Write

Silently read the question below. Circle the best response and write your reasons for choosing it.

Which model is better if you want to explain <u>how plants get food and energy in order to grow</u>? Why?

- Model C is better.
- Model D is better.
- Models C and D are equally good.
- It is impossible to say which is better.

Pair Discussion

Share and discuss your responses. Be sure to give the reasons for your ideas.

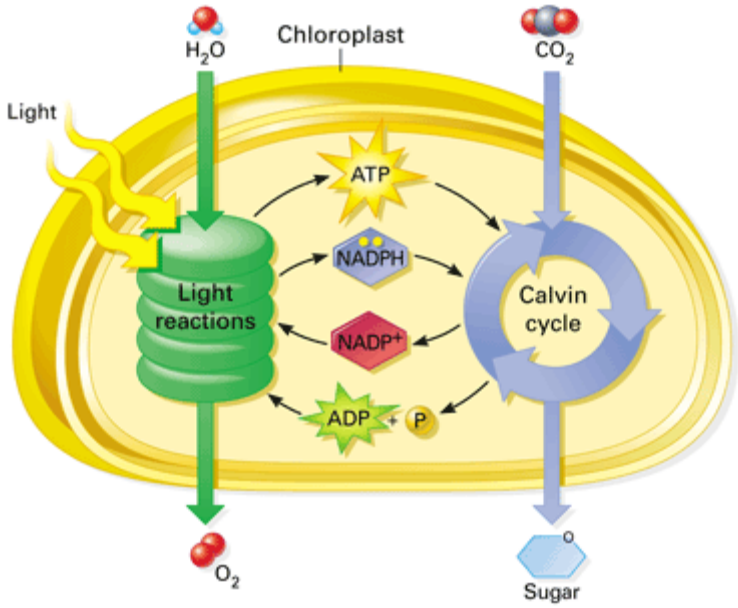
As a pair choose the best response.

Be ready to share your pair's response and reasons.

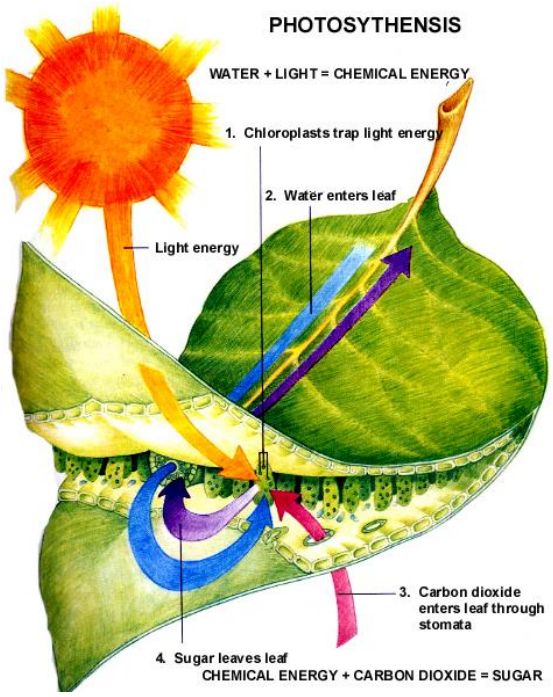
Whole Class Discussion

Notes to Remember:

Model C: Photosynthesis



Model D: Photosynthesis



What Makes a Science Model Better?

Individual/Pairs Read

Read Model E. While reading make your thinking visible using either Think-Aloud with partner note-making*, Talk to the text, or *I read / I thought* double-entry notes. Your teacher will say which to use.

*If you read and think aloud, you will each have time to read and think aloud – in effect reading the model twice.

Pair Discussion

With a partner, go through Model E, discussing your reading *bit by bit*. Take turns sharing and listening. Help each other clarify roadblocks. Add good ideas from your discussion to your notes (i.e. your annotations or double-entry notes).

Individual Think-Write

Silently read the question below. Circle the best response and write your reasons for choosing it.

How good is this model of the structure of the cell membrane?

- Very good
- Good
- Average
- Bad
- Very bad

Pair Discussion

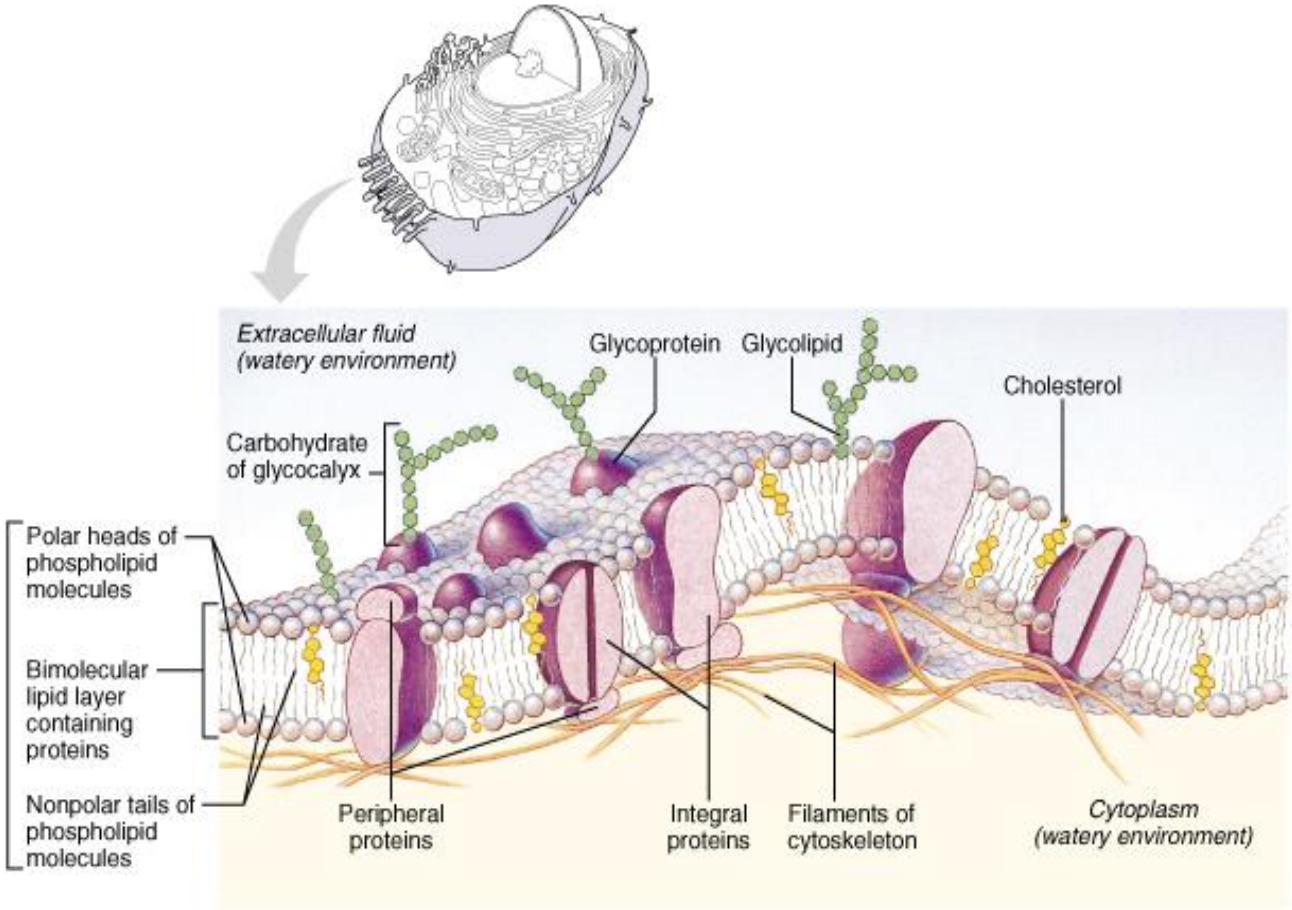
Share and discuss your responses. Be sure to give the reasons for your ideas.

As a pair choose the best response.

Whole Class Discussion

Notes to Remember:

Model E: The Fluid Mosaic Model of the Cell Membrane



Model F: The Fluid Mosaic Model of the Cell Membrane

Your teacher will show you an additional model found at:
http://www.susanahalpine.com/anim/Life/memb.htm

What Would Make This Science Model Better?

Individual Read

Your teacher will show you Model F on the screen and tell you how to make your thinking visible and where to make notes/observations about the model.

Individual Think-Write

Silently read the question below. Circle the best response and write your reasons for choosing it.

> How good is this model of the structure of the cell membrane? Why?

- Very good
- Good
- Average
- Bad
- Very bad

Teacher Note: The kind of model shifts here. Models E and F are what scientist call "structural models." They attempt to describe the structure of an object. How are these two models different from models A, B, and C? The probes may indeed elicit from the students the differences they notice. I recommend the name "structural model" in contrast to a cause-effect model or processes model.

Did this model add to your understanding of the structure of the cell membrane? If so, how?

In what ways was it similar to Model E? In what ways was it different?

Pair Discussion

Share and discuss your responses. Be sure to give the reasons for your ideas.

As a pair, agree upon answers to share with the class.

What Would Make This Science Model Better?

Whole Class Discussion

Share and discuss your responses. Be sure to give the reasons for your ideas.

Notes to Remember:

What We Learned To Do

Individual Think-Write

Silently read the three questions below. Then, write notes on this page about your thoughts, any connections you make to what you know, and any questions you have.

- What do you now know about science models that you didn't know before?
- What makes a model a "good" model?
- What did you learn about reading science texts?