![PROJECT **READi**]

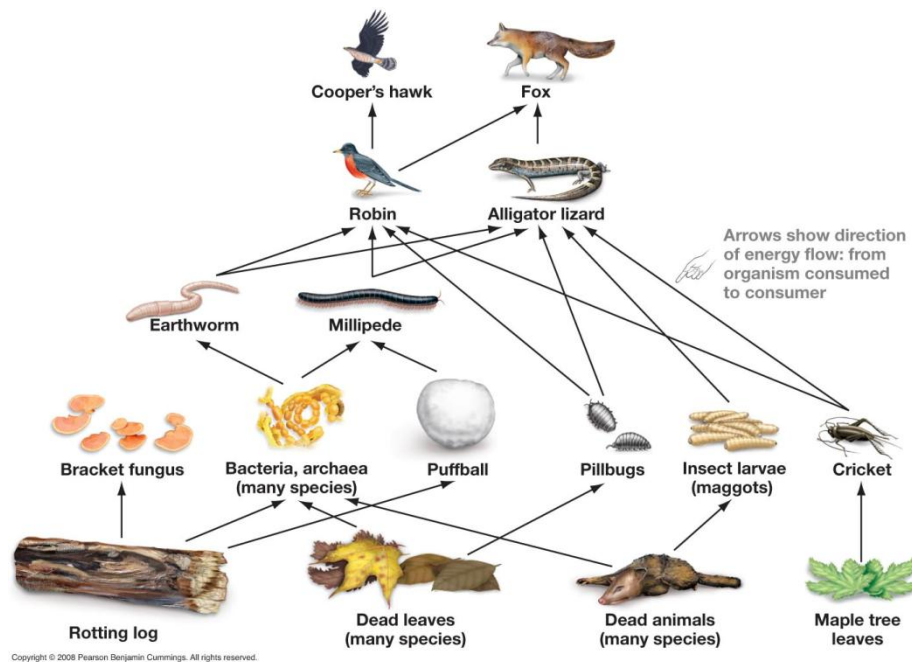# Reading Science Models

Flow of energy in an ecosystem

Inquiry Questions

What are science models?

How do we read science models?

READI reading science models high school module

Iteration 1, Fall 2013

Developed by READI Science Inquiry Network Teachers:

Rebecca Sela, High School Science Teacher, Dixon High School, Dixon, CA

Elizabeth Childers, High School Science Teacher, Logan High School, Union City, CA

Adriana Jaureguy, High School Science Teacher, Skyline High School, Oakland, CA

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Pluta, W.J., Chinn, C.A., Duncan, R.G. (2011) Learners' Epistemic Criteria for Good Scientific Models, Journal of Research in Science Teaching, 48, 486-511.

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

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?

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.

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 example

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:

Individual/pairs read

Continue the 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.

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.

Explanatory Models in Science

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

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.

Thinking and Talking about Science Models

Whole class discussion

Notes to remember:

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

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 texts: Explanatory Models in Science and Text A, "Snowshoe Hare and Canadian Lynx Populations over Time."

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 you and your partner, 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
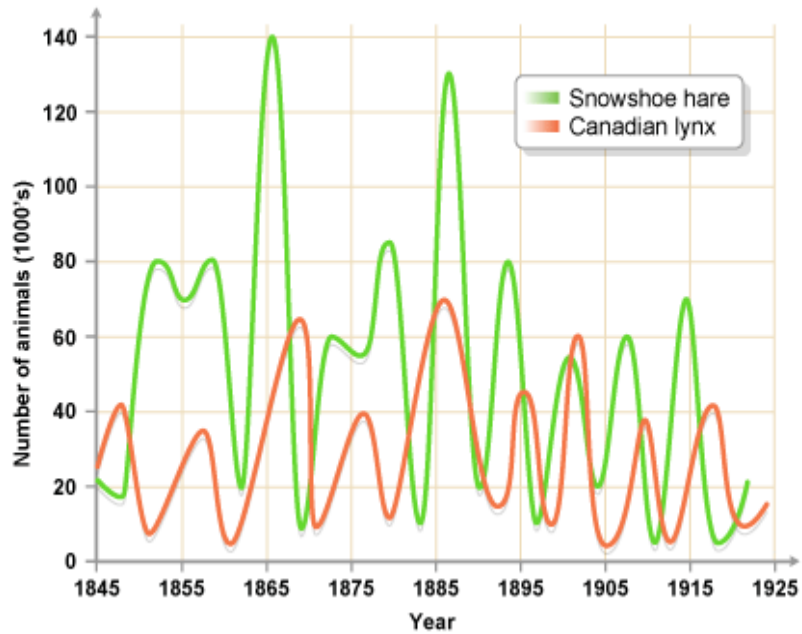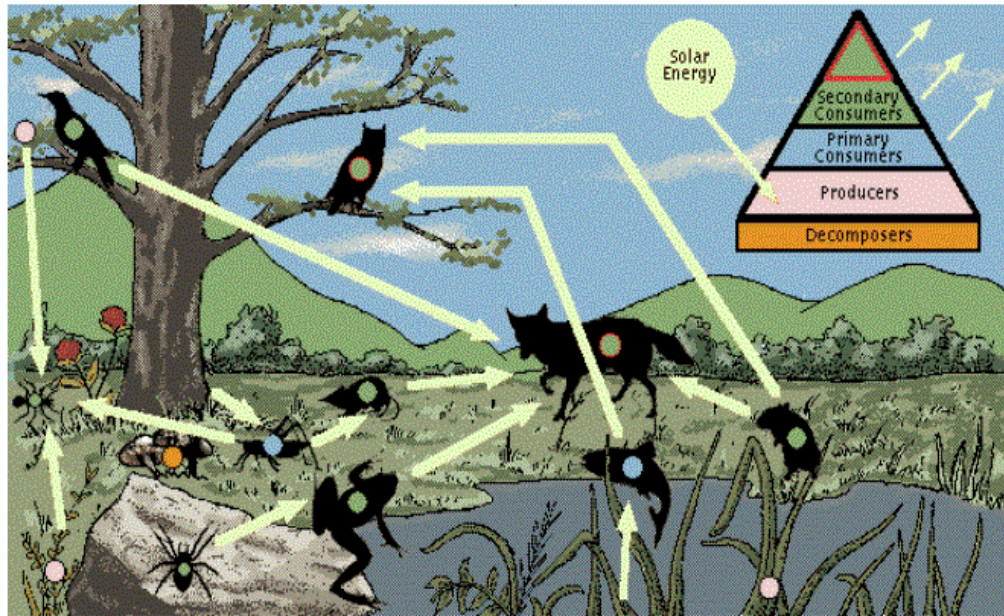

Text B

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.

Whole class discussion

Notes to remember:

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?

What Makes a Science Model Better?

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.
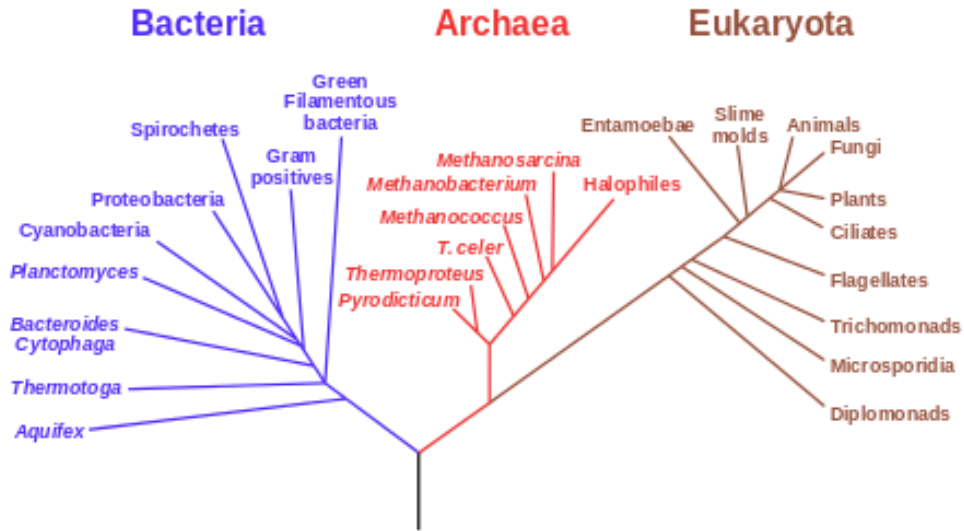
As a pair choose the best response.

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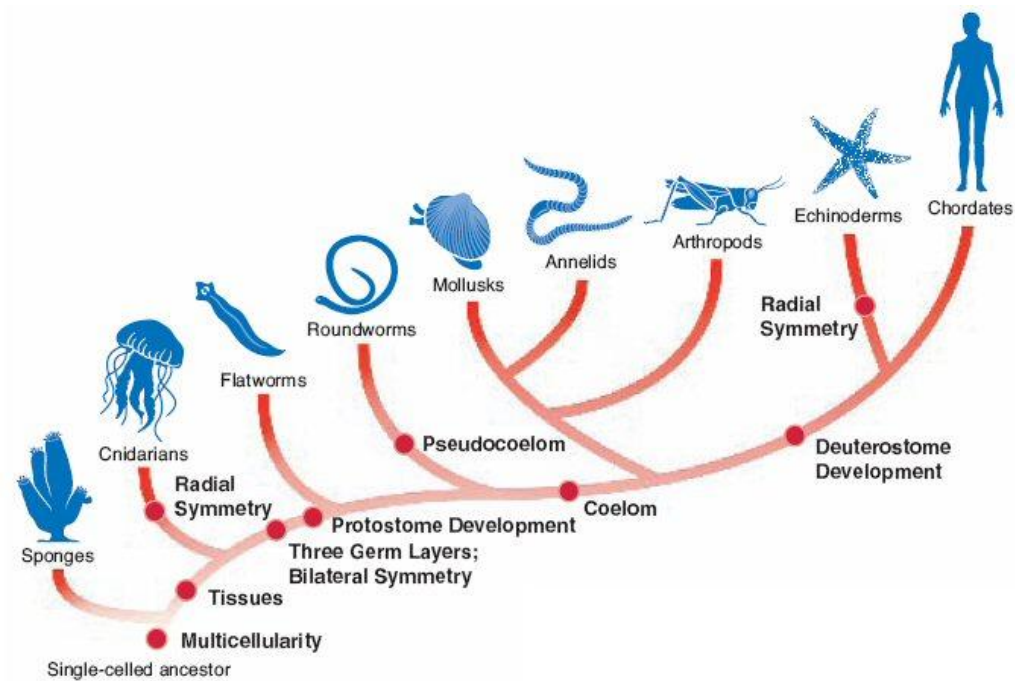
Whole class discussion

Notes to remember:

Model A: Relatedness of Life

Phylogenetic Tree of Life

Bacteria   **Archaea**   **Eukaryota**

- Spirochetes
- Green Filamentous bacteria
- Gram positives
- Proteobacteria
- Cyanobacteria
- *Planctomyces*
- *Bacteroides Cytophaga*
- *Thermotoga*
- *Aquifex*

- *Methanosarcina*
- *Methanobacterium*
- *Methanococcus*
- *T. celer*
- *Thermoproteus*
- *Pyrodicticum*
- Halophiles

- Entamoebae
- Slime molds
- Animals
- Fungi
- Plants
- Ciliates
- Flagellates
- Trichomonads
- Microsporidia
- Diplomonads

Model B: Relatedness of Life

- Sponges
- Cnidarians
- Flatworms
- Roundworms
- Mollusks
- Annelids
- Arthropods
- Echinoderms
- Chordates

- Radial Symmetry
- Radial Symmetry
- Pseudocoelom
- Protostome Development
- Coelom
- Deuterostome Development
- Three Germ Layers; Bilateral Symmetry
- Tissues
- Multicellularity
- Single-celled ancestor

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 <u>if you want to explain the shared characteristics that certain life forms have in common?</u> 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 how plants get food and energy in order to grow? 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

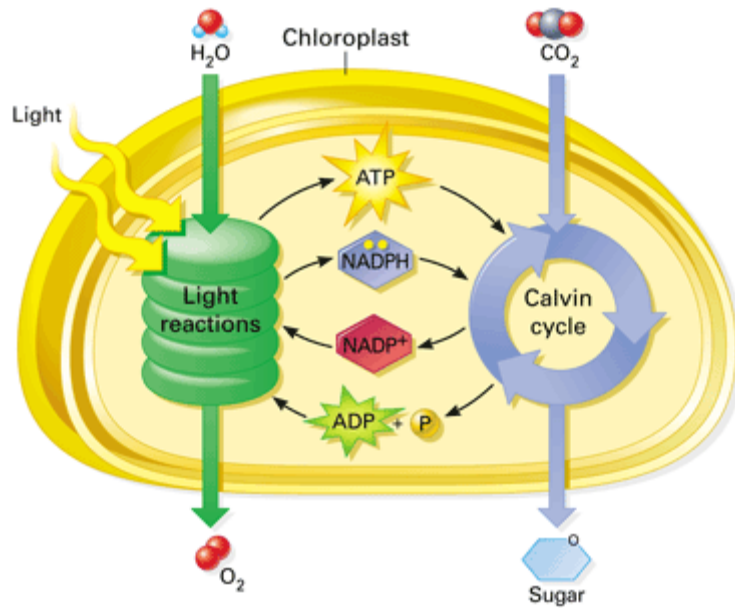Share and discuss your responses. Be sure to give the reasons for your ideas.
As a pair choose the best response.
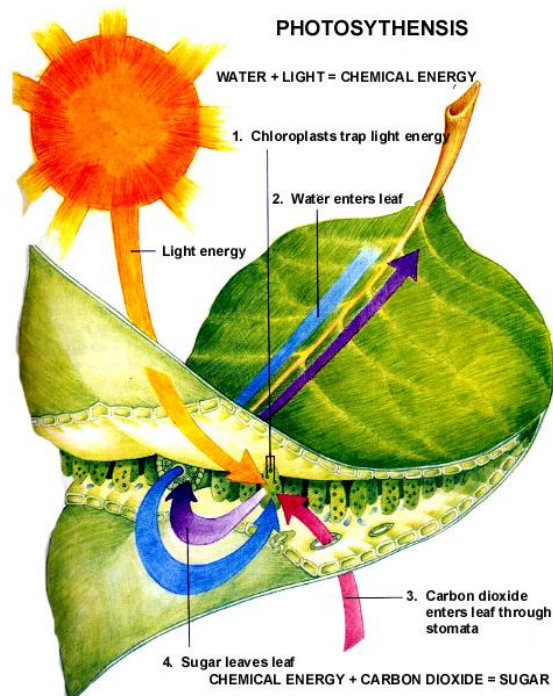Be ready to share your pair's response and reasons.

Whole class discussion

Notes to remember:

Model C: Photosynthesis

Chloroplast diagram showing H_2O and Light entering Light reactions, producing O_2; ATP, NADPH, NADP+, ADP + P cycling between Light reactions and Calvin cycle; CO_2 entering Calvin cycle producing Sugar.

Model D: Photosynthesis

PHOTOSYTHENSIS

WATER + LIGHT = CHEMICAL ENERGY

1. Chloroplasts trap light energy

2. Water enters leaf

Light energy

3. Carbon dioxide enters leaf through stomata

4. Sugar leaves leaf
CHEMICAL ENERGY + CARBON DIOXIDE = SUGAR

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
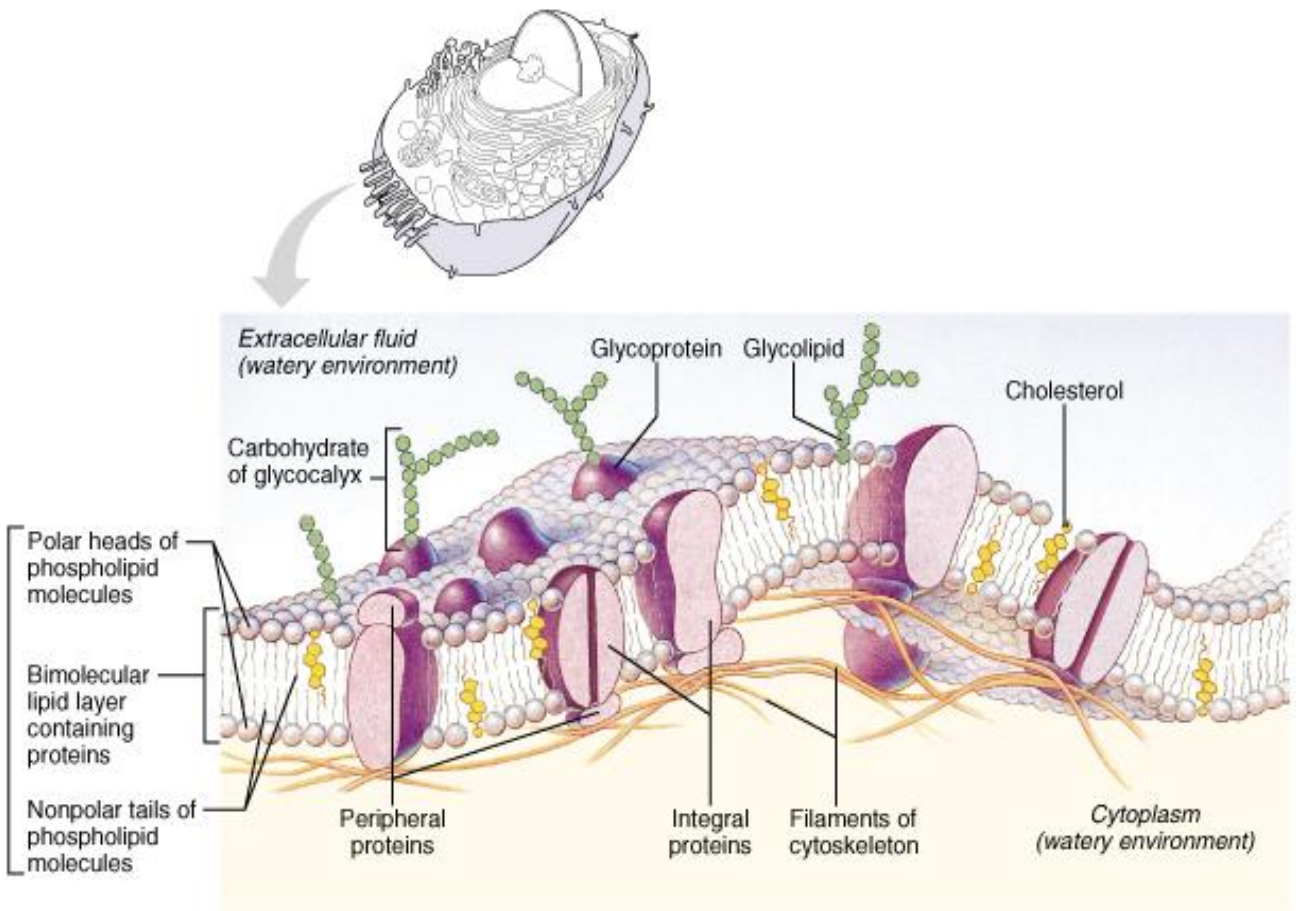- Average
- Bad
- Very bad

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

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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

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?