Shape of Life

The Secrets of Fossils

Lesson by Tucker Hirsch

Thinc Green
EDUCATION FOR SUSTAINABLE DEVELOPMENT

Video Titles:

Introduction: A New view of the Evolution of Animals Cambrian Explosion

Jenny Clack, Paleontologist: The First Vertebrate Walks on Land

Des Collins, Paleontologist: The Burgess Shale

Activity Subject: Assessing evolutionary links and evidence from comparative analysis of the fossil record and modern day organisms.

Grade Level: 6 – 8 grades

Introduction

In this lesson students make connections between fossils and modern day organisms. Using the information about the Cambrian Explosion, they explore theories about how and why organisms diversified. Students hypothesize what evidence might be helpful to connect fossil organisms to modern organisms to show evolutionary connections. Students use three videos from shapeoflife.org.

Assessments Written

Time 100-120 minutes (2 class periods)

Group Size Varies; single student, student pairs, entire class

Materials and Preparation

- Access to the Internet to watch 4 Shape of Life videos
- Video Worksheet
- "Ancient-Modern" Activity. Make copies of this Worksheet, enough for each pair or small group, and cut out the pictures before handing them out to the students.
- Science Research Worksheet

NEXT GENERATION SCIENCE STANDARDS

MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumptions that natural laws operate today as in the past. *[Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]*

MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. *[Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.]*

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Procedure - Teacher's Edition

Procedure:

1. Watch the video *Introduction: A New View of the Evolution of Animals* (3:42). As students watch the video, invite them to look for answers to the following questions, using the Video Worksheet provided.

   1. What four stages of evolution in the history of life does the narrator mention? ***(No life → simple cells → first animal (cells working together) → millions of species)***

   2. The narrator comments that there are four exciting branches of evolutionary biology working together today to help us learn what animals' shapes can tell us about their history. Take notes about each of the following and how they contribute to our understanding of evolutionary biology:

      a. Paleontology ***(fills gaps in our knowledge about extinct animals through new fossils)***

      b. Genetics ***(helps us understand how animals have developed their modern shapes)***

      c. Embryology ***(allows scientists to compare one organism with those above and below it on the evolutionary tree)***

      d. Anatomy ***(DNA sequencing demonstrates how organisms are related in the animal family tree)***

Ask students to pair and share their answers with a partner. Ask for volunteers to share answers with the whole class.

2. Watch the video *Cambrian Explosion* (13:07). As students watch, ask them to look for the following information:

   a. What was the Cambrian Explosion? ***(a sudden burst and diversification of animal life 500MYA)***

   b. What mystery are the scientists trying understand? ***(why animals suddenly diversified; what caused an increase in complexity in animal body design and relationships; what impact did the Cambrian Explosion have)***

   c. Why is the Burgess Shale important to evolutionary biologists? ***(there are tens of thousands of fossils in one location; animals seemed to appear all at once and suddenly; these fossils from the Cambrian Explosion are the basis for body plans of all animals alive today.)***

   d. What was life like before the Cambrian explosion? ***(life was slow and simple; sponges dominated the ocean)***

   e. What are some traits that characterize organisms that emerged during the Cambrian? ***(the Cambrian had complex life forms that were mobile, had competitive relationships, increased body protection, and fierce predators)***

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Procedure continued - Teacher's Edition

f. What hypotheses do the scientists in the video have to explain the Cambrian Explosion? ***((i) Genetic revolution: Sponges established early interactions between cells. Cnidarians were the first animals to move. Flatworm-like animals had head, brain, sensory organs, and could hunt; (ii) Dramatic Change: e.g. oxygen levels changed and animals could be larger; (iii) Arms Race: Predatory animals spurred prey to develop body armor)***

g. How is the elephant linked to the tiny Pikaia? ***(Pikaia's body plan was passed on to all animals living today)***

3. In pairs or small groups, perform the "Ancient-Modern" activity. Pass out the cut-out pictures and ask students to try and match the ancient, Cambrian fossil with the modern day organism to which each is most closely related. Then ask students to answer the questions on the Ancient-Modern Worksheet:

a. How did you determine which animals were related? ***(answers will vary)***

b. What are some differences between the modern animals and the fossil animals from the Cambrian period? ***(answers will vary)***

c. Can you generalize how animals have changed over 500 million years based on the comparisons you made? What patterns can you identify? ***(many animals are more complex today than they were during the Cambrian period. But there are still many relatively simple animals alive today.)***

Ask student volunteers to reveal the connections and then invite groups to share their answers to the questions.

Using the Science Research Worksheet, ask students to work in groups or pairs and brainstorm the solution to the following problem:

> Imagine you are a paleontologist. You have found a fossil from the Cambrian period. There are many similarities between the fossil animal and a modern organism, the lobster. You hypothesize that the lobster descended from an ancient group of animals similar to the fossil, but many of your colleagues think you are mistaken; that the modern organism is related to a different ancient organism. What evidence would you look for to connect your organism to the Cambrian fossil?

Ask students to share their thoughts.

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Procedure continued - Teacher's Edition

4. Watch the video Jenny Clack, Paleontologist: The First Vertebrate Walks on Land (7:04). Remind students to take notes as they watch using the Video Worksheet for Video 3. Remind students to look for clues on how to solve the problem from the Science Research Worksheet.

a. What discovery does Jenny Clack make? ***(she found the fossil that links today's modern organisms that walk on land to the predecessors that swam in the ocean; Boris is the transitional form between water and land animals)***

b. What characteristics does Jenny's fossil have that links land and water tetrapods? ***(Boris had both gills and lungs that allowed it to survive in and out of the water)***

After watching the video, ask students to review their problem set on the Science Research Worksheet. Ask them to answer the question: How would the fossil record help you make the connection between your modern organism and the Cambrian fossil? ***(answers will vary)***

5. Ask students to recall the video Cambrian Explosion. Review the organisms *Anomalocaris*, *Opabinia*, and *Wiwaxia*. Provide students with time and resources to research these animals. For one resource, suggest that students watch the Scientist video Des Collins, Paleontologist: The Burgess Shale (6:12), which talks about the challenges around the fossils of *Anomalocaris*. Ask students so answer the questions as they watch the video on the Video Worksheet.

a. What information does this video add to what you have already learned about fossils as missing links? About Anamolocaris? ***(different theories can be proposed for the same fossil or piece of evidence; Anamolocaris was originally thought to be two, separate animals; it took years to put the image of Anamolocaris together)***

b. How would you describe the process of piecing together various fossils? ***(answers will vary as there are many descriptions given in the video; trial and error; full of surprises)***

After students have done their research and watched the video, ask them to answer the questions:

a. What confusion lies in the history of these organisms? ***(it is unclear how to classify these organisms)***

b. What information would help determine how they should be classified? ***(a missing link, like Boris, that connects them to a modern organism would help to determine how they should be classified; finding a whole organism)***

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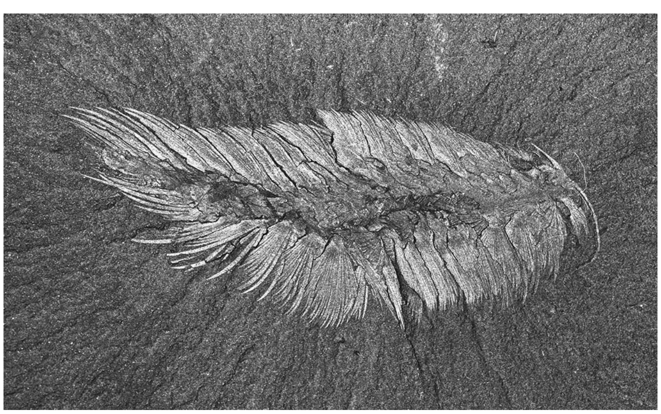
Ancient - Modern Cards

Copy enough for each group or pair. Cut out each photograph and pass out to the groups.

Aysheaia
http://paleobiology.si.edu/burgess/imgBurgess/aysheaia.gif

Velvet worm
https://c1.staticflickr.com/5/4109/5049948235_00cf4c5911_b.jpg

Canadia
https://www.mnh.si.edu/onehundredyears/expeditions/burgess_shale/BurgessShaleCanadia1-21_large.jpg



Darklined Fireworm
http://reefguide.org/indopac/chloeiafusca.html

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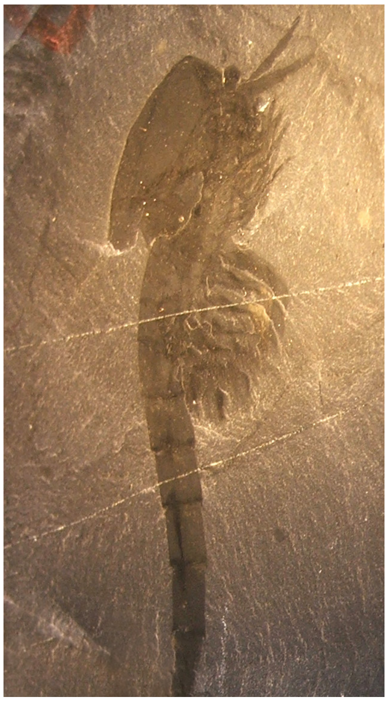
Ancient - Modern Cards

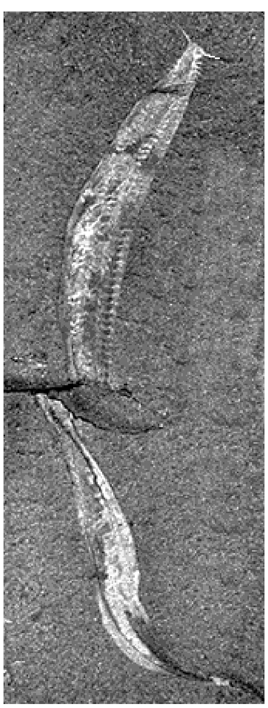
Copy enough for each group or pair. Cut out each photograph and pass out to the groups.

Waptia
http://upload.wikimedia.org/wikipedia/commons/1/15/Waptia.png



Nebalia Bipes
http://upload.wikimedia.org/wikipedia/commons/thumb/5/57/Nebalia_bipes.jpg/330px-Nebalia_bipes.jpg

Pikaia
http://paleobiology.si.edu/burgess/imgBurgess/pikaia.gif



Lancelet
http://upload.wikimedia.org/wikipedia/commons/thumb/4/47/Branchiostoma_lanceolatum.jpg/375px-Branchiostoma_lanceolatum.jpg

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Video worksheet - Student's edition

Video 1
Introduction: A New View of the Evolution of Animals
As you watch the video, take notes and look for answers to the following questions.

1. What four stages of evolution in the history of life does the narrator mention?

2. The narrator comments that there are four exciting branches of evolutionary biology working together today to help us learn what animals' shapes can tell us about their history. Take notes about each of the following branches of evolutionary biology and how they contribute to our understanding of the science:

a. Paleontology

b. Genetics

c. Embryology

d. Anatomy

Video 2
Cambrian Explosion

As you watch the video, take notes and answer the following questions.

a. What was the Cambrian Explosion?

b. What mystery are the scientists trying understand?

c. Why is the Burgess Shale important to evolutionary biologists?

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Video worksheet continued - Student's Edition

d. What was life like before the Cambrian explosion?

e. What are some traits that characterize organisms that emerged during the Cambrian?

f. What hypotheses do the scientists in the video have to explain the Cambrian Explosion?

g. How is the elephant linked to the tiny Pikaia?

Video 3
Jenny Clack, Paleontologist: The First Vertebrate Walks on Land

As you watch the video take notes and answer the following questions.

1. What discovery does Jenny Clack make?

2. What characteristics does Jenny's fossil have that links land and water tetrapods?

Video 4
Des Collins, Paleontologist: The Burgess Shale

As you watch the video take notes and answer the following questions.

1. What information does this video add to what you have already learned about fossils as missing links? About anamolocaris?

2. How would you describe the process of piecing together various fossils?

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Video worksheet continued - Student's Edition

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Look at the cutout pictures of ancient fossils and modern organisms your teacher provided. Match the ancient, Cambrian fossil with the modern day organism to which each is most closely related. Write the connections in the table below and then answer the questions.

Name of Ancient Fossil	Name of Modern Organism

1. How did you determine which animals were related?

2. After more than 500 million years there are animals still living today that look similar to those that came into being during the Cambrian Explosion. With all the animal diversity that has evolved why do you think similar looking animals still exist?

3. What are some differences between the modern animals and the fossils from the Cambrian period?

Problem:

Using the Science Research Worksheet, ask students to work in groups or pairs and brainstorm the solution to the following problem: Imagine you are a paleontologist. You have found a fossil from the Cambrian period. There are many similarities between the fossil animal and a modern organism, the lobster. You hypothesize that the lobster descended from an ancient group of animals similar to the fossil, but many of your colleagues think you are mistaken; that the modern organism is related to a different ancient organism. What evidence would you look for to connect your organism to the Cambrian fossil?

Step 1 - Brainstorm

To solve this problem, I would look for…

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Video worksheet continued - Student's Edition

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Step 2 - Compare

Watch the third video, *Jenny Clack, Paleontologist: The First Vertebrate Walks on Land*. Take notes and answer the questions on the Video Worksheet, keeping the above problem in mind as you watch.

Step 3 – Make Connections

After watching the video, review the statement you wrote above. How would the fossil record help you make the connection between your modern organism and the Cambrian fossil?

The fossil record would help me by…

Step 4 – Apply

In the video *Cambrian Explosion*, you met the organisms Anomalocaris, Opabinia, and Wiwaxia. Research these animals in the library or on the Internet.

1. What confusion lies in the history of these organisms?

2. What information would help determine how they should be classified?