LESSON #1: The Burgess Shale: Who? What? Where? When?

Focus questions

1. How do paleontologists collect and interpret information from fossils?
2. What animals are preserved in the Burgess Shale?
3. What was the environment in which the Burgess organisms lived?

What students do in this activity

Students work in groups and play the roles of paleontologists on a dig. They "unearth" a few fossils at a time and attempt to figure out what animals lived in the Burgess sea 505 million years ago and to reconstruct the ecosystem where the animals lived. They will also examine the work of other groups and compare findings.

Estimated teaching time

One or two class periods, depending on how long the introduction and wrap-up take.

General supplies to complete this lesson plan

- Envelopes for cut-up fossils from Fossil Sheets
- Scissors
- Card Stock

Each student will need the following

- **Burgess Shale Worksheet** (one per student)
- **Burgess Shale Fossils Resource Sheet** (one per student)

Each group will need the following

Envelope with drawings or photographs, five total per envelope

Learning goals

Students will:

1. Learn about some of the species that lived when the Burgess Shale was deposited.
2. Learn about the ecology of the Burgess Shale.
3. Learn how scientists discovered the Burgess Shale.
4. Learn that fossils provide concrete evidence of past life.
5. Learn that scientists pose, test and revise hypotheses based on research outcomes.
6. Learn that science explains the natural world using evidence from the natural world.

Advance preparation

1. Make one copy of the Burgess Shale Worksheet for each student.
2. Make one copy of the Burgess Shale Fossils Resource Sheet per student.
3. Copy the Fossil Sheets onto card stock.
4. Cut up the Fossil Sheets and put five fossils in each envelope. (see Teaching Tip below.) Leave a bit of white paper around each fossil to facilitate cutting.

Teaching tip

In creating the envelopes of fossils, it would be best if each envelope was different. Each packet should have five cards or pieces of paper in it, but they can be any combination of fossils, as long as each envelope has one of the fossil photos and not only drawings of the fossils.

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Please note that there is more than one picture of the *Marrella* and *Aysheaia* fossils. *Marrella* was by far the most common fossil found at Burgess (15,000 specimens out of a total of 65,000); therefore it would be more than likely that a group searching for Burgess fossils would find many of them. *Aysheaia* also appears to have been an abundant species. It is possible that one group would only have *Marrella* in its envelope.

Introducing the activity

1. Tell students that the person who studies fossils, evolution and the history of life is called a **paleontologist**.

2. Ask students how they think that paleontologists work.

3. Tell the students that they will be working in groups and playing the role of paleontologists on a dig.

4. Tell them the following story:

   You and your fellow paleontologists are on a fossil dig in the Canadian Rockies during August of 1910. You have had to climb 3,000 feet up a steep, rocky slope carrying shovels, picks and other digging equipment. Then you needed to go back to the road to lug your tents and other supplies to your camp site, in the forest about one-quarter mile from where you will be digging. The first evening, you plan the dig. A few people will take rock hammers and break rocks off of the large outcrop at the fossil site. Others will carry these rocks back to camp. Some will split the shale into thin layers, and someone will write down the exact location where the rock was found.

Facilitating the activity

1. Separate the students into groups. They will need to be sitting together in these groups so that they can work together.

2. Pass out the envelopes and the worksheets.

3. Tell them that they will be using modern drawings of the species, several of which have been reinterpreted as paleontologists have made new discoveries.

4. They will also have at least one photograph of the fossils. Tell them that to make this more realistic, they may have more than one of the same fossil or drawing in their packet.

5. Explain that they will look at the fossils in groups and make a hypothesis about what they have found. Also, each group will have a different set of fossils and some groups may have more than one of the same species.

6. Explain that they will then share their information with other groups and make a final conclusion about the species and environment of the Burgess Shale.

7. Continue with the story.

   The first morning, the team rises early and heads out to the outcrop. After several hours of breaking, carrying and splitting, you get lucky. Very lucky. Your team discovers a rock filled with unusual looking animals. They are preserved beautifully as a thin coating on the rock.

   Without looking in the envelope, randomly remove one card and lay it on the table. Now that you are back in camp for the evening, try to make as much sense as possible of what you found. Write on your worksheet what you think the animal/plant might be and how it lived.

   (Allow students time to look at the fossil, reflect and record their hypotheses. Request that students not observe the workings of other groups.)

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The second morning, your team rises even earlier, excited about the possibility of finding more interesting fossils. This day, however, you awake to an inch of snow on the ground. You have to stay in camp, make a fire and stay warm. Your team finally gets to the dig site by noon, after the sun has melted off the snow. Despite the weather, you find two new species. You return to camp warm and happy.

Again, without looking in the envelope, withdraw two cards. Use the next few minutes to compare the new fossils with the ones from yesterday. On your worksheets, record what you think the new plants/animals are and whether they change your opinion of the lifestyle of the first specimens you found.

(Allow a few minutes for this task.)

The third morning dawns bright and beautiful, with snow capping the distant peaks. The lake in the valley below glistens like an emerald. Your camp cook makes you pancakes with blueberries picked from the bushes in camp. After several hours of whacking, toting and splitting, the team makes another big discovery, two additional specimens. The team carefully maps the specific location of all of the fossil finds and returns to camp for the last time. During the final evening in camp, the team tries to interpret what it has found.

Again, without looking in the envelope, withdraw two more fossils. Put them on the table with the others and see what you have. Record the information on the worksheet.

Bright and early the next morning, the team packs up and returns to the Museum of Paleontology. Upon arriving at the Museum you learn that other teams have had successful expeditions this summer and would be glad to share their results.

End of Story

Facilitating the activity (continued)

1. Ask the students to fill in the section of their worksheet labeled Fourth Day.

2. Ask the students to pick a representative or two from their group (depends on how big each group is) to walk around the room and see what other groups have discovered on their expedition. Since they need to record information about eight fossils, their goal is to learn about the remaining fossils from other groups. They will need to carry around their worksheet and fill in the remaining lines of the Fourth Day section. When that person or persons has a description of all eight fossils they should return to their own group and share the information.

3. Pass out the **Burgess Shale Fossils Resource Sheet**.

4. Ask the students to look through the Burgess Shale Fossils Resource Sheet, compare their fossils with the descriptions in the Manual, and try to figure out what species they found.

5. Ask them to fill out the remaining section of their worksheet.

6. Return the drawings to their envelope.

Teaching tip

If you would like to use this activity again in the future, make sure students put the fossils back in the envelopes after finishing.

Summarizing and reflecting

Lead a group discussion on descriptions of each fossil. Record different opinions and questions that come up.

Ask the students the following questions:

- Did the **Burgess Shale Fossils Resource Sheet** confirm your ideas or cause you to rework your speculations about these specimens? Why or why not?

- What is the advantage of having more specimens to examine versus only having one or two?

Other ideas to think about

- If you were going to look for fossils, how would you proceed? What resources would you consult?

- Do you know of any fossils in Washington state? (This will be the subject of an article in the Seattle Times during the seventh week of this program.)

- Ask the students about how this activity used the scientific method. What evidence led to their final hypotheses?

Extensions

This is only an introduction to the Burgess Shale. The exhibit at the Burke Museum of Natural History and Culture has much more detailed information, as well as actual fossils. Students could do additional research about the species of the Burgess Shale and write about what they find. They could search the Internet and look at photographs of the fossils and create their own drawings of the animals. (See Additional Resources page on page 61.)

Notes

Teacher Background

Short version

The "fossils" are based on specimens from the Burgess Shale, a rock unit deposited 505 million years ago in what is now British Columbia. These eight species — *Vauxia, Olenoides, Opabinia, Pikaia, Aysheaia, Hallucigenia, Marrella,* and *Anomalocaris* — illustrate different modes of life in the Burgess. Vauxia was a sponge. Aysheaia was a parasite that lived on Vauxia. Hallucigenia lived on the muddy bottom and was a scavenger. Marrella, also a bottom dweller, was another scavenger. Anomalocaris, the largest animal from the Burgess, was a predator. Olenoides was a hunter scavenger that crawled on the sea floor bottom. Opabinia was a swimmer. Pikaia was probably a filter feeder.

Detailed version

Charles Doolittle Walcott made his most famous discovery, the Burgess Shale, on August 31, 1909. He was on a steep rocky slope at over 8,000 feet in the Canadian Rockies when he found numerous, smooth dark gray rocks dotted with what Walcott recognized as fossil crustaceans, but they were crustaceans unlike any he, or any other paleontologist, had ever seen.

The fossils that Walcott found were from over 120 species that lived 505 million years ago. They inhabited the muddy bottom at the base of a steep cliff in a warm sea located just off the northern coast of ancestral North America, which at the time lay on its side with the areas we know as Canada to the east and Mexico to the west. The continent straddled the equator. There were no land plants or animals, the sea lacked fishes, and no birds populated the skies.

During their life, most of the animals of the Burgess lived on the sea bottom. One day the cliff above their home collapsed, sending a wall of clay-sized sediments over the animals. The flow deposited them willy-nilly, some flat, some upside down, some upright. Transport probably killed them, either by covering them or altering their environment beyond livable conditions.

They were buried so thoroughly that no scavengers could reach them. Nor could oxygen penetrate the clay and start the decay process, though some decay did occur. As more and more layers piled on top, the soft body parts slowly hardened into carbon films, coated by silicate films, so that when paleontologists look at Burgess Shale fossils they generally see a highly detailed film of a flattened animal.

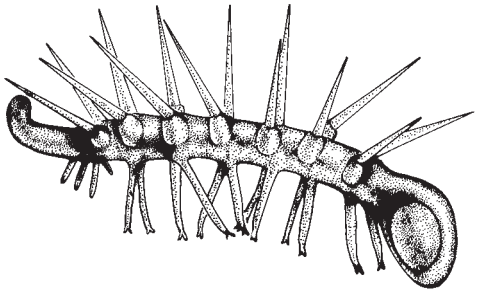
Because land slides transported the Burgess animals to their final resting place, paleontologist do not know exactly what their pre-slide environment looked like. They have good ideas though.

Most of the animals lived on the sea bottom, which was irregular and hummocky. Many, such as the brachiopods, sponges and algae, were anchored to the ground. Numerous worms burrowed in the sediments, occasionally eating unsuspecting animals that passed by their subterranean home. Abundant arthropods (particularly *Marrella*, the most prevalently found animal from the Burgess), *lobopods* (velvet worms, such as Cambrian-age Hallucigenia and Aysheaia), and two species that paleontologists have not been able to classify, *Wiwaxia* and *Opabinia*, moved about either scavenging, predating or grazing. Swimmers included the notorious *Anomalocaris*, a crustacean that swam upside down, *Odaraia*, and a wispy beast known as *Pikaia*, famous amongst paleontologists as the earliest relative of all vertebrates.

Burgess Shale Fauna

Anomalocaris

Anomalocaris swam in the open sea, probably undulating through the water like a manta ray. At up to three feet in length, the largest beast of the Cambrian sea, it used its claw-like feeding appendages to grab a meal and stuff it into its tooth-lined, circular mouth. When first discovered, scientists described the evidence as five different species. This belief persisted until new research in the 1970s proved that the five were only one. Anomalocaris fossils have now been found in China, Australia and Greenland.



Hallucigenia

Paleontologist think that Hallucigenia was a scavenger. It could not move very quickly but was well protected by a double row of spikes. When scientists first described Hallucigenia, they thought it walked on the spikes. New discoveries in China led researchers to turn the animal over. They still debate exactly what it looks like. Hallucigenia ranged in size from .2 to 1.2 inches.

Aysheaia

Known as a lobopod, or lobe-limbed animal, Aysheaia lacked jointed limbs, a trait that distinguishes it from arthropods. They appear to have been parasites living on sponges. Modern lobopods are called velvet worms and are now restricted to forests in the southern hemisphere. They ranged in size from .4 to 2.4 inches.

Marrella

Marrella, called the "lace crab" by Charles Walcott, is the most abundant of the Burgess Shale animals. Over 15,000 specimens have been collected from the Burgess. The strange head shield had two pairs of large spines curving back over the body. Two pairs of antennae project forward and the body consists of a large number of segments bearing identically shaped limbs. They appear to have fed on small animals and organic particles. They ranged in size from .1 to 2 inches.

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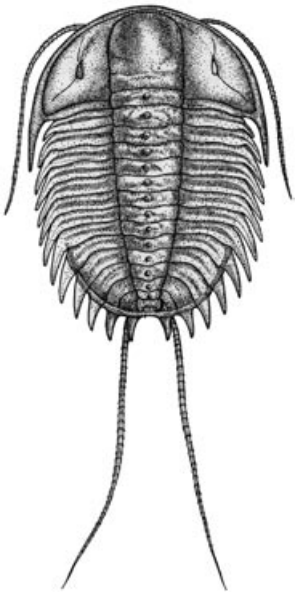
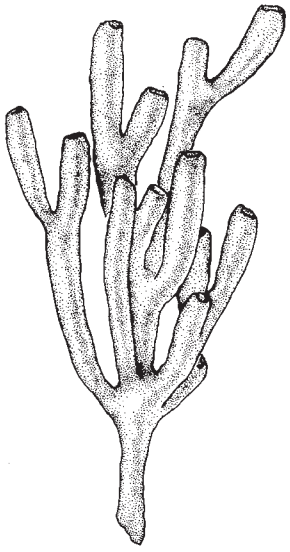
TEACHER BACKGROUND

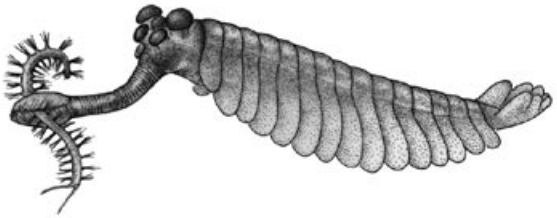
Olenoides
An example of the best known group of Cambrian animals, trilobites, Olenoides had thin limbs, indicative of a crawler. They actively hunted and scavenged soft-bodied worms on the sea bottom. Part of what makes these specimens unusual, is that the limbs are also preserved, making them one of the best known trilobites. They ranged in size from 2 to 3.4 inches.



Pikaia
Pikaia is our earliest relative, although it may not look like it. It possesses a notochord, a stiffening rod found in all members of the phylum Chordata, which includes all animals with spinal cords. Walcott first descibed it as a worm. It swam close to the sea floor and may have been a filter feeder. Average size was about 1.5 inches.

Vauxia
This is not the oldest ancestor to the saguaro cactus. It is actually an animal, one of the most primitive kind known, sponges. Vauxia is the most common sponge in the Burgess Shale; several hundred specimens have been recovered.





Opabinia
How do you classify an animal with five eyes and a clawed proboscis? When Harry Whittington, who studied this species in the 1960s, first showed it to other researchers, they laughed. Paleontologists still debate what group to place it in. The animals may have used the flexible front "appendage" to pull worms from their burrows. The tail worked as a stabilizer. They ranged in size from 1.7 to 2.75 inches.

Photographs by Chip Clark. Drawings by Mary Parish.

Courtesy of Smithsonian Institution's National Museum of Natural History

Photographs from: The Fossils of the Burgess Shale by Derek E.G. Briggs, Douglas H. Erwin and Frederick J. Collier

Fossil Sheet — Photographs

Photographs by Chip Clark. Courtesy of Smithsonian Institution's National Museum of Natural History
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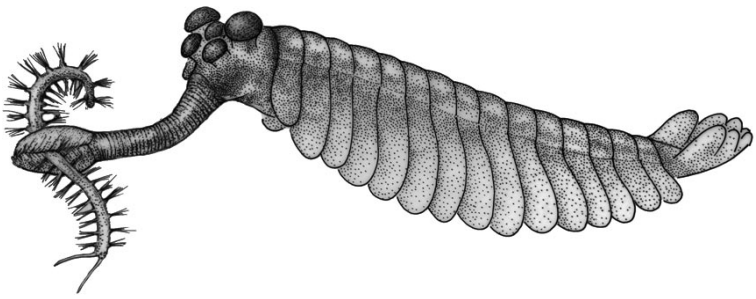
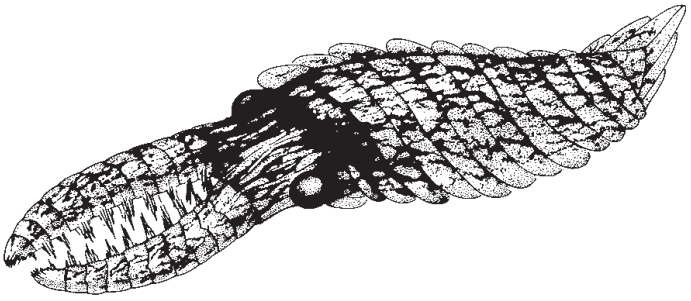
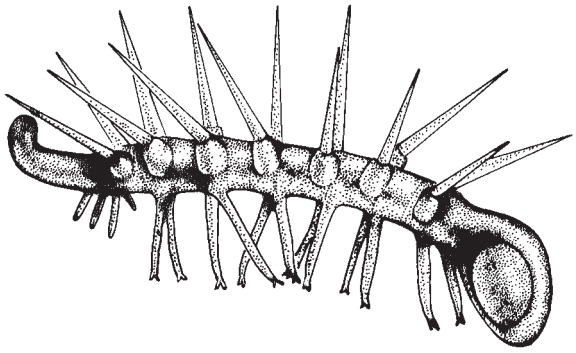
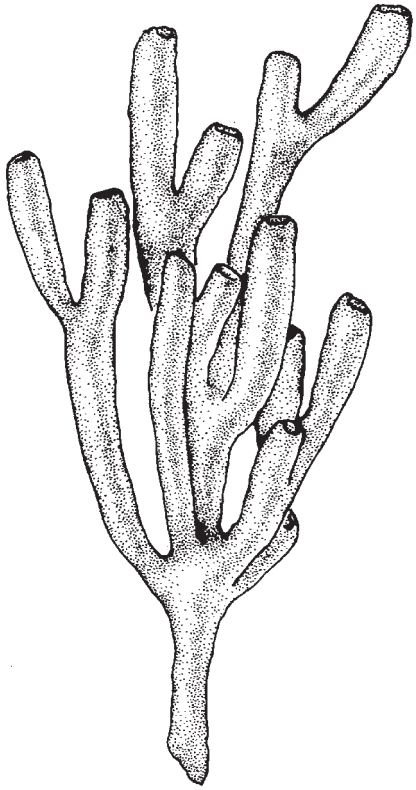


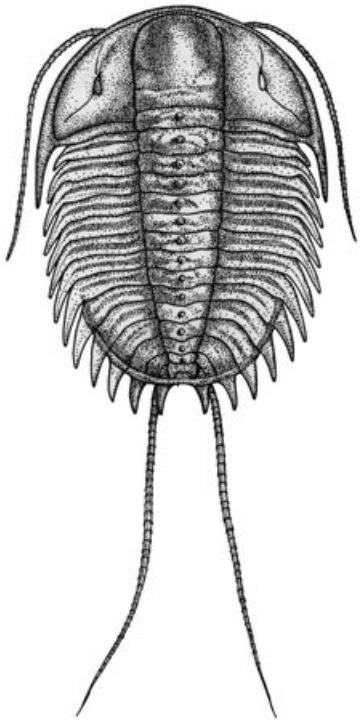


Drawings by Mary Parrish. Courtesy of Smithsonian Institution's National Museum of Natural History

Fossil Sheet — Drawings







Drawings by Mary Parrish. Courtesy of Smithsonian Institution's National Museum of Natural History

Burgess Shale Fossils Resource Sheet

Anomalocaris
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Burgess Shale Worksheet

Name _____Date _____

First day observations and hypotheses
Types of species suspected: Plant or animal? Scavenger, predator or prey? Swimmer, crawler or burrower? Fast or slow? Land or sea species?

1. _____

Second day observations and hypotheses
Types of species suspected: Plant or animal? Scavenger, predator or prey? Swimmer, crawler or burrower? Fast or slow? Land or sea species? Are any related to each other?

1. _____

2. _____

Third day observations and hypotheses
Types of species suspected: Plant or animal? Scavenger, predator or prey? Swimmer, crawler or burrower? Fast or slow? Land or sea species? Are any related to each other?

1. _____

2. _____

Draw one of the fossils you found

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STUDENT WORKSHEET

Fourth day (collaboration with peers) observations and hypotheses

Types of species suspected: Plant or animal? Scavenger, predator or prey? Swimmer, crawler or burrower? Fast or slow? Land or sea species? Are any related to each other?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

After looking at the *Burgess Shale Fossils Resource Sheet*

Name of species? Plant or animal? Scavenger, predator or prey? Swimmer, crawler or burrower? Fast or slow? Land or sea species? Are any related to each other?

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____