Activity Six

Animal Investigations

Episode Titles: "The Conquerors" (Arthropods), "Survival Game" (Molluscs)

Activity Subjects: Body plans and parts, animal behaviors, locomotion, feeding, habitats, diversity, science process

Grade Level: 3-12 (Students in elementary grades may not be able to do all of the exercises or understand all of the abstract concepts.)

National Science Education Standards:
Standards are noted as (standard:benchmarks).

Grades 3-5	
Life Sciences	(5:2,3), (6:3,4), (7:2)
Physical Science	(10:4,5,6)
Nature of Science	(11:1,2,3,4), (12:1,2,5), (13:1,2,3)
Grades 6-8	
Life Sciences	(5:5,7), (6:2), (7:1,4,5)
Physical Science	(10:4)
Nature of Science	(11:1), (12:1,2,4,7,8), (13:1,2)
Grades 9-12	
Life Sciences	(5:8), (7:1,2)
Nature of Science	(11:1,2), (12:1,3,6), (13:6)

Video Segment References: *Shape of Life* video references are noted as (episode number/minute:second) in all Animal Investigation exercises. Set your VCR counter to "0" at the first frame of the video on each tape. Remember that counter accuracy will vary.

Learning Objectives:

- Students investigate the body plan and structure of a variety of animals.
- Students use the inquiry process and design investigations to study the behavior and environmental preferences of a variety of animals.
- Students work on research teams and share their findings with others.
- Students use a science notebook to record their observations, data, and conclusions.

Assessment: Students participate in discussions, write descriptions and observations, and draw illustrations.

Time: One class period per investigation (viewing only video segments recommended in each investigation)

Group Size: Entire class or pairs or small teams of students conduct investigations.

Materials and Preparation

Each student needs a science notebook before beginning investigations. Additional information is provided with each activity.

Procedure

1) Review Arthropod Investigations and Mollusc Investigations that follow, paying particular attention to the materials required and the time needed to obtain them.

2) Based on the activity or activities selected, all students should go through Exercise 1 in Arthropod Investigations and/or in Mollusc Investigations. This will give them the opportunity to get comfortable with their animal they are investigating, observe its physical structure and body plan, and get a general sense of how it will behave. After completing these general observations, proceed with one of the following steps with your students.

• Give students the opportunity to design an investigation of their own to explore some aspect of their critters. Have students prepare a simple proposal that they present to you for approval. The proposal need not be too elaborate, but should include a) the question being asked and b) the procedures the student will use. This gives you the opportunity to discuss how investigable the student's question is and the feasibility of the procedures. For older students, the proposal could also include specific data-taking techniques and a sample data table to be filled in.

• If you prefer more specific activities, offer your students the choice of one or several of the exercises described after the initial body plan observations (Exercise 1 referenced above).

3) In the spirit of inquiry, allow students the opportunity to develop questions of their own about the animals they are observing and their behavior. Talk with students about setting up investigations that test *only one variable*. For example, if they are investigating dry versus moist, they need to make sure that factors like light and temperature are kept constant. It is rather easy to overlook these other factors, setting up the experimental system with one end pointing toward a window or a radiator. Give students the freedom to repeat an investigation and determine for themselves what needs to be controlled. Remember that the students are asking questions and making observations. Since they will be reporting on those observations, they *cannot* be wrong. What they see *is* what they see. However, they may see what they *want* to see rather than what they *actually* see. That can be a great source of individual or classroom discussion.

4) The observation techniques described in all of the following activities are general in nature and will have to be modified according to the particular animals being studied. Flexibility and creativity are important attributes for all keen observers. In general, don't let the animals get too hot or too cold, too wet or too dry. Handle them gently and for short periods of time. Give them a "rest," and then handle them some more.

See www.shapeoflife.org for links to additional animal investigations.

Arthropod Investigations

Science Background

The segmentation and flow-through gut of the annelids opened the evolutionary door for an incredibly diverse group of organisms called arthropods. The term arthropod comes from the Greek *arthron* meaning "joint"(as in arthritis) and *podos* meaning "foot" (as in tripod). These organisms (crustaceans, like crabs and lobsters, spiders, insects, and a host of others) all have a hard outer covering called an *exoskeleton* made of *chitin* (5/11:50) with protein and sometimes minerals or wax. This exoskeleton provides protection from predators and the rigors of the physical environment (heat, cold, dryness, exposure to ultraviolet light, etc.) and a support structure for the attachment of the muscle system. But in order for this exoskeleton to move, it must have lots of flexible joints. And so it does. In the investigations outlined below, students will look at many examples of this *jointedness*.

During the evolution of arthropods, jointed appendages that sprouted from segments all along their bodies were modified for many new uses. There are good old legs for walking, but there are also: mouth parts for manipulating food, antennae for sensing the environment, claws for grasping, and perhaps most wonderful of all, wings for flying (5/14:00 and 5/20:30). Arthropods evolved a set of adaptations that made it possible for them to leave the marine environment and invade dry land and ultimately even get up into the air. As a result, there are more different kinds of arthropods on Earth than all other organisms put together!

Materials and Preparation

In the investigations below, students make close observations of a particular arthropod. A list of some good classroom candidates include:

Insects

- Milkweed bugs, *Oncopeltus faciatus*, can be purchased from most reputable biological supply houses. They can be purchased in various life cycle stages or as a culture kit. They are harmless, rather nice-looking, and they won't fly away.
- Mealworms (the larvae of *Tenebrio* beetles) are another possibility. Their segments are clearly seen and could be compared to the segments of annelids. Of course, they can also be used as food for other organisms. They can be purchased from pet stores and bait shops as well as biological supply houses.

Crustaceans

- Hermit crabs, fiddler crabs, crayfish, or pill bugs (sow bugs, roly-polys, 5/26:30) can be purchased or can be rather easily collected, depending upon where you live.
- Dead crabs, shrimp, and lobsters can be purchased in grocery stores.

Arachnids

- Spiders, scorpions, ticks, and mites are not so good for classroom investigations because they tend to bite or sting.
- A display tarantula is a possibility.

Millipedes and centipedes

- Millipedes are harmless vegetarians (detritus feeders), but a bit expensive. In some habitats, they occur in very large numbers at certain times of year. If you have an outbreak of millipedes, take advantage and bring some into class.

- Centipedes, like most arachnids, are not so good for classroom use. They are fast-moving carnivores (insectivores), and they may bite.

You will need various containers, tools, and other implements to house these critters and to manipulate them a bit. Exactly which containers and tools will depend on which critters you chose. Following is a general list that might be helpful. If you buy organisms from a biological supply company, the company may also suggest and sell appropriate equipment.

- aquarium/terrarium with cover to prevent escape
- water
- shoebox or shoebox lid or clear plastic box and lid
- vinegar
- hand lenses
- pencil
- straws (for gusts of "wind")
- paper towels
- otton swabs
- science notebook
- ruler

Procedures

The following exercises are designed to be read aloud to your students. Answer guidelines are provided in brackets. *The Shape of Life* video references are noted as (episode number/minute: second).

Exercise I

What is the body plan and structure of your organism?

1) Put your critter in a convenient container so that it is easy to watch but so that it cannot escape. A shoebox lid may be just the thing. Carefully look at its body plan and structure. Draw and label the organism in your science notebook. The following questions may help you decide what to put in your notebook:

a) Dogs and cats have heads and tails and legs attached to their central bodies. Does your organism have similar structures?

[Insect bodies have three major divisions, tagmata, which are groups of segments: head, thorax, and abdomen. Crustaceans are similar, though in some cases the head and thorax are fused together into a cephalothorax. Arachnids have a cephalothorax and an abdomen.]

b) What do you see at the front end? Is there a head? Are there eyes? A nose? A mouth? Ears? Are there other sensory organs? Are there other appendages on the head?

c) If you looked at earthworms, you may remember seeing lots of body segments. Does your critter have body segments? If so, do all the segments look the same?

[The segments in centipedes and millipedes look a lot like those in earthworms. The segmentation in other arthropods is not always so obvious, though the segments can often be seen on their abdomens.]

d) How about legs? Count them. Watch them. Listen to them as your critter walks about. Feel them as your critter walks on your hand (if it is safe to do this). What do the legs look like? Can you describe how the legs move with respect to one another? How many legs do mammals have? Is this true for *all* mammals?

[The word *arthropod* means "jointed foot," or more loosely translated, "jointed leg." All of these critters have appendages with lots of joints. Insects have three pairs of legs (six all together). Arachnids have four pairs (eight all together). Crustaceans are variable, and it depends on what you call a leg. For example, there are walking legs and there are claws. Centipedes do not have 100 legs, and millipedes do not have a thousand. But the former do have *one pair* of legs per body segment, while the latter have *two pairs* of legs per body segment. The overall effect is that they sure do have lots of legs! Mammals all have four legs, though we sometimes refer to the front ones as *arms*. In the case of bats, the front ones are called *wings*!]

e) Crab legs (or even whole crabs) may be available at your local grocery store. Since arthropods have hard exoskeletons, their joint movements are constrained in ways that are different from those of mammals like humans. Examine a whole leg, noting in particular the amount and angles of bending of the various joints. Now examine your own leg. Here are some questions that might guide you in writing descriptions in your science notebook:

i) How many joints are there in a crab leg?

ii) How many joints are there in a human leg?

iii) How are the joints in your leg different from the joints in your fingers?

iv) What sort of freedom of movement do you have with your leg? (Think of the agility of a soccer player.)

v) Can the crab get its legs into the same positions?

vi) Consider the “arthropod robots” you saw in “The Conquerors” about arthropods (5/43:00).

f) How about wings (5/37:15)? If your organism has them, where are they? How many?

[The only arthropods with wings are insects. They usually have *two pairs* of wings attached to their thoraxes. But the pairs are not always obvious. For example, in beetles, one pair of wings (the *elytra*) is hard and covers the second pair of wings that are used for flight. Flies have one pair of flight wings and a second pair, called *halteres*, that are used as stabilizers.]

Bats are mammals that have wings. How many legs do bats have? Given your real life experiences in seeing mammals, do you think that a winged horse (the Pegasus of Greek mythology) could have evolved?

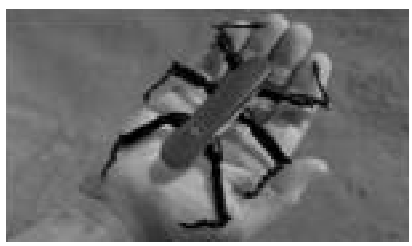
[Since all mammals have evolved from a *tetrapod* (four-footed) ancestor (8/19:20), it seems that for a horse to evolve with wings it could then only have hind legs, like a bat.]

g) Crayfish, crabs, shrimps, and lobsters live in water and have gills for breathing. If you have specimens of these critters, look for the gills as branches near the tops of their walking legs.

[Aquatic larvae of dragonflies also breathe with gills located in their rectums.]

h) How about claws, pincers, or stingers? Where are they? Are they the same size? Think about what they might be used for.

i) From your observations, you can see that arthropods have many more *appendages* than mammals. (See Swiss Army knife analogy, 5/20:30.) In fact, all those antennae, mouth parts, claws, and wings are really just modified legs! Do you think that’s true for your nose, eyes, ears, jaws, and so forth?



2) In addition to your drawings, write a few sentences in your notebook describing what you have seen, heard, and felt—your general impressions. This information may be useful for answering some questions later on.

Exercise 2

Does your arthropod move toward dry or moist conditions?

1) Set up a shoebox lid with moist paper towels on one side and dry paper towels on the other side. Place several organisms in the middle of the box. At five-minute intervals, draw a map showing where each one is. Repeat these observations for one half-hour.

2) In your notebook, write a few sentences describing what you saw and what you think it means.

3) Are you sure that differences in moisture account for the organisms’ behavior? Write a few sentences to show how you could repeat the investigation to validate your conclusion.

[Students may inadvertently be exposing their organisms to factors other than moisture—e.g., bright light or heat or even the students themselves, moving around and making noise. They could repeat this experiment by reversing the wet and dry paper towels and seeing if the organisms go the other way.]

What characteristics do animals share?
All animals must eat to survive. They are comprised of multiple cells differentiated in shape and function and possessing nuclei. (Hence, all single-celled organisms like ameba or paramecium are *not* animals.) All animals can reproduce sexually with sperm and egg; some can also reproduce asexually. After the egg is fertilized, it divides into cells and tissues, undergoing a process known as embryogenesis. Lastly, *most* animals are capable of movement during some stage of their lives, using muscles and nerves to accomplish this feat.

Exercise 3

How long is your arthropod?

1) Measure the length of your organism in millimeters.

2) If you worked with earthworms previously, you may remember that measuring their lengths was not easy. Why is it easier to measure the length of an arthropod?

[Arthropods have *rigid exoskeletons* while worms are flexible bags whose body fluid forms the skeleton—a *hydroskeleton* as opposed to an *exoskeleton.*]

3) When you are done, compare your results with those of another student group. Did they use the same techniques? If not, whose techniques seem to work better?

Exercise 4

How do arthropods respond to touch?

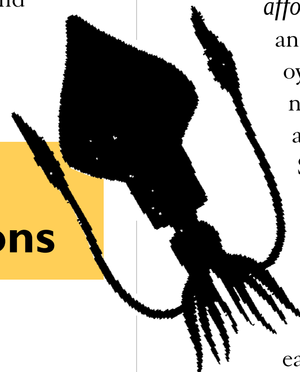
1) *Gently* touch your critter with the tip of your pencil. Use a straw to blow on your arthropod.

2) In your science notebook, record its reaction to each stimulus. Are all body parts equally sensitive? Write a few sentences describing any differences you see.

Wrap-up

The investigations above should help students explore the basic arthropod body plan and some of the behavior patterns these organisms exhibit. The possibilities for further explorations of the enormous diversity of arthropods are endless. Their segmentation, jointed appendages, and exoskeletons have allowed for an incredible evolutionary radiation. Though we, as humans, tend to think of ourselves as holding some exalted place in the hierarchy of animals, the arthropods have evolved into species that can inhabit the hottest, the coldest, the wettest, the driest, the highest and the lowest places on the surface of the Earth. Though no one species may dominate, as a whole, arthropods surely do win the numbers and diversity game.

Mollusc Investigations



Science Background

Molluscs have evolved with a remarkable diversity of different body plans. At first glance, it is difficult to see how clams and octopuses can be classified into the same phylum. However, they do share certain physical characteristics (6/6:30). All molluscs have a muscular *foot* generally used for locomotion. They all have a *radula*, a mouth-part generally used in feeding. And all molluscs have a layer of tissue called the *mantle* that usually secretes the shell. The wonderful thing about molluscs, however, is that these structures vary so widely throughout the phylum. The foot, for example, is used for gliding locomotion in snails and digging in clams, but has evolved into a jet-propulsion organ in squids and octopuses. The mantle produces the spiral shells of snails, the double shells of clams, the chambered shells of nautiloids, and the internal 'pens' of squids.

Most molluscs show characteristics similar to the other phyla explored in earlier episodes of *The Shape of Life*. For example, they have a front end with a head (except in bivalves, such as clams). They have a flow-through gut with a mouth and an anus. The exercises outlined below start with an exploration of the mollusc body plan, using snails as a convenient organism. This exploration is followed by several investigations looking at various aspects of molluscan structure and behavior.

Materials and Preparation

Probably the most interesting, *affordable* molluscs are snails and slugs. Bivalves (clams, oysters, mussels) simply will not do anything exciting in a classroom situation. Squids and octopuses are truly fascinating creatures, but are expensive and difficult to maintain. For most classrooms, snails and slugs are the easiest to get and maintain. Both snails and slugs are readily available from biological supply companies. They can also often be found in gardens and yards or under logs in most any woodland in warm weather. We suggest using terrestrial (land) snails since they are relatively active and easy to maintain in a terrarium. You can set up a simple terrarium using an empty aquarium with a lid, a water source, and lots of lettuce. Rotting sticks and leaves add a nice touch. Pond snails can be kept in an aquarium with water, and as everyone who keeps aquarium fish knows, the snails can reproduce rapidly.

You should supply several snails for each group of students. They will need one good-sized snail for close observation and several others for more general observations. This exercise is written for snails, so if you use slugs, simply make the appropriate changes. Materials for each group should include:

- snail, 1 large for close observation clear plastic cups
- snails, several (various sizes if possible)
- shoebox lid
- hand lenses
- cardboard
- cotton swabs
- straws (for gusts of "wind")
- ruler
- string
- tape
- vinegar
- paper clips
- paper towels
- markers
- science notebook

Procedures

The following exercises are designed to be read aloud to your students. Answer guidelines are provided in brackets. *The Shape of Life* video references are noted as (episode number/minute: second).

Exercise I

What is the body plan and structure of a snail?

1) Put a snail in a clear plastic cup and observe its body plan and structure. Draw and label the snail in your science notebook. The following questions may help you decide what to put in your notebook:

a) Can you tell which end is the front?

[Snails have fleshy, antenna-like structures on their front ends.]

b) The snail's shell has a spiral structure. How many turns of the spiral does your snail have? Compare several snails of different sizes.

c) Humans have a face with eyes, ears, a nose, and a mouth. Do snails have any of these structures?

2) Closely observe the foot of your snail as it moves over the surface of the plastic cup. Observe it from underneath the snail, but also try to get a side view. What do you see? Draw a sketch in your science notebook and also describe in a few sentences what you have seen.

3) Can you see the tracks of your snail? If so, describe your evidence in your notebook.

[Since snails secrete a film of mucus as they move, students should see this "slime trail" as evidence of where the snail has been.]

Exercise 2

Do snails move toward moist or dry conditions?

1) Set up a shoebox lid with moist paper towels on one side and dry paper towels on the other side. Place several snails in the middle of the box. At five-minute intervals, draw a map showing where each snail is. Repeat these observations for one-half hour.

2) In your notebook, write a few sentences describing what you saw and what you think it means.

3) Are you sure that differences in moisture account for the snails' behavior? Write a few sentences to show how you could repeat the investigation to validate your conclusion.

[Students may inadvertently be exposing their snails to factors other than moisture—e.g., bright light or heat or even the students themselves, moving around and making noise. They could repeat this experiment by reversing the wet and dry paper towels and seeing if the snails go the other way.]

Exercise 3

How do snails respond to touch?

1) *Gently* touch the snail in various places (including the shell) with the tip of your pencil.

2) How about wind? Use a straw to blow gently on your snail and record its response.

3) In your science notebook, record its reaction to each touch. Are all body parts equally sensitive? Do the different parts respond with different or similar reactions? Write a few sentences describing any differences you see.

Exercise 4

Can snails smell?

Smell and taste are defined differently. In *smell*, the chemicals that are being sensed must pass from the source to the sensor through some medium—usually air or water. In *taste*, the chemicals must come in direct contact with the sense organ. In this exercise, we suggest testing smell by holding vinegar *close to*, but *not touching* the snail. Vinegar might well damage the snail if applied directly.

1) Place a snail on a moist paper towel. Dip a cotton swab into vinegar. Hold the tip of the swab *close* to the snail's front end, but *do not touch* it. If the vinegar touches the snail, you may be testing a different sense (taste, or perhaps even pain). Record how the snail responds to the vinegar.

2) Do all parts of the snail's body have the same response? Record your data in your science notebook.

3) Do snails have a nose? What is a nose anyway? What do you use your nose for? If you were a snail, would a nose (an appendage with nostrils) help or hinder you?

4) Do snails breathe? If so, where is the air intake? If not, how do they get oxygen to their muscles? Or can they live without oxygen?

[Snails "breathe" through their skin. This is one reason land snails maintain a moist layer of mucus covering their bodies. (Frogs also breathe through their moist skin.) This makes it possible for them to exchange oxygen and carbon dioxide with the surrounding air more readily.]

[Slugs and snails have very functional lungs. In slugs, these lungs can be seen through their opening to the outside world called the *pneumostome*— the big gaping hole on their "saddles" on their right sides. The pneumostome is harder to see in snails. Blowing carbon dioxide (CO_2) simply by exhaling through a straw into the pneumostome will make the slug/snail need more oxygen (O_2), causing it to open the hole wider.]

Exercise 5

How much weight can a snail pull?

1) Attach a piece of tape like a sled to the backside of the snail's shell. How many paper clips can your snail pull?

2) Compare your results with your classmates' results. What can you conclude from these data? Are you sure the snail reached its limit? Or might it have stopped pulling for some other reason? What might that reason be? Write your conclusions in your science notebook.

Wrap-up

Snails are slow and relatively easy to work with, making them a useful organism for classroom work. But they are only one example of the twists and turns the molluscan body plan has taken during its evolution. For example, snails and clams use shells for protection, while squids use speed and octopuses use their remarkable intelligence. Thus, they are a wonderful group of organisms to study for exploring the "arms race" (6/4:30) between predator and prey. Molluscs are also interesting in the puzzle they

Electron micrograph of gastropod radula

provide for taxonomists. They show some of the characteristics seen in other phyla explored in *The Shape of Life* series—a front and back end, a head, muscles and nerves, and a circulatory system. On the other hand, they have their own peculiar adaptations—a foot, a radula, and a mantle. They are, in fact, a good example of why the evolutionary *tree* might better be described as an evolutionary *bush*! (See illustration on page 18).

Recommended Reading for Grades 3-7

Annelid Investigations

McLaughlin, Molly. *Earthworms, Dirt and Rotten Leaves*, Atheneum, 1986.
Ross, Michael Elsohn. *Wormology*, Carolrhoda Books, 1996.

Arthropod Investigations

Ross, Michael Elsohn. *Caterpillarology*, Carolrhoda Books, 1997.
Ross, Michael Elsohn. *Ladybugology*, Carolrhoda Books, 1997.
Ross, Michael Elsohn. *Rolypolyology*, Carolrhoda Books, 1996.
Ross, Michael Elsohn. *Spiderology*, Carolrhoda Books, 2000.

Mollusc Investigations

Ross, Michael Elsohn. *Snailology*, Carolrhoda Books, 1996.

Chordate Investigations

Johnson, Jinny. *Skeleton: An Inside Look At Animals*, Reader's Digest Kids, 1994.