$2.50 ISSUE #3 WINTER 1997

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Big Picture Science

The Science Newsletter for Montessori Teachers of 6-15 yr-olds #3 Winter 1997

The Simplest Animals

They have lessons that apply to the whole kingdom

Students are most familiar with vertebrate animals. They need experiences with the beginning phyla of the Animal Kingdom. This can help them see what all animals have in common and learn more about what makes up an animal's body.

The phyla of the Animal Kingdom are defined on the internal structure of the organisms. This is sometimes called the body plan of the animal. The body plan we know the best is the mammalian one – internal skeleton, four-chambered heart, brain, spinal chord, etc. Students sometimes don't think about the features that we have and the simplest animals lack. It is even harder to see features we have in common with a sponge or jellyfish.

The sponges, Phylum Porifera, are so simple that they barely make it into the animal kingdom. They are composed of loosely joined cells and an internal framework. This framework can be spicules of glass (silica) or calcium-containing minerals or it can be a protein network -- the spongin skeleton of the bath sponge, for example. Students will benefit from observing a bath sponge skeleton and a preserved sponge with the cells still present. They illustrate a basic principle of animal body construction -- **animal bodies consist of cells AND the connecting substances made by those cells**. The components of these connecting substances are manufactured inside cells and shipped outside for assembly. The connective framework supports the cells and helps hold them together. We often say that animals are made of cells and forget to add the connecting substances.

In our own bodies, there are connecting materials in all the blood vessels and organs. Connective tissue has sparse cells and lots of extracellular materials. Tendons, which bind muscle to bone, are connective tissue, as is the bone itself.

Sponges share features of development with the rest of the kingdom. **In animals, the fertilized egg divides and forms a hollow ball of cells.** In more complex phyla this ball, the blastula, continues to develop. It folds inward to produce all the layers of the mature animal's body. In sponges the blastula grows flagella on about half the cells. It is now a simple larva (immature form that looks different than the adult). With no further development, it leaves the parent animal, swims away, and settles down in a new spot. The larva attaches to a surface and turns inside out, leaving the flagellated cells inside and (Continued on page 2)

The Big Picture on animals

If it has been a while since you have studied the animal kingdom, you may want to review with the references on page 5 before you read this issue. I'm diving right in to some general concepts illustrated by phyla and leaving you to go back and study what these phyla do if you need this.

There will soon be a new animal kingdom chart with phylum descriptions and matching cards that picture the animals and have interest-grabbing text on each. It is being published by InPrint for Children, 2270 Mt. Carmel Ave., Glenside PA 19038. I have helped with this material and think you will find it attractive and useful.

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[Yes, it's back to denver.net]

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The Simplest Animals (cont. from page 1)

the plain cells as an outside covering. Many other animals have a **change of form or metamorphosis from larva to adult** in their life cycles. The adult is defined as the form that can reproduce. Other terms for young animals include juvenile (form that resembles the adult, but can't reproduce) and nymph (used for immature insects that undergo incomplete metamorphosis).

The Phylum Cnidaria, the jellyfishes, sea anemones, and hydras. The cnidarians are radially symmetrical, a body form that works well in water. They show another important principle of animals and even other kingdoms. The shape of the organism tells you something about where and how it lives. We state this idea as **"form follows function"**.

"Form follows function" holds at the cellular level. Cnidarians have a type of cell that looks totally different from their other cells and does a special job. This is the stinging cell or cnidocyte that gives the phylum its name. (Sponges have specialized cells as well. For example their collar cells have flagella and pull water into their bodies. However, the metazoan animals have more types of specialized cells and they have tissues, as well.) Cnidocytes, also called thread capsules, have a coiled thread inside, the nematocyst. When another animal contacts them, they can shoot out the thread to sting a would-be predator or capture and paralyze their own prey. They also use cnidocytes to stick to surfaces and move. When you touch a sea anemone, it is the cnidocytes that give the tentacles that sticky feel.

Cnidarians have tissues, collections of cells that look similar and work together to do a specialized job. **Tissues give animals new, advanced abilities**. Instead of digesting tiny food particles within single cells as the sponges do, cnidarians have cells that line their hollow gut cavity and expel digestive enzymes into it. This enables cnidarians to eat much larger pieces of food than a sponge or unicellular organism can.

The Phylum Ctenophora, the comb jellies. Convergent evolution happens because form follows function. **Convergent evolution produces organisms that live in the same habitat and have similar bodies, but are not related.** Examples are tuna and dolphins, and cacti and desert plants of Africa. Convergent evolution has been at work with the comb jellies and the jellyfish. They look alike, but are not closely related. Ctenophores do not have stinging cells (thread capsules). Many ctenophores use a different kind of cell to capture their food, the collocyte or adhesive cell. This cell is located on the branched tentacles, which the comb jelly can extend to twenty times its own length and retract to wipe food into its mouth. Other ctenophores scoop up food with lobes on the front of their bodies. Comb jellies use comb plates (ctenes) to move, instead of contracting their bodies like jellyfish do. Comb plates are iridescent bands of cilia; each animal has eight.

The flatworms, Phylum Platyhelminthes, have a very different form than the cnidarians, since they have something of a head and are bilaterally symmetrical. How is their function different? They are adapted to a different habitat. Instead of floating freely in the water, flatworms crawl through the mud and on surfaces. A long, thin body works much better than a rounded one for this habitat. In fact the mud at the bottom of bodies of water is a rich source of food that is used by many animals. The mineral part of mud has few nutrients, but it holds the dead bodies of organisms that once lived above it, as well as bacteria and protists.

Many animals crawl through a semisolid substance to find their food. There are about 18 different phyla of worm-like animals. People often have a negative reaction to worms. Try to minimize the "yuck" factor and have your students see this body form as an adaptation for moving directionally and traveling on surfaces and through semi-solids.

When you teach about animals, **it is important not to group all the worms together**. They may look basically alike, but their internal structures are quite different. How many worm phyla should you teach? Three are plenty for elementary levels: flatworms, roundworms, and segmented worms. If you encounter others in the course of fieldwork or research, feel free to discuss them, but there is no need to burden students with all the varieties of worms. Examples you might need to explore are the tubeworms at deep-sea volcanic vents (phylum Pogonophora), ribbon worms (phylum Nemertea), or horsehair worms (phylum Nematomorpha).

Flatworms have no circulatory system, so their bodies must be thin to allow the diffusion of oxygen in and wastes out. Their mouths are on their bottom surface, not on their heads. They have crude eyespots on that enable them to tell light from dark, but their vision serves to help them avoid predators, not locate food. They find their food by smell, as do most invertebrate animals that aren't filter feeders. (The octopus, a predator with acute vision, is one exception.)

Flatworms are the first phyla to exploit a widely used food source, the bodies of other living organisms. Parasitic flatworms include the flukes (trematodes) and the tapeworms. However repulsive we may find them, **parasites are widespread in the living world**. There are more species of parasites than of free-living organisms. In the oceans, nutrients are carried and distributed by the water. Terrestrial life does more handing nutrients (Continued on page 3)

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from organism to organism. Parasites exist in both environments, but they are more common on land. This may sound like a counterproductive system, but a good parasite does not kill or overly damage its host.

Parasites were once free-living organisms, but they have adapted to live in or on a host organism. Body parts the parasite did not need were eventually lost; tapeworms have no mouths or digestive systems. The host does all the eating and digesting; the tapeworm simply absorbs the nutrients directly from the host's intestine. It has an outer covering that resists being digested yet allows it to soak up digested food.

It is hard for us to remember that in much of the world there is a lower level of sanitation, and humans are likely to have parasitic infections. Over 200 million people suffer from schistosomiasis, caused by a flatworm, the blood fluke, *Schistosoma mansoni*. The hookworm (a roundworm) is more widespread in humans than the common cold.

The Phylum Nematoda, the roundworms. These worms have a digestive tract that runs from the mouth, located on the head, to the anus at the end of the tail. This complete digestive tract is found in all the more complex phyla. The roundworm body plan has been called "a tube within a tube", which illustrates it well. The inside tube, the gut, does not move independently from the outside body. Food is propelled by more food and by the movements of the whole organism. There is no circulatory or respiratory system. There are needed only in larger animals whose bodies are too thick for diffusion to do the work.

There are 15,000 species of roundworms, all very similar in external appearance. Although a few of the parasites are over a foot long, most measure about 1 mm. These thread-like worms are very common in sediments and soils of all climates. Most species are free-living, but there are roundworm parasites of a wide range of animals and plants. They are key players in nutrient cycling in the soil and some are used to control agricultural pests. One cannot say they are "good" or "bad", only that they make up many threads in the tapestry of life.

Nematodes and humans are extreme opposites in **reproductive strategy**. We have few offspring and invest a lot of time and resources in each one. Nematodes produce astonishing quantities of eggs and never interact with their offspring; a female *Ascaris* can lay up to 200,000 eggs a day.

You might think that nematodes have little in common with more complicated phyla, but one, *Caenorhabditis elegans*, is used to study basic events in animal development and how genes control them.

The Phylum Rotifera, the rotifers. These little "wheel bearers" are easy to find in any pond or soil. We study them because of their widespread role in nature, not just because they are such fun to watch under the microscope. Rotifers have a survival strategy that is employed by many animals and other organisms. The environment has periodic changes that would be lethal to them, so they **survive in a resting state**. For rotifers the environmental problem is drying and they solve it by forming a cyst that can survive for years until water returns.

When you watch rotifers under the microscope, remember the rhythmic pulses their bodies are caused by their jaws, not their heart, because they don't have a heart. They are too tiny to need one.

Bringing simple animals to class

1. Locate and observe the animal in its environment. (This may be difficult to do for microscopic animals.)

- This is important to help children remember that **ANIMALS DO NOT EXIST INDEPENDENT OF THEIR ENVIRONMENTS.**
- You can culture nematodes, vinegar eels (roundworms) and rotifers quite easily. See Q and A section, p. 6.
- Bring the animal into the classroom and provide a temporary environment for it. If possible, release it to its natural habitat when you are finished observing and studying it. Students will need to learn about the animal's needs to provide a good temporary habitat. For help, see Seymour Simon's *Pets in a Jar*, ISBN 0-14-049186-4.

2. Collect photographs and drawings of the animal. Watch videos of the animal in its environment.

3. Study preserved specimens and prepared slides.

- These can be valuable and necessary, especially when you are far from an ocean, but try not to have students remember animal phyla as pickled "things" in jars.
- A prepared slide of a flatworm with its intestine stained with carbon is useful.

Biological supply companies

Carolina Science Supply (1-800-334-5551)
Ward's Biology (1-800-962-2660)
Blue Spruce Biological Supply [Rocky Mountain and adjacent areas] (303-688-3396 Denver area; 1-800-825-8522)

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Matter and Energy: The basic lesson of physical science

Just as we start life science study with lessons on living and non-living (biotic and abiotic) things, we can **start physical science with matter and energy**. These lessons begin in lower elementary and should be revisited in upper levels. The only equipment you need for the initial discussion is your normal classroom surroundings.

Start by asking how we could describe all the things we see around us. Help students get to the idea that there are matter and energy in the room. Ask if there is a difference between the table and the light hitting it or between the chairs and the sounds in the room. Help students make a list of the differences, and guide them to the idea that there are things that take up space and those that do not.

Here's what you should list for **matter**. It **takes up space**. It can be weighed (on Earth, at least). A more formal definition would include that matter has inertia, which means it takes energy to start it moving or to stop it if it is moving. Expressing it another way, this means **matter has mass**. When we weigh matter, we are measuring the pull of gravity on its mass. Discuss matter in space. Ask if satellites in space have weight or if it takes force to move them. Hopefully the students can picture that it still takes force to move weightless objects (it takes a push from a thruster to change the satellite's course).

Ask students if air is matter. Give them materials to investigate. Many experiment books describe activities with clear cups inverted into pans of water, for example. They may want to weigh air, which can be done with a sensitive balance and two balloons. Weigh them empty, inflate one, and weigh again. If you make your own balance for this, give it a long lever arm to detect the difference between a full and empty balloon. The children will probably note that there is air in an empty balloon, but point out that there is more in a full one. That's what pushes out the sides of the balloon.

Energy is a bit harder to define. Of course it does not take up space and cannot be weighted. The formal definition is that **energy is the ability to do work**. This means that **energy causes changes in matter**. Examples are melting ice, lifting a weight, and heating a dark object in the sun. Energy comes in many different forms and it changes from one form to another. Examples of the forms of energy are light, sound, motion, chemical energy, electrical energy, heat, magnetic energy, and atomic energy. Light is easy to see, but the other wavelengths of electromagnetic energy are not. Remind them that microwaves, ultraviolet light, X-rays, and radio waves are also forms of energy. They will know that ultraviolet light causes changes in their skin and microwaves (short wave radar) heat food. Let them know that when they move, they are using chemical energy from their food and changing it to mechanical energy, the energy of motion.

Some forms of energy exist independent of matter. Light and radio waves travel through space. Matter carries other forms. Sound travels only through matter, a fact usually ignored in space movie battles. Heat is the energy of moving atoms and molecules. Students may be surprised to learn that there is a bottom limit to cold, absolute zero, where all movement stops. It is sometimes a little hard to remember that the chair is matter, but it has heat energy as well.

After students are comfortable with matter and energy, they are ready for several other basic lessons: mixtures and pure substances (includes solutions), states of matter and changing between states, potential and kinetic energy, and studies of the various forms of energy (how heat is transferred, properties of sound, for example.) Upper elementary students are able to follow the transformations of energy and consider the chemical elements that make up pure substances. Middle schoolers are ready to study atoms and molecules and to learn techniques for separating mixtures.

Books to help with matter and energy lessons - (Dewey decimal 530-533.6)

Ardley, Neil. 1992. ***The Science Book of Energy***. ISBN 0-15-200611-7 [LE = lower elementary]

Cobb, Vicki. 1990. ***Why Can't You Unscramble an Egg? And other not such dumb questions about matter***. ISBN 0-525-67293-1 [LE, UE]

Freidhoffer, Robert. 1992. ***Matter and Energy (Book 1, Scientific Magic series)***. ISBN 0-531-11051-6 [LE, UE]

Melbane, Robert and Thomas R. Rybolt. 1995. ***Air & Other Gases***. ISBN 0-8050-2839-0 [Experiments, LE, UE]

Morgan, Sally and Adrian. 1993. ***Using Energy (Designs in Science).*** ISBN 0-8160-2984-9 [UE]

Murphy, Brian. 1991. ***Experiments with Air.*** ISBN 0-8225-2452-X [LE]

LEARNING MATERIAL: **Matter card set** from InPrint for Children, (215-885-2722, FAX 215-886-5161)

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Resources for teaching about simple animals

Books about the simplest animals are catalogued under 592-593 in the Dewey decimal system. Here are examples of valuable resources I found in my local library system or have in my own collection. LE = lower elementary, UE = upper elementary, MS = middle school. Most useful range is given; LE may need to have the book read to them.

Sponges – Phylum Porifera

Esbensen, Barbara J. 1993. ***Sponges are Skeletons***.(Let's Read and Find Out Science Book series) HarperCollins Publishers: New York. 32p. ISBN 0-06-021034-6 [A great introduction for LE, loaded with information. Color drawings.]

Cnidarians

Campbell, Eileen. 1992. ***A Guide to the World of the Jellyfish***. Monterey Bay Aquarium Foundation, 886 Cannery Row, Monterey, CA 93940-1085. 16p. ISBN 1-878244-08-6 [The beautiful illustrations would be a treasure by themselves. Combined with clear, informative text. LE-MS]

Stone, Lynn M. 1993. ***Jellyfish: Unusual Animals***. The Rouke Corporation: Vero Beach FL. 24p. ISBN 0-86593-284-0 [Good basics for LE. Glossary with pronunciations. Good photos.]

Rotifers – Rotifera

Walsh, John. 1979. Rotifers: Nature's Water Purifiers. In: National Geographic Magazine, Feb. 1979, pp. 287-292. [Good introduction, excellent photos.]

General invertebrates

Buchsbaum, Ralph, et al. 1987. ***Animals without Backbones.*** University of Chicago Press. 572p. ISBN 0-226-07874-4 [Useful drawings for all ages. Valuable reference for MS-adult. This is the third edition.]

Doris, Ellen. 1993. ***Invertebrate Zoology (Real Kids/Real Science Books).*** Thames and Hudson: New York. 64p. ISBN 0-500-19005-4 [Good sections on sponges and flatworms. Illustrated with photos, often of children experimenting. Extensive glossary. LE-MS]

Fleisher, Paul. 1996. ***Life Cycles of a Dozen Diverse Creatures.*** The Millbrook Press, Inc.: Brookfield, CN. 80p. ISBN 0-7613-0000-7 [A winner! Well-presented information, attractive, whole-Earth perspective. Includes blood fluke, sea nettle (jellyfish), daphnia, earthworm and oyster. LE- MS]

Landau, Elaine. 1991. ***Interesting Invertebrates.*** Franklin Watts: New York. 63p. ISBN 0-531-20036-1 [For LE. Good photos. Groups worms all together, but good information on several phyla.]

Loewer, Peter. 1990. ***The Inside-Out Stomach: An Introduction to Animals without Backbones.*** Atheneum, Macmillan Publishing Co.: New York .. 57p. ISBN 0-689-31432-9 [Good sections on sponges, cnidarians, flatworms, roundworms. Ignore the pronunciations. Includes protozoa. LE-UE]

Silverstein, Alvin, Virginia, and Robert. 1996. ***Invertebrates (Kingdoms of Life Series)***. Twenty-first Century Books: New York. 64p. ISBN 0-8050-3518-4 [One of an excellent series on the Five Kingdoms. Has a Latin and Greek root listing to help translate scientific terms. LE-UE]

Stidworthy, John. 1990. ***Simple Animals (The Encyclopedia of the Animal World).*** Facts On File, Inc.: New York. 96p. ISBN 0-8160-1968-1 [For UE-MS, reference for LE with help. Lots of information. Photos and drawing illustrate it well. Includes protozoa.]

Pronunciation guide -- Note: Greek roots in italics, English meanings in quotes

blastula	BLAS-tuh-la [*blast*- "bud, sprout"]	Nematoda	NEEM-a-**TOAD**-ah [*nema*- "thread"]
Cnidaria	nye-DARE-ee-ah [*cnido*- "nettle"]	nematode	NEEM-a-toad
cnidarian	nye-DARE-ee-an	Platyhelminthes	PLAT-ee-hell-**MIN**-thez ["flat worm"]
cnidocyte	NYE-doe-SITE [*–cyte* "cell"]	Porifera	poor-IF-er-ah ["pore-bearers"]
collocyte	COLL-oh-SITE [*coll*- "glue"]	Rotifera	row-TIFF-er-ah ["wheel-bearers"]
ctene	TEEN [*cten*- "comb"]	rotifer	ROW-te-fer
Ctenophora	ten-OFF-for-ah [*phor*- "bearer"]	schistosomiasis	SHIS-tuh-so-**MY**-ah-siss
ctenophore	TEN-oh-fore	spongin	SPONGE-in
		trematodes	TREM-ah-toads

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Forum –Readers' input and addition information

Q: How can I show my students cnidarians?

A: Unless you live near the coast, your best choice is to gather or order some hydras. To gather hydras, collect a jar of pond water and some of the twigs and algae or water plants from the shallows. Allow an hour or so for the hydras to "unfold". They look like tiny pieces of frayed thread and are often white. Hydras live in cool water, less than 68° F. Our mountain ponds have hydra in summer only, so in winter we are back to ordering them. Remember to order water fleas, *Daphnia*, to feed the hydras. Students will enjoy watching the feeding process under the dissecting microscope.

Q: How can I get flatworms?

A: It is possible to collect flatworms from ponds and streams. Place a piece of liver or raw meat on the sediment and retrieve it after an hour or so. The flatworms will be small, about ¼ inch. If this option is not available (or if liver and ponds are not on your agenda), they can be ordered from a biological supply. Flatworms do not need frequent feeding. In nature they go months with little or no food.

Q: Are rotifers easy to find?

A: Rotifers are so common that if you have time to look, you are sure to find them. I found a thriving culture in a container that was used to root plant cuttings. Algae had grown and there were several kinds of rotifers feeding on it. Try some soil and water cultures – place a ¼ inch of soil in a jar, add a grain of white rice and non-chlorinated water to a depth of about 2 inches. Use a wide mouthed jar for good oxygen exchange. Place the jar where it will get bright light but stay cool. It may take a couple of weeks for this mini-ecosystem to get going. If you want something sooner, look for rotifers in pond sediments and around water plants. Try collecting some sediment from a gutter or other place that is periodically wet. Clumps of moss may also harbor them. Turn the moss upside down on a slide and wash it out into a drop of chlorine-free water. (You may get tardigrades [water bears], as well. They are another phylum, Tardigrada.) A number of rotifers are available commercially.

Q: Which roundworms are useful for class study?

A: One of the easiest to keep is the vinegar eel, *Turbatrix aceti*. This is a species that van Leeuwenhoek observed. It lives in the sediment of vinegar, but is removed by filtering and pasteurization. It provides a good look at the basic form of roundworms and their thrashing motion. One way to get soil nematodes is to set up a Berlese funnel. See Ellen Doris' *Woods, Ponds, and Fields* [ISBN 0-500-19006-2]. Once my students cultured a thriving colony of roundworms inadvertently. We had set up cultures for molds in petri dishes. We lined the bottom with paper towel and placed samples of food inside. The students were supposed to dampen the paper towel, but added enough water to make the bread samples quite moist. The bread cubes touched the lid of the petri dish. A week later, in dishes containing both a mushroom stem and bread, there was a swarm of nematodes eating the bacteria around the bread. They were easy to view through the lid of the petri dishes.

Q: What are some good Internet sites for these animals?

A: A good place to start is the Life on Earth site: [www.ucmp.berkeley.edu/phyla/phyla.html]. Select "systematics" and look for the links at the bottom of the page. Keep navigating into the site for more specific information and links for each group.

Q: What does Big Picture Science have for sale?

A: I'm so glad you asked! See below.

- ❐ Subscription for issues #2-5, $10.00
- ❐ Single copies of issues #2-3, each is $2.50 + $1.00 shipping. #2 – Microscopes and magnifiers
- ❐ Five Kingdoms poster and booklet. $3.00 each + $3.00 shipping for up to 5 posters.
- ❐ Characteristics of the Five Kingdoms, a summary table for teacher review and middle school use. $5.00 + $1.00 shipping.
- ❐ Model of an Adenovirus. Scale is 1:1,000,000. Includes an icosahedron pattern to copy and separate instructions for upper elementary and middle school. You add yarn for the DNA and pins for the fibers. $5.00 + $1.00 shipping.

To order, send a list of what you want, your address, and your payment to: Big Picture Science, PO Box 717, Conifer CO 80433. Colorado residents, please add 4.3% state sales tax.

Where are your questions? *Are you in need of a material that is not available? Don't forget to write to the above address or e-mail pspears@denver.net. Thanks!*