Phylum Lab

Pre- and Post- Visit Activities
Grades 9-12

NATIONAL AQUARIUM IN BALTIMORE®

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Phylum Lab

An hour and a half long classroom program for Grades 9-12 at The National Aquarium in Baltimore

Program Description

Even though there are as many as 35 phyla represented in the animal kingdom, students will discover that 98 percent of all animals fall into eight main phyla. Once students enter the lab, they will be surrounded by a variety of live animals, pictures and artifacts. At their own pace, students will use a phylum characteristic key, which they have created, to determine which eight phyla are represented at the eight tables. Students will have the opportunity to use their sense of sight and touch to learn about and interact with live animals. They will be challenged by the diversity and unique characteristics that are prevalent amongst and within the eight phyla.

Planning for the Program

This Phylum Lab program complements a unit on the animal kingdom. This lesson includes a pre and post visit activity that will supplement the classroom program.

Pre-Visit Activity

Before your visit to the Aquarium, have your students complete Activity 1 - Creating a Phylum Key. Students create a key, which they will use to identify the eight phyla. They will use this key during the lab program.

Day of Visit

At the Aquarium attend the Phylum Lab program in a classroom lab. Have the students bring the Phylum key worksheet with them on the day of the visit. We will provide worksheets, clipboards and pencils. If possible, have students divided into 4-6 small groups, depending on class size. To enhance the program after leaving the lab, students can search for animals throughout the Aquarium and attempt to categorize them into their appropriate phylum.

Post-Visit Activity

As a follow-up to your visit, have students complete Activity 2 - Schoolyard Phyla. This conservation activity will intrigue students and ignite their passion to protect wildlife. Additionally, follow-up research will expand their knowledge of the animal kingdom.

MD Science Content Standards

Skills and Processes

1.12.11 Critical Thinking
Construct various classification systems and infer degree of divergence and/or kinship of various objects, materials, concepts, actions, and organisms.

3.0 Life Sciences

Students will use scientific skills and processes to explain the dynamic nature of living things, their interactions, and the results from the interactions that occur over time.

Teacher Background

The diversity of animal life on Earth is astounding. Each animal has a unique body plan which allows it to survive and adapt to its given surroundings. With such an abundance of species, classifying animals into different categories is necessary. At first the diversity of animals can be overwhelming but after further research and observation, many likenesses appear. These similarities become the basis for taxonomists, the biologists who specialize in classifying animals, to organize and bring order to the animal kingdom.

Animals are classified into categories called taxa (singular-taxon) and are sorted according to their phylogeny (evolutionary history), body plan and similarity of characteristics. There are seven principle levels that organisms can be placed into: Kingdom, Phylum, Class, Order, Family, Genus, Species. All animals are in the Kingdom Animalia. As you move from species to kingdom the animals that are grouped together share fewer and fewer characteristics at each succeeding level.

The next level after Kingdom is Phylum, which is the main focus of the program. Even though there are approximately thirty-five phyla within the animal kingdom, 98 percent of all animals are classified into eight of them. To get even more specific seven of the eight phyla are invertebrates. Invertebrates comprise most of the animal kingdom, with almost 75 percent of all animals on earth being insects. They outnumber humans by a million to one!

From Phylum, animals are then broken down into more specific categories: class, order, family, genus, and species. For example, a shark, a bird and a human are all in the Phylum Chordata. So, what similarities do these animals have? Taxonomists would agree that all these animals have similar internal skeletons. However, these animals would not be grouped in the same Class. This process would continue until the animal is classified all the way to species type. Keep in mind that sub-phyla do exist and even though most animals are placed into these eight phyla, not only are there visible differences amongst the eight phyla, but also within each phyla. The following descriptions of each phylum are from the "Shape of Life" guide (Sea Studios Foundation, 2002).

Porifera

Sponges

The Phylum Porifera consists only of sponges, which is unique since these animals are entirely aquatic; with 98% found only in marine environments and a small percentage found in freshwater lakes and streams. Sponges are considered the oldest and of the animal phyla. Translated from Latin, Porifera means "pore bearer." Sponges play an important role in aquatic ecosystems, acting to filter particles out of the water, especially bacteria. Sponges can be found living with coral reefs. The surface of a sponge is covered with a skin which is one cell thick. This skin is penetrated by numerous small pores and a few larger openings. These larger openings are the entrances and exits for a complex system of canals and chambers through which the sponge pumps a current of water. The body of a sponge between this system of canals is a loose assemblage of cells that secrets a supporting skeleton of collagen fibers and mineral spicules (glass or calcium carbonate) and carries out the process of growth, repair, nourishment, and reproduction.

Sponges can filter/clean water at a rate of their entire volume in less than a minute! As the sponge pumps in water at this amazing rate, it captures tiny food items - as small as a single micron in diameter. Choanocytes are specialized flagellated cells, also called collar cells, that allows sponges to pump the water. Since sponges are filter feeders they often have to filter over a ton of water to secure just a single ounce of food!

Sponges reproduce asexually by fragmentation or budding, sexually (eggs and sperm), or hermaphroditic, a single species with both male and female gametes. Their commercial importances are for use as bath sponges as well as being tested for possible anti-cancer drugs or antibiotics. Sponges provide a micro habitat for other organisms and they aid in cleaning the water. Since sponges are considered the simplest of the all animal phyla, they are important subjects for analyzing the evolution of animals. Studies indicate that the Phylum Porifera is at the base of the animal tree of life.

Features:

* Asymmetrical
* Organized as an assemblage of different kinds of specialized cells, e.g. collar cells
* No tissues
* Skeleton lacking or made of spicules

Cnidaria

Jellyfish, Corals, Anenomes, Hydra

The phylum cnidaria includes such animals as jellyfish, corals, sea pens, sea anemones, and hydras. This phylum contains the most venomous marine creature. It is the Australian box jellyfish. It is known to kill more people than sharks, crocodiles and stonefish combined. It can cause shock and heart failure within minutes. Sea turtles prey upon the box jellyfish but are not affected by the venom. Most cnidaria alternate between two different body forms in their life: the free-swimming form, called the medusa, and the stationary form, called the polyp. Both body types follow the same basic plan. They are radially symmetrical with three layers of tissue. Each species has a single opening that serves as both the mouth and the anus. That shared opening is usually surrounded by a ring of tentacles, allowing the animal to capture prey in all directions.

Cnidarians have a defined top and bottom and two distinct layers of tissue: an epidermis outer layer and an internal gastrodermis. Between these tissue layers is a layer called the mesoglea. In the form of a medusa, the mesoglea is an elastic, clear jelly with fibers made of protein called collagen. The mesoglea aids in locomotion by elastically recoiling in response to muscle contractions. Cnidarians' muscles and nerves are located at the base of the tissue layers. The internal space, surrounded by the layers of tissue and mesoglea, is the gut or gastrovascular cavity.

In order to capture prey, cnidarians have stinging cells. Located in their tentacles, these stinging cells, called cnidocytes, contain tiny, often toxic harpoons, called nematocysts. Triggered by touch or certain chemicals, nematocysts fire out of the cnidocyte housing at lightning speed. Some hydra can fire these harpoons with an accelerated force equal to 40,000 times the acceleration of gravity. That's 10,000 times the acceleration force of a space shuttle. Once the nematocyst hits it mark, usually lethal poisons are injected into the prey. The combination of defined tissues, muscles, nerves and a gut allowed ancestral cnidarians to be the first animals on the planet to show animated behavior. The named Cnidaria comes from the Latin word meaning "nettle."

Features:

* Two tissue layers with nerve and muscle tissues
* Nematocysts - structures contained in special cells called cnidocytes or cnidoblasts that can act in both offense and defense
* Two main life forms - free-swimming medusa (e.g., jellyfish) or stationary polyp (e.g., anenome)

Platyhelminthes

Flatworms

This particular phylum is one of the lesser-known groups and includes such animals as freshwater planaria, colorful marine polycads and parasitic tapeworms and flukes. The name Platyhelminthes in Latin means "flat worm."

Fossilized worm tracks in the early Cambrian period (over 550 million years ago) hint at the origin of this body plan. While the actual classification of Platyhelminthes remains controversial, flatworms share distinctive features. They are bilaterally symmetrical with a defined head and tail region and a centralized nervous system containing a brain and nerve cords. Clusters of light-sensitive cells make up what are called eyespots. The head region of the flatworm also contains other sense organs, which are connected to the flatworm's simple brain. Like most animals, except sponges and cnidarians, flatworms possess three tissue layers making them triploblastic. The middle tissue layer, called the mesoderm, helps form true organs, including reproductive organs, such as ovaries, testes, and a penis.

Flatworms are hermaphroditic and capable of sexual and asexual reproduction. They are, as their name implies, flat. They have no circulatory system or body cavity (coelom), but they do have an excretory and digestive system. Passive diffusion through the skin supplies oxygen to their body parts. The highly branched gastrovascular (gut) cavity distributes nutrients to their cells.

Most species of flatworms are parasitic, having evolved protective skin coverings and elaborate attachment mechanisms to allow them to live inside their hosts.

Features:

* Bilaterally symmetrical with a head and tail
* Centralized nervous system
* Three tissue layers
* No coelom (body cavity), no circulatory system and no hard skeleton

Annelida

Polychaetes, Earthworms, Leeches & Cambrian Explosion

The Cambrian period began approximately 543 million years ago. Of the eight major phyla, two were known from fossils of this time - Porifera and Cnidaria. Shortly thereafter, a profuse radiation of fossils representing the other animal body plans occurred over a relatively brief span of about 10 million years (by some estimates, 530 million years ago.) The rest of the animal phyla all evolved during, or shortly after, this evolutionary explosion of new life forms in the Cambrian period.

The Annelida body plan is equal in complexity to that of chordates. Far from being lowly worms, these creatures are impressively powerful and capable animals. Annelids are bilaterally symmetrical. They also contain three tissue layers and a true body cavity, or coelom. The coelom surrounds a one-way muscular digestive tract that runs from the mouth to the anus and includes a pharynx, intestine, and other structures. Annelids have a closed-circulatory system with capillaries connecting to arteries and veins, as well as a segmented central nervous system that includes a simple brain located in the head region.

One of the distinctive traits of an annelid is that it has many segments, or rings, that comprise its body. In fact, Annelida means "little ring" in Latin. Each segment has a number of bristles, called setae, which help the worm move. The evolution of segmentation is an important step for the annelids because it provides an opportunity for separate regions of the body to specialize in different tasks. The fluid-filled coelom was another important innovation for annelids, as it insulated the gut from body locomotor muscles and provided a hydrostatic fluid skeleton against which the muscle system could work quite effectively.

Features:

* Elongate and bilateral with segmented true body cavity (coelom)
* Complete circulatory system with capillaries, arteries and veins
* Continuous gut running from mouth to anus with own musculature
* Bristle-like structures, called setae, projecting from body (except in leeches)

Arthropoda

Crustaceans, Spiders, Millipedes, Centipedes, Insects

Of all the phyla in the animal kingdom, Arthropoda is by far the largest and most diverse. All arthropods have segmented bodies and are covered in a hard, yet flexible, protective armor called an exoskeleton. Their body muscles attach to the inside of the exoskeleton. The name Arthropoda means "jointed foot" and refers to their jointed appendages. In order to grow, arthropods must shed their chiton-filled exoskeleton periodically, engaging in an activity called molting. When an arthropod passes through specific developmental stages during molting, it is said to by metamorphosing. Radical changes in body design can come from metamorphosis. For example, an arthropod like a dragonfly can start life in a pond as a swimming larva and then metamorphose nto a completely different-looking, winged adult.

Arthropods, like all animals, first appeared in the sea, yet became the first animal group to invade land and even take to the skies. (Our direct ancestors, the chordates, didn't invade land for another 100 million years.) Once on land arthropods adapted superbly to the new environment. The incredible diversity and success of the arthropods can be attributed to their extraordinarily adaptable body plan. A key feature of this plan lies in the development of myriad types of appendages (antennae, claws, wings, shields, mouthparts) that allowed arthropods to exploit nearly every niche on Earth.

Features:

* Hard exoskeleton made of chitin and protein
* Possess numerous jointed appendages and a segmented body
* Must molt to grow

Mollusca

Clams, Snails, Slugs, Nautilus, Octopus

Animals in this phylum, including chitons, snails, slugs, clams, squid, and octopus, show an amazing degree of diversity. All molluscs have soft bodies. In fact, the name Mollusc means "soft" in Latin. Most molluscs are covered by a hard shell, which is secreted by a layer of tissue called the mantle that overlays the internal organs of the mollusc. Molluscs also have a strong muscular foot, which is used for movement or grasping. The have gills, a mouth and an anus. One feature unique to molluscs is a file-like, rasping tool called a radula. This structure allows them to scrape algae and other food of rocks and even to drill into prey or catch fish.

The diversity of molluscs demonstrates how a basic body plan can evolve into a variety of different forms that allow survival in specific environments. For example, the hard shell in a land-dwelling snail is relatively large and serves to protect the animal. In the fast-swimming squid, however, the shell has been reduced to a small pen-shaped structure.

Features:

* Rasping organ called a radula- present in all groups except bivalves and Aplacophora
* Muscular foot- used for locomotion and other tasks
* A sheath of tissue called the mantle that covers body and can secrete the shell (if there is one)
* A mantle cavity that houses the gills or lungs
* A calcium shell present in most mollusks- some mollusks have greatly reduced their shells, e.g., squid; while others have completely lost it, e.g., slugs, nudibranchs, and octopus

Echinodermata

Sea stars, Sea Lilies, Sea Urchins, Sea Cucumbers, Brittle Stars

There are about 6000 living species belonging to the phylum Echinodermata. The bodies of echinoderms are made of tough, calcium-based plates that are often spiny and covered by a thin skin. This tough body is how they get their name- Echinoderms (echino-spiny, derm-skin).

Echinoderms are exclusively marine animals. This phylum includes sea stars, sea lilies, urchins, sea cucumbers, sand dollars and brittle stars. Echinoderms do not have a bilateral body plan with a distinct head and tail. Instead, many Echinoderms begin life as bilateral larvae and later develop into radial organisms with five-part symmetry. The mouths of most Echinoderms are located on the underside of their bodies. Echinoderms move, feed, and respire with a unique water-vascular system ending in tube feet. Sea stars use their tube feet to slowly pry open clams, mussels, or other prey. Some sea stars can even extrude their stomachs from their bodies and insert them into the tiny openings between the two shells of bivalves and digest the soft parts inside.

An interesting ability of both sea stars and sea urchins is that of regeneration. If body parts such as legs, tube feet, and spines are lost to a predator they can grow back. While most echinoderms are either stationary or slow-moving, methodical animals, they are nevertheless prominent members of the marine environment.

Features:

* Internal skeleton made of little calcium plates
* Five-part symmetry
* Special fluid-filled system (called a water vascular system) that operates the tube feet

Chordata

Tunicates, Lancelets, Vertebrates, including Amphibians, Reptiles, Mammals

The Phylum Chordata includes a wide range of animals from tunicates that look superficially more like sponges, to vertebrates, including fishes, frogs, snakes, birds, and humans. Despite this diversity virtually all chordates share certain features at some point in their lives. These include a stiffening rod, called a notochord, that in many members (e.g., the vertebrates) is later replaced by a bony, vertebral column. In most adult vertebrates, the notochord only remains as a disk between the vertebrae. Another chordate feature is a hollow nerve structure called a dorsal nerve cord that in most members becomes the spinal cord and brain. Also included in the chordate body plan are structures called pharyngeal gill slits, or clefts. These skeletal elements function as jaws and jaw supports, and in some animals take on a variety of other functions.

The most conspicuous group of Chordates is the subphylum Vertebrata. Vertebrates include a wide range of animals, from the jawless fishes to the more familiar mammals and birds. Unlike arthropods that wear their skeletons on the outside, chordates have their skeletons on the inside. This design, as in the echinoderms, allows chordates to grow continuously with no need for molting. Such a robust internal skeleton helps vertebrates grow to the size of an African elephant, or support the powerful movements of swimming fish.

Another major innovation in the evolution of vertebrates is the appearance of jaws and a bony skull. A quadrupling of genetic information and the appearance of a special population of migratory cells, called neural crest, are correlated with the emergence of the all-important vertebrate jaws and skulls. These new features offered a host of new opportunities. Vertebrates fall into two main categories: fishes, and a group of animals called tetrapods. Tetrapods developed from a distinct lineage of fishes that possessed unique internal fin bones. These structures eventually aided in supporting the weight of animals on land and laid the foundation for arms and legs and the first amphibians. The development of a shelled, water-retaining egg, the amniotic egg, enabled tetrapods to remain on land and develop into reptiles, birds, and mammals.

Chordata continued

From an ancient reptilian ancestor, two groups of animals, mammals and birds, independently developed the capacity to maintain constant body temperature. Mammals evolved earlier than birds, more than 220 million years ago, and are represented today by more than 4, 500 species, including humans.

Features:

* Notochord- an elongate rod-like structure located above the gut and below the nerve cord
* Dorsal nerve cord- a hollow tube that in most differentiates into a brain anteriorly and a spinal cord posteriorly
* Gill clefts- structures located behind the mouth and in front of the esophagus
* Segmented muscles (except for tunicates)
* Post-anal tail

Resources

Shape of Life — **http://www.pbs.org/kcet/shapeoflife/**

A revolutionary eight-part television series that reveals the dramatic rise of the animal kingdom through the breakthroughs of scientific discovery. The Shape of Life website features activities and resources, animal facts, and scientist biographies.

School resources

The biology textbook that your high school uses, your school library and the internet can also be used as resources for the Phylum Lab program

Activity 1- Creating a Phylum Key

Description

Students will create a phylum key to be used during the Phylum Lab program at the Aquarium. By organizing the characteristics into eight phyla, they will then have a guide to assist which phylum is represented at each table in the lab.

Procedure

1. Depending on the level of knowledge, you can either photocopy and distribute the teacher background information to your students or have them perform their own research to complete Activity 1.

2. The phylum characteristic table in this booklet, page 17, contains all the main characteristics of the eight main phyla. Photocopy and distribute the student page phylum characteristic table, page 19, along with the phylum key, page 20, to your students. Students will organize the characteristics into their respective phylum. Due to the complexity of sorting these characteristics into the phylum key worksheet, make sure students use a pencil to complete this activity. The number of lines in the table represents the number of characteristics that belong to each phylum. Have students write out the characteristics into the phylum key, page 20.

3. On the day of the program, please have students bring the correct and completed key with them to use during the program.

Activity 1 – Creating a Phylum Key

Description

You will create a phylum key to be used during the Phylum Lab program at the Aquarium. By organizing the characteristics into eight phyla, you will then have a key to assist you with determining which phylum is represented at each table in the lab.

Procedure

1. Using the phylum characteristic table and the phylum key worksheet, create a phylum key by writing the characteristics into the appropriate phylum. The number of lines in the key represents the number of characteristics that belong to each phylum. Due to the complexity of the activity, make sure to use a pencil.

2. Please remember to bring the key with you to the Aquarium program.

Activity 2 – Schoolyard Phyla

Description

In order to broaden the students' knowledge of animal phyla and to give them a better appreciation of the schoolyard habitat, this activity will get the students outside and experiencing nature. This basic activity can be as simple or as complicated as you like, according to the class' level of knowledge, interest, and accessibility.

Procedure

1. On a nice day, have students bring in binoculars, small shovels, comfortable clothing and shoes.

2. Have students divided into groups and each group will get a clipboard, pencil, and sheet of paper, rubber/latex gloves and plastic grocery bag.

3. Take students outside and tell them to explore the schoolyard for a given amount of time (it depends how much you have). They will not only be exploring for animals, but they will also be picking up any trash they come across and placing it in the plastic bags, to be further disposed of later.

4. Using their binoculars and shovels, students should write down every animal (including birds and insects) that they come across, observe or discover. Just the common name will do, since they will be doing more research in the classroom to discover its scientific name and what phylum the animal belongs to.

5. Once the students have compiled a list in a given time, as an assignment (either during class or homework), have students do group research to determine each animal's scientific name and which phylum the animal belongs to. To increase the level of difficulty of the assignment, have them answer these probing questions:

1. What is the defining body plan of phylum _____?
2. How do the animals in phylum _____ move? What type of support system is present?
3. How do the animals in phylum _____ eat? What type of digestive system do they have?
4. How do the animals in phylum _____ sense their surroundings? What type of nervous system do they have?
5. How do the animals in phylum _____ reproduce?
6. What types of fossils were found representing phylum _____?
7. Where/when were the fossils found?
8. What events/processes might have preserved the fossils found?
9. How do the fossils compare to animals of this phylum on Earth today?
10. What do these fossils tell us about the evolution of this phylum of animals?

Additional Follow-up Activities

Depending on feasibility and level of interest, there are several other activities that the students can do to expound upon the Phylum Lab program.

Additional Phyla Discovery

Since the program only touches upon eight of the thirty-five animal phyla, have students choose one of the phyla which was not discussed in the lab. Once they pick a phylum, have them research the characteristics present, what animals are included, and where the animals are found. This will expand their knowledge of the animal kingdom.

Which Phylum does your pet belong to?

Since most of your students likely have pets, it'll be fun for them to discover which phylum their pet belongs to and why, and to further classify that animal to its genus and species. Most likely, cats and dogs will be common. For those with rare pets, however, it could prove to be an interesting project. Maybe some of your students have a salt water aquarium? Or perhaps insects or reptiles?

Teacher Page

Phylum Characteristic Table

	1	2	3	4	5
A	Bilateral phylum that added segmentation	Most have a calcium-carbonate shell	Five-part radial symmetry	Specialized cells, but not organized into organs or tissues	Mantle of tissue covering the body
B	Hollow body cavity for food	Three tissue layers, but no body cavity	Fluid-filled compartments used for locomotion	Jaws and skulls important in their evolution	Complete digestive tract with two ends
C	Most members are parasitic	Water flows through its body, full of canals	Pioneered jointed legs	First phylum to venture into the air	Some have stinging structures (nematocysts)
D	Increased complexity made possible by much more DNA	Body design basically a tube within a tube	Tube feet used for locomotion	First muscle and nerves	Most have inside skeleton of bones
E	All members live in the ocean	Some of the simplest animals with bilateral symmetry	Digestive tract with the entrance being the exit	All have notochord; most have backbone	Champions of variations in appendages
F	More species than any other phylum	Some spines are little pincers (pedicellaria)	Some non-swimming polyps	Some free-drifting medusae	Some propel, using their siphon as a water jet
G	Muscular "foot" used to slide, dig or jump	No locomotion; stationary animal	Tubular mouth (pharynx) at mid-body	Phylum to which humans belong	Hard but flexible bodies with interlocking plates under their skin
H	Spicules act as a skeleton to give it structure	Feeding device like a toothed, rasping tongue (radula)	No symmetry or consistent body shape	Exoskeleton (outside skeleton) made of chitin and protein	Their active burrowing has affected global climate

*****Hints: There are 5 phyla with "Complete digestive tract with two ends"(B5)
There are 2 phyla with "Digestive tract with the entrance being the exit"(E3)
There are 3 phyla with "Bilateral phylum that added segmentation"(A1)

Teacher Page

Answer Key

Porifera	Cnidaria	Platyhelminthes	Annelida
H3	D4	E2	A1
C2	C5	G3	B5
H1	F4	B2	B3
G2	F3	E3	H5
A4	B1	C1	D2
	E3		

Arthropoda	Mollusca	Echinodermata	Chordata
E5	H2	A3	E4
H4	A2	D3	D1
C4	G1	F2	D5
C3	F5	G5	G4
F1	A5	E1	B4
B5	B5	B5	B5
A1			A1

Phylum Characteristic Table

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H	Spicules act as a skeleton to give it structure	Feeding device like a toothed, rasping tongue (radula)	No symmetry or consistent body shape	Exoskeleton (outside skeleton) made of chitin and protein	Their active burrowing has affected global climate

Student Page

Name:_____

Phylum Key

Porifera	Cnidaria	Platyhelminthes	Annelida
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
	_____		

Arthropoda	Mollusca	Echinodermata	Chordata
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____			_____

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There are 2 phyla with "Digestive tract with the entrance being the exit"(E3)
There are 2 phyla with "Bilateral phylum that added segmentation"(A1)