Invertebrate Diversity Lecture Guide

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*Number in outline corresponds to slide number the PowerPoint presentation.

1. Invertebrate Diversity
- **a.** Before we dive into the details of all of the variety of life in the animal kingdom, we need to understand first of all, where did animals come? And secondly, from what is an animal and how did so much variety come to be in this kingdom?

2. Animal Ancestor
- **a.** There is strong evidence that suggests animals evolved from a group of protozoans known as choanoflagellates. These were singled celled organisms that could exists independently, but often congregated together in colonies, sharing duties. It is believed that this close association is what eventually evolved into to specialized cells that carried out certain functions for the colony, until eventually each cell was completely dependent upon each other.

3. Key Features of the Animal Kingdom
- **a.** Every organism classified as an animal must be multicellular. There are some organisms that fulfill all the other characteristics below, but if it is a single celled organism, (like an amoeba or paramecium), it is not an animal. If you look at the individual cells in an animal, you will see that these cells do not have a cell wall, a feature that sets them apart from fungi, plants, and bacteria.
- **b.** All organisms in this kingdom are also mobile species in at least part of its life cycle. Animals like sponges and barnacles at first glance are sessile organisms, but in their young, juvenile form includes a larval form that is mobile. Animals are organisms that must consume other organisms to obtain their energy and all reproduce sexually.

4. An Evolutionary Tree of Major Animal Phyla
- **a.** This phylogeny demonstrates not only the relative relationships between each of the major groups, but also the important features that mark key steps in animal evolution. We are going to approach the study of invertebrates from two different viewpoints. Not only will we examine each phylum individually, we will also take a "big picture" approach and look at the "firsts" in the animal kingdom, or innovations that developed throughout time.
- **b.** So, the first "First" is perhaps most obviously the first animal: The sponge. Sponges are the most rudimentary of animals, and to some it is hard to believe that it is an animal at all. With no organized or distinct shape, no tissues or organs, at first glance a sponge is really nothing more than a conglomeration of cells that work together for the greater good. One of the only things that really defines a sponge as an animal instead of a colony of cells is the fact that the sponge does have specialized cells that carry out specific functions (which we will talk about a little later in this lecture.)
- **c.** The first branching point in this phylogeny represents the first big innovation in the animal kingdom, and that is the development of tissues. What this means that that animals were able to organize their cells into specialized structures such as muscles or nerve cells. And with the development of tissues came distinct shape and symmetry in body development.

5. Radial Symmetry
- **a.** There are two types of symmetry found in the animal kingdom and represent a major branching point in evolutionary history. The simpler animals, such as jelly fish and sea anemones, display radial symmetry and can essentially be divided like a pie, with each piece of pie having the same basic internal structures.
- **b.** What this means is that radial animals do not have a head, nor do they have a real internal body cavity. No head or body cavity means that they have no brain or true organ systems. They do however have rudimentary structures that can be considered precursors to these innovations.

6. Bilateral Symmetry

a. Bilateral animals on the other hand, have both a head and most have a body cavity that supports and protects internal organs. There are differing types of body cavities, which you aren't required to make distinctions between, just be aware that there are three basic types of body cavities, and for the most part, the more derived an animal the more complicated the body cavity.

b. The last really important branching point in the animal kingdom relates to the way each animal develops as an embryo. We can divide bilateral animals into two groups: the protostomes and the deuterostomes. Although this is a relatively simplistic way to view it, for our intents and purposes, we can say that as the embryo develops its body cavity, there are two orifices that need to form: the mouth and the anus. Protostomes are animals that form a mouth first, and deuterostomes are animals that form the anus first. I always remember which is which because when you say deuterostome it sounds like you say doo doo. ☺

7. Major Animal Phyla

a. Now to explore the various phyla in the animal kingdom. Each phylum that you are required to know is covered in the slides that follow. The characteristics that define that group are listed for each phylum. In addition, there are a few key points that you are required to know as well.

b. In terms of what you should focus on in your studying, focus on the information presented on the slides and use your textbook as reference to further explore the information on each slide. Just be sure that you can give several examples of species that are classified in each group. Notice that the last phylum in the animal kingdom is the chordates. That group will be covered in detail in the next module.

8. Phylum Porifera.

a. Sponges are the most ancestral and simplest of animals. They have no definite body shape, no tissues or organs. They consist of 3 types of cells that have specific functions.

1) The epithelial cells control what is allowed to move in and out of the cavity within the sponge.

2) Collar cells move water through the pores in the body of the sponge with the propeller action of flagella in the inner cavity of the sponge. These cells also filter food particles out of the water as it passes through the cavity. Notice the uncanny resemblance to the colonial protists believed to be the ancestor of all animals?

3) The third type of cell, the amoeboid cell has a couple of functions. They distribute nutrients to the epithelial cells, produce sperm and eggs, and secrete spicules that form an internal form of support for the body of the sponge.

9. Phylum Cnideria.

a. Cnidarians include animals such as jelly fish, sea anemones, and hydra. Cnidarians have two basic body plans: the medusa, the body seen in jelly fish and the polyp seen in sea anemones. Regardless of body plan, all cnidarians exhibit radial symmetry, have two tissue types and their defining feature: the stinging cell, called a nematocyst (AKA cnidocyst).

b. The nematocyst is what allows them to immobilize and capture their prey, meaning that they are carnivores. These cells are sharp barb like cells that a cnidarian can shoot out of their body to capture prey by injecting poison into them.

c. Have you every touched a sea anemone? If you have you probably noticed that they feel almost sticky. That sticky feeling is the anemone shooting you with their nematocysts, in an attempt to immobilize you with their poison and draw you into their digestive cavity. Obviously sea anemone venom is not strong enough to overcome such a large prey item as a human, but they are extremely effective against zooplankton, and other small animals. Other cnidarians do produce venom that can affect humans, some just as painful stings or some that can kill.

d. Fun fact to share at parties: clown fish have developed immunity to sea anemone venom, which allows them form a mutualistic relationship with anemones. The Disney movie Finding Nemo demonstrates two benefits to this immunity. First, clown fish use anemones as shelter from predators, and it is this immunity that allowed Nemo's father save Dora from the population of jelly fish they encountered. The phylum Ctenophora is easily mistaken for jelly fish at first glance, but they differ because they are typically very small and do not contain nematocysts.

10. Phylum Platyhelminthes.

a. More commonly known as flat worms, this phylum has bilateral symmetry, three tissue layers, and also have the first organ systems: sensory organs and a rudimentary nervous system. Flat worms can reproduce both sexually (they are hermaphroditic, meaning that they have both male and female reproductive parts), or regenerate a full body when cut in half.

b. Their characteristic flattened body shape is what gives them their common name. Most are small and inconspicuous, but some marine species have brilliant colors and spectacular color patterns. The flat worm you are probably familiar with is the tape worm, which is not nearly as aesthetically pleasing as their marine brethren!

11. Phylum Annelida

a. Phylum Annelida includes segmented worms such as earthworms and leaches. It is this segmentation that defines this group of worms and each segment is basically identical, containing all the needed nerves, muscles, digestive and excretory organs. These segments allow them much more complex movements than flatworms.

b. Annelid lifestyles are pretty diverse. Some are hermaphroditic, some can regenerate body parts, some live in marine habitats, some are parasitic, some important part of detritivore food chains.

12. Phylum Mollusca

a. Mollusks are more diverse than the other phyla we have covered so far. However, generally speaking, most mollusks have a calcium based shell. This shell is continuously secreted throughout its lifetime, and sometimes with seemingly divinely orchestrated geometry and patterns. Because of such diversity in lifestyle, body plans, and feeding strategies, it is easier to break this phylum into three of its most recognizable classes: Bivalves, cephalopods, and gastropods.

1) Bivalves include clams and oysters. These are characterized by two shells that are connected on a flexible but very sturdy hinge. An extraordinarily strong muscle can clamp these shells closed to protect itself from predators. This muscle is what you are eating when eating animals in this class. Bivalves are filter feeders and use gills to breathe and collect food particles from the water.

2) Gastropods are animals such as snails and slugs. These types of animals move around on a single muscular foot, and some lack the secreted shells that are characteristic of most mollusks (slugs for example). When shells are present, they are secreted in a spiral pattern, that interestingly enough is used in identification and classification of species. Gastropods use a structure called a radula to obtain food, either to scrape food from the surfaces they crawl across or to grab and tear plant tissue.

3) Cephalopods, like bivalves are restricted to marine habitats. All cephalopods, such as octopi and squid are marine predators, use jet propulsion for surprisingly fast movement, and all have highly developed brains. Hence the name: The prefix cephalo- means head. Instead of a foot, these animals have tentacles that grasp rey using tentacles and sometimes produce venom to immobilize their prey.

13. Phylum Nematoda
- **a.** Phylum Nematoda is another phylum entirely consisting of worms, known as roundworms. But these worms differ because they have a hard cuticle that protects its body. This cuticle is similar to the exoskeleton of insects and is shed every so often as the animal grows. This feature is one piece of evidence that nematodes are very closely related to arthropods. In fact, roundworms are more closely related to arthropods than they are to other worm phyla.
- **b.** Roundworms are bilateral, have a rudimentary nervous system, and differ from other phyla of worms because most have separate sexes rather than being hermaphroditic. Nematodes are found in nearly every habitat on the planet and are important part of any food web, being mostly decomposers. There are a few parasitic nematodes, relevant to humans, such as hookworms and heartworms.

14. Phylum Arthropoda
- **a.** Arthropods are far and away the most diverse group of animals. Arthropods make up an estimated 80% of all animal species known on the planet. Arthropods defining features include the presence of jointed appendages and an exoskeleton. These two features are key to the amazing diversity and success of this group. Both are adaptations that made it possible for this group of animals to invade land with such smashing success.
- **b.** Other key characteristics found in all arthropods are specialized body segments, sensory antennae, and highly developed vision. This phylum includes spiders, scorpions, insects, millipedes and centipedes, lobsters shrimp. The list goes on. With this much diversity, the arthropods are usually described in four subgroups: Insects, myriapods, chelicerates, and crustaceans.

15. Myriapods and Crustaceans
- **a.** Myriapods (or myriad of feet) include centipedes and millipedes. These two group look similar in that they have lots of legs and repeating body segments, but you can differentiate between the two because millipedes have 2 pairs of legs on each segment and centipedes have one pair on each segment. They are both very different in terms of lifestyle. While millipedes are herbivores, most often detritivores, centipedes are usually predatory, feeding mostly on other arthropods such as insects.
- **b.** Crustaceans are identified by their hard shell and aquatic life style. Lobsters, crabs, barnacles all fall in this category. Unlike other arthrodos groups, the number of appendages is highly variable. Crustaceans shed their hard exoskeleton often as they grow out of them. It takes 3 – 4 days to generate another shell in during this window of heightened danger for the crab, they are considered a culinary delicacy: the soft shelled crab! Soft shelled crabs are call this because it is the 2 to 3 days right after a crab has shed it old shell that it outgrew. Fun fact to share at parties: these animals are capable of regenerating limbs.

16. Arachnids and Insects
- **a.** Arachnids include spiders and scorpions. This group is characterized by having 8 legs and is one of the most commonly feared of the animal kingdom.
- **b.** And finally, the largest class of arthropods: the insects. This class is identified by having 6 legs and includes the only flying arthropods.

17. Phylum Echinodermata
- **a.** The last invertebrate phylum to discuss is the echinoderms. Echinoderms are the only invertebrate group that is classified as a deuterostome and also has both body plans, being bilateral as a juvenile, and radial as an adult. Echinoderms have a unique system known and the water vascular system. This system is the trifecta of organ systems. It serves as a respiratory system, is used in locomotion and obtaining food. Sea stars are voracious predators and can turn its stomach inside out and invert it into tiny crevices found in between the shells of bivalves. It consumes its prey by partially digesting it while the stomach is inserted into the shell of its prey.