General Biology: The Rise Of Animal Diversity

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

I. Overview and Evolutionary Context
The appearance of animals marked a significant ecological shift on Earth, making it a much more dangerous place, as animals are highly **portable eating machines**. Animals are defined by their animation, allowing them to move and carry their digestive system and food with them. Animals (Kingdom Animalia, or **Metazoa**) are a true clade, originating approximately **770 million years ago** (MYA). This timeline means that animals are an older group than plants. While animals today rely heavily on plants, early animals existed only in the ocean before plants moved onto land from algal ancestors. Land animals appeared much later in evolutionary history.

II. Basic Animal Classification and Phyla
Animals are classified into the Domain Eukarya and Kingdom Animalia. The kingdom contains several major groups called phyla (plural: Fila).
1. Basal Animals: Sponges (Phylum Porifera)
• Sponges are the **basal group** of animals, representing the lineage closest to the common ancestor.
• They are multicellular, but they do **not have true tissues**; their cells are not highly organized, meaning they lack true complex multicellularity.
• Sponges are typically **asymmetrical** (lack symmetry).
• *Porifera* means "full of holes" or pores. Water is drawn in through these pores by the movement of **choanocytes** (collar cells) which have flagella.
• Choanocytes ingest microscopic food via **phagocytosis**. Food is then distributed to other cells by **amoebocytes**.
• The **choanoflagellates**, unicellular protists that resemble choanocytes, are considered the sister taxon to animals.
2. Cnidarians
• Cnidarians (e.g., jellyfish, anemones) are more complex than sponges and possess **true tissues**, but these tissues are not organized into true organs.
• They exhibit **radial symmetry**, based on a central point.
• They possess a simple body plan with a centralized **gastrovascular cavity** that has only **one opening**, serving as both the mouth and the anus.
• Cnidarians often use stinging cells to paralyze prey.

3. Arthropods (Most Successful Phylum)
• Arthropods are the **most successful animal phylum** based on adaptive radiation and species count, accounting for the vast majority of all animal species.
• The Class **Insects** alone comprises about 1 million species.
• Arthropods have a segmented body and a hard **exoskeleton** (often made of chitin), rather than an endoskeleton.
• Insects (also called Hexapods) are characterized by having **six legs**.
• Insect wings are novel structures, **not derived from limbs**, giving them an advantage over flying vertebrates (like birds or bats) which sacrifice two limbs for flight.

III. Animal Organization and Developmental Traits
Most animals (excluding sponges) belong to **Eumetazoa** (animals with true tissues).
1. Symmetry
• **Radial Symmetry:** Based on a central point (found in Cnidarians).
• **Bilateral Symmetry:** Based on a central line, creating a left-right mirror image (found in most animals, grouped as **Bilateria**).
2. Germ Layers Germ layers form early during development and eventually give rise to all body organs:
• **Diploblasts:** Have two germ layers: **Ectoderm** (outer covering) and **Endoderm** (inner lining/digestive tract).
• **Triploblasts:** Have three germ layers: Ectoderm, Endoderm, and **Mesoderm** (intermediate layer, develops into other organs). Humans are triploblasts.
3. Body Cavity (Coelom)
• The **Coelom** is a body cavity found in coelomates.
• It is crucial for animal success as it allows different layers of the body to move relative to one another without causing injury (e.g., serous membranes around the heart), enabling **high movability**.
4. Digestive Development (Bilaterians only) Animals in Bilateria have a complete digestive tract (mouth and anus):
• **Protostomes** ("mouth first"): The first opening to develop becomes the mouth. This group includes Arthropods.
• **Deuterostomes** ("mouth second"): The first opening to develop becomes the anus; the mouth develops later. This group includes Chordates (humans).

IV. The Human Lineage: Chordates to Mammals
The vast majority of animals are **invertebrates**. Humans belong to Phylum **Chordata**, a small minority of animals.
1. Chordates All chordates must possess four defining features at least at some point in their development:
1. **Notochord:** A stiff, flexible rod for muscle attachment; allows for undulation (becomes the spinal column in humans).
2. **Dorsal hollow nerve cord:** Develops into the central nervous system (brain and spinal cord).
3. **Post-anal tail:** A tail extending beyond the anus.
4. **Pharyngeal slits:** Openings in the throat for gas exchange (gills in fish).

2. Vertebrates (within Chordata)
• Vertebrates are named for the **vertebral column**.
• They originated as ocean-dwelling chordates (the first fish).
3. Jawed vs. Jawless Fishes
• **Agnathans** (Jawless): Primitive vertebrates lacking a hinged jaw (e.g., lampreys).
• **Gnathostomes** (Jawed fishes): Vertebrates with a true jaw. The innovation of the jaw was a major evolutionary advantage.
4. Bone vs. Cartilage
• **Chondrichthians** (Cartilaginous fishes): Skeletons made of cartilage (e.g., sharks, rays).
• **Osteichthians** (Bony fishes): Skeletons made of true, mineralized bone. Humans belong here.
5. Fins and the Move to Land
• Within bony fishes, there are **Ray-finned fishes** (sharp fins) and **Lobe-finned fishes (Sarcopterygii)** (meaty, muscular fins).
• Lobe-finned fishes are the ancestors of **Tetrapods** (four-limbed animals).
• The fossil *Tiktaalik* represents a transitional "missing link" between lobe-finned fish and tetrapods, featuring characteristics of both (e.g., movable neck, fins, and gills).
6. Tetrapods and Amniotes Tetrapods include Amphibians, Reptiles (including Birds), and Mammals.
• **Amphibians** ("dual lifestyle") live partly on land and partly in water.
• **Amniotes** (Reptiles and Mammals) are defined by features allowing development away from water, primarily the **amniotic egg** and its four extraembryonic membranes:

1. **Amnion:** Cushions the embryo.
2. **Allantois:** Serves as a waste dump.
3. **Chorion:** Assists in gas exchange.
4. **Yolk Sac:** Provides a high-energy food store (lipids).

7. Mammals
• Mammals are named for the **mammary glands** (mammae).
• All mammals produce **true milk** and possess **true hair**.
The three major groups of mammals are:
• **Monotremes** (Basal Mammals): Lay hard-shelled eggs; produce milk that oozes out of skin (no nipples) (e.g., platypus).
• **Marsupials:** Give birth to extremely premature young that complete development externally in a pouch (**marsupium**).
• **Eutherians** (Placental Mammals): Offspring develop entirely within the uterus.
8. Primates and Apes
• Humans are Eutherian mammals and **Primates** (characterized by forward-facing eyes and manipulable fingers/toes).
• **Apes** are a subset of primates that includes gibbons, gorillas, chimpanzees, and humans. Humans are genetically closest to chimpanzees.

V. Ecological Dynamics and Conservation
1. Early Ecological Change The rise of animals cleared the oceans, which were previously murky, low in oxygen, and dominated by cyanobacteria. Animal activity mixed the waters, and increased predation led to clearer oceans, with eukaryotic algae becoming major producers.

2. Co-evolution Animals, particularly as pollinators, co-evolved closely with flowering plants (Angiosperms). This is exemplified by highly specialized relationships, such as the moth with a long proboscis evolved specifically to reach nectar deep within a corresponding flower tube.
3. Conservation Issues Human activity is driving a mass extinction event.
• **Overfishing:** Targeting older, larger fish has led to selection pressure favoring fish that reach sexual maturity at a younger age, which is detrimental to species survival.
• **Endangered Groups:** While mammals and birds often receive attention, **Mollusks** (snails, slugs) are the group of animals currently **most endangered**, largely due to global change, including global warming.