Bio 1101 Lecture 17
Chapter 17: Evolution of Animals

• Last time, we were discussing the evolution of plants
• Today, we move on to animal evolution and diversity

Chapter 17: Evolution of Animals

How do plants, fungi and animals compare?

<table>
<thead>
<tr>
<th>Plant</th>
<th>Fungi</th>
<th>Animal</th>
</tr>
</thead>
<tbody>
<tr>
<td>eukaryotic</td>
<td>eukaryotic</td>
<td>eukaryotic</td>
</tr>
<tr>
<td>multicellular</td>
<td>multi- &amp; unicellular</td>
<td>multicellular</td>
</tr>
<tr>
<td>autotrophs</td>
<td>heterotrophs</td>
<td>heterotrophs</td>
</tr>
<tr>
<td>lack nervous/muscle tissue</td>
<td>lack nervous/muscle tissue</td>
<td>have nervous/muscle tissue</td>
</tr>
<tr>
<td>cell walls of cellulose</td>
<td>cell walls of chitin</td>
<td>lack cell walls</td>
</tr>
</tbody>
</table>
Animal Reproduction

Most animals reproduce sexually

• Blastula → Gastrula → Embryo

  [Diagram showing the stages of animal reproduction]

  Adult Form  Larva

Larvae (plural) are sexually immature forms of some animals; they are anatomically distinct from the adult form and cannot reproduce

(example: tadpoles are the larval stage of frogs)

Here’s another example of an animal with a larval stage in its life cycle: the starfish

Click below for audio:
Larvae are sexually immature forms of animals that are morphologically different than the adult and go through metamorphosis.

• How did the first animals evolve from a protist?

• First true animals probably evolved from a flagellated protist

  – Colony → hollow sphere → specialization of cells
  → infolding to form primitive gut
• By 550-575 mya, during the Precambrian era, a variety of animals existed
  – Our oldest animal fossils
  – Soft-bodied impressions of sponges, jelly fish, worms, and difficult to classify organisms
During the Cambrian Explosion (535-525 mya), a huge variety of animals evolved in a relatively short period of time

- Predator-prey interactions necessitated adaptations for survival
- Diversification of shells and spines for protection
- The Burgess Shale fossils are a famous assemblage of Cambrian fossils in British Columbia, Canada

Click for audio:

We will now begin a survey of the animal phyla, beginning with the most primitive (oldest) and working our way up to the most advanced (newest) groups

Some major characteristics to focus on:
- Body symmetry
- Development of body cavities
- Development of more complex digestive systems
- Development of more complex tissue layers
- Development of more complex nervous system
Embryonic tissue layers and body cavities

- All animals except sponges have embryonic tissue layers, from which all body organs and tissues develop.
- Some early animals (like jellyfish) have just two tissue layers; they are called diploblastic.
  - The tissue layers are ectoderm and endoderm.
- Most animals have three tissue layers; they are called triploblastic.
  - The tissue layers are ectoderm, mesoderm, and endoderm.
- Some triploblastic animals have a fluid-filled space that holds their organs.
  - If the space is completely lined by mesoderm tissue, it is called a true body cavity, or coelom.
  - If the space is only partially lined by mesoderm tissue, it is called a false body cavity, or pseudocoelom.
  - Animals that lack any type of body cavity are called aceolomate.
Review of Embryonic Tissue Types

- Ectoderm
- Mesoderm
- Endoderm
- Mesentery

- Acoelomate
- Pseudocoelomate
- Coelomate
• Earliest and Simplest Animals: The **Sponges** (multiple phyla)

  - Asymmetrical (unlike SpongeBob)
  - Multicellular
  - Lack true tissues (no skin, muscle, nerves, etc.)
    - But individuals cells can react to environment
  - Sessile
  - Filter-feeding
– Use specialized flagellated cells, *choanocytes*, to trap bacteria
– *Amoebocyte* cells pick up food from the choanocytes and digest it
– “spicules” give them structure and are manufactured by amoebocytes
Sponges

- According to *National Geographic*, a deep sea sponge (above) may be the oldest animal on planet; some estimated to be 11,000 years old!

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**Cnidarians (Phylum Cnidaria)**

- Sea anemones, jellyfish, hydras, and corals
- Radially symmetrical
- Mostly marine
— Have a “gastrovascular cavity”
  • One opening (both mouth and anus)

— 2 different body plans:
  • Medusa
  • Polyp
• Some are polyps, some are medusas, and some go through both stages
• Polyp is the asexually reproducing stage (budding)
• Medusa is the sexually reproducing stage (produces gametes)
• Tentacles in a ring around mouth
• Named for their “cnidocytes” – special stinging cells found on their tentacles
  – Defense
  – Capture prey
  – Some inject poison (e.g. jellyfish)

Flatworms (Phylum Platyhelminthes)
  – The simplest, earliest bilaterally symmetrical organisms
  – Lack a body cavity, or coelom (acoelomate)
    • A coelom is a fluid-filled space between the gut and the outer body wall
    • Holds and protects internal organs
  – No circulatory system
  – May be free-living or parasitic
  – Either have incomplete digestive tract (only 1 opening), or lack digestive tract
– Free-living flatworms include the planarian
– The beginning of a collection of nervous tissue at front of organism, and some simple “eye spots”

Planarian:
• Flatworms were among the first animals to exhibit cephalization – the concentration of sensory organs at the “head end” of the animal
  – An adaptation for directional movement
    • Most radially symmetrical animals are stationary
    • With cephalization, animals could sense conditions of the environment into which they were moving, and make decisions (move away from light? move toward food?)
  – The head end is first to encounter food, danger, or other stimuli
  – “Head” end may contain a brain or simple ganglia, and sensory organs such as eyes

– Parasitic flatworms include flukes and tapeworms
  • Complex life cycles
    – Flukes reproduce sexually in humans; eggs shed into water with feces; hatch in water and infect snails; reproduce asexually in snails, and produces a larval form that lives in water; larval form infects fish, and then fish-eating animals
Tapeworms:

- Consist of a scolex ("head" with hooks and suckers for attachment to host) and a long chain of proglottids
  - Each proglottid contains a complete reproductive system
- May infect a variety of animals, from pigs, cows, fish, and humans
- Tapeworms are different from other flatworms in that they completely lack a digestive system
Phylum Mollusca

– Includes snails, clams, squid, and octopuses
– Soft-bodied animals
– True coelom
– Complete digestive tract
– Most protected by a hard shell, either internal or external (one exception is slugs)
– Have a specialized feeding structure called a radula
  • Scrape algae off rocks
  • Cut pieces of vegetative material

• Body plan:
  – Muscular foot for movement
  – Visceral mass contains organs
  – Thin fold of tissue called the mantle, secretes the shell
• 3 groups of Molluscs:
  – Class Gastropoda (snails and slugs)
    • Single, spiral shell (or none)
    • May have distinct head w/eyes and tentacles

![Shell images](image1)

![Snail images](image2)
– Class Bivalva (clams, oysters, mussels, scallops)
  • 2-part shell

– Class Cephalopoda (squids and octopuses)
  • Usually the shell is reduced, internalized, or absent
  • Intelligent marine predators
  • Beak-like jaws and radula
  • Foot has been extended to form tentacles
Amazing Octopuses!

- **Octopus opens jar:**
  - [http://www.youtube.com/watch?v=ocWF6d0ne1Y&feature=related](http://www.youtube.com/watch?v=ocWF6d0ne1Y&feature=related)

- **Octopus intelligence & camouflage**
  - [https://www.youtube.com/watch?v=r1bxBmJAADg](https://www.youtube.com/watch?v=r1bxBmJAADg)

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**Phylum Annelida**

- Segmented worms
- Includes earthworms, leeches, and a variety of marine worms
- Appendages located on each segment, in many species
- True coelom
- Bilaterally symmetrical with complete digestive tract
- Mostly free-living
Roundworms (Phylum Nematoda)

- Cylindrical with tapered ends
- Bilaterally symmetrical
- Found in nearly every habitat, from soil to water to within the bodies of plants and animals
  - If everything were to disappear on earth except roundworms, you would still be able to see “ghosts” of nearly every living thing due to the roundworms that live inside them
- Some parasitic, some free-living
– Have a **complete digestive tract**, and a **pseudocoelom** (a primitive body cavity)
  
  – True body cavities are completely lined by mesoderm (a type of tissue)
  – Pseudocoeloms are only partially lined by mesoderm

– Roundworms include the species that causes the disease trichinosis
  
  – From eating infected, undercooked pork
  – Worms burrow into and form cysts in muscle tissue

*Trichinella* sp. found in undercooked pork
Phylum Arthropoda

- Bilaterally symmetrical with complete digestive tract
- Segmented animals
  - Segments specialized for specific functions
- Jointed appendages
- Exoskeleton
  - Made of chitin
  - When animal grows, must “molt”

- A large diversity of species (about 2/3 of all species!)
- 5 main groups:
  - Arachnids
  - Crustaceans
  - Millipedes
  - Centipedes
  - Insects
— Arachnids
  • Spiders, scorpions, mites and ticks
  • Live on land
  • 4 pairs of walking legs, and 1 pair of feeding appendages
    — In spiders, these are fang-like and inject poison

— Spiders make webs using their spinneret glands, located in the abdomen
— Use the wind to carry the thread of silk for first strand of a web; if it sticks to a good surface, spider will walk across the thread, adding a second thread for support
— Most wait at the edge of their web with a foot on the “signal line” to detect when something is captured
– Crustaceans

- Mostly aquatic, such as crabs, lobsters, crayfish, shrimp
- One terrestrial group are the isopods, or “pill bugs”
- Millipedes and Centipedes
  - Many similar segments (resemble annelids)
  - Jointed legs
  - Millipedes eat decaying plant matter; centipedes are carnivores (poisonous)
  - Millipedes = two pairs of legs on most body segments; body round in cross-section; eat vegetation
  - Centipedes = one pair of legs on most body segments; body flattened; can be poisonous, so don’t touch!

![Millipedes vs Centipedes](image)

- Class Insecta
  - More species of insects than all other species combined
  - 3 pairs of legs
  - 3-part body: head, thorax, and abdomen
  - Other appendages for eating and flying
  - Many insects undergo a metamorphosis
    - e.g. butterflies

![Monarch Butterfly](image)
• **Phylum Echinodermata**
  - Sea urchins, sand dollars and star fish
  - All marine
  - Larvae are bilaterally symmetrical, but when transform into adults, take on radial symmetry
  - Most have an endoskeleton
  - Water-vascular system, used for gas exchange, waste disposal, and for movement
    • “tube feet” – the water vascular system pumps water into little tubes that extend into these “feet,” enabling them to extend or contract and bring about movement
• Break...
• This is the end of Part 1 of the lecture; Part 2 will be covered next time, along with a mini-lecture on Viruses & COVID-19
Lec. 17, Part 2: Animal Evolution, cont’d

- **Phylum Chordata**
  - Includes the subphylum vertebrata
    - Animals with backbones
  - All Chordates share 4 traits
    - Dorsal hollow nerve cord
    - Notochord
    - Pharyngeal gill slits
    - Post-anal tail

But we’re vertebrates, and we don’t have gill slits or tails...

Or do we???
During embryonic development, we have all of the characteristics of the Phylum Chordata, including post-anal tails and gill slits.
• Phylum Chordata includes the vertebrates, but not all chordates are vertebrates
  – A vertebrate is an animal with a backbone
• Invertebrate chordates include the tunicates and lancelets
  – Tunicates = “sea squirts”
  – Lancelets = small, blade-shaped marine animals
• Subphylum Vertebrata
  1. Fishes
     – Evolutionarily, the first vertebrates
     – Jawless fishes were the earliest
       • Example: lampreys and hagfishes
         – Note that hagfishes = fishes with a cranium but not a true backbone – however, they are considered vertebrates due to the cranium;
         – Lampreys and hagfishes are jawless fishes
• And then there came the evolution of....

JAWS!

• Class Chondrichthyes: the cartilaginous fishes
  – The first fish with jaws
  – No true bone – skeleton of cartilage
  – Includes the sharks and rays
  – Have a lateral line system, which they use to detect movement in the water (helps them locate prey, since their vision is poor)
  – Must move constantly to circulate water over gills and breathe
• Class Osteichthyes: Bony Fishes
  – More species than in any other Class of vertebrates
  – Tuna, trout, goldfish, etc.
  – Skeleton reinforced by calcium salts = bone
  – Also have lateral line system
  – Keen vision and smell
  – Have an operculum on either side of head to protect gills
    • Can move operculum to circulate water through gills
    • Allows them to breathe when not in motion
Examples of Bony Fishes

(a) Tuna

(b) Clownfish

(c) Rockfish

(d) Seahorse

Lobe-finned fish

Early amphibian

Bones supporting gills

Tetrapod limb skeleton
• Class Amphibia
  – Evolved from lobe-finned bony fishes
  – Developed arms and legs
  – Developed lungs for air-breathing
  – Also depend on their moist skin for gas exchange
  – Ectothermic (cold-blooded)
  – Eggs lack shells and usually must be laid in water
    • Undergo metamorphosis, from an aquatic larval form to a terrestrial adult form
• Amphibians were first vertebrates to colonize land
• Have four legs = “tetrapod”
• All subsequent animals evolving from amphibian ancestor are also tetrapods

• Class Reptilia – the reptiles and birds
  – First to evolve an amniotic egg
    • Fluid-filled egg with a waterproof shell
    • Allows these animals to reproduce on land (unlike amphibians, which must deposit their eggs in aquatic – or at least wet – environments)
    • Note that mammals are also classified as amniotes, even though most no longer lay eggs
• **Reptiles (Class Reptilia)**
  – Snakes, lizards, turtles, alligators, and crocodiles
  – Waterproof scales allow them to conserve water better than amphibians
  – Hard-shelled, water-containing eggs (amniotic eggs) can be laid on land (won’t dry out)
  – These characteristics allowed reptiles to exploit terrestrial habitats better than amphibians
  – Cold-blooded
• Birds (Class Reptilia)
  – Evolved from reptilian ancestor
    • Small, two-legged dinosaurs called theropods
  – Scales evolved into feathers
  – Evolved endothermy – fairly constant body temperature maintained by metabolism
  – Hard-shelled eggs
  – No teeth, so have a gizzard for grinding food (located near stomach)

• Flight
  – Bones of birds are honeycombed, making them light yet strong, an adaptation for flight
  – Frigate birds are large seagoing species
    • Wingspan of over 6 ½ feet
    • Skeleton only weighs 4 ounces!
  – Other ways birds reduce weight: eliminating some internal organs
    • For example, female birds have only one ovary
    • Lack of teeth also reduces weight
  – Wings with feathers act as airfoil
    • Feathers likely first evolved as insulation
• Class Mammalia
  – The mammals
  – Also evolved from reptiles
  – First mammals were small, mouse-sized, and nocturnal
  – Diversified after downfall of dinosaurs
  – Hair derived from scales
  – Evolved endothermy separately from birds
  – Earliest mammals were egg-layers
  – Today, only 3 species of egg-laying mammals (monotremes)
• Most mammals are born (have lost the “egg” over time)
• Marsupial mammals have a brief gestation period; tiny baby is born, attaches to mother’s nipple and is protected in a pouch
  – Example: kangaroo and koala
  – Nearly all marsupials live in Australia, New Zealand, and South America
  – North American marsupial = opossums

• **Placental Mammals**
  - Have longer gestation period and more elaborate placenta
  - Don’t have a “pouch”
  - Examples: dogs, cats, cows, rodents, bats, whales, and primates (including humans)

• **Evolution of Humankind**
  - We share a common ancestor with the chimpanzees about 7 million years ago
    - Note that this does not mean we “evolved from chimps”
    - Rather, chimpanzees are more like our phylogenetic “cousins”
    - We are related to chimpanzees through common descent
  - Bipedalism (walking upright on two legs) was an important adaptation of our ancestors
    - The fossil named “Lucy” (of the species *Australopithecus afarensis*) was an important insight into the importance of bipedalism in our early evolution
    - Lucy had small brain, but walked upright
    - This fossil hominin dates back 3.24 million years
• Fossil skeleton of “Lucy” (left), and an artist’s rendition of what Lucy may have looked like (above)

— Enlargement of the human brain is first evident in fossil hominins dating back 2.4 million years ago
— After first standing up, then evolving larger brains, human ancestors began making tools
— *Homo habilis* remains have been found with their handmade tools
— Why did we evolve larger brains? A number of different hypotheses:
  • For building tools
  • For hunting or gathering food
  • For attracting mates
First human species to extend beyond Africa was *Homo erectus*

*Homo erectus* fossils dating 1.8 million years old have been found in former Soviet republic of Georgia

This species had larger brain than *Homo habilis* and was also taller

Lived in huts or caves, built fires, made clothes from animal skin, and made stone tools

Eventually spread through Europe and Asia

A descendant of *Homo erectus* was *Homo neanderthalensis* (the “Neanderthals”)

Also had large brains and made diversity of stone and wood tools

Lived in Europe as far back as 350,000 years ago, but went extinct 28,000 years ago

Are modern humans related to Neanderthals?

- DNA evidence suggests our last common ancestor with Neanderthals lived about 500,000 years ago
- However, early *Homo sapiens* co-existed with Neanderthals and may have inter-bred with them

**Video:**

http://www.youtube.com/watch?feature=endscreen&v=HpQiBPdFtog&NR=1
– Oldest *Homo sapiens* fossils were discovered in Ethiopia and date from 160,000 to 195,000 years old

– These humans lacked the heavy browridge of the Neanderthals and had a more slender skeleton

– A uniquely human trait is that, although primate brains in general continue to grow after birth, human brains continue to grow for a longer period than any other primate

– We have an extended period of parental care, which allows our offspring to learn from earlier generations
  - The basis of culture – the social transmission of knowledge, customs, beliefs, and art over generations
  - Although not restricted to humans, it is particularly well developed in our species

Animal Evolution Activity

Log in to Carmen Canvas and complete the “Animal Evolution Activity” quiz by midnight, Wednesday, April 8th.
• Break, then mini-lecture on Viruses & COVID-19