Evolution of Animal Diversity
Bio 103 Lecture
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What Am I?
- Of some 1.5 million species of organisms known to science
  - over two-thirds are animals
- Humans have a long history of studying animal diversity
  - But do we always know what an animal is when we see one?

What is an animal?
- Animals
  - eukaryotic
  - multicellular
  - heterotrophs
  - lack cell walls
  - have unique intercellular junctions

What is an animal?
- Animals
  - Most are diploid
    - except for haploid eggs and sperm
  - proceed through a well-defined life cycle

Evolution of animals
- Animal kingdom probably originated from colonial protists
  - in which cells gradually became more specialized and layered

Evolution of animals
- Ecological, geologic, or genetic factors may have caused the Cambrian explosion in animal diversity
  - Cambrian fossils can be classified as ancient representatives of the familiar animal phyla

Characterizing the differences between animal phyla
- Animals can be classified according to pattern of development or body structure
  - Embryologic development
    - germ layers
    - blastopore fate
  - Symmetry
  - Body plan
  - Segmentation

Characterizing the differences between animal phyla
- Embryologic development
  - germ layers
    - what are they?
      - three cell layers
        - ectoderm - outer layer
        - mesoderm - middle layer
Characterizing the differences between animal phyla

**Embryologic development**
- **germ layers**
  - diploblastic organisms
    - have two germ layers
      - ectoderm - outer layer
      - endoderm - inner layer
  - triploblastic organisms
    - have three germ layers
      - ectoderm - outer layer
      - mesoderm - middle layer
      - endoderm - inner layer
- blastopore fate
  - what is the blastopore?
    - Early during embryonic development the embryo is a hollow ball of cells
    - a portion of this hollow ball invaginates inward to form an opening called the blastopore
    - blastopore can be thought of as the first opening
    - this opening, the blastopore, becomes either the mouth or the anus of animals with body cavities
  - protostomes
    - organisms in which the blastopore becomes the mouth
      - the first (proto) opening becomes mouth
  - deuterostomes
    - organisms in which the blastopore becomes the anus
      - the second (deuter) opening becomes the mouth

**Symmetry**
- refers to the arrangement of body structures in relation to some axis of the body
- three types of symmetry
  - asymmetry
  - radial symmetry
  - bilateral symmetry
- lack of any defined symmetry
- **no** plane passing through the central axis can divide the organism into halves that are mirror images of each other
  - cutting the organism in half produces dissimilar halves
- exhibited by most members of the simplest phylum of animal kingdom
  - phylum Porifera - the sponges

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✅ Symmetry
  - radial symmetry
    - can be bisected into roughly equal, mirror-image halves in any two-dimensional plane
      - multiple plans can be drawn through the central axis, each dividing the organism into two mirror images
    - exhibited by members of three phyla
      - phylum Cnidaria - jellyfish, sea anemones, corals
      - phylum Ctenophora - sea walnuts, comb jellies
      - phylum Echinodermata - sea stars, urchins, sand dollars
        - radial symmetry seen in ADULTS in this phylum

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19 Characterizing the differences between animal phyla

✅ Bilateral symmetry
  - can be bisected into roughly equal, mirror-image halves in only one plane (the sagittal plane)
    - only one plane can be drawn through the central axis which divides the organism into two mirror images
    - exhibited in all other animal phyla

20 Characterizing the differences between animal phyla

✅ Body plan
  - a widely held system for grouping animal phyla is based on
    - the presence/absence of a body cavity
    - type of body cavity

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22 Characterizing the differences between animal phyla

✅ Body plan
  - what is a body cavity?
    - a fluid-filled space inside the body
      - this space may develop between
        - between the mesoderm and endoderm, in which case it's called a pseudocoel
Characterizing the differences between animal phyla

Body plan
- four types of body plans
  - sac-like
  - acoelomate
  - pseudocoelomate
  - coelomate

Body plan
- sac-like
  - simplest of body plans
  - no formation of three embryonic germ layers
  - no digestive system
  - no body cavity
  - exhibited by phyla that are asymmetrical or radially symmetrical as juveniles

Body plan
- bilaterally symmetrical animals exhibit three basic body plans
  - acoelomate
  - pseudocoelomate
  - coelomate

Body plan
- acoelomate
  - organisms that lack a body cavity
  - have a solid body with a single opening to the outside, the mouth
  - exhibited by
    - phylum Platyhelminthes - flatworms
    - a few other minor phyla

Body plan
- pseudocoelomate
  - organism with a body cavity
    - called a pseudocoel (pseud = “false”)
    - which develops between the mesoderm and endoderm
    - and therefore it is not completely lined with mesoderm
  - exhibited by
    - phylum Nematoda - roundworms
Characterizing the differences between animal phyla

- **Body plan**
  - **coelomate**
    - organism with a body cavity
      - called a coelom
      - which develops entirely within the mesoderm
        - and therefore it is completely lined with mesoderm
    - exhibited by many phyla
      - Mollusca, Annelida, Arthropoda, Echinodermata, Chordata
    - are either protostomes or deuterostomes

Characterizing the differences between animal phyla

- Animals can be classified according to pattern of development or body structure
  - Embryologic development
    - germ layers
    - blastopore fate
  - Symmetry
  - Body plan
    - **Segmentation**

Characterizing the differences between animal phyla

- **Segmentation**
  - a key transition in animal body plan involved the subdivision of the body into segments
  - segmentation underlies the organization of all advanced animals
  - examples
    - repeating segments of earthworms
    - repeating vertebrae in vertebrates

Major phyla of the animal kingdom

**Protostome coelomates** represented by
  - phylum Mollusca - snails, clams, chiton, octopus, squids (~110,000 species)
  - phylum Annelida - earthworms, polychaetes, leeches (~12,000 species)
  - phylum Arthropoda - horseshoe crabs, shrimps, insects, spiders, centipedes, millipedes (~1,000,000 species)

**Deuterostome coelomates** represented by
  - phylum Echinodermata - sea lillies, sea stars, sea urchins, sea cucumbers (~6,000 species)
  - phylum Hemichordata - acorn worms (~90 species)
  - phylum Chordata - chordates (~42,500 species)
    - subphylum Urochordata - tunicates
    - subphylum Cephalochordata - lancelets
• subphylum Vertebrata - fish, amphibians, reptiles, birds, mammals

41 Some animals lack a body cavity
✓ Sponges, cnidarians, and flatworms lack a body cavity

42 INVERTEBRATES
✓ Sponges (Phylum Porifera)
  – have relatively simple, porous body
  – phylum Porifera
  – among simplest animals
  – many are radially symmetrical
  – parts are arranged around a central axis
  – flagellated choanocytes filter food from water passing through porous body

43 INVERTEBRATES
✓ Sponges (Phylum Porifera)
  – lineage arose very early
    • probably evolved from multicellular choanoflagellates
      – group that most likely gave rise to animal kingdom

44 Invertebrates
✓ Cnidarians (Phylum Cnidaria)
  – radial animals with stinging threads
  – simplest animals with tissues
  – exist in two radially symmetrical forms
    • Polyps
      – such as hydra, corals, and sea anemones
    • Medusas
      – jellies

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47 Invertebrates
✓ Cnidarians (Phylum Cnidaria)
  – Cnidocytes on their tentacles sting prey
    • tentacles
      – controlled by nerves
      – push food through mouth into a gastrovascular cavity
        » where food is digested and then distributed
    – only two cell layers are produced during gastrulation

48 Most animals are bilaterally symmetrical
✓ have mirror-image right and left sides
  – a head with sensory structures
  – move headfirst through their environment
Flatworms are the simplest bilateral animals

- Flatworms (Phylum Platyhelminthes)
  - also called planaria
  - have a simple nervous system
    - consisting of brain, sense organs, and branching nerves
  - as in cnidarians, mouth is only opening for its gastrovascular cavity

- Flukes and tapeworms are parasitic flatworms with complex life cycles

Most animals have a body cavity

- Sponges, cnidarians, and flatworms lack a body cavity
- Nearly all other animals have a body cavity
- Body cavity
  - fluid-filled space between digestive tract and body wall
  - aids in movement, cushions organs, and it may help in circulation

Roundworms have a pseudocoelom and a complete digestive tract

- Nematodes (Phylum Nematoda)
  - have a body cavity not completely lined by mesoderm
  - like most animals, they possess a complete digestive tract
    - a tube with a mouth and an anus
  - many are free-living
  - others are parasites

Diverse mollusks are variations on a common body plan

- Mollusks (Phylum Mollusca)
  - large and diverse phylum
  - includes
    - gastropods, such as snails and slugs
    - bivalves, such as clams and scallops
    - cephalopods, such as squids and octopuses

Diverse mollusks are variations on a common body plan

- Mollusks (Phylum Mollusca)
  - all have a muscular foot and a mantle
• mantle may secrete a shell
  – which encloses visceral mass
  – have true coelom
  – have circulatory system
  – many feed with a rasping radula

60 Many animals have a segmented body
✓ Segmentation
  – the subdivision of some or most of the body into a series of repeated parts, or segments
  – probably evolved as an adaptation for movement

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62 Earthworms and other annelids are segmented worms
✓ Annelids (Phylum Annelida)
  – their segmented bodies give them added mobility for swimming and burrowing
    • an earthworm eats its way through soil
    • polychaetes search for prey on seafloor or live in tubes and filter food particles
    • most leeches are free-living carnivores, but some suck blood

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✓ s

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65 Arthropods are the most numerous and widespread of all animals
✓ Arthropods (Phylum Arthropoda)
  – segmented animals
  – have exoskeletons
  – have jointed appendages
  – are most successful phylum of animals
    • in terms of numbers, distribution, and diversity, they
  – Horseshoe crabs are ancient marine arthropods

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68 Arthropods are the most numerous and widespread of all animals
✓ Arthropods (Phylum Arthropoda)
  – most arachnids are terrestrial and carnivorous
  – crustaceans are nearly all aquatic
  – millipedes and centipedes make up a fourth group of arthropods

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Insects are the most diverse group of organisms

- **Insects**
  - most numerous and successful arthropods
  - have three-part body consisting of
    - head, thorax, and abdomen
    - three sets of legs
    - wings (most, but not all insects)
  - development of many insects includes metamorphosis

**Insect metamorphosis**

- incomplete metamorphosis
  - young resemble adults, but are smaller with different body proportions
- complete metamorphosis
  - larvae specialized for eating & growing
    - larvae look different from adults
    - adults are specialized for dispersal and reproduction

**Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement**

- **Echinoderms** (Phylum Echinodermata)
  - includes sea stars and sea urchins
  - are radially symmetrical as adults
  - some have water vascular system
    - has suction-cup-like tube feet used for respiration and locomotion

**Our own phylum, Chordata, is distinguished by four features**

- **Chordates** (Phylum Chordata)
  - segmented animals
  - with four distinctive features
    - dorsal hollow nerve cord
    - stiff notochord
    - pharyngeal slits behind the mouth
    - muscular post-anal tail
Our own phylum, Chordata, is distinguished by four features

- **Chordates** (Phylum Chordata)
  - simplest are tunicates and lancelets
    - are marine invertebrates

A skull and a backbone are hallmarks of vertebrates

- **Vertebrates**
  - Most chordates are vertebrates
  - endoskeletons include a skull
  - backbone is composed of vertebrae

A skull and a backbone are hallmarks of vertebrates

- **Vertebrates**
  - most vertebrates have hinged jaws
  - lampreys lack hinged jaws
    - are classified as agnathans
  - jaws evolved by modification of skeletal supports of gill slits

Fishes are jawed vertebrates with gills and paired fins

- **Vertebrates**
  - two classes of fish
    - Chondrichthyes
      - cartilaginous fishes such as sharks
    - Osteichthyes
      - bony fishes such as tuna and trout

Fishes are jawed vertebrates with gills and paired fins

- **Vertebrates**
  - Bony fishes
    - more diverse and have
    - more mobile fins
    - operculi that move water over the gills
    - a buoyant swim bladder

Fishes are jawed vertebrates with gills and paired fins
Vertebrates

Verterbrates

Bony fishes

- three major classes of bony fishes
  - Ray-finned fishes
  - Lobe-finned fishes
  - Lungfishes

Amphibians were the first land vertebrates

- Class Amphibia
  - represented today by
    - frogs
    - toads
    - salamanders

Amphibians were the first land vertebrates

- Class Amphibia
  - Amphibians were the first terrestrial vertebrates
    - limbs allow them to move on land
    - larvae must develop in water

Reptiles have more terrestrial adaptations than amphibians

- Class Reptilia
  - able to live on land due to
    - waterproof scales
    - a shelled, amniotic egg
  - modern reptiles are ectotherms
    - warm their bodies by absorbing heat from environment

Reptiles have more terrestrial adaptations than amphibians

- Class Reptilia
  - dinosaurs were most diverse reptiles to inhabit land
    - included some of the largest land animals ever
    - may have been endothermic, producing their own body heat

Birds share many features with their reptilian ancestors

- Class Aves
• like reptiles, this class has
  – scales
  – amniotic eggs

103 Birds share many features with their reptilian ancestors

✓ Vertebrates
  – Class Aves
    • other bird characteristics include
      – wings
      – feathers
      – an endothermic metabolism
      – hollow bones
      – a highly efficient circulatory system

104 Mammals also evolved from reptiles

✓ Vertebrates
  – Class Mammalia
    • descended from reptiles
    • are endothermic
    • have two unique characteristics
      – hair, which insulates the body
      – mammary glands
        » which produce milk that nourishes their young

105 Mammals also evolved from reptiles

✓ Vertebrates
  – Class Mammalia
    • most give birth to young after a period of embryonic development inside body of the mother
      – embryo is nurtured by an organ called the placenta
    • a few mammals lay eggs
      – monotremes

106 Mammals also evolved from reptiles

✓ Vertebrates
  – Class Mammalia
    • marsupials
      – have a short gestation

107 Mammals also evolved from reptiles

✓ Vertebrates
  – Class Mammalia
    • most are eutherians, also called placentals

108 Mammals also evolved from reptiles

✓ Vertebrates
  – Class Mammalia
    • most are eutherians, also called placentals
– have a relatively long gestation
– complete embryonic development occurs within the mother

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112 PHYLOGENY OF THE ANIMAL KINGDOM
✓ phylogenetic tree
   – gives animal diversity an evolutionary perspective
   – traditional phylogenetic tree is based on
     • patterns of embryonic development
     • some fundamental structures
   – molecular-based tree has added two clades within the protostomes

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✓ Burgess Shale fossils

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✓ Sponges

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✓ Coral polyps

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✓ Purple striped jelly, *Pelagia panopyra*

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✓ Lion mane jelly

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✓ Sea anemones

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✓ Cnidarians: jellies, sea anemone, coral polyps

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✓ Ctenophore

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✓ Flatworm

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✓ Roundworm, *C. elegans*

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✓ Deer Cowrie, a marine gastropod with a shell

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✓ Earthworm

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✓ Beetle
Butterfly metamorphosis: larva (caterpillar), pupa, emerging adult, adult

Sea star, Bloodstar

Brittle star

Cartilaginous fishes: sharks and rays

Newt

Extant reptiles: desert tortoise, lizard, King snake, alligators

Sea turtle

Banded gecko

Emerald tree boa

Penguins, flightless birds

Marsupial mouse

The End.