ANIMAL DIVERSITY

CHAPTERS 32, 33 AND 34

WHAT IS AN ANIMAL?

- Animals are characterized by two basic traits:
  - They eat = heterotrophic
  - They move
  - They are multicellular
  - They lack cell walls
  - They have a diplontic life cycle
  - They have tissues which develop from germ layers

EATING

Heterotrophy

- Require organic molecules from other sources

Ingestion

- Consuming another organism in whole or in part
  - Food ranges in size from bacteria to giant squid
  - Active hunting or scavenging

Absorption

- Direct absorption of nutrients through their body wall
  - Organisms that don’t have a gut

MOVING

- Movement
  - Rapid, or directional
- Most animals have the ability to move from
  - Barnacles?
    - They can shake their moneymaker
    - Their larvae swim
- Or they have a rapid movement
  - Venus fly trap?
    - Rapid closing to catch flies
- As you can see, this definition is a tad subjective

OTHER CHARACTERISTICS OF ANIMALS

- They are by definition, multicellular eukaryotes
  - Unicellular heterotrophs are among the
- They lack cell walls
  - An extracellular matrix is deposited as in connective tissue
  - Cells are connected through various junctions
- Unique tissue types – related to moving “fast”
  - Nervous tissue
    - Conduct electrical impulses
    - Cognition
    - Control muscles
    - Sensory input
  - Muscle tissue
    - Contractile

ANIMAL DIVERSITY

- For convenience, there are two large groups of animals we will talk about:
- Invertebrates
- Vertebrates
- Over 1.5 million described species of animals
  - Over 1 million insects alone
  - Probably well over 10 million species exist!

ANIMAL PHYLOGENY

- This traditional phylogenetic tree is based on the body plan features shared by animal taxa
- Various morphological traits are used:
  - Are there true tissues?
    - Yes or No
    - How many layers?
      - 2 or 3
  - Type of body symmetry?
    - None
    - Radial
    - Bilateral
  - Is there a body cavity?
    - Acoelomate
    - Pseudocoelomate
    - Eucoelomate
  - What type of development?
    - Protostome
    - Deuterostome

ARE TISSUES PRESENT?

- What is a tissue?
  - Defined as a group of cells that work together to perform a specific task
  - If one or a few cells are removed:
    - They cannot perform their task
    - They will eventually die (usually)
- Two major groups of animals
  - Parazoa (*beside animal*)
    - No true tissues
  - Eumetazoa (*truly among animal*)
    - True tissues

HOW MANY TISSUE LAYERS?

- Organisms with true tissues may have 2 or 3 tissue layers
- The first animals formed by the invagination of a hollow ball of cells instantly created 2 tissue layers
  - This is called the diploblastic condition
    - Ectoderm on the outside
    - Endoderm on the inside
- Organisms with true tissues (Eumetazoa) may have two or three layers of tissue
- Cnidarians are the only diploblastic phylum we will look at
- In the remainder of the organisms, a third tissue layer is present
  - This is the triploblastic condition
    - Endoderm
    - Ectoderm
    - Mesoderm forms between

WHAT TYPE OF BODY SYMMETRY?

- What does symmetry tell us about phylogeny?
  - Most sponges are asymmetrical
    - A ‘random’ growth of cells with no plane of symmetry
  - The ancestral eumetazoan character trait is radial symmetry
    - Where there are several planes of symmetry

- The more derived trait is bilateral symmetry – 2 halves
  - These animals can only be cut along a single plane to create two ‘equal’ halves
  - Accompanied by cephalization
- To complicate matters many animals secondarily lose their bilateral symmetry
  - Many molluscs (snails and clams) become semi-asymmetrical
  - Most echinoderms become pentaradially symmetrical
- Radial symmetry
  - Cnidarians
- Bilateral symmetry
  - The rest of the Eumetazoa
- Secondary radial symmetry
  - Echinoderms

IS THERE A BODY CAVITY?

- The body cavity is called the _____
  - The gut is often confused as the body cavity
  - In fact, the coelom is the space _____ the internal organs
- The presence/type of cavity is only looked at in triploblastic animals
- Acoelomate
  - _____
- Pseudocoelomate
  - _____
- Eucoelomate
  - _____
- The benefits of a fluid-filled cavity include:
  - Room for internal organs to expand and move
  - Acts as a hydrostatic skeleton
    - Water is uncompressible, and muscles can work against it

WHAT TYPE OF DEVELOPMENT?

- In animals, the egg and sperm unite to form the _____
  - The only haploid cells are the gametes
  - Called a _____

- The zygote undergoes cleavage to produce more cells
  - Eventually yields a hollow ball of cells or _____
  - Made of a single layer of cells
- _____ – is the rearrangement of the blastula’s cells to form the
  - Establishes the tissue layers in their proper arrangement
  - Creates the primitive digestive tract and the first opening (_____) which has 1 of 2 fates
- Fates of the blastopore include:
  - Formation of the _____
    - Anus forms at a later time
      - (if it does)
    - _____ development (*mouth first*)
  - Formation of the _____
    - Mouth forms later
    - _____ development (*mouth second*)
- Other developmental traits follow the same pattern as the protostome/deuterostome dichotomy
- Protostomes
  - _____ cleavage
  - _____ development
  - Schizocoelous
    - Splitting of solid masses of mesoderm
- Deuterostomes
  - _____ cleavage
  - _____ development
  - Enterocoelous
    - Outpockets from archenteron (primitive gut)

PHYLA

- 30-35 total, depending on who you talk to
- We will only talk about the 9 ‘major’ phyla
- Why do we discuss these and not the others?
  - Features of interest
  - Conspicuousness
  - Importance to humans

PHYLA YOU NEED TO KNOW

- _____ – sponges
- _____ – jellyfish, anemones, corals, hydra
- _____ – planaria, tapeworms, flukes
- _____ – segmented worms
- _____ – snails, slugs, clams, squid, octopus
- _____ – roundworms
- _____ – insects, spiders, crustaceans, etc.
- _____ – sea urchins, sea stars, etc.
- _____ – vertebrates, sea squirts, lancelets

PHYLA YOU DON’T NEED TO KNOW

- These Phyla are mentioned in your text, but you are not responsible for them:
  - Placozoa
  - Brachiopoda
  - Priapula
  - Kinorhyncha
  - Nemertea
  - Cycliophora
  - Rotifera
  - Acanthocephala
  - Tardigrada
  - Ectoprocta
  - Ctenophora
  - Onychophora
  - Phoronida
  - Loricifera
  - Hemichordata

PHYLUM PORIFERA

- Poriferans (sponges) were the first _____ animals to evolve
  - _____ protists (Choanoflagellates) eventually developed specialized cells to perform different functions
- Currently there are 5,500 known species of sponges
  - All are _____ and _____
    - A few (~100) are freshwater, the rest are marine

PORIFERAN BODY PLAN

- Most sponges are _____
  - A few species show _____ symmetry
- Because Poriferans lack true tissues, we categorize them with respect to:
  - Number of tissue layers
  - Body cavity
  - Development pattern

- Sponges have no _____
  - Three layers of cells only
    - Pinacoderm – outside
    - Mesohyl – middle layer
    - Choanoderm – inside
  - Why aren’t these tissues?

PORIFERAN BODY PLAN

- Only a few different types of cells make up the body of a sponge
  - Pincaocytes cover the external surfaces and line the canals
    - _____ and _____ to the substrate
  - Choanocytes line the inside of the sponge
    - Flagellated _____
  - Spongocytes
    - Responsible for secreting the _____
- Each cell is _____, having the ability to become any
  - Useful for asexual reproduction

PHYLUM CNIDARIA

- There are about 10,000 species of Cnidaria
  - All are aquatic and most are marine
- Cnidarians are the first organisms we will look at with true tissues – _____
- _____ – 2 tissue layers
  - Ectoderm (_____)
  - Endoderm (_____)
  - Space between is filled with mesoglea
  - Internal space is the gastrovascular cavity

CNIDARIAN BODY PLAN

- Because Cnidarians are diploblastic, we categorize them with respect to:
  - Presence or type of body cavity
  - Developmental pattern

- There are two basic variations on the cnidarian body plan
- The _____
  - Sessile crawlers (mostly)
  - Mouth - _____
- The _____
  - Mobile, active swimmers
  - Mouth - _____
- Some have life cycles with both variations
- Many Cnidarians live as _____ organisms which feed and _____
  - All members are similar in morphology called _____
- Some colonial organisms have _____ members (zooids)
  - Portuguese man-o-war, Sea pen
  - Some members are specialized for specific jobs
    - Gastrozooid – _____ members
    - Dactylozooid – _____ members
    - Gonozooid – _____ members
- Individual members usually exhibit _____ symmetry
- Members of a colony are _____ produced by

CNIDOCYTES

- The cell that makes a cnidarian a cnidarian
- Specialized stinging cell that works like a harpoon to capture prey items
  - Highly venomous – some more so than a cobra!
  - Paralyzes prey that gets trapped in the tentacles

THE LOPHOTROCHOZOANS

- Phylum Platyhelminthes
- Phylum Annelida
- Phylum Mollusca
- Characteristics of the Lophotrochozoans:
  - Growth by _____
  - May have a _____ – tuft of cilia used in feeding
  - May have a _____ – a larval stage common to members of this group

PHYLUM PLATYHELMINTHES

- A large and diverse phylum with both free-living and parasitic forms in 3 major groups (classes)
  - >20,000 known species
  - Class _____ – free-living flat worms
    - Most are aquatic, both freshwater and marine
  - Class _____ – endoparasitic tape worms
  - Class _____ – ecto- or endoparasitic flukes

PLATYHELMINTH BODY PLAN

- Triploblastic (three tissue layers)
  - Ectoderm
  - Endoderm
  - _____
- They have a solid body construction = _____
- All flat worms exhibit bilateral symmetry
  - Some degree of cephalization
- Protostomous development

PHYLUM MOLLUSCA

- A very diverse and species rich phylum
  - 93,000 species have been described in 4 major classes
  - Class _____ – chitons
  - Class _____ – slugs and snails
  - Class _____ – clams & oysters
  - Class _____ – squid & octopi
- Can be found in all environments marine, freshwater and terrestrial (moist habitats)

MOLLUSCAN BODY PLAN

- _____ protostomes
- _____
  - The body cavity is often very _____ or _____ in many members
  - But one can still see it in the _____

- _____ symmetry
  - May be secondarily _____ in some groups
    - Try to cut a snail or an oyster in ‘half’
- No segmentation or repeating body ‘units’
- All molluscs are variations on a common theme
  - _____
  - _____
  - _____
    - Tissue that produces the shell
  - _____
- A great example of adaptive radiation

MOLLUSCAN MUSCULAR FOOT

- The muscular foot of the Molluscs is used for locomotion
- The form of the foot is modified in each group to meet their own specific needs
  - _____

MOLLUSCAN MANTLE & SHELL

- The mantle is the tissue responsible for _____
- The ancestral shell is thought to be a _____
  - Polyplacophores developed an 8-piece shell for _____
    - The name literally means *bearing many plates* (*shells*)
  - Gastropods have great _____ in their shells
    - Slugs have lost their shell all together
- Bivalves have two shells that _____
- Cephalopods may be _____
  - shelled – _____
  - or have the shell drastically reduced – _____
  - or absent – _____

MOLLUSCAN RADULA

- The radula is the feeding structure of molluscs
  - In chitons and gastropods the radula is like a flexible file/rasp to _____ _____
  - Cephalopods have modified their radula into a beak that is useful for _____ _____
  - Bivalves are filter-feeders and have

PHYLUM ANNELIDA

- The segmented worms with over 16,500 described species in three major classes
  - Class _____ – tube worms
    - Many bristle-like appendages on parapodia
  - Class _____ – leeches
    - Flattened bodies with two suckers
  - Class _____ – earthworms
    - Few bristles without parapodia

ANNELID BODY PLAN

- All are _____ploblastic, _____coelomate _____stomes with bilateral symmetry
- Paired setae (or chaetae) on nearly all segments
  - Can be very _____ bundles on parapodia
  - Or very _____ in the oligochaetes or leeches
- Metameric
  - Many repeating units or segments
  - In many, the segments are all similar – _____
  - Others have segments that are specialized – _____
- Segmented coelom provides a great _____
- Polychaetes
  - Predominantly _____ worms with elaborate appendages called _____ on each segment
    - Used for _____
  - Head contains appendages such as palps or antennae
    - Can be highly modified for filter-feeding in the tube worms

- Oligochaetes
  - Mainly _____ (some freahwater) worms with a ‘smooth’ streamline body ideal for _____
    - _____, but small setae or bristles are used for anchorage
- Hirudinida
  - Dorsoventrally _____
  - Anterior and posterior _____

THE ECDYSOZOANS

- Phylum Nematoda
- Phylum Arthropoda
- Characteristics of the Ecdysozoans:
  - These animals are covered by a _____
  - Growth occurs by _____ or shedding their _____ _____

PHYLUM NEMATODA

- Approximately 25,000 described species
- The most abundant group of the Eumetazoa
  - In terms of _____
  - 90,000 nematodes can be found in a _____
  - Found in all habitats (terrestrial, marine and freshwater)
  - Free-living and _____ forms

NEMATODE BODY PLAN

- _____ploblastic, _____coelomate _____stomes
- All display bilateral symmetry
- Free-living species are generally _____, interstitial worms
- Whereas parasitic species can be _____
  - Micrometers versus meters
    - *Dracunculus* can grow over_____
    - *Ascaris* can get quite large too

- Body is covered by a _____ which is shed periodically for growth – _____
  - A clear, tough but _____, non-living covering
- A unique feature of the nematodes is how their nerves and muscles connect
  - Normally, the _____
  - Nematodes do it the other way around _____ _____

PHYLUM ARTHROPODA

- Well over 1,000,000 species described!
  - By far the most numerous of all phyla

ARTHROPOD BODY PLAN

- _____ploblastic, _____, _____coelomate _____stomes

All arthropods are characterized by:

- External jointed skeleton with _____
  - Arthropoda literally means *jointed legs*
  - _____

PHYLUM ARTHROPODA

- Divided into four major Subphyla
  - Subphylum _____
    - Centipedes & millipedes
  - Subphylum _____
    - Spiders, scorpions, ticks & mites
  - Subphylum _____
    - Flies, beetles, butterflies, …
  - Subphylum _____
    - Crabs, shrimp, lobsters, barnacles

ARTHROPOD BODY PLAN

- Like the annelids, Metameric _____
  - Generally each segment has a _____
  - Tagmatization is the grouping of _____ into body regions
    - _____, _____ and _____
    - _____

- Periodic _____ followed by periods of growth
  - _____ prior to moulting is common

SUBPHYLUM MYRIAPODA

- The centipedes and millipedes
  - 11,600 species are terrestrial
- Both have a _____ body plan with all segments
  - Except for the head region
- Legs are simple and _____
  - Contrary to the popular belief, they do not have 100 or 1000 legs
  - The major difference is the number of legs per segment _____
  - And their cross-sectional shape _____

  ~30 segments × **2** legs/segment = _____

  ~190 segments × **4** legs/segment = _____

SUBPHYLUM CHELICERATA

- The spiders, mites, scorpions and ticks
  - 70,000 describe species are mainly terrestrial
  - A few marine species
- Segments are grouped into 2 common regions or tagmata
  - Anterior _____ – legs & sensory structures
  - Posterior _____ – lacks appendages
    - (except for spinnerets)
- One pair of appendages near the mouth is common to this subphylum
  - The _____
- 4 pairs of walking legs, no antennae
  - Simple unbranched appendages

SUBPHYLUM HEXAPODA

- The beetles, butterflies, flies, bees, etc
- Over 1,000,000 described species!
  - Dominate terrestrial environments, but many are aquatic at some stage

- Three tagmata
  - _____ – 5 segments most with a pair of appendages
  - _____ – 3 segments each with a pair of legs and sometimes wings on 1 or 2
  - _____ – up to 11 segments
- Order Coleoptera – the Beetles
  - 2 pairs of wings – one hardened
  - Mouthparts designed for biting & chewing
- Order Lepidoptera – the Butterflies
  - 2 pairs of scaly wings
  - Mouthparts for fluid feeding
- Order Hymenoptera – the Bees & Wasps & Ants
  - Very social insects
  - 2 pairs of wings
  - Chewing or sucking mouthparts
- Order Diptera – the Flies
  - 1 pair of wings – one pair of halteres
  - Mouthparts for sucking fluid
    or piercing/biting

SUBPHYLUM CRUSTACEA

- The crabs, lobsters, shrimp, copepods, barnacles
- 67,000 described species
  - Predominantly _____ with a few terrestrial species
- Body divided into
  - Cephalothorax – 5 ‘head’ + 5 ‘thorax’ segments
    - Each with a pair of generally _____ (_____) appendages
    - Head with several (2+) pairs of antennae
    - Often covered by a hard carapace which may extend forward as the rostrum

  Abdomen – _____

THE DEUTEROSTOMES

- Phylum Echinodermata
- Phylum Chordata
- Characteristics of the deuterostomes:
  - The blastopore is destined to become the
  - Cleavage = _____
  - Development = _____
  - Coelom formation = _____

PHYLUM ECHINODERMATA

- Approximately 7,000 species
  - All are marine
- Divided into 5 major classes
  - Class Crinoidea – the feather stars
  - Class _____ – the sea stars
  - Class Ophiroidea – the brittle & basket stars
  - Class _____ – the sea urchins
  - Class _____ – the sea cucumbers

ECHINODERM BODY PLAN

- _____ symmetry with no cephalization
  - Secondary as they start out _____
  - Except for the Holothuroidea (sea cucumbers)
- Bodies are arranged on the _____ axis
  - Again, a slight modification for the sea cucumbers
- All have a unique multi-purpose system, the water vascular system with tube feet
  - _____
  - _____
  - _____
  - _____
- An adaptation of their _____
- All have a calcareous _____ of several plates or ossicles
  - Reduced to microscopic _____ in the sea cucumbers

- Echinoderms are highly capable of _____
  - Any arm with a piece of the central disc can _____
- Sea cucumbers can _____ when under duress
  - They will then _____

PHYLUM CHORDATA

- Approximately 52,000 described species
  - Found in all habitats
- Divided into 3 major subphyla
  - Subphylum _____
  - Subphylum _____
  - Subphylum _____
- Characteristics of the Chordates
  - _____
    - The central nervous system
  - _____
    - Support for some, replaced in others
  - _____
    - Wags when you’re happy
  - _____

PHARYNGEAL GILL SLITS

- The pharyngeal arches become highly modified in the more derived chordates
  - Ancestrally used for _____ & _____
  - In fish they form _____ and the _____
  - In terrestrial chordates they form the _____

SUBPHYLUM UROCHORDATA

- Notochord and arches are only present during the _____
- As adults, they look more like cnidarians than chordates
- Most are filter-feeders, but one is an active predator

SUBPHYLUM CEPHALOCHORDATA

- Small, fish-like animals
- Only 25 species have been described
- Filter-feeders, catching food in their 100+ gill arches
- Believed to be the first chordates on the scene
  - Fossils found in the Burgess Shale and Chengjiang deposits

SUBPHYLUM VERTEBRATA

- The first vertebrates to evolve were fish
  - These fish were _____ and had a skeleton made of _____
  - Hagfish, lampreys
- Modification of the pharyngeal arches into _____
  - Sharks and rays
- _____ of the skeleton
  - Boney fish
- Fins became _____ and useful for ‘walking’
  - *Coelacanth* thought to be extinct
  - *Tiktaalik roseae* as a missing link
- Movement to land
  - Amphibians can breath air but still require water for reproduction
- Independence from water gained
  - Reptiles evolved an _____ egg and are no longer dependent on water
- Reptilian scales modified into _____
  - Dinosaurs take flight and evolve into birds
- Other reptilian scales evolve into _____
  - Enter the first egg-laying mammals
- Evolution of the placenta and gestation
  - _____
  - _____

TRADITIONAL PHYLOGENY

Animals were traditionally grouped into taxa using the following:

- Anatomical features
  - True tissues
  - Body symmetry
  - etc.
- Developmental or embryological characters
  - Fate of the blastopore
  - etc.

- The likely sequence of evolutionary events in this school of thought would be:
  - Choanoflagellates (_____) became multicellular and evolved into _____
  - True tissues and radial symmetry evolved _____
  - Bilateral symmetry accompanied by cephalization
  - Three major groups of body cavities
    - Acoelomate
    - Pseudocoelomate
    - Eucoelomate
  - Segmentation evolved independently in both protostomes and deuterostomes
- Recall the idea of parsimony
- The idea that the _____ hypothesis consistent with the comparative data must be the _____ one
  - Occam’s Razor
  - The fewest steps from point A to B

MOLECULAR PHYLOGENIES

- With the development of new technologies comes a new data set for comparison – _____
  - DNA and rRNA sequencing
- _____ hypotheses had to be developed in order to include this new data

- Points of agreement between the two schools:
  - The _____ – _____ dichotomy
  - The _____ – _____ dichotomy
  - The _____ – _____ dichotomy
- Points of disagreement:
- Traditional view:
  - Molluscs, Annelids & Arthropods were grouped based on a _____
  - Annelids & Arthropods were grouped based on _____
  - Nematodes are in a group of _____
  - Acoelomate flatworms were considered _____
- This explanation was parsimonious with the data at the time
- Molecular view:
  - Platyhelminths, Annelids & Molluscs are more related and grouped together as the _____
  - Nematodes & Arthropods are more related and grouped as the _____
- This data suggests that _____ of the true coelom in round worms and flatworms was actually _____, not ancestral
- Support from other data
  - The _____ larva shared by Molluscs and Annelids
  - Both Nematodes and Arthropods have a hard external cuticle
    - _____ is required to allow growth