Diversity of Invertebrate Animals

Classification
• Dependent on physical, physiological and behavioral characteristics

Single-celled Organisms
• Single-celled (protozoans – animal-like protists) vs multicellular animals
• Single-celled organism must carry on all functions of the animal individually including feeding, reproduction and locomotion
  – Asexual reproduction is typical

Phylum Foraminifera
• Foraminiferans (shelled amoebae)
• Shell composed of CaC0₃ or cemented sand grains
• Typically benthic, some planktonic
• Have pseudopodia for feeding (trapping and conveying of food) and locomotion (unless attached)
• Contribute to geologic limestone and chalk

Foraminiferans (graphic)

Phylum Polycystina
• Radiolarians
• Shell usually from silica
• Primarily planktonic
• Have pseudopodia for food collection and increased surface area
• Previously foraminiferans and radiolarians together in Phylum Sarcomastigophora

Radiolarians (graphic)
Radiolarians (graphic)

Phylum Ciliophora
• Ciliates
• Have cilia for moving and feeding
• Many parasitic in gills, digestive tract and skin
• Some in sediments or attached to surfaces

Ciliates (graphic)

Multi-cellular Organisms
• Typical of animals though the transition is vague between colonial protozoans and loosely organized multicellular organisms
• Leads to tissue organization, e.g. contractile muscles and conducting nerve tissue; and further to organ systems

More Multi-cellular
• Includes sexual reproduction with meiotic production of haploid sex cells
  – Frequently includes larval stage (distribution for benthic organisms)
• Developmental formation of blastula - process of layering tissue
Requires skeletal support - internal or external

**Kindom Animalia (graphic)**

**Phylum Porifera**

- Sponges – most marine
- Multicellular with minimum of cell specialization
  - Pinacocyte - exterior protection
  - Porocyte (pore cell) – line pores (ostia)
  - Chaonocytes (collar cell) - interior water movement and food collection
  - Amoebocyte - establish the spongin and/or spicule skeleton and distribute nutrients
- Suspension/Filter feeder
  - Water flow in ostia; out osculum

**Sponge Structure**

- Flagella of choanocytes generate water flow

**More Sponge Structure (graphic)**

**Suspension Feeders (graphic)**

**More Porifera**

- Typically benthic
- Support by spongin and/or spicules (silica or calcium carbonate) in intermediate gelatinous layer
- Sexual reproduction with short-lived larval stage
  - Gametes not produced by gonads; derivative of other cells, e.g. choanocytes
- Also asexually reproduce by budding

**Spicules (graphic)**

**Sexual Reproduction (graphic)**

**Sponge Cell Plasticity (graphic)**

**Any Relationship? (graphic)**

**Symmetry**

- Radial vs. bilateral
- Some Porifera are radial, others not
- Phylum Cnidaria are the largest group that highlight radial symmetry
  - Class Hydrozoa - hydroids and man-of-war (colonies are not radial...individual specialization of responsibility)
  - Class Scyphozoa and Cubozoa - jellyfishes
  - Class Anthozoa - corals and anemones

**Examples of Symmetry (graphic)**

**Phylum Cnidaria**

- Or Coelenterata
- Usually have both medusa & polyp stages
- Sexual and asexual reproduction
• Blind-ended gut with oral and aboral surface
• Mouth surrounded by tentacles with nematocyts
• Nerve net controls movement
  – Some with simple sense, e.g. statocyst

**Medusa and Polyp Stages (graphic)**

**Class Hydrozoa (graphic)**

**Class Hydrozoa**
• Siphonophores – detached, drifting colonial forms

**Siphonophore (graphic)**

**Class Scyphozoa (graphic)**

**Class Cubozoa (graphic)**

**Class Anthozoa (graphic)**

**More Symmetry**
• Phylum Ctenophora also radial symmetry (all marine and usually planktonic)
  – Comb jellies
  – Ctenes – eight bands of cilia
  – Carnivorous plankton feeders
    • No nematocysts, instead colloblasts (sticky)

**Phylum Ctenophora (graphic)**

**Bilateral Symmetry**
• Platyhelminthes and above
• Left and right, front and back
• True body cavity - coelom
• Cephalization and increased development of sensory apparatus
  – Highlighted by the mollusks (cephalopods)
  – Simplest forms are a range of small or microscopic benthic worms (seven phyla)

**Phylum Platyhelminthes**
• Flatworms
• Presence of simple organs
  – Including nervous system and small brain to control muscle movement
• Third layer of tissue replaces gelatinous layer – mesoderm
• Free living types are turbellarians, but many are parasitic
• Hermaphroditic, but many can reproduce by budding too

**Platyhelminthes (graphic)**

**Phylum Mollusca**
• Complete digestive tract with mouth and anus
  – Chitinous radula (absent in bivalves) and digestive enzymes
• Open circulatory system except in cephalopods
• Trend toward more centralized nervous system
• Variation in reproduction but usually separate sexes
Class Polyplacophora (graphic)
Class Gastropoda (graphic)
Class Bivalvia (graphic)
Class Cephalopoda (graphic)

More Bilateral Symmetry

• Skeleton - external, hydrostatic (two layers of muscle), internal
  – Hydrostatic skeleton based on two layers of muscle surrounding a space - sipuncula (peanut worms) - all marine, benthic and usually intertidal

• Segmentation (Annelida and above)

Phylum Annelida

• Polychaetes
  – 10,000 in class, most marine
  – Parapodia with setae
    • Gills on parapodia
  – Closed circulatory system
  – Some are deposit feeders, some filter feeders

Class Polyclaeta (graphic)
Deposit Feeders (graphic)
Class Polychaeta (graphic)

Even More Bilateral

– Arthropods
  • Class Insecta - few related to marine environment
  • Class Merostomata - Horseshoe crab
  • Subphylum Crustacea - two pairs of antennae and gills (barnacles, crabs, shrimps, lobsters)
    – Subclass Copeopoda

Phylum Arthropoda

• Evident segmentation
• Exoskeleton made of chitin – molting
• Developed sensory function
• Complete digestive tract
• Open circulation

Subphylum Crustacea (graphic)
Subphylum Crustacea (graphic)
Subclass Copepoda (graphic)

Still More Bilateral Symmetry

– Echinoderms secondarily radial (pentaradial or pentamerous)
  • Class Echinoidea - sea urchins and sand dollars
  • Class Crinoidea - seal lilies
  • Class Ophiuroidea - brittle stars
  • Class Holothuroidea - sea cucumbers
  • Class Asteroidea - starfishes

Phylum Echinodermata
• Much more advanced than other radial animals
• Endoskeleton (even sea urchins – test)
• Complete digestive tract (except brittle stars)
• Tube feet system for locomotion, respiration, excretion and sensation
• Larval forms that are bilateral
• Usually separate sexes
• Some capable of regeneration

**Phylum Echinodermata (graphic)**

Echinodermata (graphic)

**Phylum Chordata**

• Notochord, hollow dorsal nerve cord, pharyngeal arches, and post-anal tail
  – Subphylum Urochordata (tunicates)- sea squirts and salps
  – Subphylum Cephalochordata - lancelet (*Branchistoma*)
  – Subphylum Vertebrata - spinal column (with hollow nerve tube) replaces notochord, pharyngeal pouches, sensory structures and brain

**Sponge Look-alike? (graphic)**

**Overview of Invertebrates (graphic)**