Animal Body Plans

- Aggregate
- Blind sac
- Tube-within-a-tube
- Segmented
- Molluscan
- Arthropod

- Sponges
- Cnidaria, Ctenophora, Platyhelminthes
- Acoelomate - Eucoelomate
- Annelid
- Mollusca
- Arthropoda

Constraints Imposed by Animal Body Plans

- Size
- Exchange of substances with the environment (diffusion, separation of alimentary and excretory pores)
- Movement/Locomotion
- Feeding and Foraging
- Habitat/Environment

Physical laws constrain animal form

- Physical requirements constrain what natural selection can “invent,” including the size of single cells.
  - This prevents an amoeba the size of a pro wrestler engulfing your legs when wading into a murky lake.
  - An amoeba the size of a human could never move materials across its membrane fast enough to satisfy such a large blob of cytoplasm.
  - In this example, a physical law - the math of surface-to-volume relations - limits the evolution of an organism’s form.
Body size and shape affect interactions with the environment

- An animal’s size and shape have a direct effect on how the animal exchanges energy and materials with its surroundings.
  - As a requirement for maintaining the fluid integrity of the plasma membrane of its cells, an animal’s body must be arranged so that all of its living cells are bathed in an aqueous medium.
  - Exchange with the environment occurs as dissolved substances diffuse and are transported across the plasma membranes between the cells and their aqueous surroundings.

For example, a single-celled protist living in water has a sufficient surface area of plasma membrane to service its entire volume because it is so small.
  - A large cell has less surface area relative to its volume than a smaller cell of the same shape.
  - These considerations place a physical constraint on cell size.

Aggregate Body Plans

- Porifera (Sponges) (9000 species mostly marine, 100 species in fresh water)

Sponges are sessile with porous bodies

- The germ layers of sponges are loose federations of cells, which are not really tissues because the cells are relatively unspecialized.
- Sponges are sessile animals that lack nerves or muscles. Individual cells sense and react to changes in the environment.
- The body of a simple sponge resembles a sac perforated with holes.
  - Water is drawn through the pores into a central cavity, the spongocoel, and flows out through a larger opening, the osculum.
• Nearly all sponges are suspension feeders, collecting food particles from water passing through food-trapping equipment.
  – Flagellated choanocytes, or collar cells, line the spongocoel (internal water chambers) create a flow of water through the sponge with their flagella, and trap food with their collars.

• The body of a sponge consists of two cell layers separated by a gelatinous region, the **mesohyl**.

• Wandering though the mesohyl are amoebocytes.
  – They take up food from water and from choanocytes, digest it, and carry nutrients to other cells.
  – They also secrete tough skeletal fibers within the mesohyl.

  * In some groups of sponges, these fibers are sharp spicules of calcium carbonate or silica.
  * Other sponges produce more flexible fibers from a collagen protein called spongin.
    – We use these pliant, honeycombed skeletons as bath sponges.

**Sponges**

**Constraints Imposed by Aggregate Body Plan**

• Sessile (immobile)
• Size limitation (1 cm to 2 m for Sponges)
• No separation of consumption and excretion
• Little opportunity for specialization of functions
• Restricted to Aquatic/Marine Environment
Blind Sac Body Plans

- Cnidaria (anenomes, jellyfish, corals, hydroids)
- Ctenophora (Comb jellies)
- Platyhelminthes (Flatworms)

Multicellular animals are composed of microscopic cells, each with its own plasma membrane that acts as a loading and unloading platform for a modest volume of cytoplasm.

- This only works if all the cells of the animal have access to a suitable aqueous environment.
- For example, a hydra, built on the blind sac plan, has a body wall only two cell layers thick.
- Because its gastrovascular cavity opens to the exterior, both outer and inner layers of cells are bathed in water.

Phylum Cnidaria: radial symmetry and a gastrovascular cavity

- The cnidarians (hydras, jellies, sea anemones, and coral animals) have a relatively simple body construction.
- They are a diverse group with over 10,000 living species, most of which are marine.
- The basic cnidarian body plan is a sac with a central digestive compartment, the gastrovascular cavity.

This basic body plan has two variations: the sessile polyp and the floating medusa.

- The cylindrical polyps, such as hydras and sea anemones, adhere to the substratum by the aboral end and extend their tentacles, waiting for prey.
- Medusas (also called jellies) are flattened, mouth-down versions of polyps that move by drifting passively and by contacting their bell-shaped bodies.
• Muscles and nerves exist in their simplest forms in cnidarians.
• Cells of the epidermis and gastrodermis have bundles of microfilaments arranged into contractile fibers.
  – True muscle tissue appears first in triploblastic animals.
  – When the animal closes its mouth, the gastrovascular cavity acts as a hydrostatic skeleton against which the contractile cells can work.
• Movements are controlled by a noncentralized nerve net associated with simple sensory receptors that are distributed radially around the body.

The three cnidarian classes show variations on the same body theme of polyp and medusa.

Corals, Anenomes, Hydroids and Jelly Fish - Phylum Cnidaria

Phylum Ctenophora: Comb jellies possess rows of ciliary plates

• Comb jellies, or ctenophores, superficially resemble cnidarian medusas.
  – However, the relationship between phyla is uncertain.
• All of the approximately 100 species are marine.
• Some species are spherical or ovoid, others are elongate and ribbonlike.
• *Ctenophora* means “comb-bearer” and these animals are named for their eight rows of comblike plates composed of fused cilia.
• Most comb jellies have a pair of long retractable tentacles.
  – These tentacles are armed with adhesive structures (*colloblasts*) that secrete a sticky thread to capture their food.

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**Comb Jellies – Phylum Ctenophora**

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• Another way to maximize exposure to the surrounding medium is to have a flat body.
  – For instance, a tapeworm may be several meters long, but because it is very thin, most of its cells are bathed in the intestinal fluid of the worm’s vertebrate host, from which it obtains nutrients.
• While two-layered sacs and flat shapes are designs that put a large surface area in contact with the environment, these solutions do not lead to much complexity in internal organization.

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• Planarians and other flatworms lack organs specialized for gas exchange and circulation.
  – Their flat shape places all cells close to the surrounding water and fine branching of the digestive system distributes food throughout the animal.
  – Nitrogenous wastes are removed by diffusion and simple ciliated flame cells help maintain osmotic balance.
• Planarians move using cilia on the ventral epidermis, gliding along a film of mucus they secrete.
  – Some turbellarians use muscles for undulatory swimming.

**Flatworms**  
*(Phylum Platyhelminthes)*

- *Pseudoceros bimarginatus*
- *Thysanozoon sp*

**Constraints Imposed by Blind Sac Body Plans**

- Size
- Limited locomotion
- No Separation of Consumption and Excretion
- Restricted to Aquatic or Marine environment, or as an internal parasite of terrestrial animals

**Tube within a tube Body Plans**

- Acoelomate
- Pseudocoelomate
- Coelomate
Advantages of Tube within a Tube Body Plans

- Separation of feeding and excretory pores
- Specialization of tissues for different functions
- Development of true muscle tissue permitting greater movement

Segmented Body Plans

- Annelida
- Arthropoda

The coelom of the earthworm, a typical annelid, is partitioned by septa, but the digestive tract, longitudinal blood vessels, and nerve cords penetrate the septa and run the animal's length.

Support Systems & Size

The significance of support systems

- Strengthening and structural support
  - In water: Water is a very supportive medium but can also exert great pressure (eg waves, currents)
  - On land: Animals out of water need a support structure to counteract the force of gravity
- Muscle action and movement
  - Muscles only do work by contracting, so they must have something to act against
- Functional integrity
  - Some structures require support to function correctly and efficiently (eg gills)
- Protection from predators
  - Support structures may hinder or deter attacks by predators
- Large animals lacking a support structure can be very vulnerable (and few exist)

Types of support structures

- Hydrostatic skeletons in Phylum Annelida
- Partial shells in Phylum Mollusca
- Complete shells in Phylum Echinodermata
Evolution of the Exoskeleton

- Calcareous or chitinous plates that provide protection and rigid structure against muscles can do work
- Mollusca – Calcium carbonate
- Arthropoda - Chitin
The diversity and success of **arthropods** is largely due to three features: body segmentation, a hard exoskeleton, and jointed appendages.

Groups of segments and their appendages have become specialized for a variety of functions, permitting efficient division of labor among regions.

**Echinoderm Body Plan**
- Radially Symmetrical (pentameric)
- Endoskeleton (calcium carbonate)
- Slow moving, bottom dwelling
Phylum – Echinodermata (starfish, urchins, sea cucumbers, crinoids, sand dollars, sea biscuits, etc.)