Metazoans

The diversity seen among the unicellular protozoa is a product of their various subcellular structures and organelles. In contrast, the complexity of **metazoans** or **multicellular animals** is due to the evolution of cells working together to form larger units each dedicated to a specific function necessary for the survival of the entire animal. Metazoan cells cannot survive on their own outside of the whole organism (except in cell culture with lots of feeding and maintenance by biologists). The simplest metazoans such as the sponges are collections of cells that show some division of labor, but less distinction in the tasks of specific cells seen in more complex metazoans. Animals that have true tissues possess cells that work together as a highly coordinated unit. In most animals, these tissues are further organized into organs. Metazoans are part of the **opisthokont** lineage (the eukaryotic clade that has a single posterior flagellum, if a flagellum is present) along with the fungi, choanoflagellates and microsporidians. **Microsporidians** are protozoan parasites living inside the cells of many animals including humans. **Choanoflagellates** are solitary and colonial protozoans in which each cell has a flagellum surrounded by a collar of microvilli.

Choanoflagellates closely resemble the feeding cells (**choanocytes**) seen in sponges. Sponges are basically aggregations of cells held together by an extracellular matrix. Biologists are currently studying the cell-to-cell interactions and signaling mechanisms that lead to colony formation in choanoflagellates in order to better understand the evolution of the first simple multicellular animals. See text page 240 regarding the **syncytical ciliate hypothesis** and the **colonial flagellate hypothesis**.

syncytical ciliate hypothesis = metazoans arose from an ancestor shared with single-celled ciliates. The common ancestors is thought to have acquired multiple cell nuclei within a single cell membrane that later became compartmentalized to form multiple cells. The assumption is that these were similar to modern ciliates and tended toward bilateral symmetry. This hypothesis tends to ignore the embryology of other forms especially flatworms and cannot easily explain the presence of flagellated sperm in metazoans. This hypothesis implies that radial symmetry is derived from an early type of bilateral symmetry.

colonial flagellate hypothesis = proposed by Ernst Haeckel in 1874 (who popularized Darwin's work in Germany), this theory is probably more widely supported. Metazoans descended from a hollow, spherical colony of flagellated cells in which individual cells within the colony became functionally different for various roles (feeding, reproduction, nerve cells, etc.). Cellular independence was lost as this specialization evolved in order to support the survival of the entire colony. The hypothesis implies that a radially symmetrical (blastula-like) ancestor evolved first. Some biologists believe an ancestral form similar to a gastrula may have existed which could have given rise to the Cnidarians. Bilateral symmetry would have evolved later in this scheme.

Advantages to multicellularity:

- more cell surface area available for metabolic activities and exchanges with the environment
- necessary in order to maintain a useful surface-to-mass ratio (versus increasing the size of a single-celled organisms) and thus increased body size

Phylum Porifera: The Sponges

Average Sizes
- millimeters to meters

Life Span
- highly variable – years?

Symmetry & Body Plan
- **none or radially symmetrical**
- body with pores (**ostia**), canals and chambers that serve as water passageways required for digestion and reproduction
- **asconoid**, **syconoid** and **leuconoid** canal system

Development & Coelom Formation
- no true tissues
- no coelom
- free swimming ciliated larval forms

Type of Skeleton
- **spicules** that are **silicon** based or **calcium carbonate** and/or protein fibers such as **spongin** or collagen

Appendage Types
- none

Basic Form & Function
- **asconoid canal system** = simplest organization with water drawn in by choanocytes through ostia into the spongocoel; water flows out the osculum. Limited surface area contact between choanocytes and water flow limits the ability to collect food.
- **synconoid canal system** = typically larger than asconoid sponges with tubular body plan. Body wall is folded creating radial canals lined with choanocytes so that a greater amount of food particles can be trapped (due to increased surface area).
- **leuconoid canal system** = most complex of sponge types allowing for greatest potential sponge size. Surface area of the flagellated chambers lined with choanocytes is greatly increased to filter most of the water which flows through them. While each chamber is small, there are many of them between the incurrent and excurrent canals.

Specialized Cell Types
- **choanocytes =** flagellated "collar cells" for feeding by phagocytosis or pinocytosis. Trapped food particles are digested within these cells (intracellular digestion).
- **archaeocytes (sclerocytes and spiculocytes) =** ameboid cells that move within the mesohyl for a variety of functions including the secretion of spicules and spongin/collagen fibers.
- **Pinacocytes** = cells that form the pinacoderm (epidermis/"skin") which covers the exterior surface of the sponge. These cells are essentially simple squamous epithelial cells that are flat and thin. Some of these cells have a limited contractile ability.

"Organ Systems"

Integumentary System (skin)
- epidermis of flat pinacyocytes with most interior surfaces lined with choanocytes that create water currents

Muscular System
- none – limited myocyte capability in some pinacocytes

Circulatory System
- none – nutritent/waste removal by diffusion/osmosis/cell transport (phagocytosis/pinocytosis)

Respiratory System (gas exchange)
- none – gas exchange by simple diffusion

Nervous System
- only rudimentary nerve-like cells

Sensory Organs
- none (?)

Digestive System (food/water supply)
- intracellular by diffusion/osmosis/cell transport (phagocytosis & pinocytosis)
- essentially filter feeding system using canal system and choanocytes

Immune System
- none (?)

Excretory System (waste removal)
- none – waste removal by diffusion/osmosis/cell transport

Reproduction
- asexual reproduction regeneration by buds or **gemmules** (freshwater sponges)
- sexual reproduction by eggs and sperm
- most sponges are **monoecious**

Mechanism/Mode of Locomotion
- free swimming ciliated larval forms
- all adults sessile attached to a substratum

Specialized Defenses/Toxin/Poisons
- none (?)

Ecology & Adaptive Radiation
- nearly all marine
- a few freshwater

Social Organization
- none

Communication
- none(?)

Evolution
- origination previous to the Cambrian period (previous to 570 mya)
- early Paleozoic reefs show calcareous sponge-like organisms
- glass sponge evolution increases during the Devonian period
- There is continued discussion/argument of the evolution of the three classes of sponges

Human Relationship/Interaction

- used as food supply and for limited medicinal uses by a few cultures
- bath sponges (loufa) for washing

Thermoregulation

- none

General Poriferan Characteristics

While lacking true tissues, sponges have a cellular level of organization. There is division of labor among their cells, but there are no organs, no systems, no mouth or digestive tract, and only the hints of nervous integration. There are **no germ layers** (ectoderm, mesoderm or endoderm). Adult sponges are all **sessile** in form. Some have no regular form or symmetry; others have a characteristic shape and radial symmetry. They may be either solitary or colonial.

Important characteristics of sponges are their:

- **pores** and **canal systems**
- flagellated sponge feeding cells, called **choanocytes,** which line their cavities and create currents of water
- internal skeletons of **spicules** and/or protein fibers **(spongin).**
- internal cavity **(spongocoel)** that opens to the outside by an **osculum.**
- **most sponges are marine**, but there are a few freshwater species. Freshwater forms are found in small, slimy masses attached to sticks, leaves, or other objects in quiet ponds and streams

Classification of the Phylum Porifera

Class Calcarea Cal-ca're-a (Gr. *calc is)* limy).

- about 700 species
- sponges with spicules of calcium carbonate, needle-shaped or three-rayed or four-rayed
- canal systems: asconoid, syconoid, or leuconoid
- all marine
- examples: *Sycon, Leucosolenia.*

Class Hexactinellida (hex-ak-tin-el'i-da) (Gr. *hex)* six, + *aktis,* ray).

- about 500 species
- sponges with three-dimensional, six-rayed siliceous spicules
- spicules often united to form network
- body often cylindrical or funnel-shaped
- canal systems: syconoid or leuconoid
- all marine, mostly deep water
- examples: *Euplectella* (Venus' flower basket), *Hyalonema.*

Class Demospongiae (de-mo-spun'je-e) (Gr. *demos,* people, + *spongos)* sponge).

- about 7000 species
- sponges with siliceous spicules (not six-rayed), spongin, or both
- canal system: leuconoid
- one family freshwater, all others marine
- examples: *Spongilla* (freshwater sponge), *Spongia,* (commercial bath sponge), *Cliona* (a boring sponge)
- most sponges belong to this class