Chapter 9

Architectural Pattern of an Animal

Levels of Organization in Organismal Complexity

- Zoologists recognize 32 major phyla of living multicellular animals.
- 500 million years ago in the Cambrian, nearly 100 phyla had evolved representing nearly all major modern body plans.
- Major body plans are the result of extensive selection and are a limiting determinant of future adaptational variants.
- Animals share structural complexities that reflect common ancestry.

Hierarchical Organization of Animal Complexity

- More complex grades of metazoan organization permit and promote evolution of large body size.
- Surface-area-to-volume ratios have important consequences for animal respiration, heat, etc.
- Surface area increases are the square of body length; volume is the cube of body length.
- A large animal has less surface area compared to its volume than does a smaller animal.
- Flattening or infolding the body increases surface area, as in flatworms.
- Most animals had to develop internal transport systems to shuttle nutrients, gases and waste products as they became larger.

Complexity and Body Size

- Larger size buffers against environmental fluctuations in temperature, etc.
- Size provides protection against predators and promotes offensive tactics.
- Cost of maintaining body temperature is less per gram of weight in large than in small animals.
- Energy costs of moving a gram of body over a given distance are less for larger animals.

Benefits of Being Large

"Cope's Law of Phyletic Increase" noted that lineages began with small individuals and eventually evolved toward giant forms; it holds for nonflying vertebrates and many invertebrates.
Extracellular Components of the Metazoan Body

- **Body fluids** and extracellular structural elements are noncellular components of metazoan animals.
  - In contrast to intracellular fluids, extracellular fluids are outside the cells.
  - Blood plasma and interstitial fluid are part of the extracellular fluids in open and closed circulatory systems.

- **Architectural Extracellular Structural Elements**
  - Loose connective tissue is well-developed in vertebrates.
  - Cartilage is found in molluscs and chordates.
  - Bone is found in vertebrates.
  - Cuticle is pervasive in arthropods, nematodes, annelids and others.

Fig. 9.3

Types of Tissues

**Histology** is the study of types of tissues.

Epithelial Tissue

- Epithelium is a sheet of cells that covers an internal or external surface.
- It provides outside protection and internal linings, often modified to produce lubricants, hormones or enzymes.
- Simple epithelia are found in all metazoa.

Fig. 9.4

Epithelial Tissue continued;

- Stratified epithelia are restricted to vertebrates.
- All epithelia have an underlying basement membrane.
- Blood vessels never penetrate epithelial tissues.

Fig. 9.5

Types of Epithelial Tissues (Simple)

Types of Epithelial Tissues (Stratified)
Connective Tissue
- Connective tissues are nearly everywhere in the body.
- It is made up of few cells, many extracellular fibers and a ground substance or matrix.
- In vertebrates, there are two types of connective tissue proper.
- Loose connective tissue has fibers and both fixed and wandering cells in a syrupy matrix.
- Dense connective tissues (e.g., ligaments and tendons) are characterized by densely packed fibers.
- Much fibrous tissue is made of protein collagen, the most abundant protein in the animal kingdom.
- Connective tissue also includes blood, lymph, and tissue fluid.
- Cartilage is semirigid connective tissue with closely packed fibers embedded in a gel-like matrix.
- Bone is calcified connective tissue with calcium salts organized around collagen fibers.

Examples of Connective Tissues

Muscular Tissue
- Muscle is the most abundant tissue in most animals.
- Muscle originates from mesoderm.
- The cell is the muscle fiber, specialized for contraction.
- Striated muscles include skeletal and cardiac muscles.
- Smooth muscles lack the alternating bands seen in striated muscle.
- Myofibrils are contractile elements and the unspecialized cytoplasm is sarcoplasm.

Examples of Muscle Tissue

Nervous Tissue
- Nervous tissue receives and conducts impulses.
- Nervous tissue cell types are neurons and neuroglia that support the neurons.

Animal Body Plans

Animal Symmetry
- Spherical symmetry occurs when any plane divides the body into mirrored halves, as in cutting a globe in half.
- Radial symmetry occurs when any plane passing through the longitudinal axis divides the body into mirrored halves, as in cutting a pie; the Cnidaria and Ctenophora are the Radiata.
- Biradial symmetry occurs in an animal that is radial, except for some paired feature that allows only two mirrored halves.
- In bilateral symmetry, an organism can be cut in a sagittal plane into two mirror halves; this usually provides for a head (cephalization), in bilateral animals classified in the Bilateria.
Anterior indicates the head end; the opposite or tail end is posterior.
Dorsal is the back side, and ventral is the front or belly side.
Medial is on the midline of the body; lateral is to the sides.
Distal parts are far from the body; proximal parts are near.

A frontal plane divides the body into dorsal and ventral halves.
A sagittal plane divides an animal into right and left halves.
A transverse plane (or cross section) separates anterior and posterior portions.
In vertebrates, pectoral is the chest region or area supported by the forelegs.
Pelvic refers to the hip region or area supported by the hind legs.

The major evolutionary innovation of Bilateria is the coelom.
The coelom is a fluid-filled space around the gut; it provides a tube-within-a-tube arrangement with greater flexibility.
A coelom provides more space for organs and surface area for exchange.
Worms rely on the coelom for a hydrostatic skeleton to aid in burrowing.

Acoelomate Bilateria
- Acoelomate animals lack a body cavity surrounding the gut.
- Internal regions are filled with mesoderm and a spongy mass of parenchyma from ectodermal cells.
- Sometimes, parenchymal cells are cell bodies of muscle cells.

Pseudocoelomate Bilateria
- Nematodes and some others have a cavity around the gut but it is derived from the blastocoele of the embryo.
- It provides a tube-within-a-tube but it is not derived from mesoderm.
- Unlike a true coelom, the pseudocoelom is derived from the embryonic blastocoele.
- Pseudocoelomates also lack a peritoneum.
**Animal Body Plans**

**Body Cavities**

**Eucoelomate Bilateria**
- A true coelom is lined with mesodermal peritoneum.
- It is formed in one of two methods but both produce a mesodermal peritoneum.
  - **Schizococoelous formation** involves splitting of mesodermal bands that originate from cells in the blastopore region.
  - **Enteroceolous formation** comes from pouches of the archenteron or primitive gut.

**Metamerism (Segmentation)**
- Metamerism is serial repetition of similar body segments.
- Each segment is a metamere or somite.
- True metamerism is found in Annelida, Arthropoda and Chordata; other groups show a superficial segmentation.

**Cephalization**
- Differentiation of the head, or cephalization, is mainly found in bilaterally symmetrical animals.
- Concentrating the sense organs at the head, as well as the mouth, is efficient for sensing and responding to the environment and food.
- Polarity is the gradient in activities between anterior and posterior ends.