INTERPRETING NATURE: A PRIMER FOR UNDERSTANDING NATURAL HISTORY

VOLUME 2 – Kingdom Animalia

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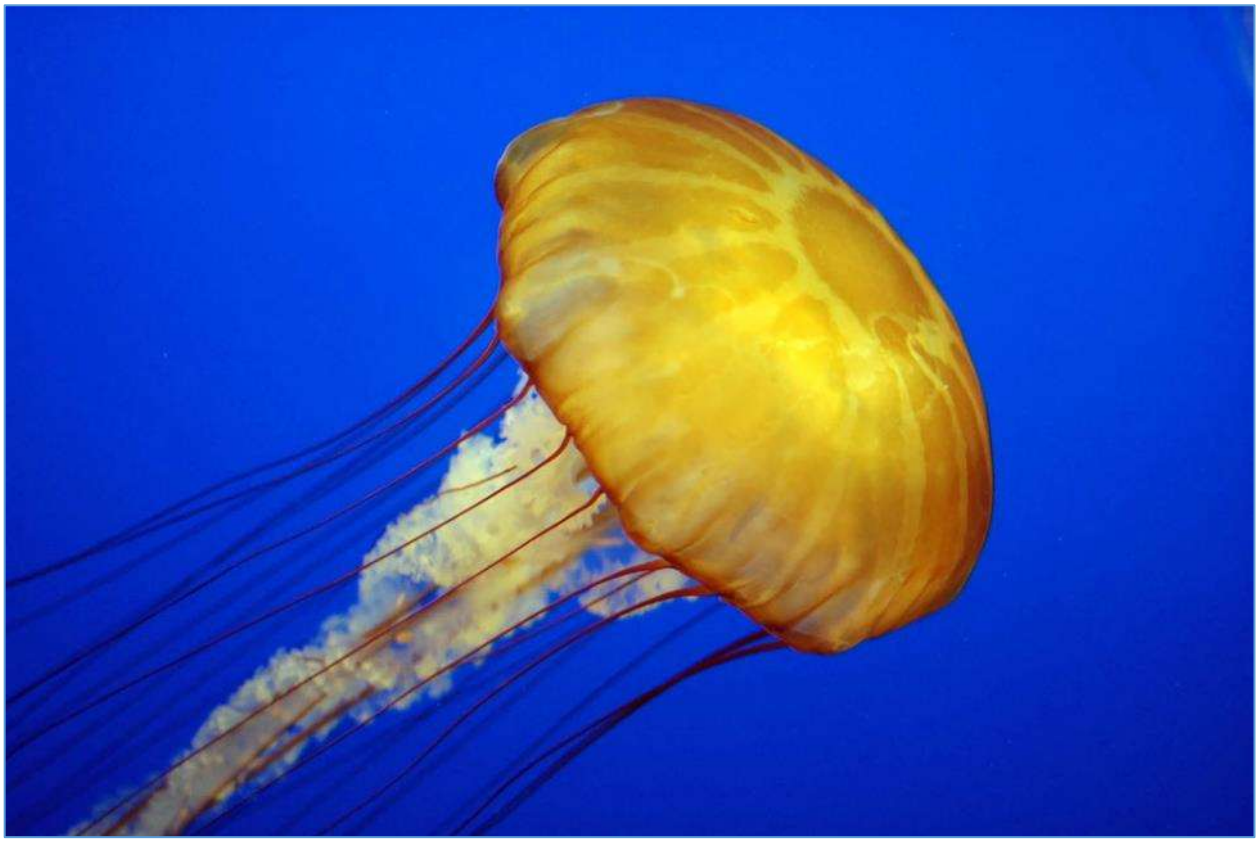
Table of Contents

Koala Bears

Chapter 7 Invertebrate Biology



Pacific Sea Nettle (Chrysaora fuscescens)

LEARNING OUTCOMES

Successful completion of this unit will enable you to:

1. Describe defining features and evolutionary relationships within the Kingdom Animalia.
2. Describe functional diversity in invertebrate animals with respect to circulation, excretion, digestion, reproduction, and support.
3. Apply knowledge of anatomical features to recognize types of invertebrate animals.
4. Identify characteristics of the major invertebrate Phyla and Classes.

Chapter Outline:

- Kingdom Animalia
- Invertebrates
- Phylum Porifera – sponges
- Phylum Cnidaria (Coelenterata)
    - Class Hydrozoa
    - Class Scyphozoa
    - Class Anthozoa
- Phylum Platyhelminthes – flatworms
- Phylum Nematoda – roundworms
- Phylum Rotifera – rotifers
- Phylum Annelida – segmented worms
- Phylum Mollusca – slugs, clams, snails
    - Class Amphineura – chiton
    - Class Gasropoda – snails, slugs, limpets
    - Class Bivalva – clams, oysters, mussels
    - Class Cephalopoda – squids, octopus
- Phylum Arthropoda – animals with exoskeletons and jointed appendages
    - Class Crustacea – crabs, barnacles, shrimp
    - Class Insecta – insects
    - Class Arachnida – spiders, scorpions
    - Class Myriapoda – millipedes, centipedes
- Phylum Echinodermata – starfish, sea urchins
- Bibliography

KINGDOM ANIMALIA

Animals are a diverse group of organisms ranging from the relatively simple undifferentiated sponges to the more advanced vertebrates. They are unique in their capacity to respond to environmental stimuli and as a result, maintain a constant internal environment, a condition known as homeostasis. They possess an elaborate array of organ systems which are not seen in any of the other kingdoms. As a group they are the most viable of all organisms.

All animals are multicellular and differentiated. They are heterotrophic, relying on organic material obtained from other organisms for their nutrition. In general, they ingest their food material rather than absorb it as occurs in fungi. Their cells have no cell walls or chloroplasts.

A key for distinguishing the major groups of animals is provided in Figure 7.2.

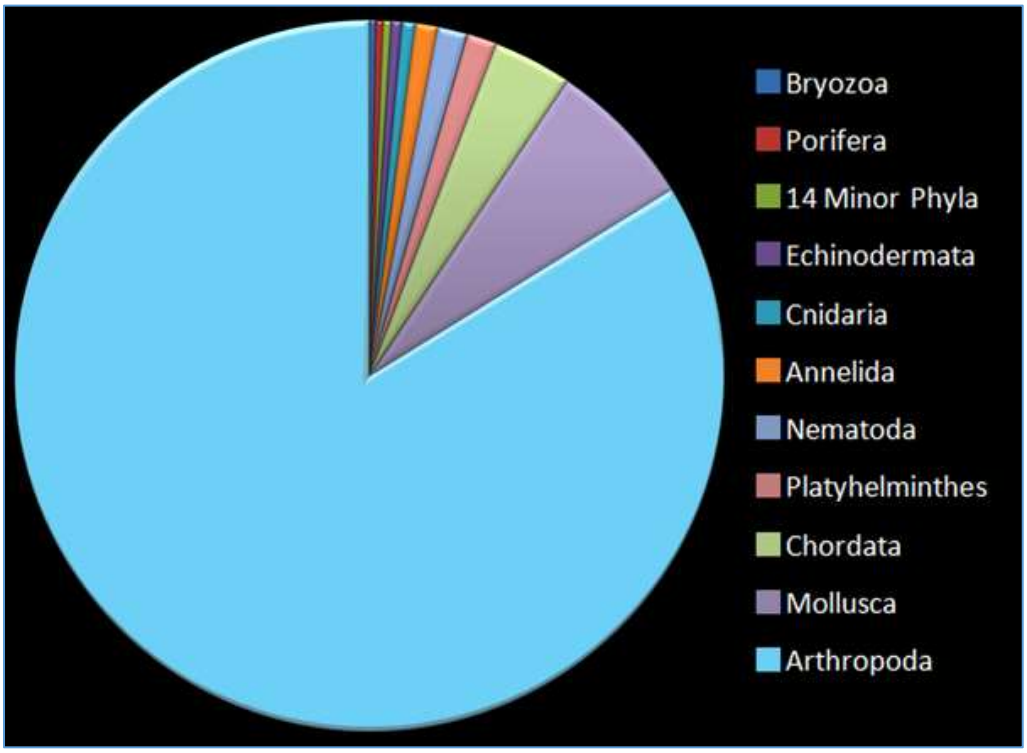


Figure 7.1 Relative number of species in each of the phyla of invertebrates.

Kingdom Animalia Key

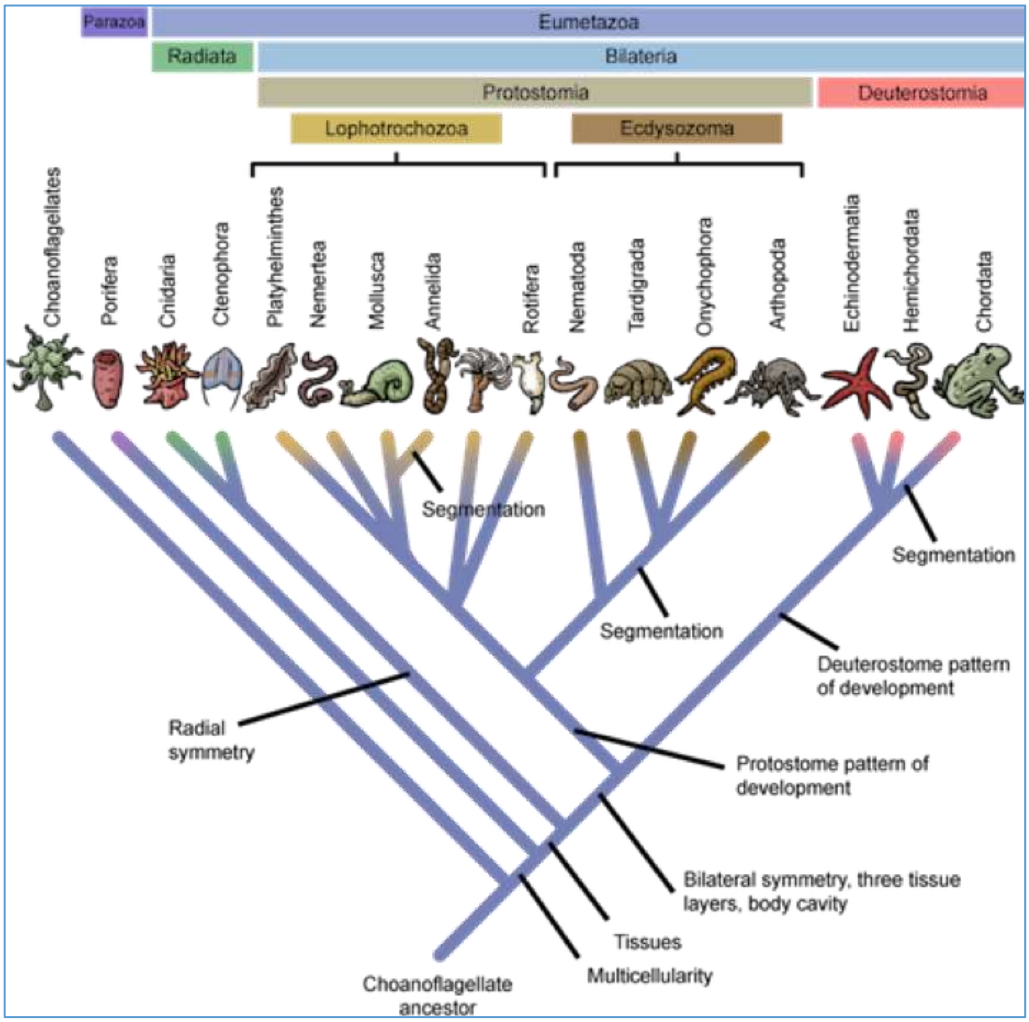


Figure 7.2 Major taxa in the Kingdom Animalia.

Figure 7.3 Examples of invertebrates – sea anemone, earthworm, crab, jellyfish, and snail.

Invertebrates

The invertebrates include many phyla with diverse and numerous species. The major phyla and classes are described in this section to emphasize common characteristics of their members. The detailed information on specific and smaller groups has been left for the field books to provide.

Circulatory System

Some organisms do not require a circulatory system because they are small and thin. Most parts of the body are close to the environment, and materials can diffuse into and out of the organism easily. In unicellular organisms that live in aquatic environments (e.g. *Amoeba*, *Paramecium*), oxygen and nutrients can diffuse into the cell and wastes can diffuse out. Because sponges, cnidarians and flatworms are multicellular, their circulation problems are more complex than unicellular organisms. However, materials only need to pass through a few cell layers at most to service the cells of the body. A circulatory system is still not required. Materials circulate within cells by the process of diffusion or movement of the cytoplasm by the process of Brownian movement.

The processes of diffusion, osmosis, active transport, phagocytosis and pinocytosis are methods by which materials cross cell membranes. Diffusion is the random movement of solute molecules from a more concentrated to a less concentrated area i.e. along a concentration gradient (Figure 7.4). Notice that as one type of molecule (indicated by a dark color) diffuses in one direction, the other type of molecule (indicated by a light color) diffuses in the opposite direction. The result will be an even distribution of both types of molecules in the solution.

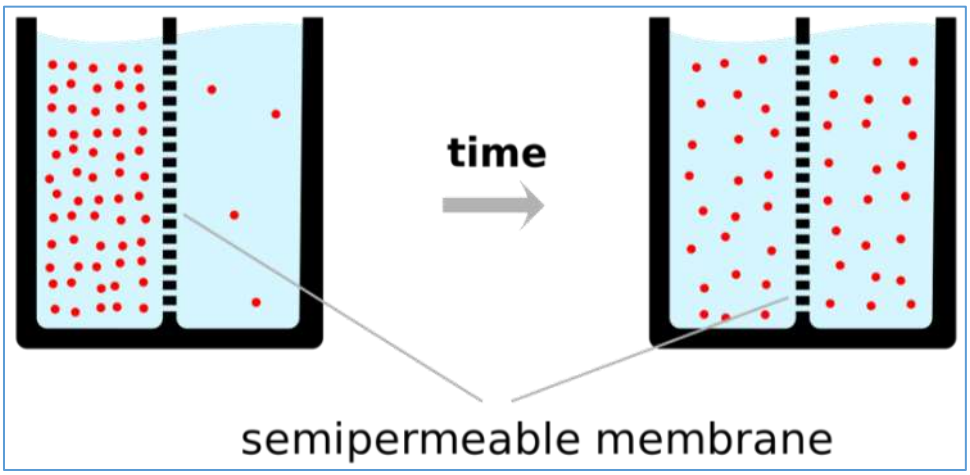


Figure 7.4 Diffusion is the random movement of solute molecules from a more concentrated to a less concentrated area i.e. along a concentration gradient. If a semipermeable membrane is not involved it may lead to a higher concentration of solutes on one side as shown on the left. When the water molecules try to equalize themselves i.e. move to the left, they create osmotic pressure.

Osmosis is the net movement of solvent (usually water) molecules across a selectively permeable membrane from an area of high solvent concentration to an area of low solvent concentration.

With active transport, proteins in the cell membrane move a solute across the cell membrane from an area of low solute concentration to an area of high solute concentration i.e. against a concentration gradient. Cellular energy (ATP) is used. Active transport is involved in maintaining the concentrations of fluids in the body in the kidney, counteracting the impacts of diffusion or osmosis which are occurring passively to maintain homeostsasis.

Phagocytosis or cell eating, involves part of the cell membrane flows around a large particle, or even a whole cell, to form a large pocket in the cell membrane. The pocket pinches off to form a large vesicle, which travels through the cytoplasm. The enclosed material is then digested by enzymes secreted into the vesicle. This is the primary method by which Amoeba and many other single-celled organisms feed but is also one of the methods that monocytes, a type of white blood cell, will kill bacteria or remove foreign material.

Pinocytosis or cell drinking involves part of the cell membrane flows around some extracellular fluid and dissolved solutes to form a pocket in the cell membrane. The pocket pinches off to form a vesicle, which travels through the cytoplasm. The enclosed material then leaves the vesicle by either osmosis or diffusion and enters the cytoplasm.

Large organisms require transport systems involving circulatory fluids to allow every part of the body to exchange nutrients and gases. Circulatory fluids which transport these dissolved or suspended materials are blood and lymph, or a mixture of the two - hemolymph. These fluids transport food, respiratory gases, waste materials and water. In addition to the exchange of nutrients and gases, body fluids are also involved in defence of the body; they carry white blood cells and antibodies which destroy bacteria.

Circulatory systems can be open or closed. Figure 7.5 illustrates the difference between open and closed circulatory systems. In an open circulatory system as is found in an insect, the blood is only partially contained in vessels. For part of the time it flows freely in the body cavity. Blood vessels are only found

in the dorsal or upper part of the insect. Blood is pumped from the anterior or open end of the vessel into the hemocoel where it bathes the tissues. The circulatory fluid in an open system is called hemolymph and it re-enters the chambers of the heart through openings which are guarded by valves.

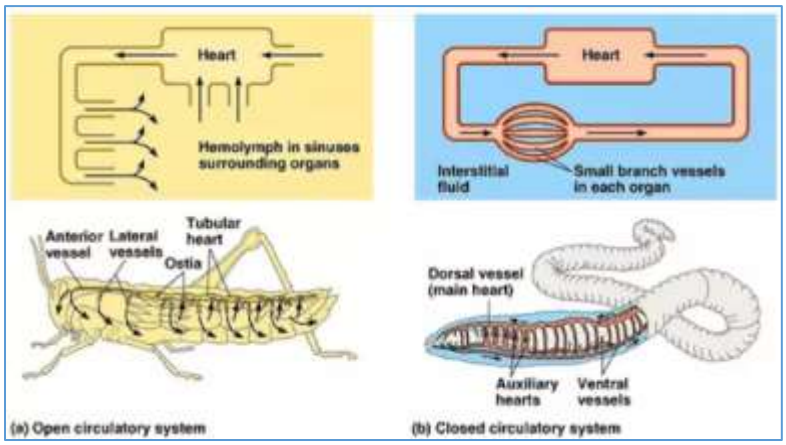


Figure 7.5 Comparison of open versus closed circulatory systems.

Closed circulatory systems are found in the vertebrates and some invertebrates. Blood is always contained in vessels. Blood flows from the heart through an artery, flows through capillaries for the exchange of materials and then flows back to the heart in veins. Tissues are never bathed directly by blood and are only indirectly exposed to the blood. The tissues are bathed in tissue fluid which is collected by the lymphatic vessels that eventually drain into the venous system.

Blood is composed of plasma, cells and platelets. Plasma is the fluid portion of blood. The cells in the blood include white blood cells for defense and red blood cells for gas transport. Platelets are cell fragments involved in clotting of the blood.

Both blood and lymph are required for a closed circulatory system. During circulation, some of the fluid portion of the blood leaves the capillaries and moves into surrounding tissues and is called tissue fluid. This fluid bathes the cells with nutrients and gases. It also collects wastes. Tissue fluid does not return to blood vessels directly. It is collected in a series of lymph vessels in the tissues. These lymph vessels join together to form the lymphatic system. Once the tissue fluid enters the lymph vessels the fluid is called lymph. Tissue fluid is necessary for bathing all the cells of the body and lymphatic tissue is necessary for returning tissue fluids into a series of lymph vessels back to the blood stream. Two large lymphatic ducts which return lymph back to veins are near the heart in the upper thorax. The veins that the lymph drains into are the subclavian veins.

Excretion and the main functions of excretory systems.

Excretion is the process by which living things main their water balance (osmoregulation), and return the waste products of their metabolism to the environment. The most abundant products of metabolism are carbon dioxide, water and ammonia. It is only when these products accumulate to levels in excess of the organism’s needs that they must be excreted.

Excretory systems have three main functions: they are responsible for maintaining the proper concentration of inorganic ions, maintaining the right amount of water in the organism's body to

provide the appropriate environment for metabolic reactions and to remove toxic wastes. An example of a toxic waste is ammonia which is a by-product of amino acid metabolism. Excess ammonia is highly toxic to an organism that does not have access to a lot of water. In animals, an excess of hydrogen ions can be toxic when they lower the pH of the internal environment and alter the organism's metabolic activity.

Osmosis and osmotic pressure are passive processes occurring in isotonic, hypotonic and hypertonic solutions. Osmosis is the movement of a solvent, usually water, through a differentially permeable membrane from a region of lower concentration of solute to that of a higher concentration of solute, thus tending to equalize the concentrations of the two solutions.

Osmotic pressure (of a solution) is a measure of the tendency of water to move by osmosis into the solution. It is a measure of the tendency of the solution to take in water. The greater the difference in concentration of solutions, the greater the osmotic pressure.

When there is a greater solute concentration inside the cell or organism the solution outside the cell is called hypotonic and the cell will gain water by osmosis. In the Figure 7.6, the solute molecules inside a cell in distilled water attract the water molecules from its surrounding environment. In a Hypertonic solution water diffuses out of the cell or organism because there is a lower solute concentration inside the cell. In the Figure 7.6, shows the water inside the cell flowing out. The water is attracted by the greater solute concentration in the surrounding solution so the cell shrivels up.

In isotonic solutions, the solute and water concentrations are the same inside and outside the cell. Water still moves across the membrane but there is no net change. Animals which are hypotonic or hypertonic to their environment have a problem maintaining homeostasis.

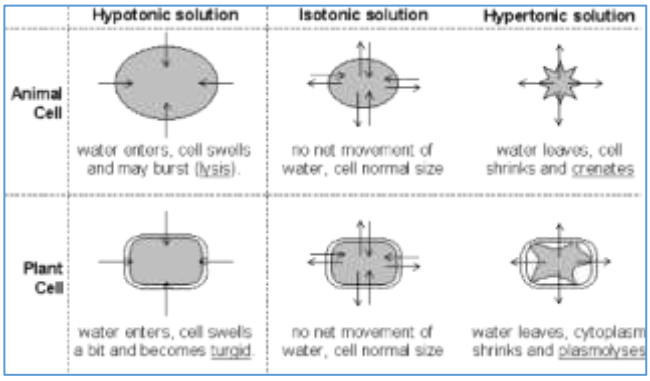


Figure 7.6 Effects of osmosis ion the size and shape of cells (fluid filled sacs) bathed in solutions with different solute concentrations. The arrows represent the direction of water movement.

The osmotic difficulties of fresh water and marine fishes are similar to one another but opposite in direction (Figure 7.7). Freshwater fish are hypertonic to their environment - they gain water osmotically and lose salt to the environment by diffusion. Marine bony fish are hypotonic to their environment and consequently lose water and gain salt.

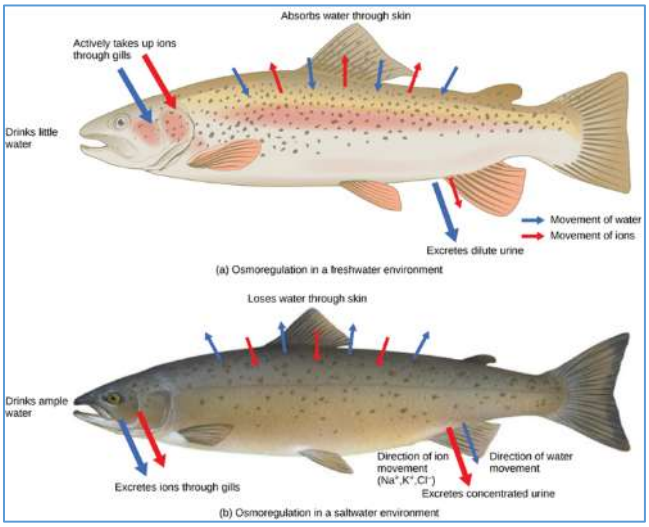


Figure 7.7 Comparison of hypotonic environment (above) where solute concentrations are less outside the fish versus hypertonic environments (below) where solute concentrations are greater outside.

Excretion

The principal waste products generated by metabolic activity in most animals are water, carbon dioxide, and nitrogenous wastes. Carbon dioxide is mainly excreted by gills, lungs or other respiratory surfaces. Nitrogenous wastes and water are excreted by excretory organs such as kidneys. Nitrogenous wastes are excreted in three principal forms: 1) ammonia 2) urea and 3) uric acid (Table 7.1). As shown in the table, the compound that is actually excreted correlates with the habitat and life style of the species. The first nitrogenous waste formed by the deamination of amino acids is ammonia. Ammonia is a highly toxic compound. No organism can survive a significant concentration in their body.

The small highly soluble molecules of ammonia readily diffuse across cell membranes so that there is no difficulty getting rid of ammonia if an adequate supply of water is available. Animals without ready access to water meet the problem of ammonia disposal by converting the ammonia to a less toxic product - either urea or uric acid. Urea is an organic compound made from carbon dioxide and ammonia. To convert ammonia to urea requires specific enzymes and the input of energy by the cells. Urea is far less toxic than ammonia and so can be accumulated in higher concentrations without tissue damage. Urea is fairly soluble in water and is excreted by fish, mammals and amphibians. Uric acid is excreted by animals with an exceptional need to preserve water. This is the least toxic of the three forms of excreted nitrogen and the least soluble in water. Typically, uric acid is excreted as a solid. Organisms which excrete uric acid are all terrestrial and lose very little water in the process. However, they pay a substantial price for this benefit because considerable energy is required to convert ammonia to uric acid.

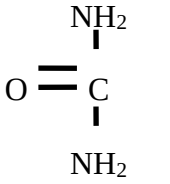
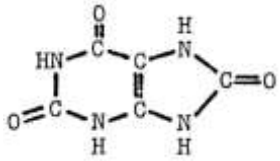
	Ammonia	Urea	Uric Acid
Chemical structure	NH_3		
Origin	breakdown of proteins	built up from NH_3 and CO_2	built up from NH_3, CO_2 and other molecules
Toxicity to tissues	high	medium	low
Solubility in water	excellent	fair	poor
Most common habitat	aquatic	aquatic and terrestrial	terrestrial
Examples of animals	aquatic invertebrates e.g. crabs and worms	fish, mammals, amphibians	birds, reptiles, insects

Table 7.1 The principal forms of nitrogenous wastes excreted are ammonia, urea and uric acid, each of which has its own advantages and disadvantages for animals.

Excretory processes in the following organisms provide a good overview of how invertebrates maintain their water and electrolyte balance: a) Unicellular (both marine and fresh water) b) Flatworm c) Earthworm d) Insect.

Freshwater unicellular organisms. The small size of a unicellular organism results in a large surface area to volume ratio. Therefore, nitrogenous wastes can easily diffuse across cell membranes into the surrounding water. In fact, many single celled organisms require no special excretory structures and rely on the passive processes of diffusion and osmosis for osmoregulation and the disposal of wastes. However, in *Paramecium* which has a large surface area, large amounts of water flow into this unicell from its hypotonic fresh water environment. Protozoans like the paramecium have a special excretory organelle called a contractile vacuole which helps it expel excess water. Each contractile vacuole goes through a regular cycle of filling with fluid and then contracting to expel the water along with any dissolved ammonia.

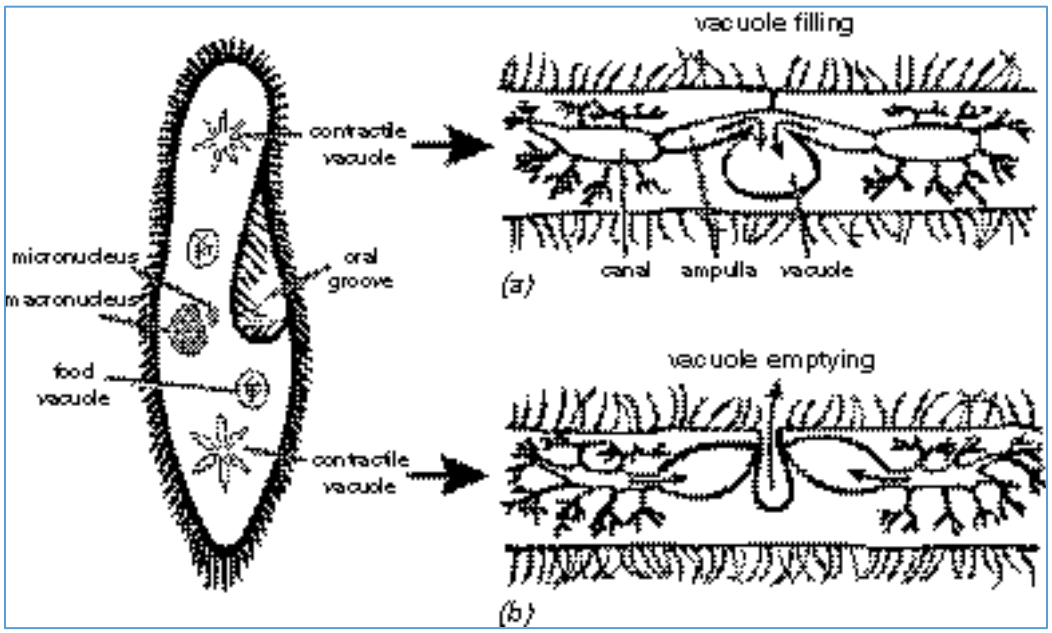


Figure 7.8 Excretion in paramecium. The contractile vacuole of a protozoan, Paramecium. a) the contractile vacuole fills with water from channels called ampullae. At the same time water enters the end canals from tiny tubules spread throughout the organism. b) the vacuole contracts, forcing water out through the pore. Simultaneously the canals contract, moving more water through the ampullae.

Amoeba, like the *Paramecium,* lives in fresh water and also possesses a contractile vacuole. The figure below shows the contractile vacuole expanding until extended, then the vacuole contracts and expels water from the cell body.

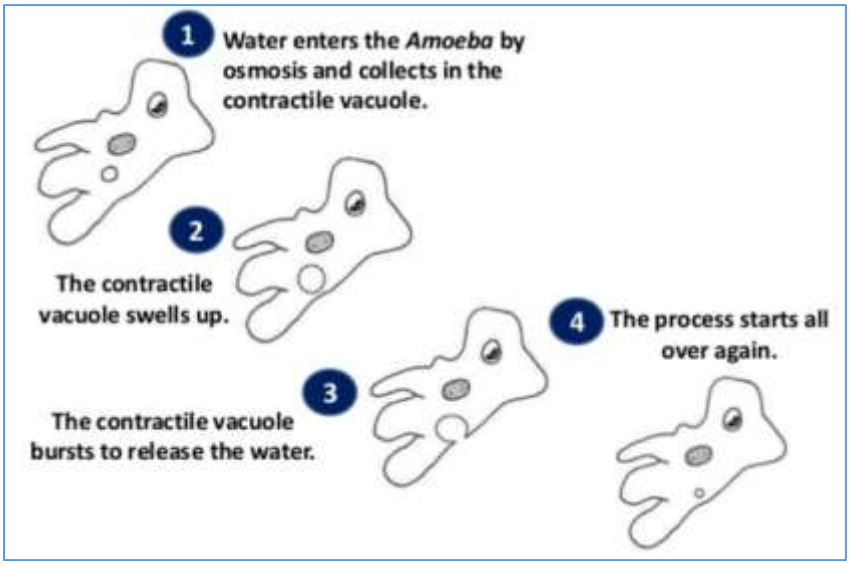


Figure 7.9 Osmoregulation in the Amoeba

Salt water unicellular organisms. Because marine animals live in a hypertonic or isotonic environment they have fewer problems with excess water intake. Contractile vacuoles are less well developed in marine unicells.

The **flatworm** *Planaria* is found in fresh water. Its flattened, leaf-like shape represents a large surface area. This small multicellular organism has a coating of mucus to slow the entry of water, which is drawn osmotically from the hypotonic environment. In addition, Planaria has an excretory system which consists of a network of tubular excretory canals, which open to the outside of the body through pores. Located along the canals are bulb-like flame cells, each having a cluster of beating cilia that are said to look like a flickering flame under the microscope (Figure 7.10). The beating of **f**lame cell cilia propels fluid through the excretory canals and out of the body. The chief role of the flame cell is to regulate the water content. The number of flame cells is adjusted to the salinity of the environment. For example, *Planaria* grown in slightly salty water develop slightly fewer flame cells than those living in fresh water.

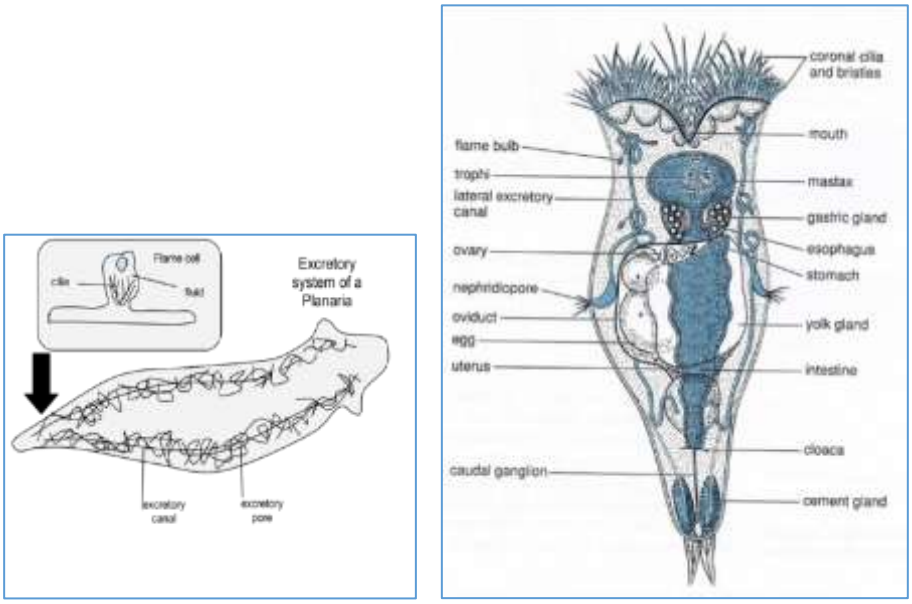


Figure 7.10 Components of the excretory system of a planarian (left) and a rotifer (right) and an enlarged aspect of a single flame cell (left).

Rotifers (small multicellular invertebrates common to most lakes and ponds) use a flame cell system as well. Flame cell systems, because they function in animals without circulatory systems, pick up substances only from tissue fluids.

Earthworms: Annelids have evolved closed circulatory systems. The intimate association of blood vessels and the excretory organs makes possible for a direct exchange of materials between the blood and the excretory system. Earthworms live on land in moist, humid habitats. Their body is composed of a series of segments internally partitioned from each other by membranes (see Figure 7.12). Each segment has its own pair of excretory organs called nephridia which open independently to the outside. A ciliated funnel collects coelomic fluid from the segment in front of the major portion of a nephridia. As the fluid passes along the long looped tubule, wastes are removed from the blood travelling in the capillaries which are wrapped around the tubule. At the same time, salts and substances such as glucose are selectively reabsorbed back into these capillaries. Nitrogenous wastes pass out as urea in large volumes of dilute urine. The earthworm excretes about 60% off its total body weight each day as urine.

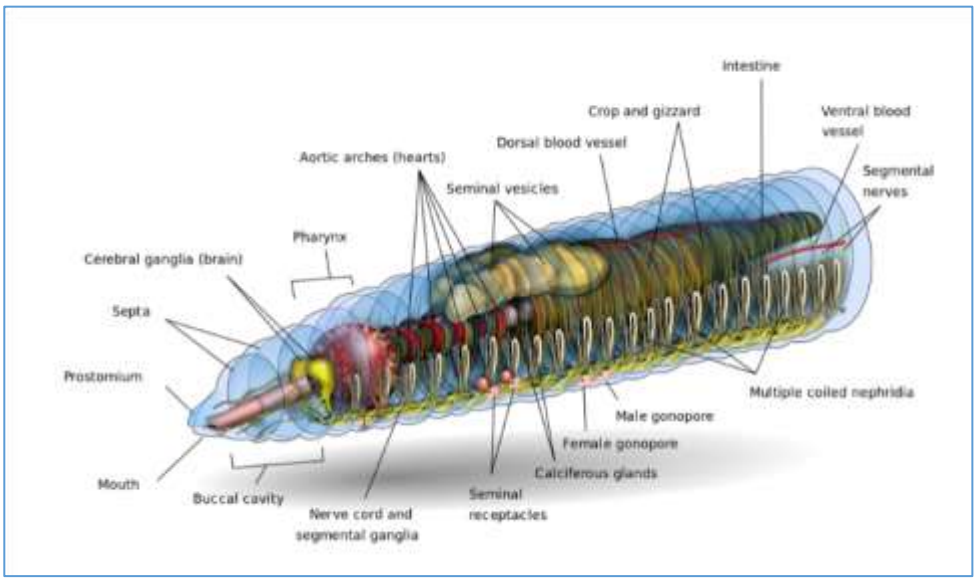


Figure 7.11 Excretion in the earthworm - nephridia.

Insects: Insects possess special excretory organs called Malpighian tubules (see Figure 7.12). This excretory system does not rely on the dilution of nitrogenous wastes with water because insects need to conserve water. These organisms which fly and live in a dry terrestrial environment require a system adapted to water conservation. So, instead of diluting urea in water, nitrogenous wastes in insects are excreted as uric acid which is relatively insoluble in water. The Malpighian tubules are blind sacs, located at the junction of the midgut and hindgut and are bathed directly by the blood in the open sinuses of the animal's body. There may be two to over one hundred of these tubules depending on the species of insect. Fluid is absorbed into the closed end of the Malpighian tubules and the fluid moves to the end of the tubule. Nitrogenous wastes are precipitated as uric acid and much of the water and salts are reabsorbed in the intestine. The remaining fluid waste is passed into the hind gut where it is combined with digestive wastes and then passed into the rectum. The rectum is able to reabsorb large quantities of water and the semi solid uric acid is expelled while water conservation is achieved.

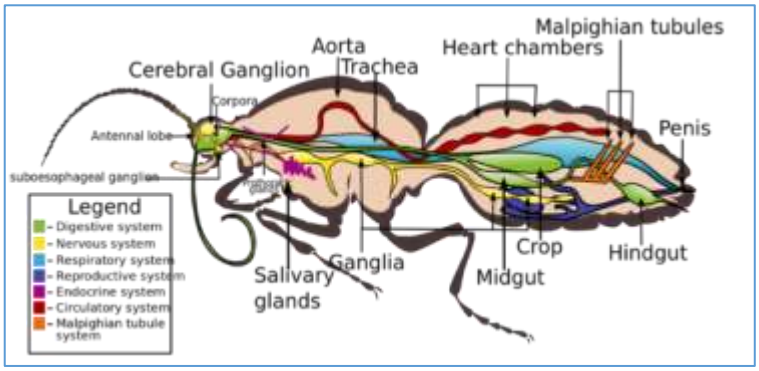


Figure 7.12 Excretion in an insect- Malpighian tubules.

Describe the structure of a nephron and explain how nephrons are arranged in the kidney.

The nephron is the functional unit of the kidney (see Figure 7.13). Each kidney contains about a million nephrons. Each nephron consists of a tubular and a vascular component. The tubular component consists of the glomerular capsule also called the Bowman's capsule, which lies in the cortex of the kidney. The capsule opens into the proximal convoluted tubule which is in the cortex. The word proximal signifies that the Bowman's capsule is the origin of the tubule and convoluted means the tubule is coiled. Where the renal tubule dips into the medulla it is the descending limb of Henle. This structure bends at the loop of Henle and ascends towards the cortex as the ascending limb of Henle. In the cortex, the tubule becomes the distal convoluted tubule. This distal convoluted tubule merges with a straight collecting duct in the medulla. Each collecting duct is attached to distal tubules of several nephrons. The renal artery becomes the intralobular artery which carries blood to the afferent arterioles. One afferent arteriole is distributed to each Bowman's capsule where the arteriole divides into the tangled capillary network, the glomerulus. The Glomerular capillaries reunite to form an efferent arteriole which leads away from the capsule and is smaller in diameter than the afferent arteriole. The afferent to efferent arteriole structure is unique in the body. Blood usually flows out of capillaries into venules not into arterioles. Each efferent arteriole divides to form a network of capillaries, the peritubular capillaries which surround the convoluted tubules. These capillaries reunite to form the intralobular veins which drain into the renal veins and then into the inferior vena cava.

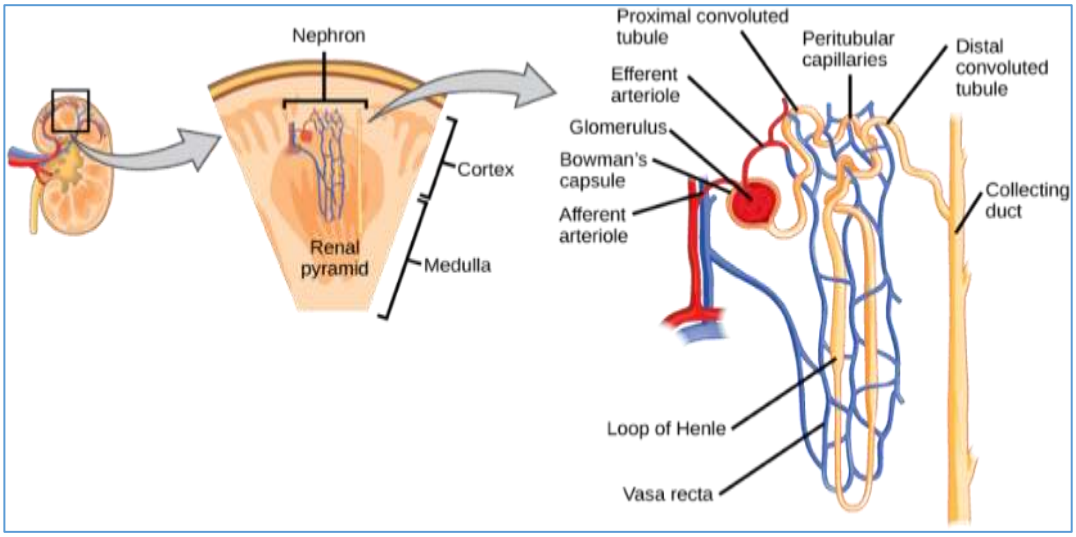


Figure 7.13 Nephron and its relationship to medulla and cortex..

Invertebrate Phyla

PHYLUM PORIFERA – THE SPONGES

Sponges are aquatic and mostly marine existing from mid-tide level on the shore, down to the deep ocean floor. They are considered to be the most primitive of all multicellular animals and are composed of a loose aggregation of cells but do not form tissues. The cells are specialized for different functions: some feed, others protect, some support or reproduce.

The characteristic feature of sponges is that they are porous and lack symmetry. The pores are vents in the body wall through which water is drawn into the chambers. The chambers are lined with collar cells,

each of which bears a flagellum. This acts like a whip to lash the water to create a current which brings in food and oxygen. The exhalent water carries out waste through a large opening called an osculum. Between the body wall cells and flagellate collar cells (choanocytes) is a nonliving jelly. Within this jelly are amoeboid cells (mesenchyme cells) which can develop into any of the more specialized cell types. They are thought to transport waste materials out of the sponges. Some of the mesenchyme cells secrete spicules. Spicules are made of calcium carbonate or silica or an organic substance called spongin and form the skeletal framework which supports the soft cellular mass.

Sponges occur in many forms. On shores they are flat and encrust rocks. In deep water their form is more varied and protrusive from rocks, particularly in still water. Their shape tends to be more symmetrical and regular in general as the water depth increases.

The sponges' colour is a result of their symbiotic relationship with algae. The shallow water provides more light for the algae to grow, thus the sponges are more colourful in shallow water.
Sponges can be hard or soft in texture. They reproduce sexually and asexually. The larvae are free flowing before attaching to objects to develop into a sessile organism. Sponges have no nervous system.

Sponges have few predators because of their uninviting texture. Nudibranchs (sea slugs) are one of the few creatures that will eat sponges.

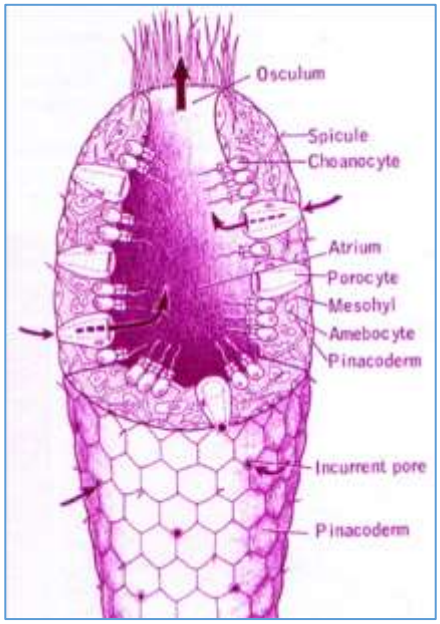


Figure 7.14 A sponge in the Phylum Porifera with some spicules, small skeletal elements in the body wall.

Figure 7.15 Diversity in the Phylum Porifera.

PHYLUM CNIDARIA (COELENTERATA)

This phylum is made up of three Classes: **Hydrozoa** (hydroids or sea firs), **Scyphozoa** (large jellyfish) and **Anthozoa** (sea anemones and corals). They are simple in structure with an inner skin (endoderm) and an outer skin (ectoderm) which can make up the body wall. The internal cavity functions as a digestive cavity.

Cnidarians are radially symmetrical. They have a simple undefined circulatory system and a simple nervous system consisting of nerve nets. A nerve net radiates out from a central point so a contraction of muscles occurs in all directions, creating a pulsation movement. Remnants of the nerve net are still apparent in the smooth muscles of organs in Chordates creating a contraction called peristalsis that moves material down a tube.

Cnidarians take on two main forms:

1) The polyp (hydroid)
2) The medusa

The polyp is sessile and cylindrical. It is closed at one end with a mouth and tentacles at the open end. The medusa is a free-swimming form. It may be well- or umbrella-shaped. Both forms occur in alternate generations in some species.

Figure 7.16 Diversity in the Phylum Cnidaria showing sea anemones, jellyfish and a sea pen.

Cnidarians and flatworms have both intracellular and extracellular digestion. Extracellular digestion occurs outside of the cell. Digestive enzymes are passed out of the cell and digestion occurs outside the cell. Once food has been digested outside the cell the soluble molecules are taken inside the cell by active transport or by diffusing into the cell. Animals that are more complex than cnidarians and flatworms show extracellular digestion only. Cnidarians and flatworms have both intracellular and extracellular digestion. Intracellular digestion would be a problem for larger animals in that the size of food particles that can be taken into a cell is relatively small so extracellular digestion seems to be an evolutionary solution to providing adequate nutrition to large animals.

Intracellular digestion occurs within the cells of organisms. It occurs in all of the animal like protists (protozoans). Solid food particles are taken into single cells by means of a process called phagocytosis. Food particles become enclosed in a food vacuole. Digestive enzymes in organelles called lysosomes enter the food vacuole by fusing of the lysosome with the food vacuole. The enzymes digest the food into soluble food molecules. The soluble molecules produced diffuse through the membrane of the vacuole into the cytoplasm of the cell where they can be utilized by the cell.

Many of the smaller animals such as cnidarians and various worms (e.g. annelids) lack a rigid skeleton for support and movement. Many of these organisms utilize fluid filled cavities to provide for body support, called a hydrostatic skeleton. Water is not compressible, so it provides support and flexibility when pressure is applied to it. In many organisms there are both circular and longitudinal muscle layers. Contractions of the circular muscles puts pressure on fluid in body cavities causing an organism to elongate. Contractions of longitudinal muscles causes the body to shorten and thicken. At the same time the hydrostatic skeleton provides great flexibility. Only small organisms can utilize this type of skeleton. The water needed for support is very heavy and larger organisms would need excessive volumes of water to provide adequate support. Also, the hydrostatic skeleton provides essentially no protection to internal organs.

Class Hydrozoa
Sea Firs, Sea Plumes

Hydroids are small and often mistaken for plants. Their branching plant-like shape is formed by a colony of tiny polyps connected to a common digestive canal and stiffened by calcium or other firm material. The polyps reproduce asexually by budding. The buds sprout into little medusae, complete with stalk, tentacles and mouth. The medusa eventually detaches from the polyp parent. It develops into a sexually reproducing animal which will give rise to another hydroid colony.

The hydroid medusa is distinguished from the scyphozoan medusa by the presence of a vellum. The vellum is a shelf which faces inward from the margin of the bell. It is also distinguished by the four-chambered stomach.

Medusae have light-sensitive ocelli which appear as red, brown, or black spots at the base of the tentacles.

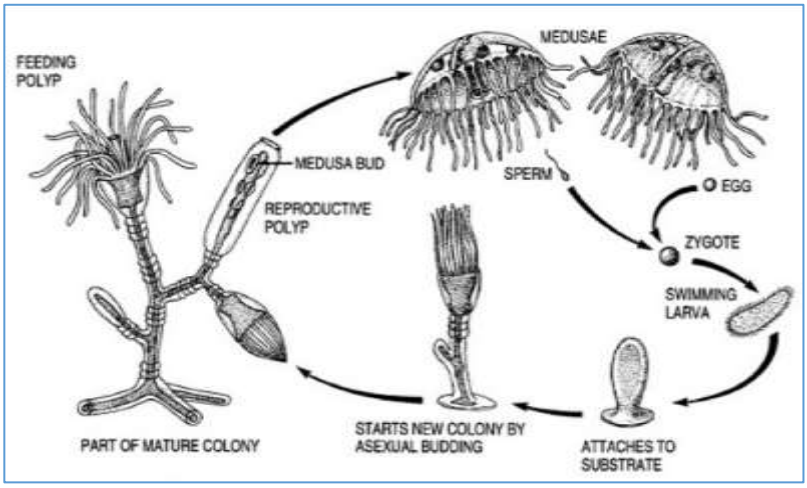


Figure 7.17 *Obelia*, an example of a hydroid coelenterate

Class Scyphozoa
True Jellyfish

In the Class Scyphozoa the jellyfish/medusiod phase is dominant over the polyp phase. The polyp stage (if it exists in the species) is small. The polyp is never colonial as it is in hydroids.
Scyphozoa jellyfish can be distinguished from hydroid jellyfish by their lack of a vellum, their large size and the existence of oral lobes. They have a four-rayed symmetry.
Jellyfish have tentacles that fringe the perimeter and surround the mouth. Around the medusa bell is a muscle band controlled by a nerve net which contracts and expands the bell to propel the animal through the water.

Figure 7.18 A jellyfish with tentacles extending below the body.

Class Anthozoa
Sea anemones, Sea pens, Corals
In the Class Anthozoa, only the polyp stage exists. These creatures are mostly stationary. They have a short main axis from which the wide disc mouth region extends. The muscular and nervous system are more developed than that of the other two classes of the Phylum Cnidaria.

Sea anemones are carnivorous, feeding on fish and invertebrates. Their tentacles are lined with stinging cells that have a poisonous barb at the end of a thread that immobilizes their prey and the tentacles then guide the food to the mouth. They have been known to live well over 80 years.

Corals are colonial animals, some of which have hard calcareous skeletons secreted by the hydroid animals. Algae live symbiotically in the bodies of the hydroids. In the tropics the rock corals are responsible for building reefs.

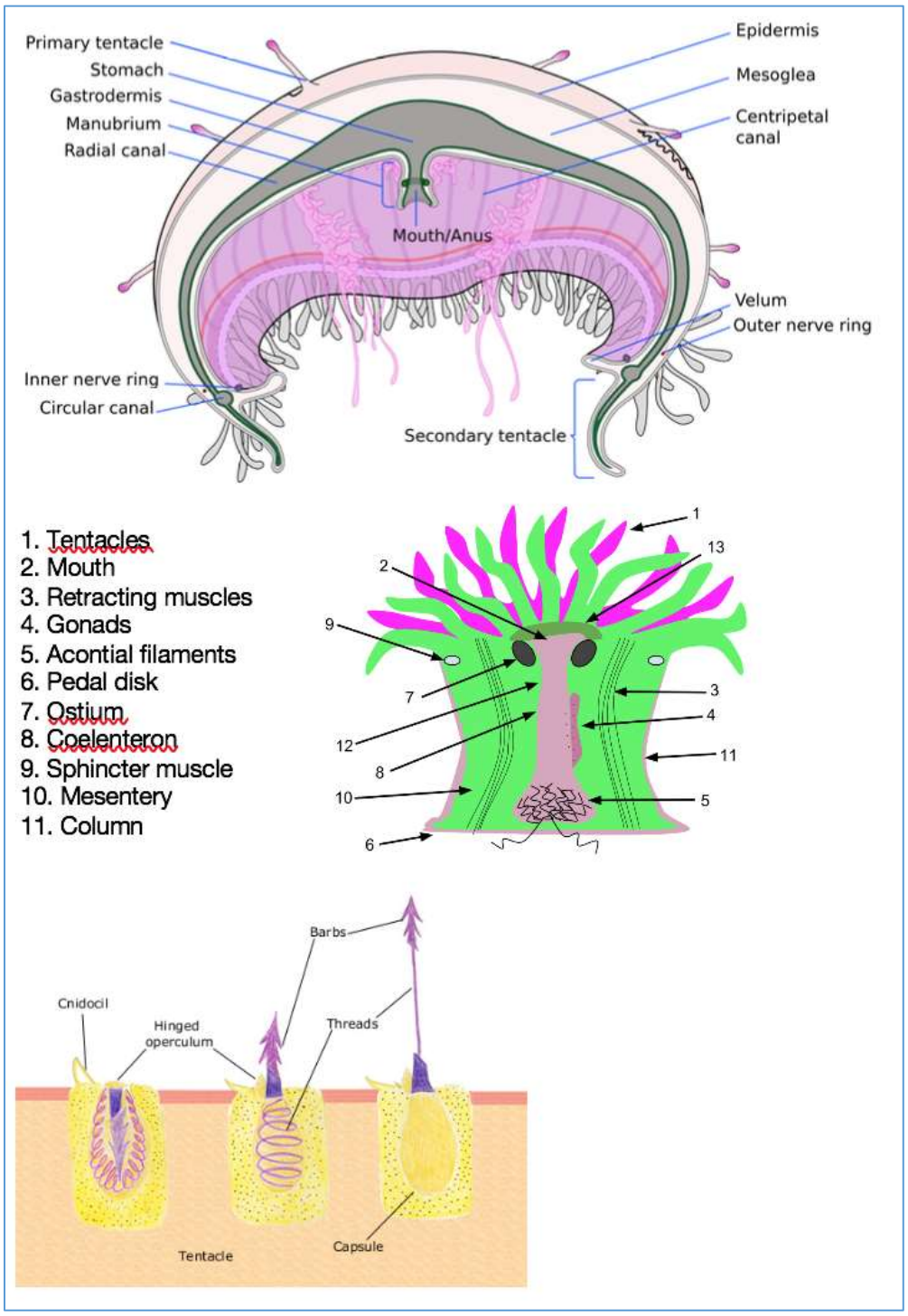


Figure 7.19 The basic structure of a Cnidarian is to have a body with tentacles. In the case of an anemone the tentacles point upward, with a jellyfish they point downward. The tentacles are lined with stinging cells called nematocysts that immobilize prey so it can be brought into the mouth.

PHYLUM PLATYHELMINTHES – The Flatworms

Members of this phylum are bilaterally symmetrical. They have no body cavity or coelom, a condition called acoelomate. The body is flattened dorso-ventrally i.e. top to bottom as opposed to side to side as with most fish, with three tissue layers. They have a nervous system with two major nerve cords and cerebral ganglia, male and female genitalia, gut, mouth, eyes and other sense organs. They absorb oxygen through the skin. There is no anus so digested waste must leave through the mouth – a condition called a one-holed gut.

Flatworms have the three embryonic tissue cell layers called ectoderm, mesoderm and endoderm found in all animals except Poriferans and Cnidarians. Their smooth skin may be covered with cilia or mucus. Locomotion is done by moving cilia or muscular contractions.
.
Platyhelminthes are usually carnivorous or parasitic but a few are free-living in both freshwater and marine environments.

Flatworms consist of four classes:

- Class Turbellaria – include all the sub-groups not exclusively parasitic
- Class Trematoda – flukes, internal parasites of molluscs and vertebrates
- Class Monogenea – group of ectoparasites commonly found on fish
- Class Cestoda – parasitic worms such as the tapeworm living in the gut of vertebrates

At the seaside or freshwater habitats you will find them in dark sheltered places. They thrive in mudflats and estuaries where there is an abundant microbial food supply.

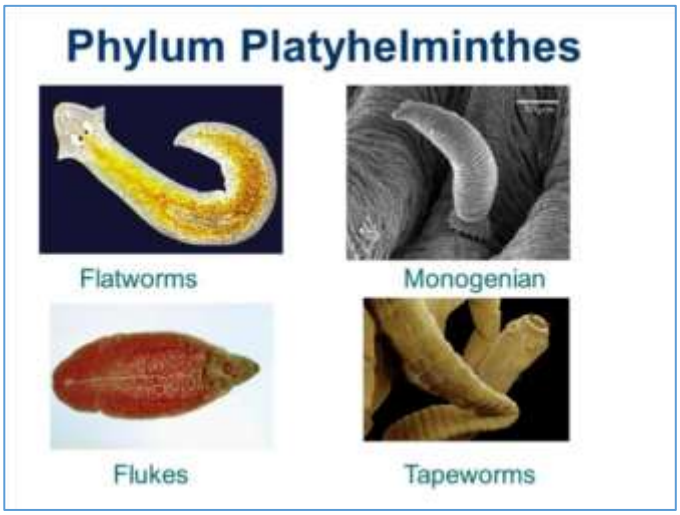


Figure 7.20 Diversity of the Phylum Platyhelminthes – flatworms, tapeworms and flukes

PHYLUM NEMATODA – Roundworms

Among the most widespread of all animals, roundworms are found as free-living forms in most aquatic and terrestrial habitats, and in fluids and moist tissues of plants and animals. Their cylindrical bodies are not segmented and range in size from 1 mm to more than a m long. Their body cavity is a pseudocoelom, a fluid-filled cavity inside the external body wall that bathes the internal organs that is derived from a persistent blastocoel rather than a true coelom. The nematode's body is protected by a tough cuticle that must be periodically shed as it grows. They have an alimentary canal (digestive tract) but no circulatory system. They only have longitudinal muscles in their body so they move by thrashing rather than peristaltically like segmented worms which requires that horizontal muscles also be present. Free-living forms play a major role in decomposition and nutrient cycling. There are many parasitic forms that are major agricultural pests. Humans are host to about 50 species, including pinworms and hookworms and the nematode *Trichinella spiralis* that causes trichinosis by eating raw or undercooked pork or wild game such as bear and walrus.

Nematoda consists of two classes:

Class Adenophorea (also Aphasmidia) – usually found in water, simple excretory and digestive systems, males have two testicles, no phasmids on the tail

Class Secernentea (also Phasmidia) – usually found in soil, main class of roundworms with excretory and digestive systems but no circulatory or respiratory systems, males have one testicle, phasmids on their tail make them sensitive to chemicals

PHYLUM ROTIFERA – Rotifers (wheel animals)

Like the nematodes, rotifers have a pseudocoelom. They are small, microscopic or near microscopic in size; most are 200-500 µm. They are found in freshwater habitats or in moist terrestrial habitats such as soil where they occupy thin films of water found on soil particles, on lichens and mosses, on mushrooms and in gutters. Like nematodes, they have a complete digestive tract with a mouth and anus. They are called wheel animals because a crown of cilia (corona) on the head around the mouth beats rapidly and resembles a wheel. Unlike the roundworms, the body is segmented internally.

Phylum Rotifera consists of three classes:

Class Monogononta – 1,500 species, have a reduced corona and males have a single gonad

Class Bdelloidea – 350 species occurring worldwide, occasionally found in brackish and marine habitats, reproduce only parthenogenetically and can withstand drying through a process of dessication-induced dormancy (anhydrobiosis) that can occur at any stage in the life cycle.

Class Seisonidea – only 2 species, found on the gills of *Nebalia*, a marine crustacean.

PHYLUM ANNELIDA – Segmented Worms

Except for the head and tail each segment is similar, having a pair of excretory structures (nephridia) and a nerve centre (ganglia). Nerve cords run longitudinally through the body. With evolution there is an increased concentration of sense organs and nervous control at the front of the body, a process known as cephalization. Cephalization eventually results in the formation of a head and brain.
Some marine worms have leg-like appendages called parapodia attached to each segment. These function for movement and respiration.

The digestive tract runs through the segments. The earthworm has both a mouth and an anus. The advantage of this digestive system compared to a gastrovascular cavity, where food and waste pass through the same opening, is that food can pass in one direction, through a tube divided into partitions or chambers. Each chamber has a particular function. In an earthworm organic matter and soil are sucked into the mouth by a muscular pharynx. The food then passes through a passageway called the esophagus into the crop. The crop functions as a storage site much like the stomach in humans. Food then enters a compartment with thick muscular walls called the gizzard. In the gizzard food is ground up with the help of small stones to increase its surface area. The ground food then passes into the intestine where digestion and absorption occurs. Earthworms have a fold called the typhlosole which projects down the lumen or cavity of the intestine. This fold increases the overall surface area of the intestine without making the intestine prohibitively large. Finally, in the last part of the intestine, water is absorbed. The undigested waste is eliminated through the anus. In the case of earthworms and all animals above the level of cnidarians and flatworms, digestion is completely extracellular.

Some of these worms will bite, especially the nereid worms found at the seashore. Tube worms are found under rocks and logs where they build calcareous tubes in which they live. They feed by trapping plankton on their plumed, feathered heads and direct the food to the mouth by beating hairs.

Phylum Annelida consists of three classes:

Class Polychaeta – marine segmented worms

Class Oligochaeta – terrestrial, freshwater and marine segmented worms, including the well-known earthworm, *Lumbricus terrestris*

Class Hirundinea – aquatic and terrestrial leeches

Figure 7.21 Leeches.

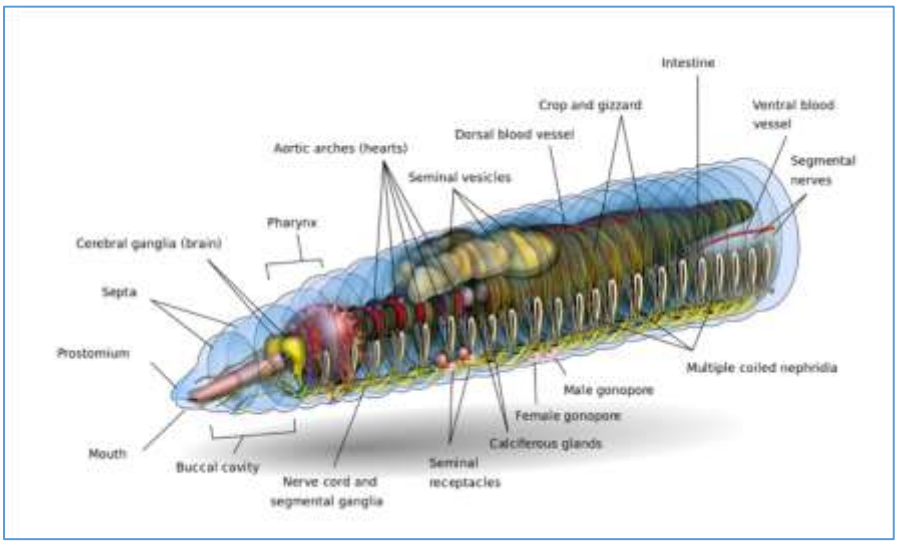


Figure 7.22 Digestive system of an earthworm – mouth, pharynx, crop, gizzard, intestine.

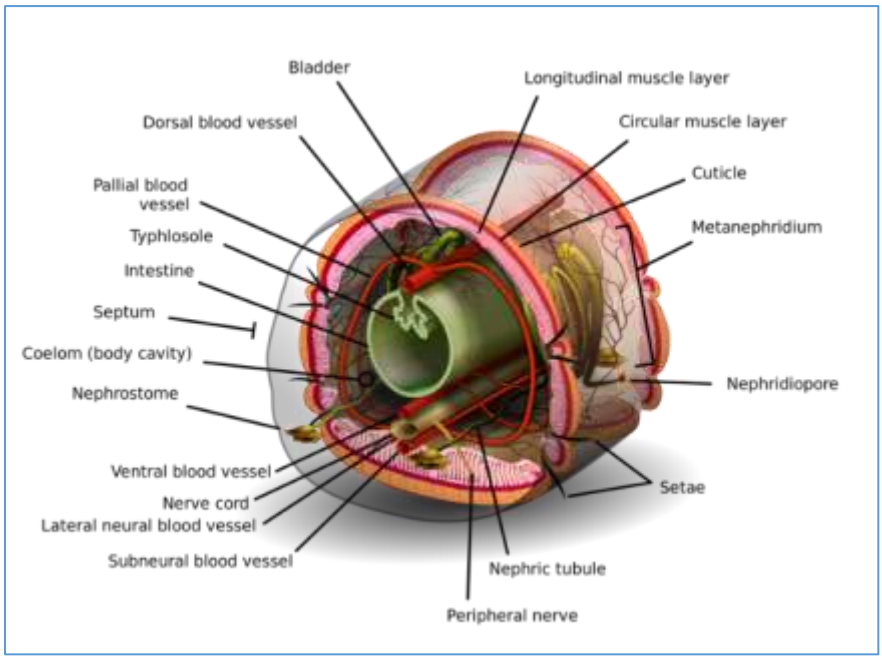


Figure 7.23 Excretory system of an earthworm. The unit of excretion in each segment is the nephridum with the opening in one segment and the pore eliminating waste outside the worms body in the adjacent segment.

PHYLUM MOLLUSCA

Mollusca means soft bodied. All members of this phylum have soft bodies divided into four regions:

1. The head with a mouth, tentacles and eyes
2. A ventral and muscular foot
3. A dorsal visceral mass containing the internal organs (coiled in gastropods) and,
4. A mantle from which the animal can secrete a calcareous shell to protect the visceral mass

A shell is a handicap to active movement so many groups have reduced this protection as a compromise for faster locomotion.

Figure 7.24 Diversity in the Phylum Mollusca (chitons, clam, squids, octopus, snails)

This group is diverse and the typical mollusk features are modified in the different classes. Some of these classes are described as follows:

Class Amphineura - Chitons

Chitons have long flattened bodies and a foot covered with a row of eight long connecting plates. These plates help to conserve moisture when the animal is out of water and protect it from wave action while clinging to rocks.

A chiton moves slowly along rocks by the undulating foot muscles. It scrapes vegetation from the rocks with its radula mouth. If a chiton is removed from a rock it will curl up its shell as a protective measure.

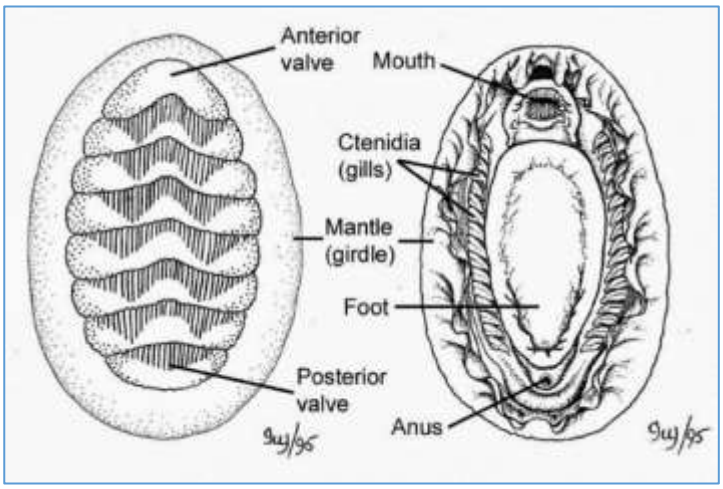


Figure 7.25 External and internal anatomy of a chiton.

Class: Gastropoda - Snails, Slugs, Limpets, Whelks

This class includes snails, slugs, nudibranch, limpets and whelks. Most have a protective single shell. In snails the shell is spiraled. The oxygen absorbing gills are tucked under the shell. Gastropods have a large basal foot which is used for clasping and locomotion. These organisms are generally slow moving. They eat with the radula (tongue) in the mouth which scrapes the food.

Figure 7.26 Diversity in Class Gastropoda.

Class Bivalvia - Two-shelled Animals

Figure 7.27 Diversity in clams.

The name bivalve means two valves or two shells. Bivalves have flattened bodies covered by two flattened shells. The shells are connected to each other dorsally by a strong ligament. As the animal grows, so does the shell at the ventral section. The growth leaves rings on the shell. The shells are closed by two large muscles when the animal needs protection. They open when the animal is feeding. Bivalves are filter feeders. Most use their gills to collect plankton as well as to absorb oxygen.

Some bivalves such as mussels and oysters are stationary, being attached to rocks. Mussels are attached by filaments (byssal threads) that anchor the animal to rocks. Clams bury themselves in the substrate. The foot is used to dig the burrow. Scallops move through the water by opening and closing their shells.

Most bivalves are either male or female but some such as cockles are hermaphroditic. The Japanese oyster conveniently changes its gender.

Class Cephalopoda - Squids, Octopus & Nautiluses

Cephalopods include nautiluses, squids, and octopus. The name means “head-footed” because the foot is wrapped around the head and extends to the tentacles. Members of this group are the most elaborate and active in the Phylum Mollusca. The octopus is said to be the most intelligent of all marine invertebrates. The mantle’s shell has been reduced in all members except the nautilus which has a coiled shell. The mantle cavity is modified as an organ of jet propulsion with the foot converted into a funnel directing the propulsive stream. Some of the other modifications are a more efficient circulatory system with a branchial heart. Digestion is extracellular and the Cephalopods eat through a strong jaw. Sexes are separate.

Figure 7.28 Examples of squid, octopus and nautilus.

PHYLUM ARTHROPODA

The name Arthropoda means “joint footed.” These animals have jointed appendages and exoskeletons which they must shed as they grow. This group is the most numerous and widespread of all animals. It includes insects, spiders, and crustaceans.

Figure 7.29 Examples of arthropods, all of which have an exoskeleton and jointed appendages.

Class Crustacea – Crabs, Lobsters, Shrimp, Woodlice, Barnacles

Like most other arthropods, crustaceans have a segmented body, paired jointed appendages, an exoskeleton, antennae, eyes and other common characteristics.

The exoskeleton supports the body as well as protects it. It can vary from a thin light layer as in water fleas, to a thick calcareous suit of armour as found on crabs and lobsters. This covering is segmented with the segments attached to each other by a flexible ligament to allow easy movement. The exoskeleton must be shed as the crustacean grows. A person can often find crab carapaces on the beach which have been shed to be replaced by a new exoskeleton.

The crustacean is able to absorb water and swell once the skeleton is shed. The period immediately after molting is when the females (particularly crabs) are receptive to fertilization. Sexes are usually separate in the crustaceans but hermaphrodites are found in some groups. Crustaceans produce eggs. The young emerge from the eggs. In some species the larvae resemble the adults and others show no resemblance. They are often planktonic in early life but develop into adults through several growth stages.

Figure 7.30 Crustaceans have 5-7 pairs of legs and 2 pairs of antennae.

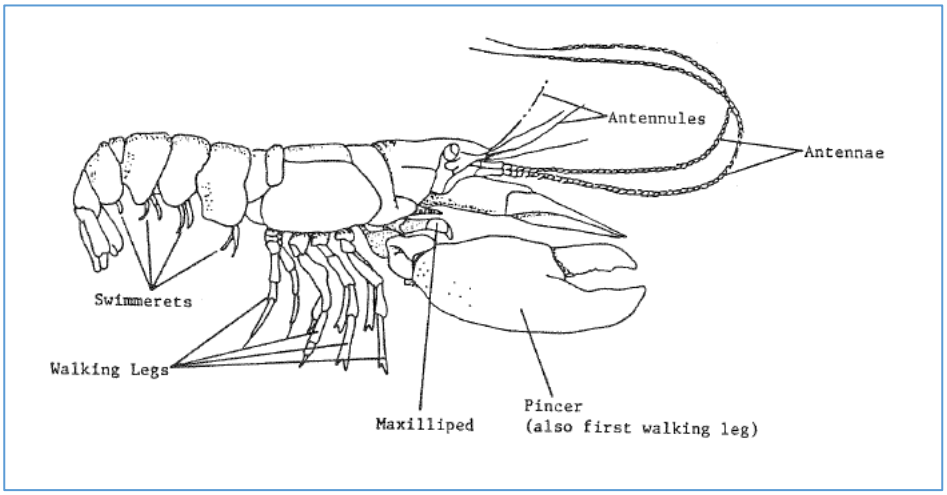


Figure 7.31 External anatomy of a lobster, Note the 5 pairs of walking legs.

Figure 7.32 Some freshwater crustacean inhabitants in their characteristic habitats.

Class Insecta - Insects

Next to plants, insects are probably the most conspicuous members of the natural environment throughout most of the year. They occur in almost all terrestrial and freshwater habitats. They are the most numerous and diverse of all the animals. They generate considerable interest because of their body structure and life histories.

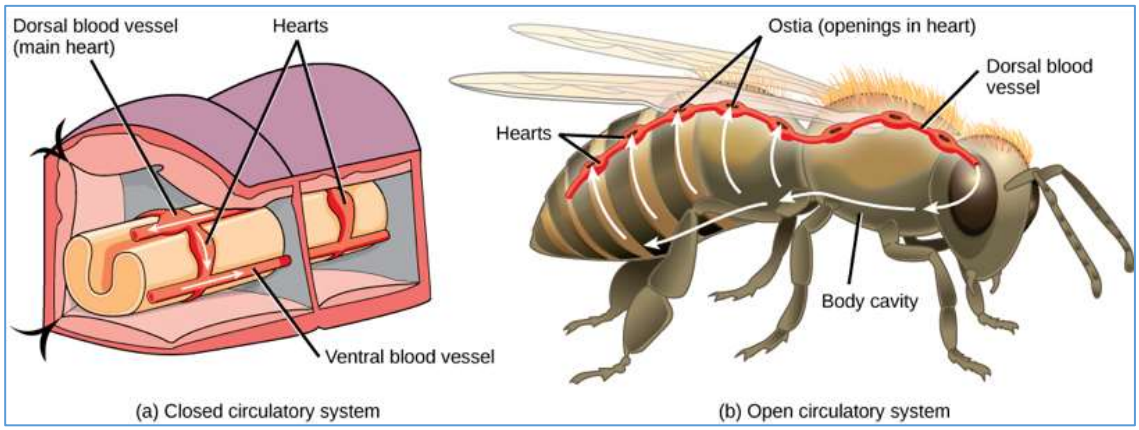


Figure 7.33 Insect open circulatory system where the circulatory fluid called the hemolymph is only partially contained in vessels.

Insects, like all arthropods, possess an exoskeleton (unlike humans whose skeleton is inside i.e. an endoskeleton). The exoskeleton affords insects excellent protection from damage to soft tissue, and it prevents water loss, allowing insects to live under arid conditions for extended periods of time. It is also articulated which allows for more efficient movement compared to other non-arthropod invertebrates. An exoskeleton has three major disadvantages. First, it is extremely heavy, which restricts the maximum body size of insects; most are very small. Three quarters of the several hundred thousand species of insects are less than 6 mm long. Secondly, it is rather clumsy and not very flexible in the joints. This accounts for the mechanical appearance of locomotion in insects. Finally, in order for the animal to grow it must shed its exoskeleton and grow a new expanded version. During the times the exoskeleton has been shed the animal's body is soft and vulnerable to predation.

The senses of insects are remarkable and differ considerably from that of our own. Their eyes are compound eyes, consisting of hundreds of individual units (ommatidia). Such an arrangement makes the eyes extremely sensitive to movement (different units are stimulated as an animal moves through the field of view). Everyone knows how difficult it is to catch a fly, and the reason is found in the unique sense of vision. Some insects, such as bees, are sensitive to polarized light which provides them with a different perspective of the world. Besides vision, insects are unusual in other senses. They are sensitive to chemicals suspended in the air, a capacity which we refer to as "smell." Similarly, they do have a sense of taste but the sensation is perceived by the feet rather than taste buds with gustatory cells. Finally, some insects can hear but they do so without ears. Sound can be detected by specialized organs in various body parts – the abdomen, front legs, or antennae.

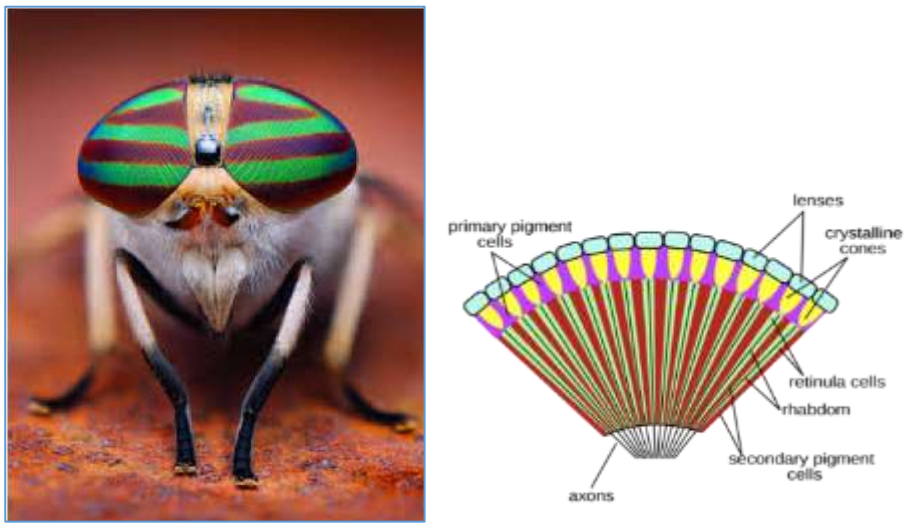


Figure 7.34 Compound eye of the horsefly. The many facets that comprise the compound eye make it very sensitive to detecting movement.

Gas exchange in insects is accomplished by an internal system of tubes (tracheal tubes). There are no lungs.

Arachnids, such as spiders (Class Arachnida described later, have a body composed of a cephalothorax, a fused head and thorax, and an abdomen. They have two organs of respiratory exchange: trachea and book lungs. The trachea are a system of tubes which extend into the interior of the spider and bring the gases close to most of cells of the body. The tubes take gases to and from the body tissues directly so no circulatory fluid is required for respiratory exchange. They open on the outside of the insect's body wall by means of little pores called "spiracles." Spiders also have book lungs in the anterior end of the abdomen. They are moist flaps of tissue arranged like the pages of a partly open book. Air is drawn across them and gases diffuse into the body cavity and circulate in an open circulatory system. Book lungs are paired and there may be up to four pairs. Air is moved in and out by contractions of muscles in the abdomen.

Insects depend on a tracheal system which is similar to but evolved independently from the tracheal systems of spiders. They don't have book lungs like spiders, but their tracheal system is very well developed. Many fine tubes make up the tracheal network and the branches get finer and finer and extend to all parts of the body. Trachea are lined with chitin, the substance which also forms the insect's exoskeleton. Spiracles are the openings to the tracheal system and the insect can open and close these spiracles depending on whether or not it wants to exchange gas. Tracheal tubes terminate in microscopic tubes called tracheoles. From the tracheoles, gases diffuse directly to and from the cells of the body. Gases can't diffuse across the chitin lined tracheal tubes. They must go through the tracheoles. The body walls of the insect pulsate to draw air in and out of the tracheal system. In the grasshopper, when the abdomen expands the first four pairs of spiracles draw in air and when the abdomen contracts air is expelled out of the last six pairs of spiracles.

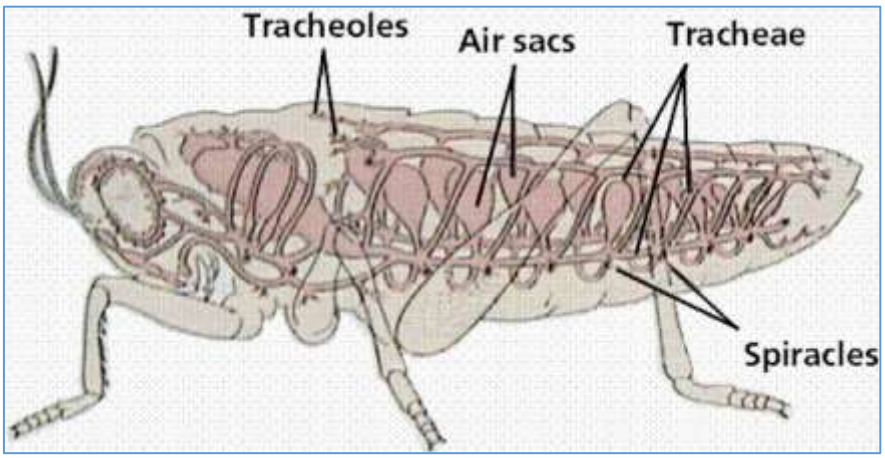


Figure 7.35 Respiratory system of an insect. The tracheal tubes take gases directly to the tissues from the spiracles without using the circulatory fluid.

An adaptation for excretion in insects, spiders and centipedes is Malpighian tubules. These are tubules which branch from the gut that can absorb water, solutes and wastes from the hemolymph, the circulatory fluid in insects that also bathes the tissues.

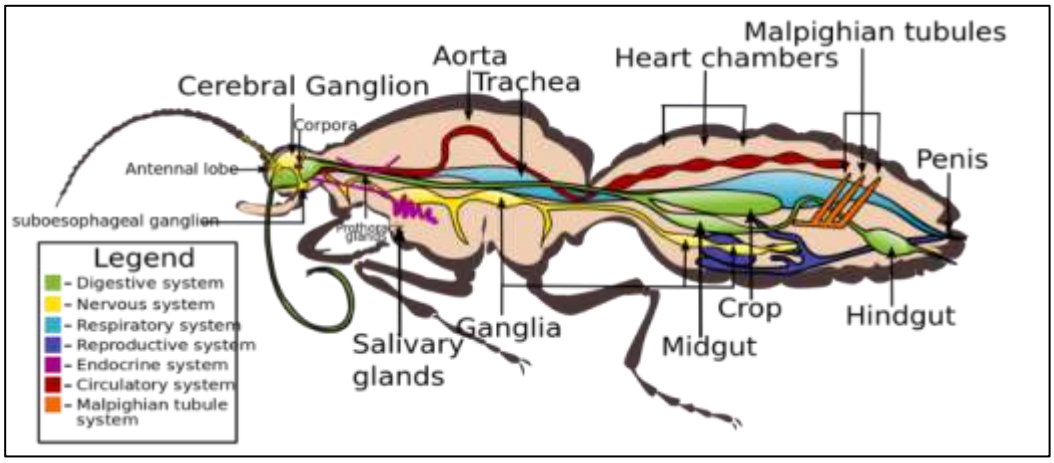


Figure 7.36 Malpighian tubules are associated with the gut.

Insects are unique amongst the invertebrates in their ability to fly. They are the only invertebrates with wings. Their ability to fly contributes significantly to their relatively dominant position amongst animals on earth. The wings of insects are not modified appendages as in the case of birds and bats. Rather, they represent structures which supplement the regular locomotory organs of the animal.

Metamorphosis is a remarkable feature of the life history of an insect. It can be complete (holometabolous) or incomplete (hemimetabolous). Complete metamorphosis is represented by the life history of a butterfly where the animal goes from an egg – larvae – pupa – adult. The larval caterpillar is familiar to everyone. Inside the larva is a group of cells which will later use the larval tissue to form a butterfly. The pupa of a butterfly is contained by a chrysalis or cocoon. Incomplete metamorphosis is represented by a grasshopper. In this case, the egg hatches into a

nymph, which is essentially a miniature version of the adult. This goes through a number of successive molts (instars), the last of which produces the mature adult.

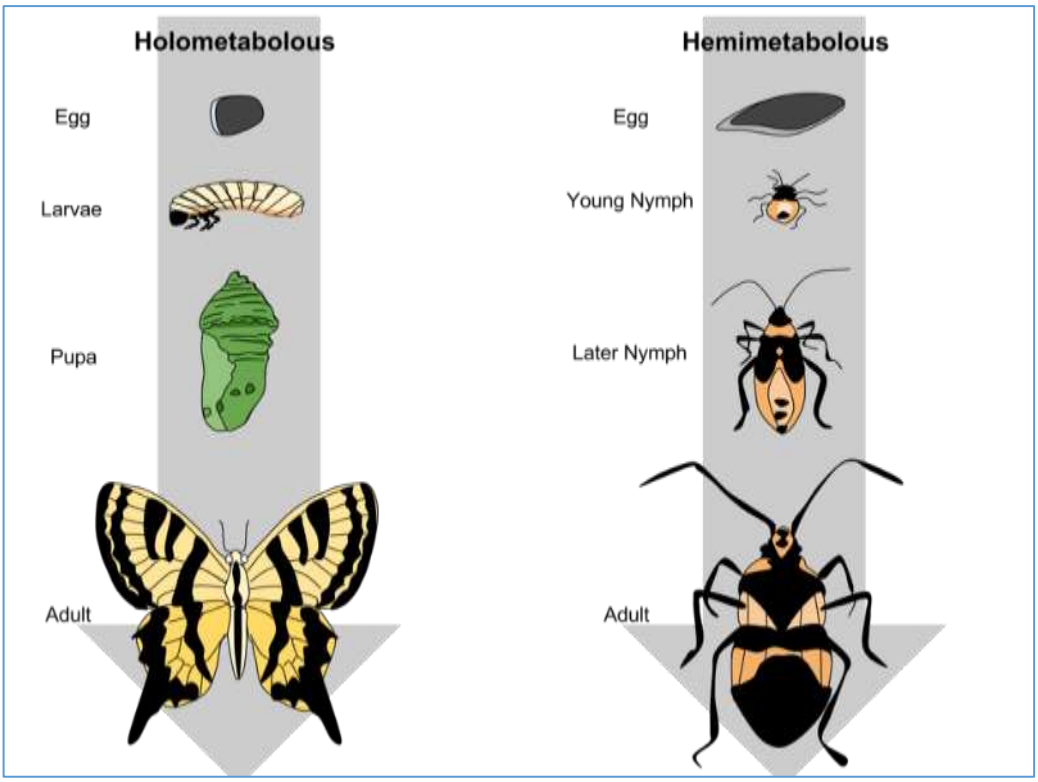


Figure 7.37 Comparison of complete (holometabolous) and incomplete (hemimetabolous) metamorphosis**.** In incomplete metamorphosis the young nymphs are similar in appearance to the adult and molt into larger bodies called instars. With complete metamorphosis the egg hatches into a caterpillar which pupates and turns into an adult butterfly or moth.

An interesting feature of some insects is their ability to withstand freezing temperatures. Not all insects have this capacity. Many insects from warmer climates often die quickly at temperatures above freezing (e.g. 5^{o} C). However, some can withstand temperatures as low as -47^{o} C. Ice crystals form around a nucleus of some material, and insects which 'supercool' have unusually low concentrations of these materials. Some insects with a low supercooling point may also have glycerol in their circulatory fluid (hemolymph). This is formed from glycogen.

Finally, insects have a tremendous potential for reproduction. As adults females tend to lay large numbers of eggs, sometimes many thousands per individual. The generation time tends to be short, and there may be a significantly greater proportion of females to males in each generation. All of these factors result in a staggering ability to reproduce. For example, a pair of fruit flies can produce 1.192 x 10^{41} flies by the 25th generation which, if packed together tightly, would form a ball 96,372,988 miles in diameter. This situation of course does not occur because of the high mortality rates of flies.

Figure 7.38 A female ichneumon fly with ovipositor inserted into plant stem so eggs may be laid into an insect host within the plant tissue

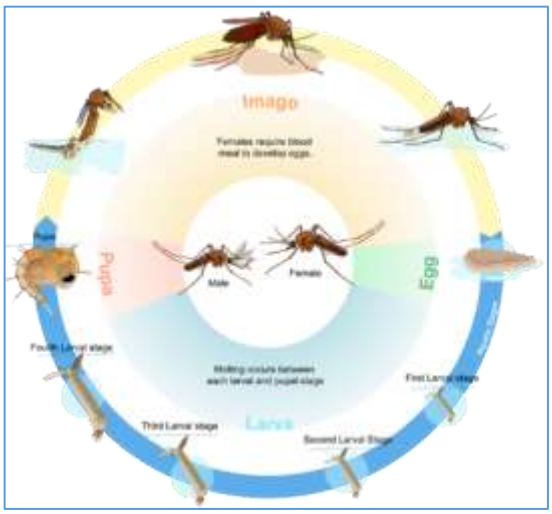


Figure 7.39 Life stages in mosquito

Figure 7.40 Predacious diving beetle (*Dytiscus*) – larva and adult

Figure 7.41 Giant water bug (*Lethocerus*)

As diverse as insects are, they do possess two common characteristics. All of them have three pairs of walking legs, and one pair of antennae.

A few of the more common Orders are as follows:

Order Orthoptera – grasshoppers, katydids, locusts, cockroaches, crickets

- Front wings narrow, thickened, covering fan-like fragile hind wings when in repose.

Figure 7.42 A katydid is well camouflaged in leaves.

Order Hemiptera – true bugs and relatives (cicadas, hoppers, aphids)

- Two pairs of wings locked in flight

Figure 7.43 A giant water bug.

Order Odonata – dragonflies and damselflies

- Carnivorous, large with long, narrow transparent pair of wings, net veined

Figure 7.44 A dragonfly.

Order Coleoptera – beetles

- Front wings hard, cup-shaped protecting fragile hind flight wings when in repose

Figure 7.45 A cockroach.

Order Lepidoptera – moths and butterflies

- Wide membranous wings with scales

Order Diptera – true or two-winged flies

- Front pair of wings membranous, narrow
- Hind pair of wings reduced to short rods acting as balancers

Figure 7.46 True flies have two wings.

Order Hymenoptera – wasps, ants, bees

- Narrow membranous front wings
- Hind wings much reduced, firmly coupled to front wings

Figure 7.47 Bees, wasps and ants have two pairs of wings.

Class Arachnida - Spiders, Mites, Ticks, Scorpions

They are all characterized by possessing four pairs of walking legs and no antennae.

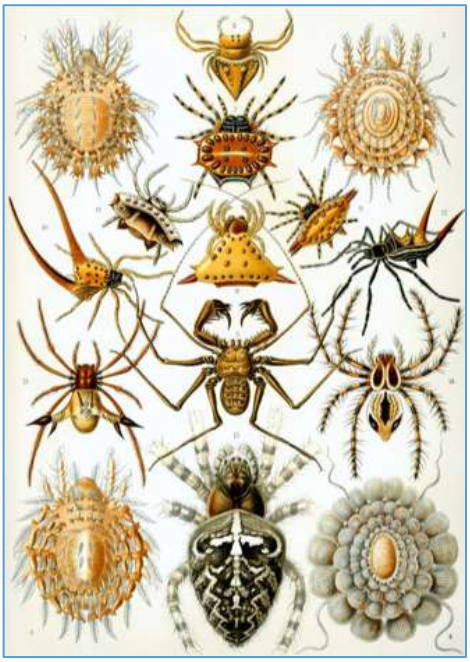


Figure 7.48 Animals in the Class Arachnida have four pairs of legs and no antennae.
There are about 30,000 species of spiders worldwide. They can be found in almost all terrestrial habitats. However, any one species is usually specifically adapted to a particular habitat and it not generally found outside of these limits. Spiders are carnivorous, feeding mainly upon other arthropods, especially insects.

Unlike other Arthropods which possess three distinct body segments, (head, thorax and abdomen), the segmentation of Arachnids is more obscure. The head and thorax have become fused forming a single 'cephalothorax.' This in turn is connected to the abdomen by a very narrow waist called a 'pedicel.' There is a tough plate called a carapace covering the cephalothorax.

On the upper side of the head are a number of eyes, usually eight, but in some species, six, four, or two. At the front on the lower side of the head are the jaws, called chelicerae. These often bear sharp teeth on the inner edge and a fang. These are necessary to penetrate the exoskeleton of the prey. The fang is connected to poison sacs. In addition to the eyes and jaws, the cephalothorax contains a pair of pedipalps (palps for short), and four pairs of legs.

Figure 7.49 Orb-weaving and basket-weaving spiders with their webs.

A spider does not feed by tearing off bits of prey and swallowing them. Rather, the spider releases digestive enzymes into the soft body tissues of its prey. Digestion is initially external. Then, the spider uses its sucking stomach to pump the liquid contents of its prey into the alimentary canal.

Silk production is an important ability in their daily lives. The spider silk is a protein in the scleroprotein group like collagen and keratin. It is in the form of a liquid, manufactured by silk glands in the abdomen. It is secreted from spinnerets. As a group the spiders manufacture seven different kinds of silk, but no one group produces all. Different silks are used for wrapping prey, making egg sacs, or spinning a web.

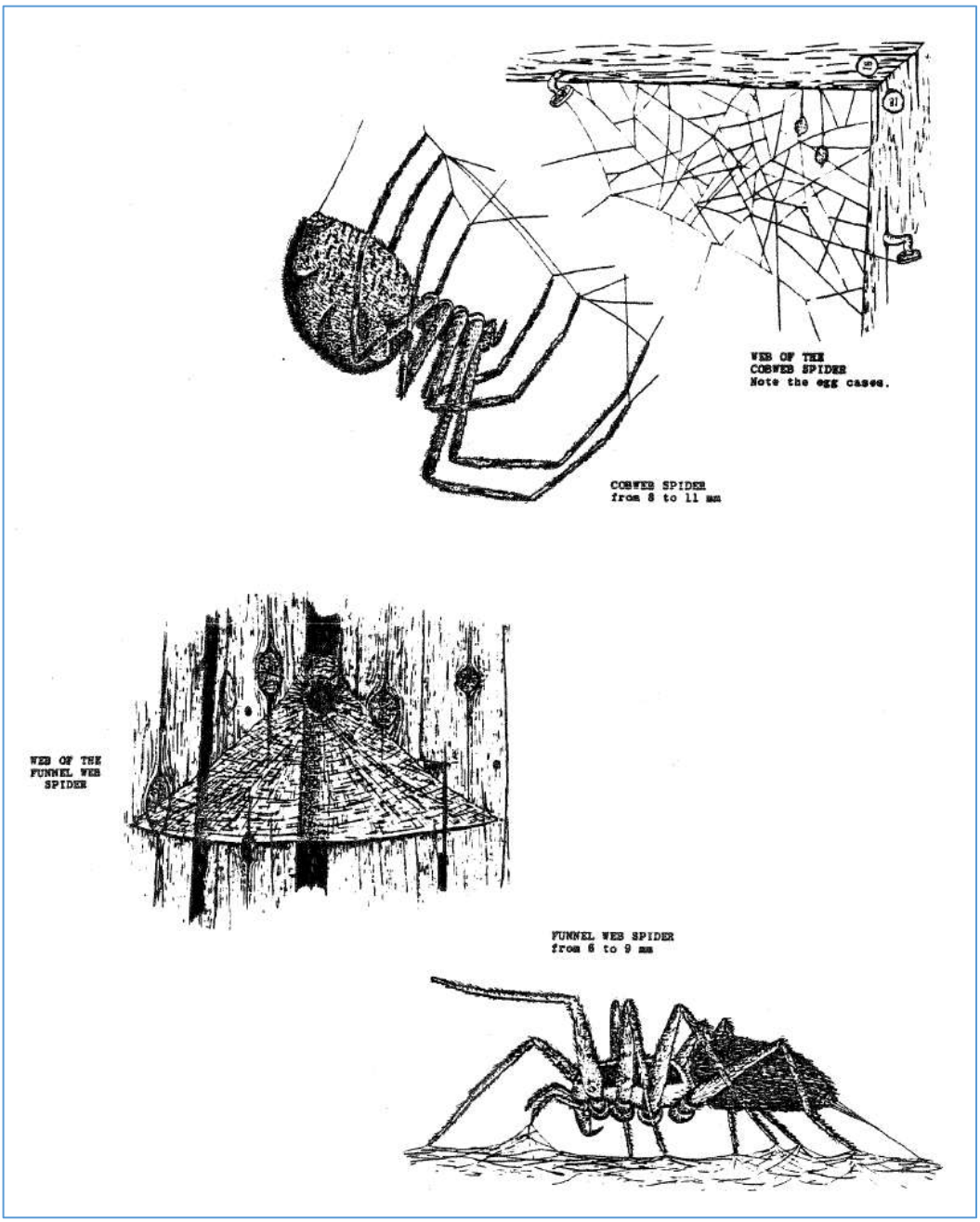


Figure 7.50 Different feeding strategies in spiders. A daddy long legs spider with its web to trap prey, a basket weaving spider uses its web on a tree trunk to catch insects falling from branches above, and a wolf spider stalks its prey.

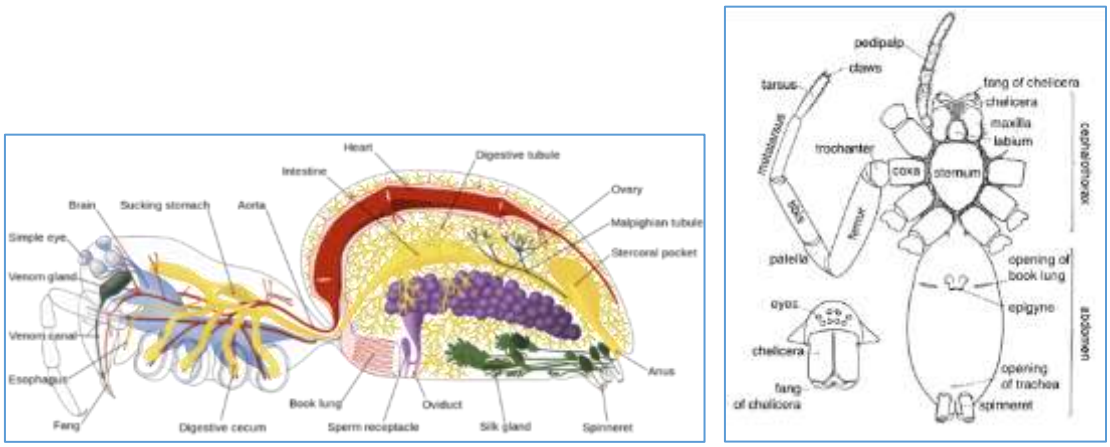


Figure 7.51 Anatomy of a spider.

Class Myriapoda - Millipedes and Centipedes

This group includes the millipedes (also called Class Diplopoda) and centipedes (Class Chilipoda). They have more than 10 similar segments and one pair of antennae. Millipedes have 4 legs on each segment (except head), and centipedes have 2 legs per segment. All are terrestrial.

Figure 7.52 Millipedes have two pairs of legs for each segment, velvet worms (*Peripatus*) and centipedes have one pair of legs per segment.

PHYLUM ECHINODERMATA

Sea Stars, Urchins, Lilies and Cucumbers

Echinoderms start their lives as free swimming bilaterally symmetrical larvae which develop into radially symmetrical adults. They have calcareous exoskeletons under the skin. Their surface is spiny.
A distinctive feature of echinoderms is the presence of tube feet. These are used for grasping and locomotion.

Echinoderms have a body cavity and a water vascular system of canals used in respiration or locomotion or both. This phylum is exclusively marine. Its members are starfish, serpent stars, sea urchins, sea cucumbers, sand dollars, and sea lilies.

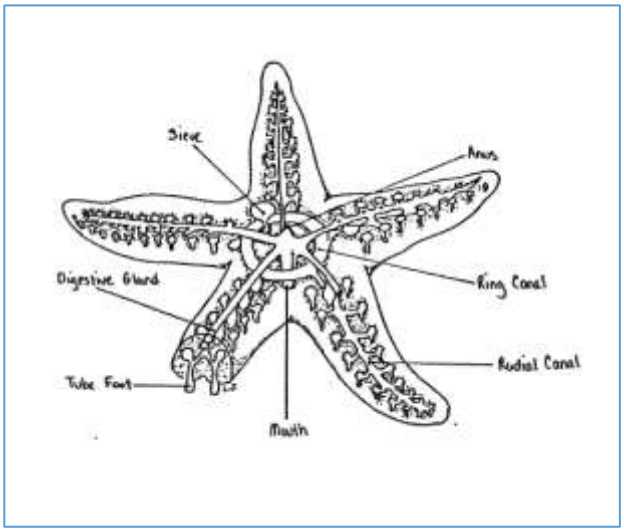


Figure 7.53 Anatomy of a starfish.

Class Asteroidea – Sea Stars and Sea Daisies

Characteristics

- Arms radiate from a central disk
- Tube feet on the ventral surface of the arms, adhere to surfaces through adhesive chemicals, not suction
- Feed by extending stomach through the mouth through a narrow opening into the bivalve shell, exude enzymes that digest bivalve in its own shell, and liquified tissue then brought into body of starfish
- Sea daisies are armless

Class Ophiuroidea – Brittle Stars

Characteristics

- Distinct central disk with long flexible arms
- Have tube feet but lack flattened disks as in the sea stars
- Some are suspension feeders, other predators and scavengers

Class Crinoidea – Sea Lilies and Feather Stars

Characteristics

- Sea stars attach themselves to a substrate with a stalk
- Feather stars crawl about substrate
- Both are suspension feeders
- Some fossilized forms 500 million years old look like present day species

Class Holothuroidea – Sea Cucumbers

Characteristics

- Lack spines, endoskeleton much reduced
- Elongated
- Five rows of tube feet
- Tube feet around mouth developed into feeding tentacles

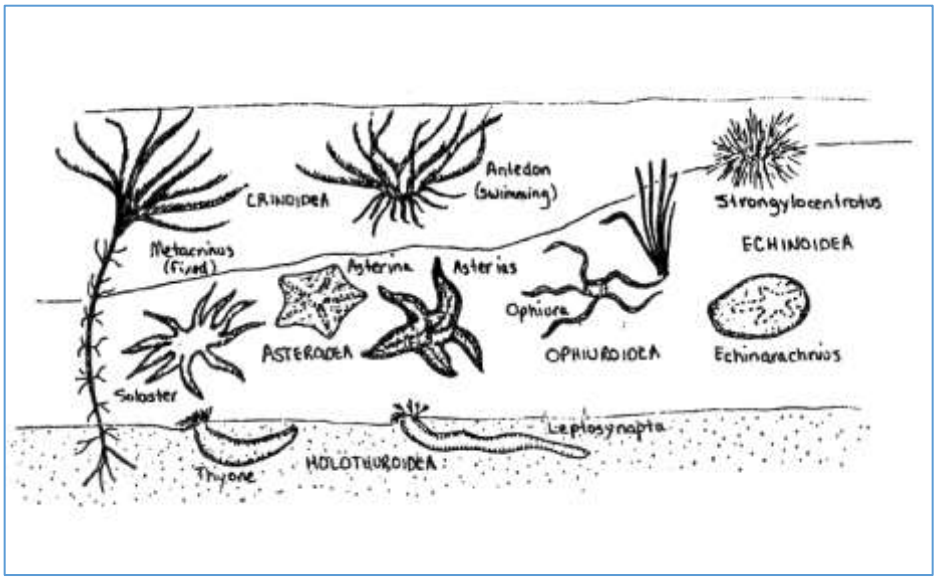


Figure 7.54 Representative echinoderms as they live in the sea.

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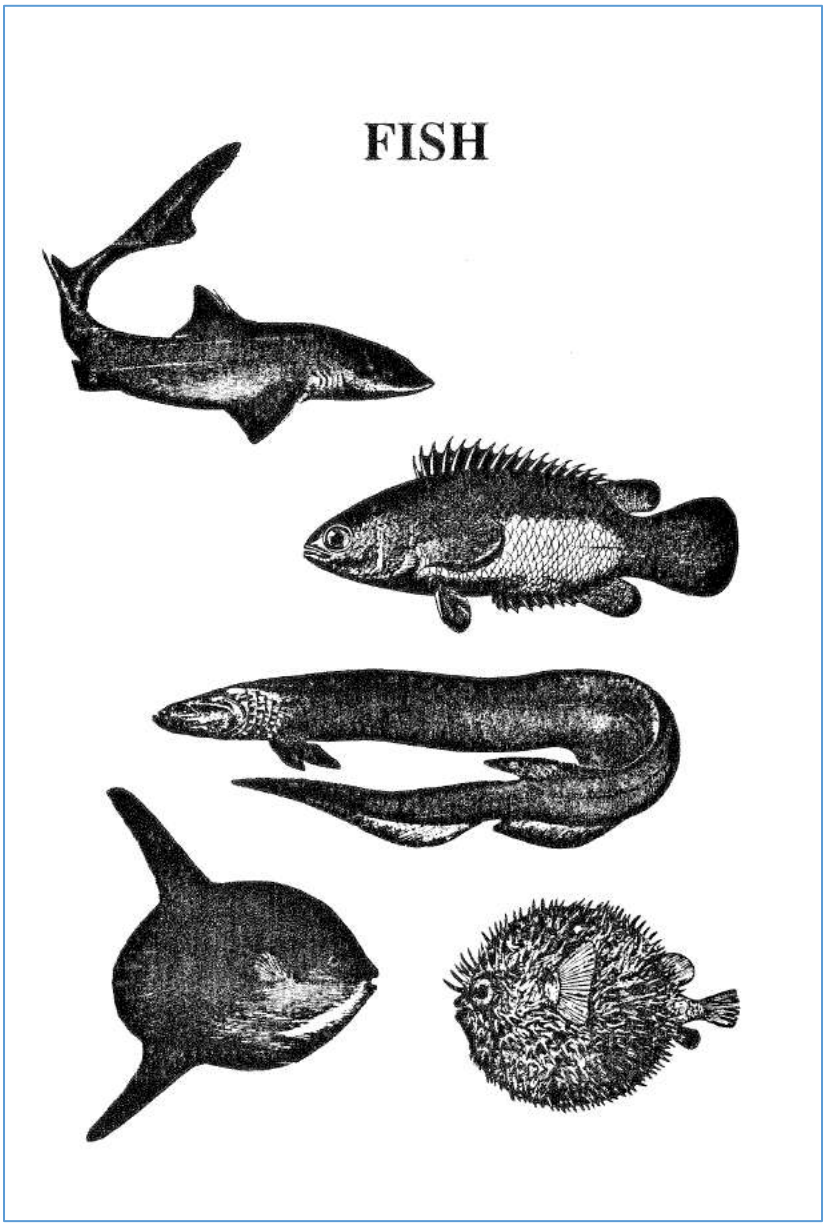
Chapter 8 Fish



LEARNING OUTCOMES

Successful completion of this unit will enable you to:

1. Describe best practices and ethical requirements for identifying, collecting, and displaying fish.
2. Describe anatomical and functional diversity in fish with respect to skeletal system, digestion, circulation, reproduction, excretion, sensory organs, and scales.
3. Apply knowledge of anatomical features to fish identification.
4. Identify distinguishing characteristics of the three fish Classes and the major Orders and Families within.

Chapter Outline

- Notes
  - Interpreting a fish habitat
  - Collecting and Displaying
  - Does Red Tide affect you?
- What is Fish?
- Anatomy
- Classification of Fishes
  - Class Agnatha
  - Class Chondrichthyes
  - Class Osteichthyes (examples)
    - Order Acipenseriformes – Sturgeon
    - Order Semionotiformes – Gar
    - Order Anguilliformes – Eels
    - Order Salmoniformes – Salmon, Trout, Smelt, Pike
    - Order Cypriniformes – Minnows, Carp, Suckers, Catfish
    - Order Gadiformes – Cod, Haddock
    - Order Gasterosteiformes – Stickleback, Seahorse
    - Order Perciformes – largest order - Grouper, Bass, Perch, Snapper, Seaperch, Blenny, Sculpin
    - Order Pleuronectiformes – Halibut, Flounder, Sole

Bibliography

Figure 8.1 Catfish.

FISH TIPS FOR BEGINNERS

Interpreting Fish Habitat

You may find that your known species may not change their geographical area throughout their life whereas other species may travel many hundreds or even thousands of miles before the end of their lifespan.

Another aspect which sometimes interest visitors is the economy of the given fish population. Is the fish valued? If so, know how the fish is utilized. For example, is the fish useful for sport fishing and commercial fishing?

In any fish habitat there are nine important parameters which cumulatively determine the species of fish that populate the area. Limitations are set by the ability of each species of fish to adapt and therefore tolerate combinations of these parameters.

When interpreting the habitat, keep these following points in mind as reasons why, for example, brown trout can and brook trout cannot live together in a particular body of water:

- Dissolved oxygen content
- Light (penetration and availability)
- Cover (vegetation in and surrounding habitat)
- pH of water
- Temperature of water
- Food availability (terrestrial and aquatic)
- Sedimentation (suspended and deposited)
- Protection (from predators)

- Water depth and flow

Often representative fish species are used as indicators of the 'health' of the habitat. For example, people may be concerned about the disappearing trout population but do not know the reason behind this decrease.

Identifying Fish
What should you look for? Be familiar with how to identify local fish by noting any or all of the following points:

- Whether or not the head has spines
- Are there any distinguishing markings? If yes, where? (for example distinguishing black spots on the tail fin)
- What is the average length and weight of the species?
- How many gill rakers does the fish possess?
- Are any of the fin shapes particularly distinguishing to the fish in question?

For yourself, find a distinguishing shape or mark which represents the fish to you. The above is only a guideline to help you see the fish in a variety of ways. Visitors are often interested in finding out about the life history of the fish. Know where you can secure information on the physical and geographical information dealing with the life cycle. For instance, find out where the fish spawn, where the young are reared, what they look like and whether the fish migrate or are year-round residents.

There are many different ways to collect fish. They include beach seining, Gee trapping, dip netting, electro-fishing, or obtaining fish from a pet store or fish market. Depending on the methods used, permits may have to be obtained from the Department of Fisheries and Oceans or Ministry of Environment, Fisheries Branch.

Dip netting is probably the easiest and least expensive method of obtaining fish, but is probably the least successful. This method is particularly good for hands on participation. Dip nets can be made by forming a loop or heavy wire, e.g. a coat hanger, and sewing a nylon stocking to the frame. Using a dip net usually requires wading, so boots are essential. Slow movements and patience 'net' the best results.

Gee traps or minnow traps are an effective way of catching smaller fish and should be installed in quiet backwater areas such as pools, sloughs and back eddies. Traps can be constructed of wire mesh (about ¼ inch grid) obtained from a hardware store. They should be baited daily, (roe is the best bait). Traps should be well-marked and checked daily. One of the problems of Gee trapping for interpretation purposes is that it can be hit and miss for catching fish as the traps must be placed in areas where there are fish.

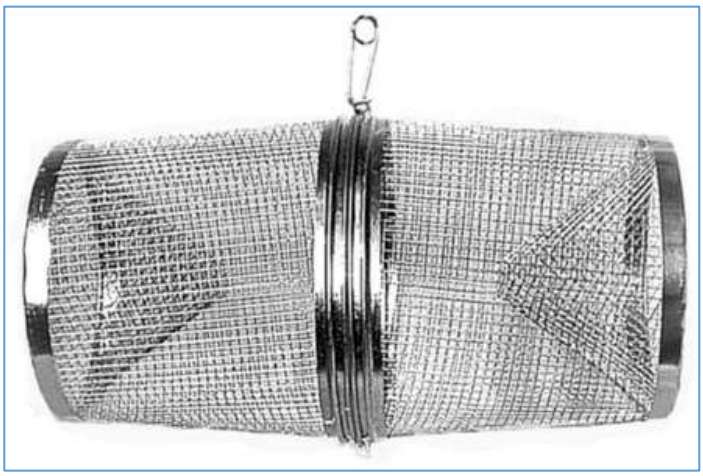


Figure 8.2 Gee trap used to catch minnows and other small fish.

Electro-fishing

Electrofishing is probably the most complicated and dangerous method of collection and can be hard on the fish. It should only be utilized by persons who are trained in electroshocker use.

Beach-seining

Beach-seining is probably the most reliable method of catching fish. Beach seines come in various lengths, depths and mesh sizes. What you use depends on the size of what you want to catch and the nature of the terrain in which you are netting.

A beach-seine is set by carrying one end of the net out from shore (distance depends on size of net), walking along the shoreline and bringing the end into shore. The lead line should have a good seal with the bottom. The net is then brought in towards shore, hauling at both ends. The lead line should be brought in ahead of the float line so that the net has a bagged appearance. When sufficient net has been brought in, the lead line should be quickly brought in onto shore. The fish can then be taken out of the net.

Figure 8.3 A beach seine.

Easy fishin'
The pet store and the fish market are the most reliable methods of obtaining examples of finned fauna. While not as 'fun' as the other methods they should be considered as an alternative to catching no fish. If all else fails, you can use pictures.

Keeping and displaying fish
Keeping live animals must be done in a manner that minimalizes stress. A home aquarium is a good method for displaying fish. It allows the observer to see what the fish looks like. The tanks should be aerated and kept cool.

For the temporary tank, airstones operated by a line from a scuba cylinder or air pump (AC or DC) can be sufficient for aeration. Tanks can be kept cool by insulating them (put them in old Styrofoam coolers), keeping them in shade and packing the outside with ice. It is important to keep the top of the tanks covered as some fish try to jump out. Release the fish back to where you got them.

For a more permanent fixture (eg. In a nature house) there is a wealth of material available from local libraries, pet stores, scientific supply houses, and internet resources.

Dealing with offenders
You do not have the legal means to apprehend offenders of the Fisheries and Wildlife Act. What you can do is to be familiar with the most updated federally issued guidebooks which would be useful in your area; for example, regionally issued tidal water sports fishing guides, freshwater fishing guides, or hunting guides.

If you happen to witness an offender (for example, keeping more than their limit of sport fish), what you can do is record the date, time and location of the witnessed event. The license of the offender's boat or vehicle is also valuable information to record.

With all this information, the best thing that can be done is to send it to the appropriate government agency who can then act legally.

Red Tide
If you are working in a marine environment, knowledge of 'red tide' and its effects is very important. Red tide an algal bloom caused by a few species of single-celled phytoplankton, dinoflagellates, which produce toxins. Their photosynthetic pigments can be green, red or brown. A reference leaflet is very useful in this respect. Having read the guide, you can apply your knowledge to situations where members of the public need to know why it is unsafe to, for example, harvest shellfish when a red tide warning has been posted, or what causes a red tide.

What is a fish?
Most of the fish species you will deal with can be described as:

> "jaws present, nostrils paired, paired pelvic and or pectoral fins present, gill openings as slits covered by a flap-like operculum, body in a wide variety of shapes with or without scales."

Fish are aquatic vertebrates whose ancestors were also aquatic. This is in contrast to whales, sea turtles and certain other vertebrates who had terrestrial ancestors but underwent a secondary adaptation to aquatic life. Each of the three living classes and one extinct class of fish has unique characteristics, but all share certain primitive vertebrate features and others that adapt them to the water.

- Fishes are ectothermic (internal body temperature of an animal is dependent on external heat)
- Their integument contains many simple mucous glands and usually bony scales
- Their skeleton is less massive than in terrestrial vertebrates. There is little differentiation of the vertebral column other than trunk and tail; the visceral skeleton is well-developed; and the appendicular skeleton consists only of fin supports.
- Fishes generally do not have a fleshy muscular tongue, and the intestine is not divided into small and large segments.
- Bony fish have special blind sacs called ceca which branch out from the small intestine in the pyloric region, the region near the stomach, to increase the absorptive surface area of the intestine.
- In sharks there is a special structure called a spiral valve in the lumen of the intestine. As food moves through the intestine it must take a circular path, allowing more time for the absorption of nutrients
- Adults exchange gases with the environment through gills located in gill pouches; lungs or other accessory respiratory organs are present in a few groups.

Figure 8.4 A salmon.

Fish Anatomy

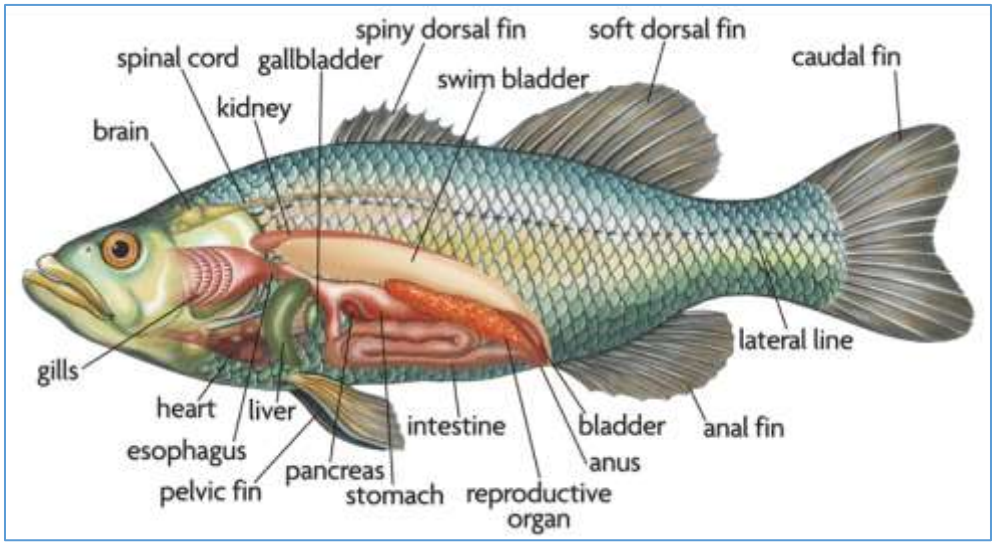


Figure 8.5 Anatomy of a fish.

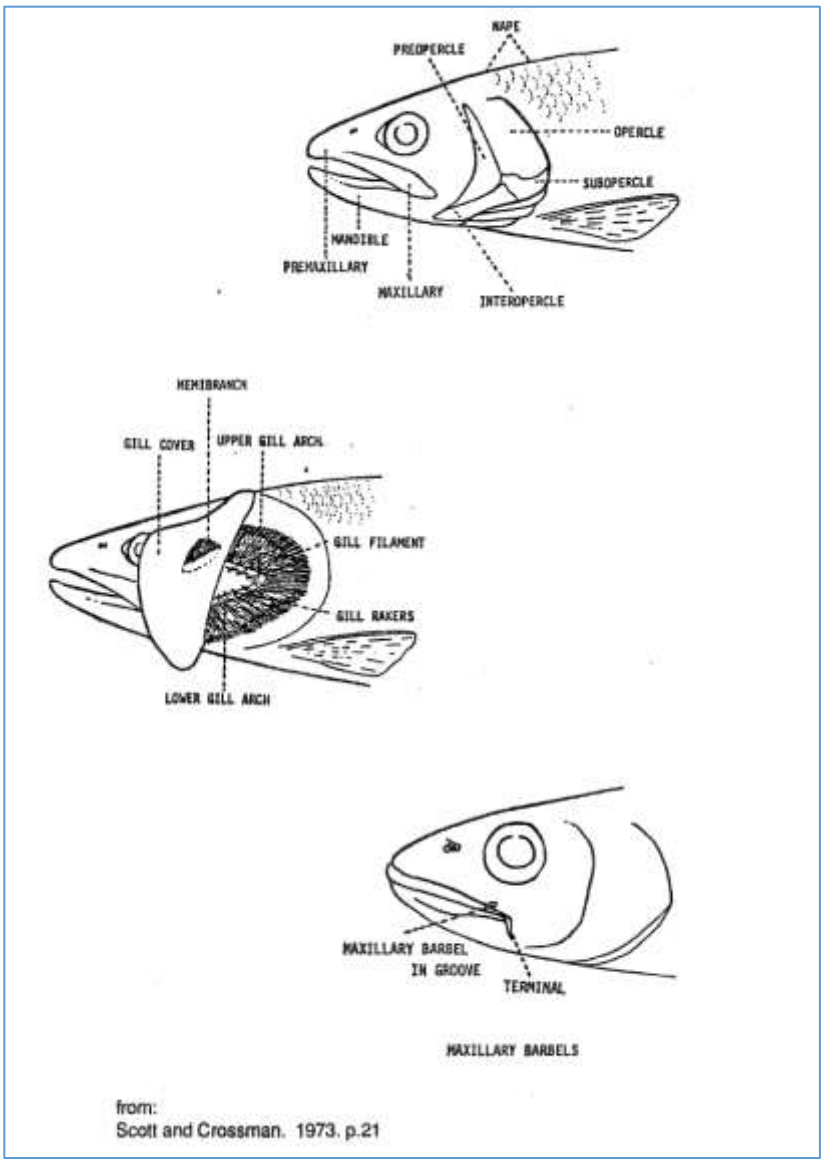


Figure 8.6 Anatomy of a fish head.

Skeletal System

Essential to a good biological presentation is being able to speak the language of the subject matter. For fish this includes some simple external anatomy. This will aid you in not only the talking but also the identifying of any fish found.

A common observation about the skeleton of a fish is that there are a large number of bones (Figure 8.7). This is especially true if you are eating a fish – there seems to be a bone or two in every mouthful. For convenience, the skeleton of a fish is divided into three components:

- The axial skeleton (vertebral column or backbone)
- The skull (head)
- The appendicular skeleton (the fins and their supporting structures)

The vertebral column of a fish is very different between the major groups. In hagfishes there is a simple rod of cartilage (notochord); in lampreys there are vertebrae made of cartilage; in ratfish the vertebral column contains some bony material; and in the bony fishes (teleosts) it is solid bone. Unlike terrestrial organisms with an elaborate musculature for support, the vertebrae of fish do not require such muscles and as a result, lack the elaborate projections (processes) of vertebrae to which they are attached. In fish there is generally one vertebra per segment to allow for the flexibility of swimming movements.

The ribs of fish extend downward (vertically) between each of the adjacent muscle masses. The bony fish also have ribs extending loosely upwards (dorsally) between dorsal muscle masses. The vertebrae in the trunk region have dorsal projections (processes) to accommodate and protect the spinal cord.

The skull of a fish is extremely complex compared to that of our own. The brain case alone typically has 40-50 bones, many of which are fused. The complex skull structure of a fish reflects the varied uses of the head region; the ingestion of food, the passage of water for respiration, the presence of many sense organs, the protection of the brain, gills, and other organs, the attachment of muscles, and the streamlining of the animal for swimming. The gills are supported by rakers which are part of the brachiohyoid apparatus which also makes up the floor of the mouth.

The appendicular skeleton refers to the fins (appendages – pectoral in the front, pelvic in the back, caudal in the tail) and the girdles used to attach the pectoral and pelvic fins to the vertebra column. The girdles are usually quite simple in the cartilaginous fish, and more complex in the bony fish.

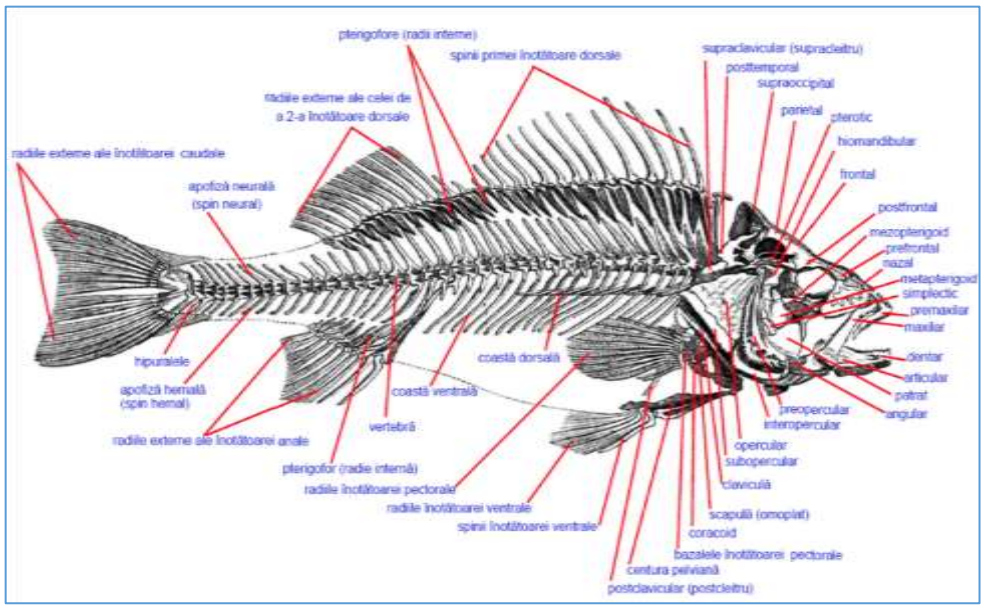


Figure 8.7 Skeleton of a fish.

Digestive System

Fish are broadly categorized as either:

- Detritivores (eating dead partially decomposed organic material)
- Herbivores (eating plant material)
- Carnivores (eating other animals)
- Omnivores (eating both plants and animals)

Within each of these categories the fish can be considered to have a varied diet (euryphagous), a more restricted diet (stenophagous), or a diet of only one food item (monophagous). Most fish are carnivorous with varied diets.

The structure of the fish mouth (buccal cavity) is highly variable due partly to evolution. The primitive fish mouth (still found in barracuda and pike) consists of firm jaws with sharp teeth to grasp prey. Modern fish have their mouth parts modified to feed by a sucking action, which is very common in fish today.

Certain structures in the mouth and throat (buccal-pharyngeal cavity) reflects different feeding habits. In carp there is a dorsal pad at the entrance to the esophagus and this may be used to remove excess water from food. In certain coral-eating fishes there is a dorsal pharyngeal valve and pharyngeal teeth for grinding coral. The gill rakers of cartilaginous and bony fish can also be modified for feeding.

The length of a fish's gut is also related to diet. Long intestines are associated with detritus and algae feeders which ingest large amounts of indigestible materials such as sand, mud, or cellulose. Gut lengths in carnivorous fish are shorter, with carnivores feeding on large prey (relative to their own body length) being the shortest. Carnivorous fish typically have a true stomach, and fish which eat small food items (microphagus) possess a gizzard (which masticates food as well as secreting digestive enzymes).

Circulation

The blood of fish is similar to that of other vertebrates in that it contains red blood cells for the transport of oxygen, and white blood cells for immunity. However, fish do not have bone marrow, so these cells are produced in a different location. Both cells originate in a variety of organs. In the hagfish they are produced by an envelope of tissue surrounding the gut. In cartilaginous fish they are produced in an organ found in the esophagus (organ of Leydig, some tissue by the gonads, and the spleen). The red blood cells (erythrocytes) of fish contain nuclei as in the case with other vertebrates except mammals.

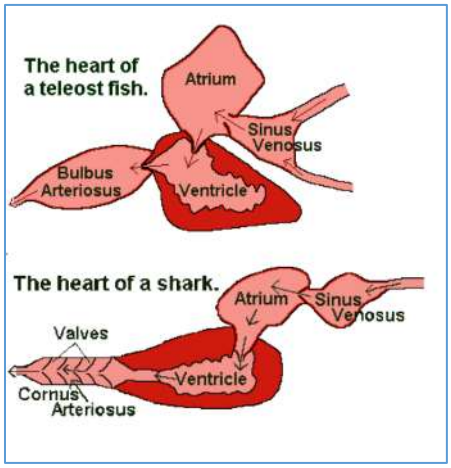


Figure 8.8 Diagram of the heart of trout and shark

The flow of blood through the fish body is from the heart to the gills, from the gills to the body general, and then to the heart again. The fish heart has a single atrium and ventricle, reflecting this single circulation. Birds and animals have a double circulation, the blood coming back to the heart after it is oxygenated before going back out to the rest of the body. This increases the pressure of the blood before it is pumped out to the body after it is oxygenated and supports the higher metabolic rate required to be warm-blooded; birds and mammals are the only animals with four-chambered hearts. In addition to the atrium the fish heart has an additional collecting chamber called the sinus venosus which precedes the atrium. There is also a fourth chamber after the ventricle, called the bulbus arteriosus (or the cornus arteriosus in cartilaginous fish). This dampens the pulses in pressure from the ventricle.

Reproduction

The gonads of fish are usually paired structures found over the roof of the body cavity, associated with the kidneys. Sperm from the testes may be shed into the abdominal cavity and leave the body through a pore (lampreys and salmonids). It may instead, as in the sharks, be stored in a seminal vesicle before being expelled through a duct also used by the kidneys. In bony fish the sperm passes through a separate duct. The passage of eggs follows a similar pattern to that of sperm.

Many fish show almost no sexual dimorphism in external appearance even after spawning. Most fish, however have permanent differences. Sharks and guppies (which have internal fertilization) possess an intromittent organ in males which is usually a modified fin. Egg-laying fish with territorial males (as in salmon) have larger males than females. Generally, however, if there is a size difference between the sexes the female is larger; this is the rule with live-bearing fish. The males of these species then are usually brightly coloured.

In sexually-reproducing animals, fertilization of the egg by the sperm may occur externally (to the parent's body) or internally. In external fertilization, male and female gametes are released into the surrounding water and the gametes meet only after being released from the parents' bodies. This is possible only in aquatic environments. There are a number of problems with external fertilization. Eggs and sperm are rapidly diluted in water. To ensure fertilization, organisms must release eggs and sperm at the same time (the cycles must be synchronized). Also, they must release eggs and sperm in the same place. In the ocean, the lunar cycle is thought to be important in providing the cue to breeding. The number of eggs released is inversely proportional to the degree of parental protection of the eggs (Table 8.1). If the species does not invest in parental care of eggs, it may lay larger numbers of eggs to ensure that some fertilized eggs survive and grow to maturity.

Internal fertilization is an adaptation to terrestrial environments. Eggs are retained within the female, where they are fertilized by sperm that have made their way through fluid filled tubes. The species involved provide their own watery environment for the gametes and do not require a water habitat to mate. Examples of internally-fertilizing organisms include most terrestrial animals (e.g. insects, reptiles, birds and mammals) and some aquatic animals (e.g. dog fish, sharks, cephalopods and crustaceans). Timing is still critical. Hormonal interactions play a critical role in attracting parents of each sex to each other in order that mating occurs at the right time for successful fertilization. Synchrony requires complex hormonal control mechanisms and sensory receptors that detect various stimuli and environmental cues.

Species, class	Average number of eggs	
Ocean sunfish (*Mola mola*, Teleostei)	28,000,000	Freely floating pelagic eggs - no parental care
Cod (*Gadus morrhua*, Teleostei)	9,000,000	
Haddock (*Melannogrammus aeglefinus*, Teleostei)	2,000,000	
Sturgeon (*Acipenser stellatus*, Chondrostei)	200,000	Bury eggs but no further care
Salmon (*Salmo salar*, Teleostei)	5,000	
Sculpin, (*Cottus asper*, Teleostei)	140	Considerable parental care
Stilckleback (*Gasterosteus aculeatus*, Teleostei)	60	
Medaka (*Oryzias latipes*, Teleostei)	30	

Table 8.1. Relationship between the number of eggs laid by a fish, and the degree of parental protection of the eggs.

Reproductive success for a species depends on a number of aspects of its life history such as:

1) Age at first reproduction. A population that bears its offspring at an earlier age than others grows more rapidly because each succeeding generation reproduces at an earlier time.

2) Brood size. Organisms that produce more offspring in each individual brood have a greater reproductive rate. In some organisms there are costs associated with parental care (e.g. birds) and individual animals do not produce as many eggs as they are physiologically capable of doing, but only as many as they can successively raise.

3) Number of broods per life time. Organisms that reproduce several times throughout their lives have a higher reproductive rate than those that reproduce only once. In order to compensate for low survivorship of offpsring to adulthood, some organisms have very large brood sizes and some have more broods per lifetime.

4) Inter brood interval. Some organisms are reproductively active during only certain stages of their adult lives. Others reproduce continuously after reaching adulthood. The number of broods per lifetime depends on the length of the interval between broods and fraction of the life span devoted to reproduction.

5) Reproductive cost for young. Organisms that invest a greater amount of time, energy and care in offspring increase the offspring's chances of survival. Parental investment involves energetic costs (e.g. costs of foraging for food for offspring) and may even put the parent in danger (e.g. of predation while gathering food for offspring). Parents must strike a balance between the costs and benefits of investing in offspring. If parents invest very little in their offspring (e.g. fish) , the cost to parents is minimized, but offspring survival is lower. Conversely, in organisms like mammals offspring are nourished and protected until they are well developed. Offspring survival is greatly increased but so is the per capita reproductive cost to parents.

Excretion and Salt-water Balance

The kidneys of bony fish are elongated and found above the swim bladder. The duct from each kidney joins with the other and form a smaller bladder. The bladder voids through a urinary duct which goes to the outside behind the anus. In the cartilaginous fish the urinary duct and anus empty into a common opening called the cloaca.

Most of the wastes (nitrogenous) are eliminated through the gills in the form of ammonia and urea (about 6 times as much nitrogenous wastes as the kidneys). The kidneys excrete creatine, uric acid, and trimethylanmineoxide. In cartilaginous fish the main nitrogenous waste is urea.

Some bony fish live in both freshwater and marine environments, and they can move from one to the other (anadromous fish). In freshwater environments there is a strong need to retain salts. As a result the kidney is highly adapted to conserve salts. The skin of fish also has very little blood supply, and is covered with mucus, which waterproofs the skin and prevents the loss of salt.

In marine fish there is the opposite problem of losing water and gaining salts. The kidneys in these fish are not as adapted for re-absorbing salts, and there are specialized cells (ionocytes) in gills to remove salts from the blood. In freshwater these cells absorb salts.

Freshwater and marine bony fish face different osmotic environments. Freshwater fishes have body fluids hypertonic to their surroundings and are continually flooded with water; marine bony fishes have body fluids hypotonic to seawater and are continually losing water.

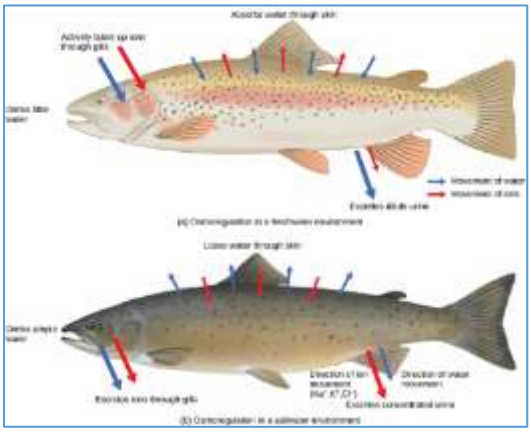


Figure 8.9 Freshwater fish live in a hypotonic environment (above) and need to excrete water and conserve salt ions using their kidneys and gills, marine fish live in a hypertonic environment (below) and need to excrete salt ions and conserve water.

Sense Organs
Fish possess the senses we have – sight, sound, smell, taste and touch. In addition, they are able to detect pressure changes in the water around them by means of a lateral line system, and electric currents (electroreception).

Smell and taste are both involved in perceiving chemical stimuli. Smell (olfaction) is the perception of molecules from a distant source whereas taste (gustation) involves physical contact with the source. In fish the olfactory receptors are located in pits on the head. Water is drawn into the pits through an incurrent channel (nares) by cilia, swimming, the movement of the gills, or a combination of these factors. Water leaves the pit through an excurrent channel (nares).

Within the pit is a structure with many folds of tissue called an olfactory rosette which contains numerous receptor cells. Elongated rosettes are characteristic of fish relying heavily on the sense of smell.

Taste (gustatory) receptors are localized in taste buds in the mouth and various exterior surfaces nearby – for example, on the fins and barbels of catfish, the well-developed lips of minnows and suckers, and the free pelvic fin rays of codfishes.

Hearing is an important sense in fishes because water is an efficient conductor of sound (much more so than air). Sound waves at the lower frequencies have enough energy to travel into the body of the fish and be perceived by the inner ear. At higher frequencies the tissue is not sufficiently displaced to stimulate the inner ear and other anatomical structures are used to enhance the process. In bony fishes the air bubble in the swim bladder is more readily compressed by a sound wave than the surrounding tissues. The swim bladder pulsates with a high frequency sound and will displace the adjacent tissue, which in turn will stimulate the inner ear. In some fishes (minnows and catfishes) the swim bladder is connected to inner ear by a chain of small bones (Weberian ossicles).

Pressure changes in the water around a fish can be detected by receptors (neuromasts) found in the lateral line. The pattern of stimulation from the lateral line, running the length of the body on either side, will provide information on the presence of predators and prey, help the animal orientate itself in moving water, and help it to avoid objects (such as transparent walls of aquaria). The lateral line may also be used in hearing.

Electroreception is accomplished by external pit organs in bony fish which open on the body surface through canals filled with a gel. In marine cartilaginous fish the canals are similar structures called the ampullae of Lorenzini. The receptors can detect very small changes in electrical currents in the water. This sense can allow fish to detect the electrical phenomena associated with the magnetic force field of the earth. It also helps to detect the presence of prey or a conspecific (members of the same species) due to electrical currents generated by the contraction of their muscles). In sharks the ampullae of Lorenzini can number in the hundreds of thousands making sharks the most sensitive animal to electrical fields.

The eye of a bony fish has a cornea of constant thickness. Therefore, all the focusing of light is accomplished by the lens, reducing optical alternations of light coming into the eye. The lens of the eye protrudes through the opening of the pupil, and the eye bulges outward from the surface of the body. This feature, along with the alternating head movements and fish, allows the fish to see behind itself.

The focusing action of the lens is not accomplished by changing its shape as in mammals. Rather, the lens is pulled inward and outward. The fish eye contains both rods and cones, so it can perceive colour. Cartilaginous fish and many bony fish have a reflective layer (tapetum), increasing their ability to see in poor light. The tapetum is responsible for eyeshine.

Scales

Fish are quite variable in the types and quantities of scales present on their bodies. To a large degree this reflects their different living habits. Some fish which are rather slow in their movements, such as sturgeon, many South American catfish, and seahorses, have large modified scales in the form of bony plates which serve for protection. Numerous fine scales are characteristic of fish which are fast swimmers or live in strong currents, such as trout. Fish living in calm waters and which do not swim at high speeds, such as perch and sunfish, have coarse scales.

The scales of bony fish are either of the cycloid or ctenoid type. The cycloid scales are found in fish such as trout, minnows, and herring. They are round, flat, and thin. The ctenoid scales are similar but possess tiny comb-like projections (ctenii) on the exposed edge which may improve their hydrodynamic efficiency. They are found in the perches, for example. Sharks possess tiny tooth-like scales called placoid scales which may serve a similar function. Because of these projections fish with ctenoid or placoid scales feel rough when touched.

Some fish have no scales, or have them modified for another purpose. These fish include sculpins, catfishes, and eels which live in tight places. Some fast-swimming open water marine (pelagic) fish also have no scales on the surface of the body (swordfish and some mackerels), although some do have scales which are deeply embedded (such as most tunas).

A juvenile fish will have the same number of scales as it grows. The scale grows along with the fish with cells (fibroblasts) in a growth region towards the edge responsible for adding protein (collagen) and calcification. The growth in the diameter of a scale is at a relatively constant rate, and the additions on the edge form growth rings called circuli. The rings show annual variations called annuli, and these can be used to determine the age of the fish. The growth rate of a fish can be determined by examining the spacing between the circuli. Close spacing indicates slow growth due to cold, fasting, or reproductive cycles.

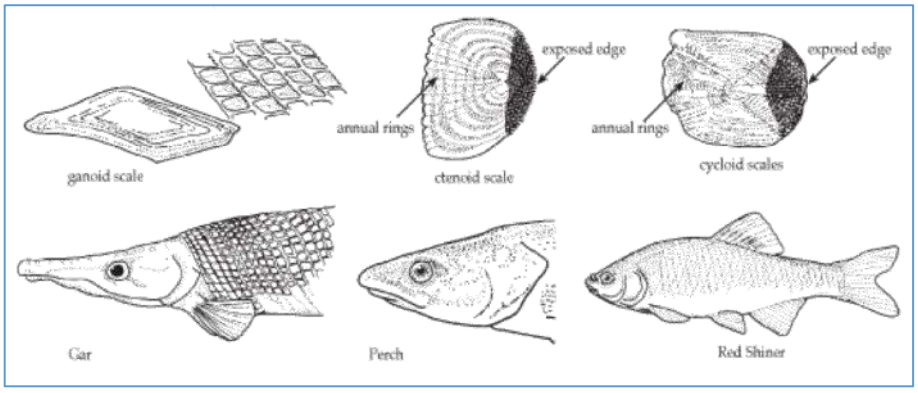


Figure 8.10 Examples of fish with different scales.

Figure 8.11 Diversity in bony fish, Class Osteichthyes.

Classification of Fishes

There are about 20,000-22,000 living species of fish, making them the most diverse group of vertebrates. They can be found in most aquatic environments. The modern fish contain three major groups:

Class Agnatha	jawless fish
Class Chondrichthyes	cartilaginous fish
Class Osteichthyes	bony fish

Class Agnatha

45 species, hagfish and lampreys

General characteristics

- Eel-like body
- Cartilaginous skeleton
- No jaw, paired limbs, or girdles
- Single nostril
- 6-14 gill pouches

Species

Atlantic Hagfish	*Myxine glutinosa*
Sea Lamprey	*Petromyzon marinus*
Pacific Lamprey	*Entosphenus tridentate*

Class Chondrichthyes

600 species, sharks, skates, rays, ratfish

General characteristics

- Cartilaginous skeleton
- Well-developed jaws
- Placoid scales
- 5-7 gill slits
- No air bladder (creates buoyancy problems)
- Paired claspers for reproduction
- Fixed gills so need to keep moving for water to flow over gills for respiration

Superorder Galeomorphi - Galean Sharks

Characteristics

- ground sharks
- Include all modern sharks except dogfish
- found in tropical and temperate waters
- live closer to the ocean floor
- have two dorsal fins and an anal fin
- long mouth extends behind the eyes

Order Carcharhiniformes – ground sharks
Order Heterodontiformes – bullhead sharks
Order Lamniformes – mackerel sharks
Order Orectolobiformes – carpet sharks

Species

Sand Tiger Shark	*Odontapis taurus*
Smooth Hammerhead	*Sphyrna lewini*
Blue Shark	*Prionace glauca*
Giant Basking Shark	*Cetorinus maximus*
Whale Shark	*Rhincodon typus*

Superorder Squalomorphi – Squalomorph Sharks

Characteristics

- lack anal fin
- Lack nictitating membrane

Order Hexanchiformes – frilled and cow sharks
Order Pristiophoriformes – saw sharks
Order Squaliformes – dogfish sharks
Order Squatiniformes – angel sharks

Species

Sixgill Cowshark	*Hexanchus griseus*
Spiny Dogfish	*Squalus acanthias*

Figure 8.12 The Spiny Dogfish (left) is a Squalamorph shark and the Basking Shark (right) is a Galean shark.

Superorder Batoidea - Rays

Characteristics

- Flattened bodies
- Enlarged pectoral fins
- Gills on ventral surface
- Pectoral fins fused to their heads
- Most species have a long, whip-like tail

Order Myliobatiformes – stingrays and relatives
Order Pristiformes – sawfish
Order Rajiformes – skates and guitarfishes
Order Torpediniformes – electric rays

Species

Lesser Electric Ray	*Narcine brasilliensis*
American Big Skate	*Baja binoculata*
Sawfish	*Pristis pectinate*

Figure 8.13 American Big Skate.

Superorder Holocephali – Chimaera

Characteristics

- Large heads with big eyes
- Thick body ending with a long thin rat-like tail
- Flat wing-like fins to swim
- Poisonous dorsal fins

Order Chimaeriformes – chimaera

Species

Pacific Ratfish *Hydrolagus colliei*

Figure 8.14. Pacific Ratfish.

Class Osteichthyes

General characteristics

- Skeleton of bone
- Air bladder or primitive lung
- Single gill flap (operculum) covering gill openings

Order Acipenseriformes

Family Acipenseridae – sturgeons

General characteristics

- Cartilaginous skeleton with dermal cones covering cranium
- Plate-like scales along sides
- Whiskers on snout
- Poor eyesight

Species

American Lake Sturgeon *Acipenser fulvescens*
Pacific Coast White Sturgeon *Acipenser transmontanum*

Order Semionotiformes

Family Lepisosteidae – gars

General characteristics

- Scales arranged in flat plates forming protective armor
- Anal and dorsal fins with few rays

Species

Giant Tropical Gar *Lepisosteus tristoechus*

Order Anguilliformes

Family Anguillidae – freshwater eels

General characteristics

- No pelvic or ventral fin
- Dorsal and anal fin continuous with tail fin
- Air bladder with open duct to throat
- Scales present

Species

American Eel *Anguilla rostrate*

Family Muraenidae- Moray Eels

General characteristics

- No pectoral fins

Species

Atlantic Blackedge Moray *Gymnothorax nigromarginatus*

Order Clupeiformes

Family Clupeidae

General characteristics

- Body deeply compressed laterally
- Oily flesh
- Deciduous scales

Species

Pacific American Sardine *Sardinops sagax*
American Shad *Alosa sapidissima*
Pacific Herring *Chipea pallasl*

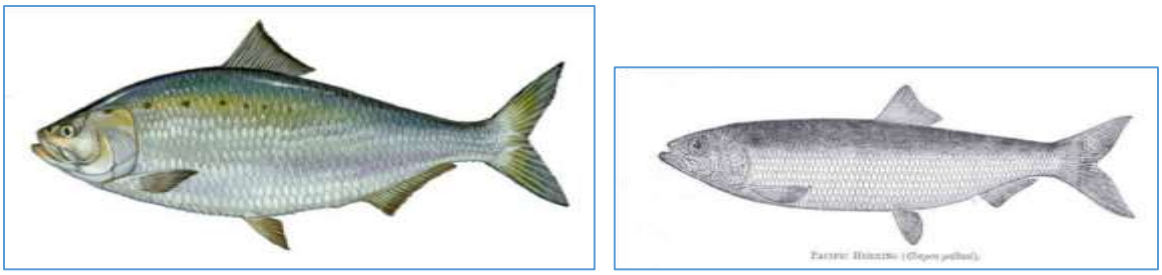


Figure 8.15 American Shad and Pacific Herring.

Order Salmoniformes

General characteristics

- Lack spines
- Pelvic fins abdominal, widely separated from pectoral fins
- Swim bladder connected by a duct to gut

Family Salmonidae – trout, salmon, whitefish, graylings

General characteristics

- Streamlined body

- Forked tail
- Axillary process by pelvic fins

Species

Rainbow Trout	*Salmo gardneri*
Chinook Salmon	*Onchorhynchus tshawytscha*
Mountain Whitefish	*Prosopium williamsoni*
Char	*Salvelinus fontinalis*

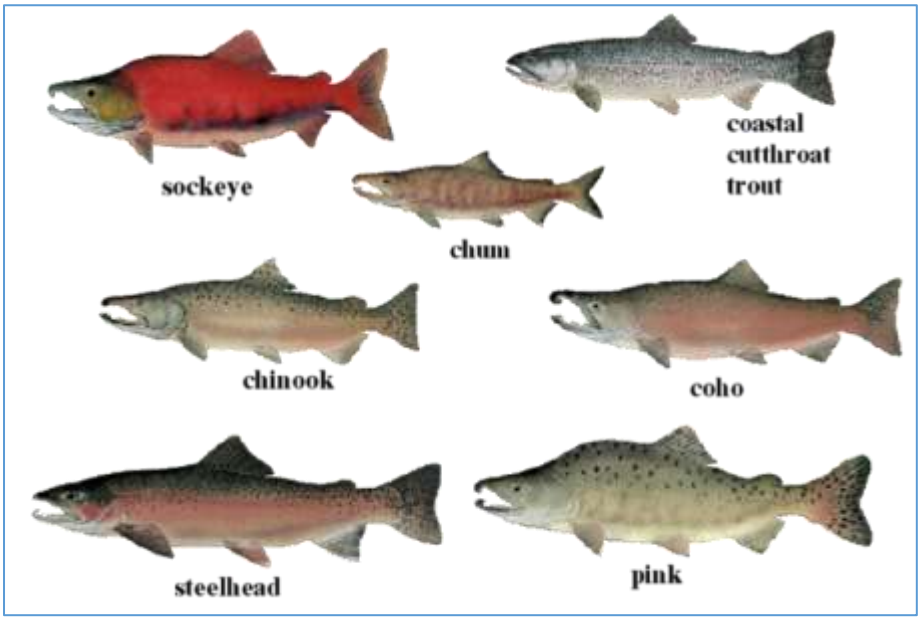


Figure 8.16 Salmonids have round, thin cycloid scales that gives their skin a smoother texture.

Family Osmeridae – true smelts

General characterics

- Small adipose fin on dorsal surface

Species

Eulachon	*Thaleichthys pacificus*
Surf Smelt	*Hypomesus transpacificus*

Figure 8.17 Eulachon and Surf Smelt are fed upon by salmon and diving sea birds.

Family Esocidae – pikes

General characteristics

- Ducklike bill
- Sharp teeth

Species

Northern Pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Grass Pickerel	*Esox americanus*

Order Cypriniformes

General characteristics

- Chain of bones connecting inner ear to swimbladder
- Upper jaw protractile
- Pharyngeal teeth
- Abdominal pelvic fin

Family Cyprinidae – minnows and carps

General characteristics

- Soft rays in fins
- Largest family of fish (1600 species)
- Rays modified into spines in some forms
- Thin lips

Species

Coastal Shiner	*Notropis petersoni*
Dace	*Phoxinys sp.*
Blackstripe Minnow	*Fundulus nofatus*
Flathead Chub	*Hybopsis gracilis*
Common Carp	*Cyprinus carpio*

Figure 8.18 Carp are characteristic of eutrophic lakes low in dissolved oxygen.

Family Catostomidae – suckers
General characteristics

- Mouth on underside of head
- Fleshy lips

Species

Humpback Sucker	*Zyrauchen texanus*

Family Ictaluridae – catfish
General characteristics

- 4 pairs of short barbels around mouth
- Spines in front of dorsal and pectoral fins

Species

V-tailed Channel Catfish	*Ictalurus punctatus*
Brown Bullhead	*Ictalurus nebulosus*
Black Bullhead	*Ictalurus melas*

Black Catfish

Brown Bullhead

Figure 8.19 Young catfish feed on aquatic insect larvae while adult catfish feed on aquatic plants, snails, crayfish and sees. Their barbels help them to find food in the murky bottoms of streams and lakes.

Family Amblyopsidae – cavefish
General characteristics

- Whitish colour
- Sensory papillae in rows on head, body and tail

Species

Northern Cavefish	*Amblyopsis spelaean*
Spring Cavefish	*Chologaster agassizi*

Order Gadiformes
General characteristics

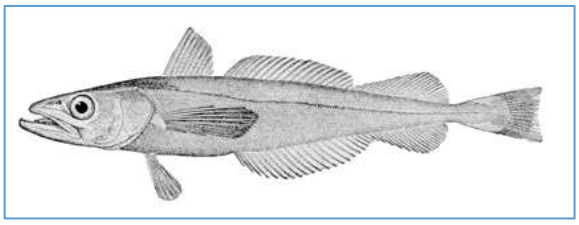
- Soft-rayed fins, no spines
- Pelvic fins anterior to pectoral fins
- Ductless air bladder
- Codfish, hakes, rattails

Family Gadidae
General Characteristics

- Caudal fin separate from dorsal and anal fins
- Dorsal fin divided into two or three sections

Species

Atlantic Cod	*Gadu morhua*
Pacific Cod	*Gadus macrocephalus*
Pollock	*Pollachius virens*
Burbot	*Lota lota*
Haddock	*Melanogrammus aegelfinus*
Hake	*Phycis sp*.



Hake

Pacific Cod

Figure 8.20 Species in the Family Gadidae are part of a large commercial fishery.

Order Gasterosteiformes – tube-mouthed fish
General characteristics

- Tube-like snout
- Bony plates forming complete or partial external armour

Family Gasterosteidae – sticklebacks
General Characteristics

- Bony plates along sides
- Spines

Species

Three-spine Stickleback *Gasterosteus aucleatus*

Figure **8.21** The Three-spine Stickleback is a common freshwater fish.

Order Perciformes
General characteristics

- Largest order of vertebrates, 7000 species, 156 families
- Extremely diverse
- Predators
- Spines
- No adipose fin
- Pelvic fins with one spine, five or less rays
- Scales ctenoid or absent

Family Centrarchidae – Sunfishes
General Characteristics

- Carnivorous
- Freshwater

Species
Smallmouth Bass (*Micropterus dolomieu*)

Figure 8.22 Bass (above) are a popular sports fish that feed on smaller fish such as salmon fry and sunfish (below).

Family Serranidae- sea basses and groupers
General Characteristics

- Carnivorous
- Large mouth, sharp teeth

Species
Atlantic Tiger Grouper *Mycteroperca tigris*

Family Percidae – perches
General characteristics

- Small
- Two anal spines

Species
Yellow Perch *Perca flavescens*
Walleye *Stizostedion vitreum*
Darters *Etheostoma sp.*

Figure 8.23 Yellow Perch.

Family Lutjanidae – snappers
General characteristics

- Top of snout flattened
- Sharp teeth

Species
Atlantic Gray Snapper *Lutjanus griseus*
Blue-line Snapper *Lutjanus viridis*

Figure 8.24 Diversity in the Family Lutjianidae -Vermillion Rockfish and Copper Rockfish.

Family Embiotocidae
General Characteristics

- Cycloid scales
- Small mouth
- Viviparous

Species

Striped Seaperch	*Embiotoca lateralis*
White Seaperch	*Phanerodon furcatus*

Figure 8.25 Pile Seaperch *Rhacochilus vacca*

Family Blenniidae – combtooth blennies
General characteristics

- No scales
- Often with crests, ridges, and fringes on head

Species

Redlip Blenny	*Ophioblennius atlanticus*


[

Figure 8.26 Black Prickleback.

Family Cottidae – sculpins

General characteristics

- Mostly bottom-dwelling
- Often scaleless
- Two dorsal fins
- Pectoral fins fan-shaped, large

Species

Red Irish Lord *Hemilepidotus hemilepidotus*


Figure 8.27 Two species of sculpin: Staghorn Sculpin (left) and Sailfin Sculpin (right).

Order Pleuronectiformes – flatfish

General Characteristics

- One side of body white, eyeless
- Benthic
- Long dorsal and anal fins
- Swim bladder absent

Family Bothidae – left eye flounders

Species	
Pacific Sanddab	*Citharichthys sordidus*

Family Peuronectidae – right eye flounders

Species	
Pacific Halibut	*Hipposglossus stenolepsis*
Pacific Starry Flounder	*Platichthys stellatus*
Turbot	*Pleuronichthys sp*
Sole	*Pleuronichthys coenosus*

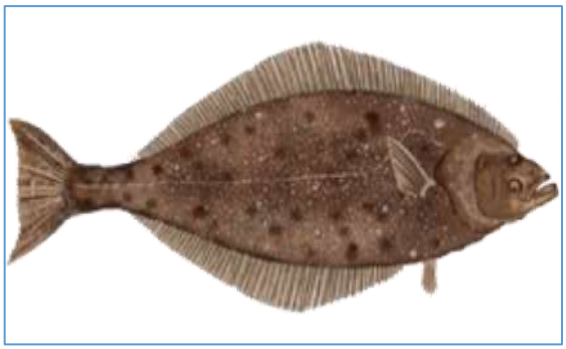


Figure 8.28 Pacific halibut is a species of righteye flounder that can weigh over 200 kgs.

Family Soleidae – soles

Species	
Naked Sole	*Gymnachirus melas*

Figure 8.29 Starry Flounder.

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Chapter 9 Amphibians and Reptiles

LEARNING OUTCOMES

Successful completion of this unit will enable you to:

1. Compare general features of amphibians and reptiles with other members of the Phylum Chordata.
2. Relate amphibian respiration and reproduction to their respective habitats.
3. Identify distinguishing characteristics of the Class Amphibia and the major Orders and Families within.
4. Identify distinguishing characteristics of the Class Reptilia and the major Orders and Families within.

Amphibians and Reptiles Outline

- What is an Amphibian?
- What is a Reptile?
- Classification
    - Class Amphibia
        - Order Caudata or Urodela– have tails as adults - salamanders, newts
        - Order Gymnophiona or Apoda – legless - caecilians
        - Order Anura – lack tails as adults - frogs, toads
    - Class Reptilia
        - Order Crocodilia – crocodiles, alligators, caimans
        - Order Testudines – turtles and tortoises
        - Order Squamata – lizards, snakes
- Bibliography

INTRODUCTION

Amphibians and reptiles are grouped together in the science of Herpetology and are often referred to collectively as herpetiles. They are distinguished from other terrestrial vertebrates in that they are cold-blooded or poikilothermic while birds and mammals are warm-blooded or homeothermic. The amphibians and reptiles also have three-chambered hearts, with two atria and a single ventricle. Only the most advanced reptiles have a divided ventricle. The birds and mammals on the other hand, have four-chambered hearts forming a double circulatory system which allows for a complete separation of oxygenated and deoxygenated blood.

AMPHIBIANS

As a group, the amphibians possess three characteristics which are immediately evident and draw interesting comments from people on nature walks:

1. The eggs of amphibians possess one or more layers of protective jelly. The inner embryonic membranes (amnion, chorion and allantois) never develop and as a result the eggs of amphibians are vulnerable to desiccation and must be deposited in moist environments, usually in the form of standing water along moving streams and rivers. An exception to this rule is the Family Plethodontidae or the lungless salamanders. In this family, the majority of species do not depend upon temporary or permanent water in which to breed. Instead, eggs are laid beneath or within ground substrate such as logs, boulders, leaf litter, etc.

Figure 9.1 A cluster of frog eggs laid amongst emergent aquatic vegetation at the edge of a pond.

2. Amphibians undergo metamorphosis – a transition from egg to larva to adult. The larvae of amphibians are aquatic and respire through external gills. In the case of larval frogs (tadpoles), the external gills are covered with a layer of skin after a few days of development. A single opening called the spiracle acts like a fish's gill opening allowing water to be pumped from the mouth across the internal gills and out the spiracle. In the case of frogs and toads the larvae (tadpoles) are herbivorous and eat algae, diatoms, and the feces of other tadpoles. Adults are carnivorous, primarily insectivorous, although large bullfrogs and toads are known to eat snakes, other frogs, mice and small toads.

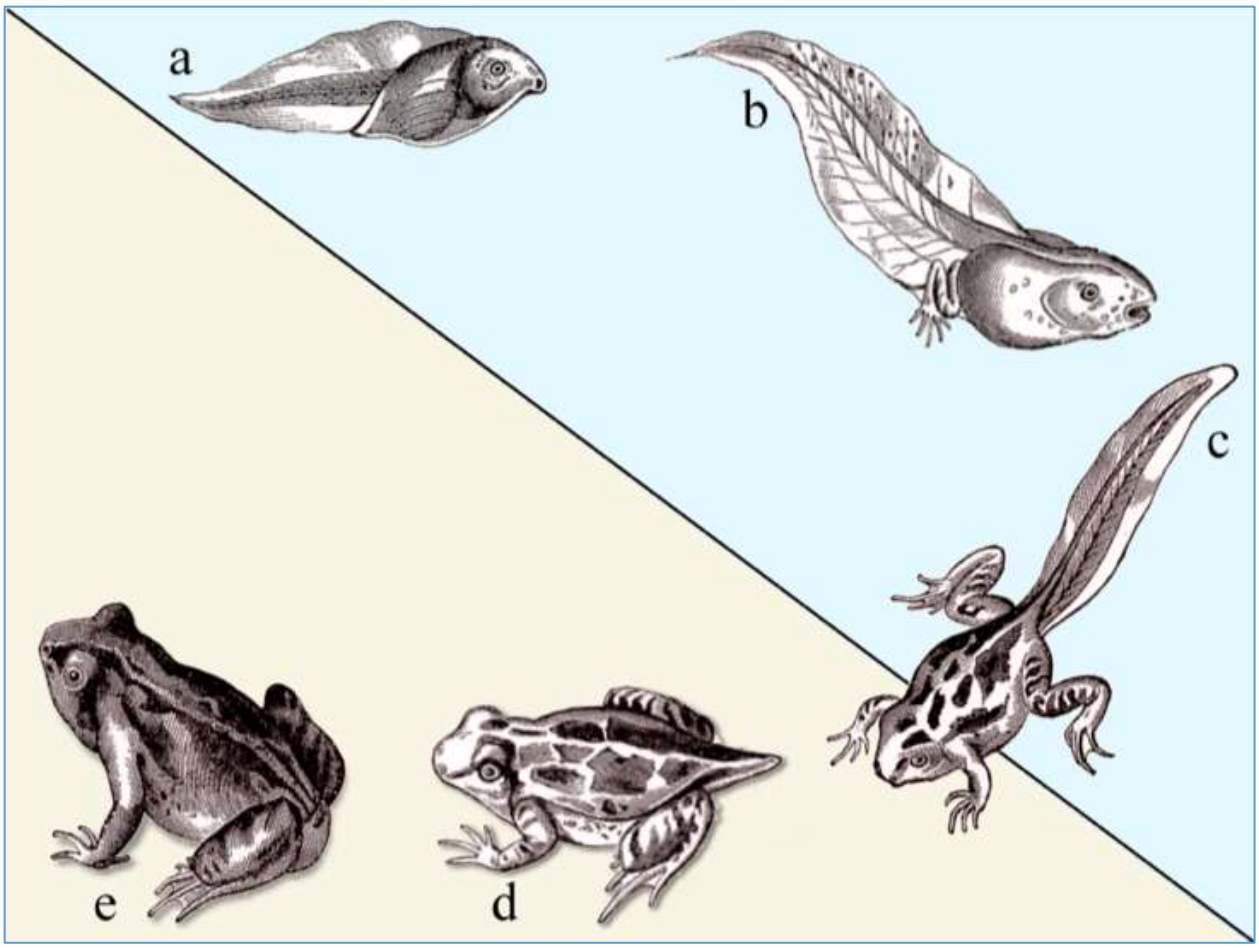


Figure 9.2 Amphibian metamorphosis.

3. Amphibians live in a combination of terrestrial and aquatic environments during different stages of their lives. The dependency on water extends beyond reproduction. In vertebrates the respiratory surfaces are typically gills (fish, larval amphibians) or alveolar surfaces in lungs (reptiles, birds, mammals). In adult amphibians the lungs have a simple structure and do not have a large internal surface area for gas exchange. As a result, amphibians exchange gas through two additional mechanisms, both of which are features of the integumentary system (skin). Depending upon the species, amphibians respire through the outer skin of the body, or through the thin lining of the buccal cavity and pharynx (buccopharyngeal respiration). Usually an amphibian will use a combination of two or three respiratory mechanisms for gas exchange. The respiratory surface must be kept moist for gas exchange to occur, and as a result, adult amphibians are tied to moist environments. If the skin of an amphibian dries out it will suffocate.

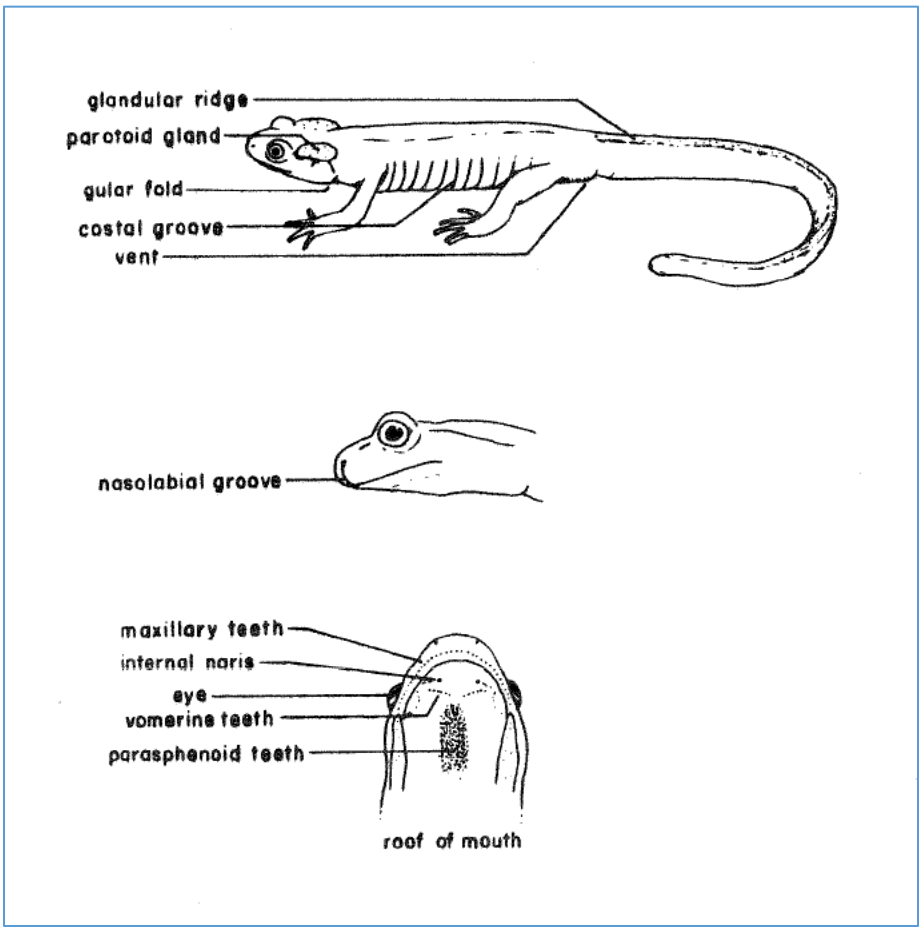


Figure 9.3 Anatomy of a salamander.

REPTILES

The skin of a reptile is significantly different from that of an amphibian, enabling the reptile to live in drier environments. The horny layer of the epidermis is much thicker, forming a protective barrier between the environment and the moist tissue of the organism, enabling the reptile to conserve body fluids. Some of the more conspicuous characteristics of a reptile are as follows:

1. The horny layer of reptiles' epidermis forms a cornified epithelium which is constantly being replaced. As underlying layers of the epithelium develop, the outer layer loosens and is lost. This is the basis of a reptile "shedding" its skin (ecdysis). In most snakes and some lizards there is an abrupt period of ecdysis, which results in the shed skin coming off intact. In other snakes and lizards the skin is shed in pieces.
2. All reptiles except a few turtles have well-developed epidermal scales. These arise from a folding of the epidermis and the outermost layers of the dermis. The scales vary dramatically in structure within the Class Reptilia, ranging from small and granular to large and rectangular, or spiny scales. The larger scales may occur in definite patterns. The scales of reptiles have become specialized to perform functions other than those related to water conservation. These include protective devices (spines of horned lizards), warning devices (rattles of rattlesnakes), and locomotive devices (large ventral scales of some snakes and lizards).

3. Reptiles undergo two types of development found in animals with internal fertilization. Most reptiles lay eggs (oviparity) which have a large amount of yolk. These are complete with amnion, chorion, allantois and a protective outer shell. However, instead of laying eggs, some reptiles give birth to live young. This is called ovoviviparity, a situation where the egg is essentially retained and hatched within the female, with the young born live (the garter snake (*Thamnophis sirtalis*) is a good example). Unlike mammals, however, which also give birth to live young, the reptilian mother provides no nourishment to the developing individual.

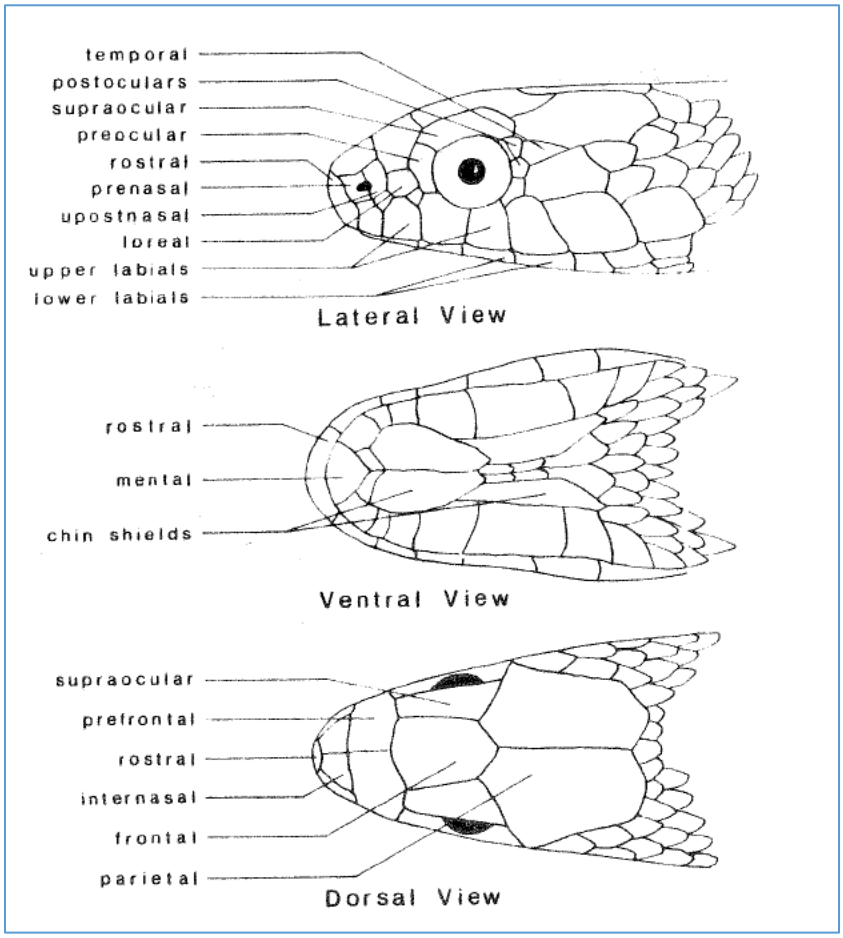


Figure 9.4 Snake scale types – lateral, ventral and dorsal view

CLASSIFICATION

Amphibians and reptiles belong to the Phylum Chordata. They are in the Subphylum Vertebrata with the fish, birds and mammals. Amphibians, reptiles, birds and mammals are all classified in the Superclass Tetrapoda and have the following characteristics:

- paired appendages, typically limbs ending with 5 digits
- cornified layer in the skin
- lungs in the adult forms
- ossified skeleton

The reptiles and amphibians differ from the other tetrapods on the basis of the following characteristics:

- absence of hair or feathers on the skin
- depend on external sources for body heat

CLASS AMPHIBIA

There are three major orders of living amphibians, represented by

- salamanders
- caecilians
- frogs

The name Amphibia is from the Greek word amphibios meaning “two lives” and refers to the part terrestrial and part aquatic lives of many members of this group.

- breeding generally occurs in an aquatic environment
- metamorphosis is typical for most of group
- external gills and lateral lines present in larval stage
- skin without scales in temperate groups
- four modern orders are recognized

ORDER: CAUDATA – SALAMANDERS (formerly called Urodela)

- body resembles that of lizards – with which they are often confused
- females larger than males
- external ears absent
- lungs may or may not be present
- 8 families worldwide, 7 in North America
- 112 species north of Mexico

FAMILY SIRENIDAE – The Sirens

- 2 genera in North America
- forage at night

General Characteristics

- aquatic permanent larvae
- long bodies and external gills and gill slits
- no hind limbs, tiny forelimbs
- often confused for eels
- gender not determined visually

- range – southern USA

Species

Dwarf Siren *Pseudobranchus striatus*
Greater Siren *Siren lacertian*

FAMILY SALAMANDRIDAE – the Newts

- 74 species in Northern Hemisphere
- 2 genera and 6 species occur in North America
- eastern newts aquatic, western terrestrial
- Also occurs in Asia, Europe and North Africa

General Characteristics

- metamorphosis is typically complete in newts
- costal grooves are absent
- skin is rough (except on males in breeding season)
- back (dorsal region) is generally dark in colour and the belly (ventrical) is bright orange
- slender bodies
- well defined limbs
- aquatic species have caudal and dorsal body fins (more prevalent in males)
- toxic skin secretions from glands that cover the entire body

Species

Eastern Newt *Notophthalmus viridescens*
Rough-skinned Newt *Taricha granulosa*
Striped Newt *Notophthalmus perstriatus*

Figure 9.5 Eastern Newt.

FAMILY PROTEIDAE – Mudpuppys and Waterdogs

- 2 genera with 5 species in eastern North America
- 1 species in Europe which are blind and cave dwelling

General Characteristics

- aquatic permanent larvae
- have deep red plume-like gills
- eggs laid on stones in streams
- female guards eggs until young hatch

Species

Mudpuppy	*Necturus maculosus*
Gulf Coast Waterdog	*Necturus beyeri*

FAMILY AMPHIUMIDAE – The Amphiumas

- smallest family of salamanders – 1 genus with 3 species
- found in southeastern United States

General Characteristics

- eel-like
- tiny limbs with 1-3 toes
- hatch with external gills
- do not transform completely
- nocturnal
- carnivorous

Species

Two-toed Amphiuma	*Amphiuma means*

FAMILY AMBYSTOMATIDAE – The Mole Salamanders

- three genera in North America, approximately 18 species
- most breed in ponds or lakes
- live in moist terrestrial shelters during rest of year

General Characteristics

- length 5 – 30 cm (tip of snout to tip of tail)
- short, blunt heads for digging into substrate
- robust bodies and limbs
- larvae with broad heads and long filamentous gills
- conspicuous costal grooves
- laterally flattened tail

Species

Tiger Salamander	*Ambystoma tigrinum*
Northwestern Salamander	*Ambystoma gracile*
*Pacific Giant Salamander	*Dicamptodon ensatua*

* Protected under the Wildlife Act in British Columbia as an Endangered Species.

Figure 9.6 Examples of salamanders in the Family Ambystomatidae.

FAMILY PLETHODONTIDAE – The Lungless Salamanders

- 23 genera, approximately 215 species
- found only in North and South America
- largest family of salamanders
- complete their entire life cycle on land
- use elaborate courtship

General Characteristics

- all species lungless
- long slender bodies and limbs
- costal grooves well developed
- use skin and buccal region for respiratory exchange
- nasolabial groove key feature
- eggs laid in moist areas (under bark) singly or in clusters
- embryos pass through gilled larval stage within egg
- hatch as miniature replica of adult

Species	
Clouded Salamander	*Aneides ferreus*
Dusky Salamander	*Desmognathus fuscus*
Ensatina	*Ensatina eschschotzi*
Western Red-backed Salamander	*Plethodon vehiculum*

Figure 9.7 Dusky Salamander**.**

ORDER GYMNOPHIONA – CAECILANS

FAMILY CAECILIIDAE

General Characteristics

- elongated bodies segmented by annular grooves
- small rudimentary eyes covered with skin
- larvae, if present, with gill slits but not external gills
- no limbs (eel-like)
- no tail
- recessed mouth

Species

No common name *Oscaecilia ochrocephala*

ORDER ANURA - FROGS AND TOADS (formerly Salientia)

- 16 families in world with 9 occurring in North America
- Nearly 2,700 species in world – 80 in North America
- The Latin Anura means 'without tail'

General Characteristics

- adults lack tails
- limbs well-developed – hind developed for jumping
- well-developed eye with lids
- large ears on side of head (tympanum)
- generally loud voice to attract mates and scare off intruders
- microscopic mucus glands keep the skin moist
- some species have poison gland in skin
- most species breed in water
- eggs hatch into tadpoles and later (between 12 days to 3 years) change into frogs
- some species hatch directly as small frogs

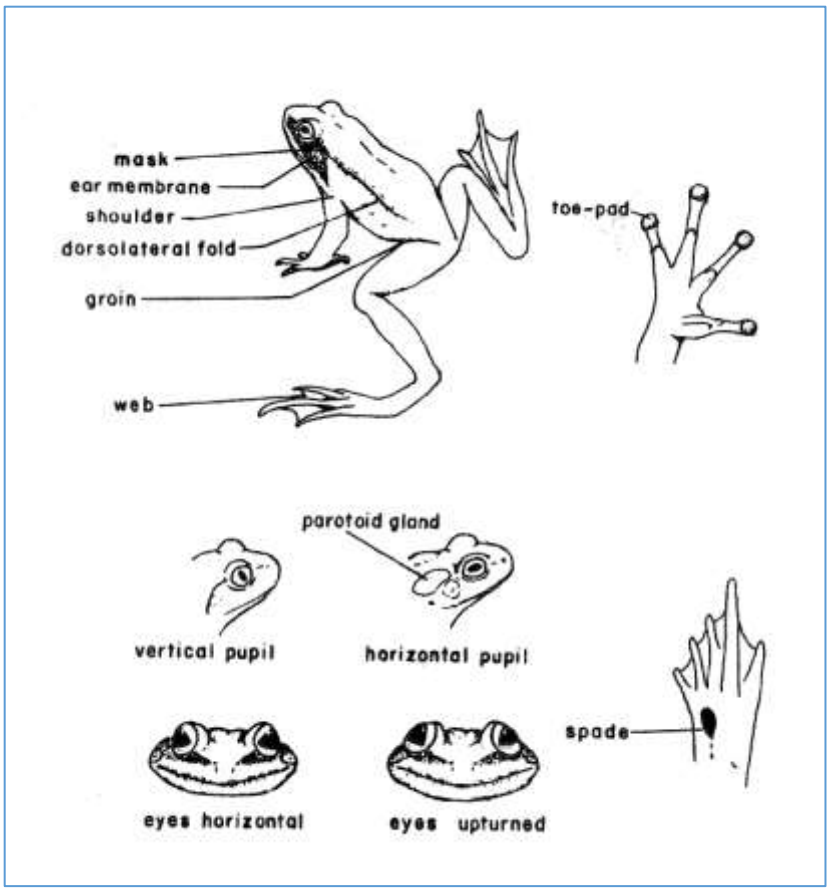


Figure 9.8 Anatomy of a frog.

Figure 9.9 Tailed Frog

FAMILY ASCAPHIDAE – Tailed Frogs

- 2 genera world wide
- 1 in North America

General Characteristics

- primitive frogs with 2 pairs unattached ribs and presacral vertebrae
- vertical pupil

- do not have a true tail – but a tail-wagging muscle
- live in cool mountain habitats
- lay eggs in cold streams
- hatch into tadpoles and transform 6 months later

Species

Tailed Frog *Ascaphus truei*

FAMILY RHINOPHRYNIDAE – Burrowing Toads

- 1 species in North America

General Characteristics

- lacks a breastbone
- pupil is vertical
- robust body with smooth skin
- short limbs
- small pointed head
- adapted to burrowing – has spade on hind foot
- eggs laid in water

Species

Mexican Burrowing Toad *Rhinophrynus dorsalis*

FAMILY PELOBATIDAE – Spadefoot Toads

- 10 genera with 69 species world wide
- 1 genera in North America with 5 species

General Characteristics

- vertical pupil
- spade (tubercle) for digging on hind limbs at ankle
- nocturnal
- teeth on the upper jaw
- generally smooth skin
- lack parotid gland

Species

Plain Spadefoot *Scaphiopus bombifrons*
Great Basin Spadefoot *Scaphiopus intermontanus*

Figure 9.10 Great Basin Spadefoot Toad.

FAMILY RANIDAE – True Frogs

- 46 genus with 569 species worldwide
- 1 genus with 21 species in North America

General Characteristics

- bony breastbone
- horizontal pupils
- generally large, long legs, pointed toes and extensive webbing on the hind toes
- excellent jumpers
- carnivorous
- mate in spring
- females lay up to 20,000 eggs in the water
- eggs hatch into tadpoles and change into frogs 6 to 24 months later

Species

Red-legged Frog	*Rana aurora*
Northern Leopard Frog	*Rana pipiens*
Bullfrog	*Lithobates catesbeiana*

Figure 9.11 The American Bullfrog is a serious invasive species and the subject of control in many areas. Unlike many other frog species it takes two years to metamorphose into an adult so seasonal vernal pools do not support its population. If this species is a problem in an area care must be taken to ensure that any wetlands created are vernal pools that dry up over the summer.

Figure 9.12 Adult and tadpole of Wood Frog.

FAMILY MICROHYLIDAE – Narrow-Mouthed Frog

- 61 genera with 270 species worldwide
- 2 genera and 3 species in North America

General Characteristics

- very small
- body shape variable
- nocturnal
- hind legs have tubercles used for digging
- feed on ants

Species

Eastern Narrow-mouthed Frog *Gastrophryne carolinensis*

Sheep Frog *Hypopachus variolosus*

FAMILY BUFONIDAE – True Toads

- 19 genera and approx. 300 species world wide
- 1 genus in North America – approx 18 species

General Characteristics

- chunky body with rough warty skin
- lack anterior breastbone
- parotid gland on the neck – secretes poison to would-be predators
- the warts also contain poison
- do not have teeth on upper jaw
- toads do not cause warts on people!
- breed spring and summer usually after rains
- some true toads lay up to 25,000 eggs in a single clutch
- tadpoles are black

Species

American Toad *Bufo americanus*
Western Toad *Bufo boreas*

Figure 9.13 American Toad

FAMILY HYLIDAE – Treefrogs

- 34 genera with approx. 600 species worldwide
- 7 genera with 26 species in North America

General Characteristics

- horizontal pupils
- generally small
- slender legs

- have adhesive toe pads to aid climbing
- most are arboreal but breed in water

Species

Northern Cricket Frog	*Acris crepitans*
Pacific Treefrog	*Hyla regilla*
Chorus Frog	*Pseudacris triseriata*

Figure 9.14 Pacific Treefrog and Northern Chorus Frog.

FAMILY LEPTODACTYLIDAE – Leptodactylid Frogs

- 50 genera of about 650 species worldwide
- 4 genera and 7 species in North America

General Characteristics

- extremely variable in size, structure and appearance
- horizontal pupils
- teeth in upper jaw
- young hatch as miniature frogs
- most lay eggs in water nests but some species are terrestrial
- nocturnal
- prominent tubercles at joints on undersides of toes

Species

Barking Frog	*Hylactophryne augusti*
White-lipped Frog	*Leptodactylus labialis*
Rio Grande Chirping Frog	*Syrrhophu cystignathoides*

Figure 9.15 Comparison of the markings between the Western Painted Turtle carapace (upper shell) and plastron (lower shell) and Pond Turtle.

CLASS REPTILIA – THE REPTILES

- 4 major orders worldwide representing some 6, 500 species
- the orders include:
    - Order Crocodilia – crocodiles, alligators, caimans
    - Order Sphenodontia - tuataras
    - Order Squamata – lizards, snakes
    - Order Testudines – turtles and tortoises
- most species found in tropics or subtropics
- first reptiles appeared some 30 million years ago
- reptiles were important in the evolution of birds and mammals
- in B.C. 18 species – turtles – 6; lizards -3; snakes -9

ORDER CROCODILIA – CROCODILES

General Characteristics

- 3 families, 8 genera and 21 species distributed worldwide in tropical and subtropical regions
- American Crocodile, American Alligator are native while the Spectacles Caiman has been introduced
- first appeared 160 million years ago
- are large and well armored
- all are aquatic, carnivorous and fond of basking
- ear is covered with a moveable flap

- females lay 20 – 80 eggs in a cavity in a sandbank

Species

American Alligator	*Alligator mississippiensis*
Spectacled Caimen	*Caiman crododilus*
American Crocodile	*Crocodylus acutus*

Figure 9.16 American Crocodile.

ORDER TESTUDINES – THE TURTLES

- an old group of reptiles dating back over 200 million years
- 12 families in world
- 7 families in North America – 18 genera with 48 species

General Characteristics

- body short and broad covered by a bony shell (carapace)
- in adults the teeth are replaced by a horny beak
- large land-dwelling turtles are often called tortoises
- turtles with hard shell, edible and aquatic are terrapins
- all turtles lay eggs although the number of eggs varies greatly

FAMILY CHELYDRIDAE – Snapping Turtles

- long tail
- massive heads with powerful hooked jaw
- small plastron (half the width of the carapace)
- males larger than females

Species

Snapping Turtle	*Chelydra serpentine*
Alligator Snapping Turtle	*Macroclemys temmi*

FAMILY KINOSTERNIDAE – Musk and Mud Turtles

- New World Family of 4 genera and 23 species
- 2 genera north of Mexico
- Genus Kinosternon- 5 species

General Characteristics

- give off musky odor when handled
- odor glands located on the side of the body where the skin meets the underside of the carapace
- strongly aquatic
- tail is short and blunt (prehensile in males)

Species

Yellow Mud Turtle	*Kinosternon flavescens*
Mexican Mud Turtle	*Kinosternon hirtipes*
Stinkpot	*Sternotherus odoratus*

FAMILY EMYDIDAE – Water and Box Turtles

- largest of the living turtle families
- 30 genera and 82 species world wide
- 7 genera and 26 species in North America

General Characteristics

- generally small to medium-sized turtles
- most species are semi-aquatic
- hind legs elongated with some webbing between toes
- box turtles are mainly terrestrial
- mostly omnivorous

Species

Western Pond Turtle	*Clemnys marmorata*
Painted Turtle	*Chrysemys picta*
Chicken Turtle	*Deirochelys reticularia*
Blanding's Turtle	*Emydoidea blandingi*
Map Turtle	*Graptemys geographica*
Diamondback Terrapin	*Malaclemys terrapin*
Eastern Box Turtle	*Terrapene carolina*

FAMILY TESTUDINIDAE – The Tortoises

- 10 genera and 39 species worldwide
- 1 genera and 4 species in North America
- This group includes the giant tortoises of the Galapagos Islands

General Characteristics

- terrestrial – and are good burrowers
- domed shell and large limbs with no webbing between toes
- herbivorous

Species

Desert Tortoise	*Gopherus agassizii*

FAMILY CHELONIIDAE – Sea Turtles

- 4 genera and 6 species in the Atlantic and Pacific Oceans off North America
- Largest living marine turtles
- Generally tropical or subtropical

General Characteristics

- Low stream-lined heart-shaped shell
- Powerful flippers with claws
- Nest along shores with females often laying over 100 eggs

Species

Loggerhead	*Caretta caretta*
Green Turtle	*Chelonia mydas*
Hawksbill	*Eretmochelys imbricata*
Atlantic Ridley	*Lepidochelys kempi*

Conservation note: Sea turtles are vanishing. Some scientists feel the species will soon become extinct.

Figure 9.17 A Green Turtle about to eat a jellyfish. Single use plastic shopping bags floating in an ocean resemble jellyfish and are eaten by sea turtles with potentially deadly results.

FAMILY DERMOCHELYIDAE – The Leatherback Turtle

- 1 living species in world
- largest living turtle in the pelagic – often found in tropical waters but move into temperate zones in summer

General Characteristics

- most specialized turtle
- covered with smooth leathery skin rather than horny scutes
- carapace made up of small bony plates in the skin
- ribs and vertebrae not attached to carapace
- powerful swimmer – covers long distances
- main food is jellyfish

Species

Leatherback *Dermochelys coriacea*

Conservation Note: Endangered

Figure 9.18 A Leatherback Turtle.

FAMILY TRIONYCHIDAE – Softshelled Turtles

- 7 genera of 23 species worldwide
- 3 species in North America
- Found in freshwater

General Characteristics

- have round flat flexible shell
- neck is long
- feet broadly webbed with claws and paddle-like
- strong swimmers
- generally aquatic but will go onto the land to rest and nest
- females larger than males

Species

Spiny Softshell *Trionyx spiniferus*

ORDER SQUAMATA – THE LIZARDS AND SNAKES

SUBORDER LACERTILIA – THE LIZARDS

- 17 families with 3,000 species worldwide
- 8 families and 115 species native to North America lizard comprise the largest living group of reptile

General Characteristics

- vary greatly in size, colour, and shape
- dry scaly skin
- clawed feet
- external ear openings
- varied life style
- generally diurnal
- most egg laying but some species' young are born alive

FAMILY GEKKONIDAE – The Geckos

- 89 genera with 750 species in the world
- 3 genera and 5 species are native to North America with 2 genera and 5 species introduced

General Characteristics

- have flattened bodies and short limbs
- many species have claws and/or extended toe pads – have hair like bristles that are tipped with minute suction cups – to allow the Gecko to climb walls
- most vocal of lizards
- skin tears easily and tail can be dropped, then new tail is regenerated

Species

Banded Gecko	*Coleonyx variegatus*
Yellow-headed Gecko	*Gonatodes albogularis*
Mediterranean Gecko	*Hemidactylus turcicus*
Leaf-toed Gecko	*Phyllodactylus xanti*
Reef Gecko	*Sphaerodactylus notatus*

FAMILY IGUANIDAE – The Iguanids

- 60 genera with approximately 628 species in the Americas, Madagascar and Fiji
- 14 genera with 44 species native to North America with 4 genera with 8 species introduced

General Characteristics

- range in size from 4 to 72 inches in length
- 5 clawed toes on each of 4 legs
- long tail
- teeth attached to a ledge on the inside of the jaw
- most species arboreal or terrestrial
- most eat insects and other invertebrates while few eat fruit and blossoms
- communicate by show of color and behavioral signals

Species

Green Anole	*Anolos carolinesis*
Zebra-tailed Lizard	*Callisaurus draconoides*
Collared Lizard	*Crotaphytus collaris*
Spiny-Tailed Iguana	*Ctenosuara pectinate*

Desert Lizard	*Dipsosaurus dorsalis*
Blunt-nosed Leopard Lizard	*Gambelia silus*
Spot-tailed Earless Lizard	*Holbrookia lacerata*
Common Iquana	*Iguana iguana*
Curly-tailed Lizard	*Leiocephalus carinatus*
Banded Rock Lizard	*Petrosaurus mearnsi*
Texas Horned Lizard	*Phrynosoma cornutum*
Chuckwalla	*Sauromalus obesus*
Clark's Spiny Lizard	*Sceloporus clarki*
Fringe-toed Lizard	*Uma notata*
Long-tailed Bush Lizard	*Urosaurus graciosus*
Side-blotched Lizard	*Uta stansburiana*

FAMILY ANGUIDAE –The Anguid Lizards

- 11 genera with about 60 species worldwide
- 2 genera with 8 species found in North America

General Characteristics

- elongated, shiny stiff bodies and tail caused by bony armour (osteoderms) in the skin
- have a lengthwise flexible groove of soft granular scales along their sides to allow them to breathe
- closeble eyelids
- external ear openings
- tiny (or absent) legs and toes
- most are terrestrial or burrowing
- carnivores – eat insects, small mammals and other lizards
- most are egg-layers but few mountain-dwellers bear live young
- defence techniques include fleeing, smearing the predator with excrement and shedding the tail
- can regenerate tail

Species

Northern Alligator Lizard	*Gerrohonotus coaeruleus*
Slender Glass Lizard	*Ophisaurus attenuates*

Figure 9.19 Northern Alligator Lizard.

FAMILY HELODERMATIDAE – The Gila Monsters

- 1 genus of 2 species confined to North America

General Characteristics

- heavy bodied lizards with short stout legs and a thick tail
- tail acts as a storage area for fat when food is abundant
- tail may lose up to 20% of bulk when food is scarce
- the back and head are covered with bead-like scales of shiny black, pink or yellow
- scales contain osteoderms, a sort of bony armor
- carnivores- they use taste and smell rather than sight to locate prey, small birds, rodents and other lizards
- they inflict a venomous bite that can cause great pain

Species

Gila Monster *Heloderma suspectum*

FAMILY ANNIELLIDAE – California Legless Lizards

- 1 genus of 2 species found only in California and adjacent Baja
- 1 species occurs in North America (above Mexico)

General Characteristics

- long and slender lizards
- moveable eyelids
- legless – but have shoulder and hip bones internally
- do not have an external ear opening
- no bony armor within the skin
- burrow in loose soil – seldom seen on surface
- eat insects

- young are born alive
- nocturnal

Species
California Legless Lizard *Anniella pulchra*

Conservation note: some populations have been affected by the use of pesticides on agricultural lands.

FAMILY XANTUSIIDAE – The Night Lizards

- 3 genera of 18 species found only in North America and Cuba
- 3 species north of Mexico

General Characteristics

- are related to gecko and have soft skin, flattened body and no movable eyelids
- differ in that they have small rounded scales on back
- large rectangular scales on the belly
- large shield on the head
- toes end in sharp claws
- light sensitive eyes have vertically elliptical pupils
- mostly nocturnal
- young are born tail first and live

Species
Desert Night Lizard *Xantusia vigilis*

FAMILY TEIIDAE – The Whiptails and Racerunners

- 40 genera of about 230 species confined to New World
- Most abundant in South America
- 16 species are native to the US and 1 species has been introduced

General Characteristics

- long slender lizards with long whip like tails and well-developed legs
- size from 4 to 48 inches in length
- generally have small round, non-overlapping scales on the back
- large rectangular scales on the belly
- no bony plates in the skin
- diurnal, terrestrial carnivores
- prey located by sight and smell or taste
- 1 species – *Cnemidophorus burti* - all individuals are females
- the female can lay fertile – but unfertilized – eggs that hatch into more females.

Species
Jungle Runner *Ameiva ameiva*
Giant Spotted Whiptail *Cnemidophorus burti*

FAMILY LACERTIDAE – Typical Old World Lizards

- native to Europe, Africa and Asia
- 2 species have been introduced in North America

General Characteristics

- Slender round bodies
- Well-developed legs
- Long tails
- Large head usually contains bony plates (osteoderms) that are not fused to the skull
- Most species have moveable eyelids
- Daytime hunters of insects, spiders, scorpions and small vertebrates

Species

Green Lizard	*Lacerta viridus*

FAMILY SCINCIDAE – The Skinks

- 87 genera and 1280 species found on every continent except Antarctica
- Most abundant in the tropics
- 3 genera of 15 species in North America

General Characteristics

- Generally have long body and tail which is covered with smooth scales containing bony plates (osteoderms)
- Terrestrial skinks have small legs while burrowing species have small or no legs
- Tail contains fracture plates that allows the tail to break off when grasped by a predator
- Tail is often brightly coloured to attract predator from vulnerable body
- Most diurnal
- Most eat insects, some are herbivorous
- All North American species are egg-layers

Species

Western Skink	*Eumeces skiltonaianus*
Sand Skink	*Neoseps reynoldsi*
Ground Skink	*Scincella lateralis*

Figure 9.20 Western Skink.

FAMILY AMPHISBAENIDAE – The Amphisbaenids

- 19 genera and 135 species found in Africa, Mediterranean countries, South America north to Mexico
- 1 species in North America (Florida)

General Characteristics

- Resemble earthworms in appearance
- Body scales are fused into rings which encircle the body
- Lack external ear openings
- Only one species has short front legs – rest legless
- Florida species eats worms and termites

Species

Worm Lizard *Rhineura floridana*

SUBORDER SERPENTES – THE SNAKES

- Found throughout the world except Antarctica, Iceland, Ireland and New Zealand
- 11 families with over 2700 species
- 115 species in North America

General Characteristics

- Elongated bodies with no limbs
- Scaly skin
- No eyelids or external ear openings
- Shed skin
- Carnivores who eat prey whole
- Some poisonous

FAMILY LEPTOTYPHLOPIDAE – The Slender Blind Snakes

- 2 species in southern USA

- Sometimes called worm snake

General Characteristics

- Vestigial eyes
- Few teeth, upper jaw toothless slender form
- Females lay eggs

Species

Texas Blind Snake	*Leptotyphlops dulcis*
Western Blind Snake	*Leptotyphlops humilis*

FAMILY BOIDAE – The Boas and Pythons

- 20 genera with 59 species worldwide
- 2 species of boa occur in North America
- No pythons are found here

General Characteristics

- Wide mobile jaw
- Enlarged ventral scales
- Well developed eyes
- Kills prey by constriction
- Feed on birds and mammals
- Boas have vestiges of hind limbs in the form of a spur located near the vent
- Boas bear young alive

Species

Rubber Boa	*Charina bottae*
Rosy Boa	*Lichanura trivirgat*

Figure 9.21 Rubber Boa.

FAMILY COLUBRIDAE – The Colubrids

- The largest of all snake families
- Over ¾ of the world's snakes
- 92 species in North America
- A very diversified group

General Characteristics

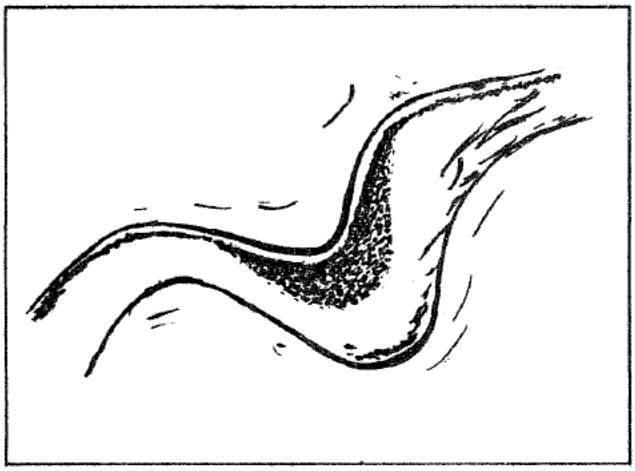
- Head is wider than the neck
- Eyes are well developed
- Back scales smooth or keeled
- Teeth present in both jaws
- No fangs
- Several species are harmful (Africa)
- Most lay eggs
- Feed on birds, mammals, some eat reptiles, amphibians, insects and fish

Species

Western Yellow-bellied Racer	*Coluber constrictor*
Sharp-tailed Snake	*Contia tenuis*
Pine Gopher Snake	*Pituophis melanoleucus*
Western Terrestrial Garter Snake	*Thamnophis elegans*

Figure 9.22 Common Garter Snake.

Figure 9.23 Western Rattlesnake.



Do you know how snakes get around without any legs? A snake pushes sideways against rocks, sticks and other objects it finds on the ground and gets a grip. Using the muscles attached to each of its ribs, the snake then pushes each set of ribs against each gripping point and moves forward.

FAMILY ELAPIDAE – The Coral Snakes

- 2 species in North America
- Highly venomous
- Tropical and subtropical in distribution

General Characteristics

- 2 large grooved fangs in upper jaw
- Can be confused with non-poisonous snakes
- Strikingly coloured
- Blunt snout

Species

Arizona Coral Snake	*Micruroides euryxanthus*
Eastern Coral Snake	*Midrurus fulvius*

FAMILY VIPERIDAE – The Pit Vipers

- 290 species worldwide
- 3 genera in North America, 17 species

General Characteristics

- All poisonous
- Most highly evolved of the snakes
- Most are nocturnal
- Most bear young alive

Species

Copperhead	*Agkistrodon contortrix*
Western Rattlesnake	*Crotalus viridis*
Massasauga Rattlesnake	*Sistrurus catenatus*

Figure 9.24 Rattle of rattlesnake.

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Chapter 10 Class Aves - Birds

LEARNING OUTCOMES

Successful completion of this unit will enable you to:

1. Describe the resources, equipment, and best practices to aid in bird identification.
2. Describe major functional features of birds with respect to respiration, digestion, circulation, excretion, reproduction, and sensory perception.
3. Apply knowledge of anatomical features to bird identification.
4. Identify distinguishing characteristics of the Class Aves and the major Orders and Families within.

BIRDS CHAPTER OUTLINE

WHAT IS A BIRD?
ANATOMY
CLASSIFICATION

- ORDER GAVIIFORMES – Loons
- ORDER PODICIPEDIFORMES – Grebes
- ORDER PELECANIFORMES – Pelicans, Cormorants, Boobies, Frigatebirds
- ORDER CICONIIFORMES – Herons, Storks, Ibis, Flamingos
- ORDER GRUIFORMES – Cranes, Rails, Coots
- ORDER ANSERIFORMES - Ducks, Geese, Swans
- OREDER CHARADRIIFORMES – Sandpipers, Plovers, Gulls, Auks
- ORDER COLUMBIFORMES – Doves, Pigeons
- ORDER FALCONIFORMES – Vultures, Hawks, Falcons
- ORDER GALLIFORMES – Grouse, Pheasants, Turkey
- ORDER STRIGIFORMES – Owls
- ORDER CAPRIMULGIFORMES – Nightjars
- ORDER APODIFORMES – Hummingbirds, Swifts
- ORDER CORACIIFORMES – Kingfishers
- ORDER PICIFORMES – Woodpeckers
- ORDER PASSERIFORMES – Perching or Song Birds

BIBLIOGRAPHY

TIPS FOR BEGINNING BIRDERS

FINDING LOCAL INFORMATION

Often finding that one particular person who has the local birding information can be a task. If your agency can not refer you to someone, try some of the following routes.

(a) Local naturalists club or in the U.S.A. the local Audubon Society Chapter. Small communities may have to rely on a state or provincial group to give them local information.
(b) Ministry of Environment (Provincial or Federal) or Department of the Interior – Wildlife Branch. These professionals often work with the local amateur in collecting data.
(c) Local fish and game (wildlife) clubs.
(d) National or Provincial/State/Regional Parks – the Park Naturalist or Park Ranger
(e) Forest Service, Agriculture, or Lands Branch officer
(f) The local librarian – many groups use libraries for meetings, displays or giving courses. The librarian often gets the newsletters of these various groups.

Birding is one of the fastest growing recreational activities in North America. Over 20 million people have taken up this hobby and participate to various degrees. Some watch the birds of their yard, others travel throughout the world to "list" species on their personal life list of bird species they have seen. Many enjoy feeding birds in winter and putting up nesting boxes in summer to attract the little feathered friends. To walk through a forest on a warm spring morning and listen to the numerous calls of two dozen birds is what birding is about. The road to natural history appreciation began for many with their own "discovery" of birds.
To appreciate birds we often think we have to have numerous pieces of equipment – bird books for identifying, binoculars and spotting scopes for seeing birds, rain gear, sun gear, note books, bird, tape recorder with bird tapes and, if you are a photographer, well you get the picture.
Let us look at basic equipment.

EQUIPMENT

Binoculars: Most birders recommend 7 x 35 binoculars for standard everyday use. Those that like to watch shorebirds and birds of prey often prefer the stronger 7 x 50 or 10 x 50 binoculars. They are much brighter on dark, overcast days. The one problem is that either you must be fairly steady holding them or must place the binoculars on a tripod. One thing to watch when buying new binoculars is the coating used on the lens. Some are so highly coloured that they actually affect the colour of the subject seen. Ask your dealer if you can take them outside of the store and try them in natural light for brightness, colour and ease of focus. Remember that binoculars are delicate optical equipment. Banging or dropping them, getting them wet or dirty, will affect the life and quality of use you get.

Spotting Scope: Not a requirement for a beginning birder – but sure a nice piece of equipment to have just the same. Provides close up viewing for distant species like hawks sitting in trees, shorebirds or offshore gulls. A good tip is to go along on birding outings where the leaders and more experienced birders take spotting scopes along. You can look through various scopes, talk to their owners and decide which model would suit your needs best. They are expensive – don't rush into buying one!

Bird Books and Guides: Many a beginning birder feels a little discouraged when they first open a bird guide and find out how many bird species there are in North America. A good guide will prove invaluable

in the field if it contains a good drawing of the bird, a brief but clear write-up and a good map showing the range of a species. Sonograms are of little use to the beginner.

One of the best tips to give a beginner is STUDY YOUR FIELD GUIDE! Become familiar with the order in which the birds are listed so that when you see a "sparrow-like-bird" you can turn to the sparrow section and begin your hunt. Most birds will not sit long enough for you to fumble through the guide, look through the binoculars and back to guide again. Familiarity with the birds that occur in your area is a great asset. Birding in teams or with a group also makes it easier as you can share describing and looking up the bird. Nothing is more frustrating than having the bird fly off while your head is buried in the field guide. Be patient, practice on species that generally do not fly off like the ducks and geese and leave the gulls, shorebirds and "little brown birds" for birding with your friends.
There are numerous field guides available. The three listed here are among the most popular in North America at this time. Each have good and bad points about them but generally they are good. Before buying a guide visit a library or borrow a friend's guide to see which one you prefer.

- A Field Guide to the Birds of North America
  R.T. Peterson H.M. Co. "Peterson" series
- Bird of North America
  Robbins, Bruun, Zim; A Golden Guide
- Field Guide to Birds of North America
  National Geographic Society

Clothing: Little needs to be said here except that a warm, dry birder is a happy birder. Dress in layers. Rain gear is especially important, as are wind-resistant clothes. Standing on a dyke overlooking a field or the open ocean on a cold, windy day can often take the enjoyment out of your birding outing. Remember the motto: BE PREPARED. The dry pair of socks and shoes and the ever important coffee break make the day more enjoyable.

Note Book: Recording your daily bird findings serves two purposes. It helps you learn to identify the birds and provides a record of your findings. Many birders keep detailed notes of what they see, how many, where, when and what the bird was doing. Others only keep special records. Whatever you decide to keep it is important. Local museums, wildlife branches, parks and bird clubs keep records and develop check-list and status reports from notes just like yours.

Bird Tapes: A very good tool for learning bird songs. There are several excellent tapes on the market. Again your library may have a copy you can borrow (comes in records and tapes). Using bird calls to attract birds is not recommended (and is illegal in some areas of the country). Too many birders using tapes in too small an area puts stress onto species that are trying to nest, causing birds to abort nesting. Using owl calls to attract owls in the non-breeding season can provide good views of the night time critters. Again, care should be used not to harass any bird.
Now armed with all the above information you are ready to begin birding.

Bird Anatomy

A bird is a very distinctive and unique living creature. Birds are unique because they are covered with feathers – a feature that no other animal possess. Birds also share some common features with other animals in that they are warm-blooded and can control the temperature of their bodies relative to that of the surrounding environment.

The nearest relatives of birds are their immediate ancestors, the reptiles. Their skeleton closely resembles that of a reptile but has been modified for the adaptation of flight. The feathers of birds resemble reptilian scales in that they are similar in composition and are arranged similarly on the body. Scientists now believe that the first birds were "gliders"; that the birds climbed to high places and then jumped into space and glided with the aid of feathered forelimbs. In time their skeletons developed other flight modifications, including modification for lightness, the fusion of various bones and the creation of a broad sternum or breastbone for the attachment of powerful wing and flight muscles.
In this first section we look at the skeleton of a bird and discuss key features of their anatomy from their bones, to the systems of digestion, circulation, excretion, reproduction, their special senses like smell, hearing and sight, and most importantly their feathers.

SKELETON SYSTEM

The skeleton system of birds has two notable features. They are:

(1) the tendency for joining (fusion) of adjacent bones;
(2) hollow air spaces in the bones resulting in lighter weight

The skeleton consists of three main parts:

(1) bones of the limbs
(2) bones of the trunk, and
(3) bones of the head

Trunk: Vertebral Column – This provides a base for the bones of the trunk and limbs and is a main support for the head. In most vertebrates the vertebral column is divided into regions:

(a) cervical neck
(b) thoracic chest
(c) lumbar loin
(d) sacral pelvis
(e) caudal tail

In humans and other mammals the bones of the vertebral column (vertebrae) are relatively separate, like spools strung along a thread, but in birds the main groups are often fused, and have undergone considerable modifications. The cervical (neck vertebrae) alone remain unfused and relatively mobile. In humans and most mammals the number of cervical vertebrae is seven. In birds it ranges from 8-24. Thus, even a small sparrow has more neck vertebrae than a giraffe.

Sternum: This is one of the most specialized parts of the bird skeleton. Flightless birds, such as the ostrich, have a sternum with no "keel" or downward projection. In flying birds, however, the sternum has a prominent keel which allows more surface for the attachment of important wing muscles.

Skull: The bird skull, compared to that of humans and other mammals, shows several features. The eye sockets (**orbits**) are comparatively large and spacious. They are so large, in fact, that the bones enclosing the brain are crowded behind the eye socket area. There are also no teeth present in modern birds. Certain bones have become greatly elongated and covered with a horny covering, to form the bill, replacing the teeth functionally. Finally, the lower jaw (**mandible**) is made up of several bones, or of two compound bones, one on each side of the head.

Respiratory System

The lungs of birds are extraordinarily efficient. These small organs are expanded and compressed by movements of the body wall. Each lung has several air sacs attached to it. These fill and empty with each breath. The air sacs penetrate the abdomen, neck, and wings, and act as bellows to keep air flowing through the lungs in one direction only. Some of these even penetrate into the marrow cavities of the wing bone. During inhalation, air is drawn into the posterior sacs. Air which was in the lung before inhalation is moved into a system of anterior air sacs. Upon exhalation, the anterior air sacs empty themselves of air and the air stored in the posterior air sacs moves into the now empty anterior air sacs. This design allows for an extremely efficient gas exchange necessary for flight in birds. No gas exchange occurs in the sacs. Instead, they appear to act like bellows, flushing to the lungs with each breath, so there is very little residual "dead" air left in bird lungs. (Dead air is a common phenomenon in mammals.)

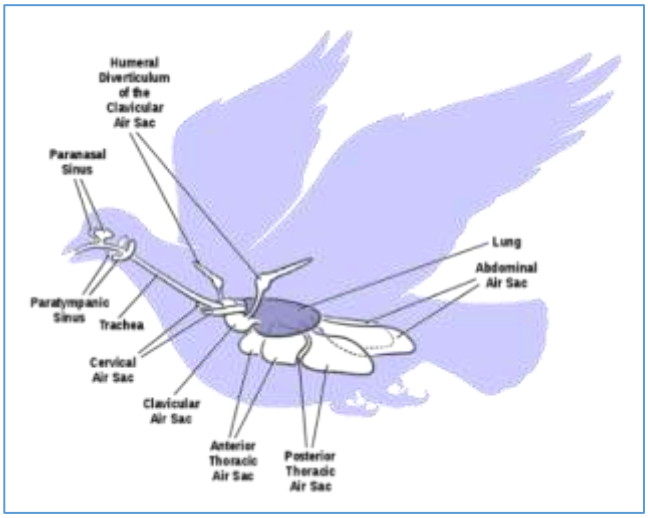

Figure 10.1 Air sacs associated with the lungs of a bird. Oxygen rich air is in constant contact with the blood supply of the lung on both the inhale and exhale because of the air sacs, supporting the increased metabolism required by birds to fly.

BIRD BILLS

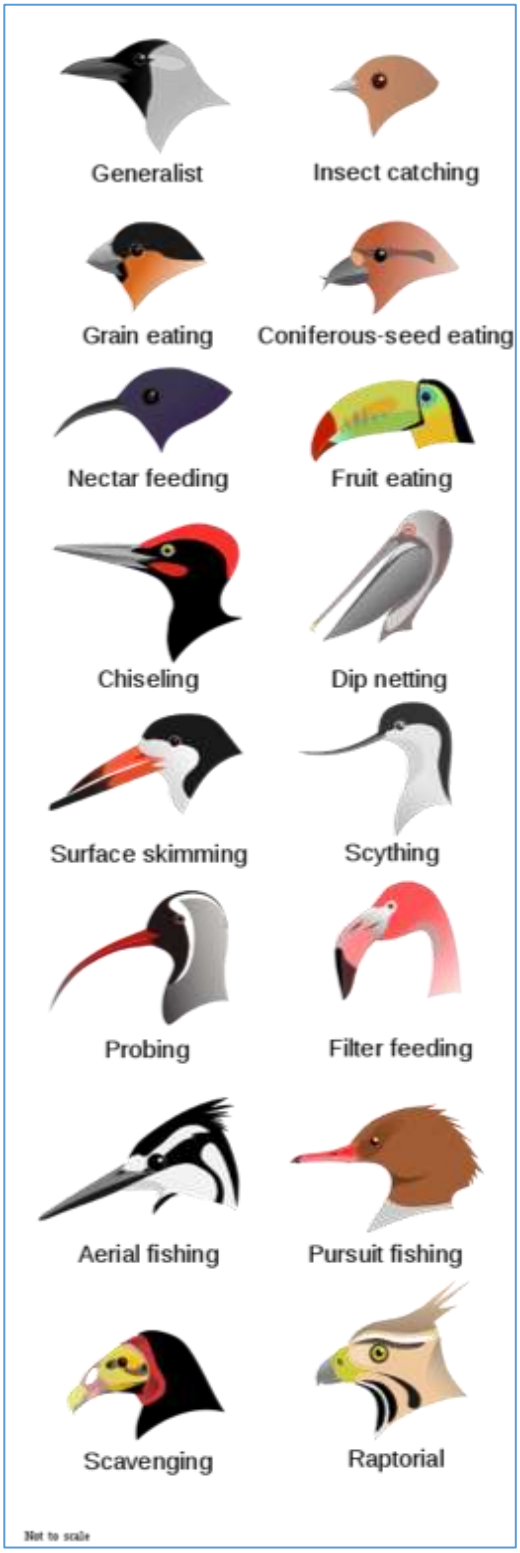

Figure 10.2 The variety of bird bills reflects their different diets.

DIGESTIVE SYSTEM

Mouth: The number of mouth glands is variable in birds, being considerable in seed-eating birds, lower in waterfowl and sometimes completely absent, as in the Pelicaniformes (Pelicans). Mouth glands lubricate the mouth and begin the process of digestion via the secretion of enzymes. However, mouth glands may also have special functions:

(a) secretions of a sticky fluid – woodpeckers
(b) secretion of "glue" for nest building – swifts

Tongue: The organ is much adapted to various modes of life in different bird groups. The tongue of hummingbirds is adapted to their nectar-feeding habit, as a long, extensile, tube. Parrots have a thick, fleshy tongue for the manipulation of seeds and fruit before crushing them in their mandibles. Duck's tongues are modified to help strain food from the water. In birds which swallow their prey whole (Pelicans and Kingfishers) the tongue may be much reduced and may be attached to the floor of the mouth.

Esophagus: The esophagus is essentially an extensile tube, lined with a mucous epithelium. In all birds it serves as a temporary reservoir for food. In most birds it can be engorged with food, sometimes noticeably so. In pigeons it is extended into a pocket, known as the crop. The crop is essentially an organ of food storage – its digestive functions are minor.
In some crop-bearing birds, such as pigeons, the lining of the crop is rough which produces a milky substance (Pigeon's Milk) that is mixed with stored food and regurgitated to feed the young.

Stomach: A major modification of the bird stomach is the gizzard, actually a hold-over from the bird's reptilian origins. The gizzard is very muscular in those birds which eat large amounts of seed and herbage, and less so in birds which eat fruit. The mucous glands of the gizzard secrete a horny lining which helps seed-eating birds to grind their hard food. In flesh-eating and fruit-eating birds the gizzard is less developed and the mucous does not form a horny layer.

Small Intestine: The intestine is generally longer in seed and herbage eaters than in flesh eaters. In birds which are primarily herbivorous, the intestine has pockets (caecae) which increase the surface area of the intestine and provide a place for cellulose-digesting bacteria to live.

CIRCULATORY SYSTEM

Blood: Birds share with mammals the distinction of having the 'richest' blood, that is, their blood contains the greatest number of red-blood cells per unit volume. Smaller birds generally have a greater number of the red blood cells than do large birds. Because these are the oxygen-carrying cells, this means that the blood of small birds is very effective in oxygen transport.

Heart Rate: In birds the heart rate is generally greater than in mammals of equivalent size. In small birds, the heart rate is very much greater. In the resting human, for example, the heart rate is about 72 beats per minute. In a resting wren, the heart rate is 550-650 beats per minute. The rate may be much greater during the night when the temperature is lowest.

Body Temperature: The body temperature of Passerine birds varies between 102 degrees F. to 112.3 degrees F. There is no bird which has a normal body temperature as low as that of humans – 98.6 degrees F. (37 C).

Birds are warm-blooded and are able to remain active in low environmental temperatures. They have feathers to prevent heat loss as opposed to mammals that have fur to prevent heat loss. Birds control or regulate their temperature, depending on the temperature of their surroundings, by certain responses, i.e., fluffing the feathers or shivering in low temperatures. When it is hot they can compress their feathers and they can pant.

Blood vessels in the legs of birds are arranged to have the arteries leaving the body going to the feet to be adjacent to the veins returning blood to the body. This allows colder blood in veins to be warmed by the arterial blood, conserving heat – a physiological design called a counter-current system.
Some young birds are essentially "cold-blooded" or semi-cold-blooded and it takes them a while to establish temperature control.

Some birds, such as the Poorwill have the capacity to hibernate. During these torpid periods their temperatures may be very close to that of their surroundings. This dormant state enables them to survive periods without food.

EXCRETORY SYSTEM

Avian kidneys are relatively larger than those of reptiles or mammals. In bird urine, as in reptiles, the nitrogenous wastes are in the form of uric acid, a practically insoluble material, whereas in mammals these wastes take the form of urea, a much less concentrated material. The urine is usually voided by birds in a semi-solid, whiteish coloured condition. About 98% of the water filtered by the kidneys is reabsorbed for further use either in the bird's kidney or in the cloaca. Birds lose more water through evaporation from the lungs and air sacs than via the urine.

REPRODUCTIVE SYSTEM

Ovary and Eggs: The avian ovary may contain as many as 13,000 ova. Only a small fraction of these will actually develop to maturity in the life of the bird. Following ovulation, the ovum moves through the oviduct, to the uterus, where it may remain for 18-20 hours before being forced by contraction through the vagina, cloaca, and anus. During the last 5 hours in the uterus the egg gets its coloration.

Spermatozoa: The sperm are produced in testicles which are inside the bird's body cavity. They may mature in seminal vesicles, which are often inside the cavity, but which may protrude into the cloacal chamber where the lower temperature may aid in the maturation of the sperm. The sperm are motile, having a head and tail, but they are differently shaped from those of mammals. The sperm swim from the cloaca, up the oviduct, where they fertilize the egg. The time between copulation and fertilization is usually 72 hours, but it may be as low as 19.5 hours.

SPECIAL SENSES & FEATHERS
Some species of birds have a keen sense of **smell**, while others have nearly none. In most birds the sense of smell is moderately developed.

The **eyes** of birds are generally very highly developed and have a number of special features.

Eye Glands: The tear glands and oil glands of birds' eyes vary in development according to the habitat of the bird. In sea birds the tear glands are small, probably due to the watery environment of the birds, but the oil glands are large and secrete a thick, oil substance which protects the bird's eyes from salt water.

Size and Shape of Birds' Eyes: Birds have huge eyes. They are the largest structures of the head and they often outweigh the brain. The shape of birds' eyeballs may vary from flat, in pigeon-like birds, to globular, elongated or tubular in birds of prey. These elongated eyeballs broaden and sharpen the image thrown on the retina and afford better vision at a distance. This is an important advantage for hunting birds who seek their prey from the air.

Adjustment in Birds' Eyes: In mammals, including humans, the eye adjusts in order to form a properly focused image on the retina, regardless of the distance of the object from the eye. This adjustment in birds and in mammals is mainly accomplished via contraction of the lens muscles, thus changing the shape of the lens. In some birds the shape of the whole cornea can also be altered.

Visual Acuity: Bird eyes have a remarkable resolving power or ability to produce distinct images of objects as they become smaller or closer together. In the human portion of the retina there are 200,000 visual cells per square millimeter, in the English Sparrow the number is 400,000. In the Red-tailed Hawk the number in the same area is about 1,000,000/mm2. The retina of most birds have both **cones** (the image forming, colour sensitive cells) and **rods** (the light sensitive, black and white sensitive cells). The relative proportions of the rods and cones varies depending on whether the bird is nocturnal (night) or diurnal (day) dwelling.

Colour Vision: Birds have a 4-cone system for colour vision in their eyes compared to the 3-cone system of people. They have a broader spectral sensitivity. By comparison, this is quite different than a cat or dog which has a more narrow spectral sensitivity than people and see even fewer colours.

Sensitivity to Light Spectrum: Twilight is an example of birds perceiving more information and twilight is affected by artificial light at night (ALAN). Artificial light at night shifts the internal clocks of birds by extending the limits of natural light, or civil twilight, and interferes with the body's synchronization of its internal clock, its circadian rhythm. In birds this affects their songs (birds begin to sing earlier in the morning in cities), mating, reproduction, and migration.

The spectral signature of twilight is used by birds and other vertebrates to synchronize their internal circadian rhythm with the natural rhythm of the external world, a process called entrainment. Because the spectral composition of twilight varies with latitude and time of year, it gives migrating birds information about where they are, where they should be, and when. A number of American cities now have a program that encourages building managers to dim or turn off decorative lighting late at night, and encourages high-rise residents to draw their shades or dim interior lights, in an effort to prevent "confusing" migrating birds. Astronomical twilight (natural from the sun as opposed to artificial lighting or ALAN), helps birds calibrate their magneto-receptors to local conditions. Strong sources of artificial light can also attract migratory birds and trap them in the light beams. This was especially a problem with the 9/11 light memorial in New York City where birds flew in circles in intense light beams until they dropped exhausted from the sky.

ALAN contributes to the restlessness associated with migration in birds. The restlessness seen in migrating birds that is due seasonal oscillations of light is modulated by the synthesis of melatonin in a

bird's pineal gland. This is the same melatonin that is reduced during winter months by human pineal glands and contributes to Seasonal Affective Disorder (SAD) or depression in winter. The pineal gland is sometimes referred to as the "third eye" because it is stimulated by light, a response mediated through the eyes. It is located at the base of the brain, above the hypothalamus, the major gland responsible for coordinating nervous stimuli in the body with chemical signals of the endocrine system. The pineal gland is part of the area of the brain where the external environment of a person and the internal environment of the body speak to each other.

Earth's Magnetic Field: Remarkably, the bird also has oil droplets in cones in its eyes that are spectrally sensitive and can see the earth's magnetic field. Birds don't need a compass to find north, they can see it.

Hearing: This is keen and ranks next to sight in its importance to birds and their survival. The ear openings in most birds are covered with feathers, and are on the sides of the head. In nocturnal birds such as owls the ear placement can be asymmetrical (left and right ears are different shaped and usually one opening is higher than the other). It is believed this helps the bird to locate the exact spot from where the sound is originating.

Feathers: These are peculiar to birds and constitute their principal covering. Like the horny sheath of the bill, the scales on the feet, and the claws on the toes, feathers are outgrowths of the skin, modifications of the lifeless, outermost layers of epidermal cells. It is probable that feathers represent modifications of the reptilian scale.
Bird feathers serve a variety of functions:

- Insulation
- The increase of surface area and control surface for flight
- Aid in camouflage
- Aid in courtship, sex and species recognition

Feathers of Adult Birds

Contour Feathers: These feathers take part in forming the shape or outline of the bird. The primary wing feathers are a good example of this type of feather. This is the typical quill pen feather.

Down Feathers: This type of feather is hidden beneath the contour feathers. The barbs are very slender, and arise from a common point. Barbules have hooklets for interlocking.

Filoplume: This is a hair-like feather, frequently located on the underside of the bird, under the contour feathers. It is sparsely distributed and grows usually at the base and on the dorsal side of a contour feather. A number of barbs will be found growing as a tuft at the tip of this type of feather.

Powder-down Feather: This type of feather is present only on certain groups of birds, such as herons and bitterns. It is a modified down feather which grows throughout the life of the bird, the barbs continually disintegrating into a fine powder. This powder is used as a dressing to clean slime, etc, from the other feathers.

Feather Colouration: Feather colours may be produced by the actual presence in the feather of a pigment. Alternatively, the colour may be produced via the diffraction of light passing through the structure of the feather, or by a combination of pigment and diffraction and refraction of light. Reds,

oranges, yellow, brown, gray, black, tawny, and some greens are produced by pigments. White is produced by the absence of pigments plus feather structure. Blue and some green, as well as iridescent colours are produced by structure or by structure plus pigment granules.

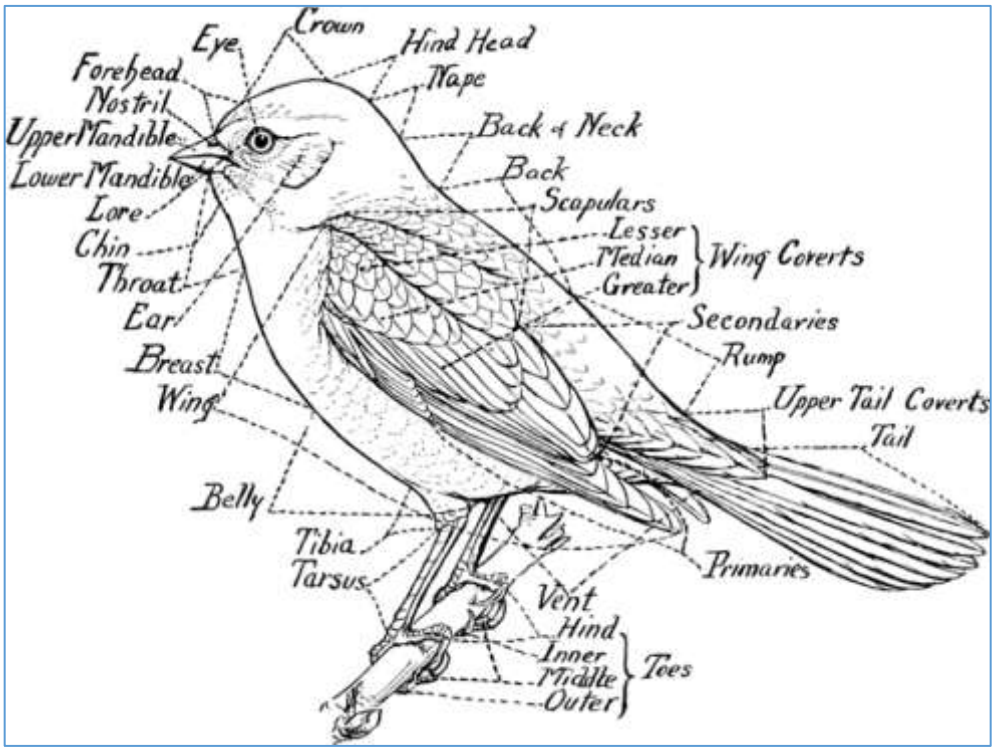

Figure 10.3 Bird topography.

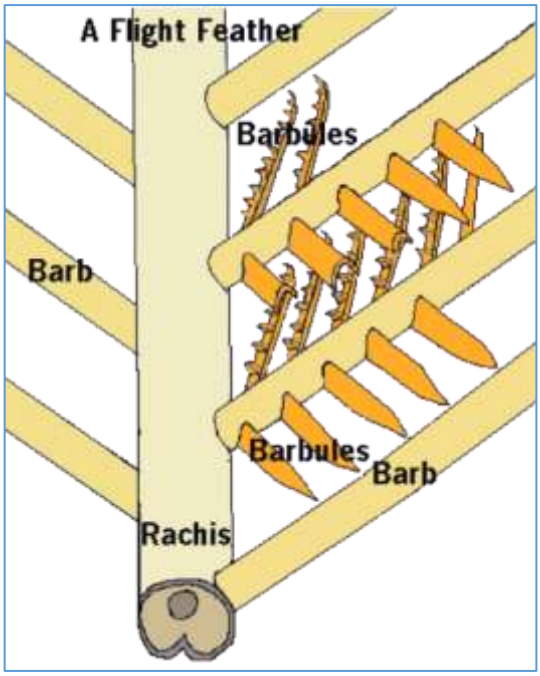

Figure 10.4 Structure of a feather.

CLASSIFICATION

In North America ornithologists have classified – or grouped – bird species into groups based on species' relationships beginning with the most primitive or ancient birds. North American birds are ranked in 20 ORDERS and the birds of each order resemble each other fundamentally in structure – usually the shape of the bones of the head and their arrangement; the shape of the breastbone, the number of toes, the number of tail feathers, etc.

As an example, the following is a taxonomic classification of the Common Crow:

Kingdom Animalia
Phylum Chordata
Subphylum Vertebrata
Class Aves
Order Passeriformes
Family Corvidae (Crow)
Genus *Corvus*
Species *brachyrynchos*

In this section we will be dealing with the ORDER, FAMILY and some of the GENUS/SPECIES for some of the key North American species.

This list represents only part of the total North American bird fauna. The order of species followed is based on the American Ornithologist Union (A.O.U.) 7th Edition, 1998 and with supplements published annually in the journal the *Auk*. This committee determines Order, Family and Species name based on the most up to date scientific studies and will be the reason that some of the older field guides may list older classifications, names or orders for birds.

ORDER GAVIIFORMES – Loons

- The oldest living group of birds dating back 65 million years

FAMILY GAVIIDAE – Loons

- 5 species nest in North America

General Characteristics

- Long sharp pointed beak
- Bones are heavy and solid for diving unlike most birds which are hollow and air filled
- Nests are on or near water and made as mounds of mud and reeds
- Wings are short and in flight, head is held lower than body
- Legs completely encased in skin and placed far back on the body therefore walk awkwardly
- Run long distances to take off from water
- Adapted to swimming and diving (web footed)
- Young often carried on parent's back
- Sexes are alike
- Generally migrate

Species:

Red-throated Loon	*Gavia stellate*
Arctic Loon	*Gavia arctica*
Pacific Loon	*Gavia pacifica*
Common Loon	*Gavia immer*
Yellow-billed Loon	*Gavia adamsii*

Figure 10.5 Common Loon.

ORDER PODICIPEDIFORMES – GREBES

FAMILY PODICIPEDIDAE – Grebes

- 6 species in North America

General Characteristics

- Legs are short and placed well back on the body
- Take offs are long and strenuous
- Wings are short, in flight rapid wing beats
- Feet with lobed fringing membrane outlining only the three front toes
- Nest built on floating vegetation

Species

Pied-billed Grebe	*Podilymbus podiceps*
Horned Grebe	*Podiceps auritus*
Red-necked Grebe	*Podiceps grisegena*
Eared Grebe	*Podiceps nigricollis*
Western Grebe	*Aechmophorus occidentalis*
Clark's Grebe	*Aechmophorus clarkia*

Figure 10.6 Western Grebe and a Pied-billed Grebe

ORDER PELECANIFORMES – PELICANS, CORMORANTS, BOOBIES, FRIGATEBIRDS

- Among the largest living birds with a wing span up to 9 feet

FAMILY PELECANIDAE – Pelicans

- 2 species in North America

General Characteristics

- All four toes are joined by webs of skin (totalpalmate)
- Have extensible beak pouch for catching and carrying food
- Nest in large colonies
- Chicks are dependent on adults when first hatched (altricial)

Species

American White Pelican	*Pelecanus erythrorhynchos*
Brown Pelican	*Pelecanus occidentalis*

In British Columbia the American White Pelican is on the Provincial Endangered Species List.

Figure 10.7 White Pelican.

FAMILY PHALACROCORACIDAE – Cormorants

- 6 species in North America

General Characteristics

- Dive from the water surface
- Often perch with wings half open to dry their feathers – do not have complete waterproofing as in other water birds
- Tail long, wide, stiff, and wedge shaped
- Is used as a rudder along with webbed feet when under the water
- Gregarious, nest in colonies

Species

Great Cormorant	*Phalacrocorax carbo*
Double-crested Cormorant	*Phalacrocorax auritus*
Brandt's Cormorant	*Phalacrocorax penicillatus*
Pelagic Cormorant	*Phalacrocorax pelagicus*

Figure 10.8 Silhouettes of a Double-crested Cormorant drying its wings and a Pelagic Cormorant. Despite their aquatic habit cormorants have poorly developed oil glands and their feathers become water-logged.

ORDER CICONIIFORMES - HERONS, STORKS, IBISES, FLAMINGOS

- Waders associated with fresh, salt or brackish water, especially marshes or shallow bays
- Long legs, neck and bill

FAMILY ARDEIDAE – Herons

- 15 species in North America

General Characteristics

- Diet includes frogs, small mammals, and fish which are swallowed whole
- Undigested food is regurgitated in pellets
- Nest in colonies called heronries

Flight profile:

- Legs straight back, neck tucked onto shoulder in S shape

Species

Great Blue Heron	*Ardea herodias*
Black-crowned Night Heron	*Nycticorax nycticorax*
American Bittern	*Botaurus lentiginosus*
Snowy Egret	*Egretta thula*

Figure 10.9 Great Blue Heron. Herons fly with their necks bent. Despite their feeding in aquatic habitats and fields during the day, they roost and breed in colonies in trees.

Did you know that herons use their long skinny legs to help them fish? A heron wades in shallow water, then stands motionless. When a fish comes close, the heron slowly folds its neck back and moves one leg in the direction of the prey. Suddenly, its head plunges towards the fish, catching it in its beak and swallowing it. Great Blue Herons also feed on rodents in farm fields. Young herons especially rely on rodents and amphibians until they learn how to catch fish in water.

ORDER GRUIFORMES – CRANES AND RAILS

- 3 species in North America
- Live in marshlands, wet plains and prairies
- Migration in V-shaped flocks or long lines
- Long necks and legs

Flight profile:

- Fly with necks extended forward and legs trailing behind

FAMILY GRUIDAE – Cranes

- 3 species in North America

General Characteristics

- Long heavy bill
- Courtship rites include dancing
- Wing feathers droop over rump forming a bustle that distinguish cranes from herons

Species

Sandhill Crane	*Antigone canadensis*
Whooping Crane	*Grus americana*

Whooping Cranes have been on the Endangered Species list in North America for many years. The small population winters in Gulf Coast region of Texas and spends the summer in northern Alberta and Saskatchewan, Canada.

Figure 10.10 Sandhill Crane. Cranes fly with their necks outstretched.

FAMILY RALLIDAE – Rails

- 13 species in North America, (9 native, 4 foreign)

General Characteristics

- Lobed feet with long toes adapted for water and muddy environments
- Compact with short tails and rounded wings
- Most species secretive can be identified by distinctive call

Species

Virginia Rail	*Rallus limicola*
Sora	*Prozana carolina*
American Coot	*Fulica americana*

ORDER ANSERIFORMES – DUCKS, GEESE AND SWANS
FAMILY ANATIDAE – Swans, Geese and Ducks

- 64 species in North America

General Characteristics

- Smallest ducks weigh one pound while the largest swans range up to 30 pounds
- Water birds
- The front three toes are webbed and the hind toe is free

- Young are covered in down when hatched
- Adult plumage is thick and waterproof
- Bill broad and rounded with a soft membranous covering and a “nail” or hard hooked tip on the upper mandible
- Migrate in well-defined north-south flyways in North America

SUBFAMILY ANSERINI – Swans, Geese and Whistling Ducks

Swans

- 4 species in North America

General Characteristics

- Largest of the waterfowl
- Have long slender necks
- North American species are white
- Seldom dive – but can do to avoid predators
- Male-cob, female-pen, young-cygnet
- Must run along water to take off (15-20 ft)

Species

Tundra Swan (formerly Whistling)	*Cygnus columbianus*
Trumpeter Swan	*Cygnus buccinators*
Mute Swan (introduced to N.A.)	*Cygnus olor*

Figure 10.11 Trumpeter Swan.

Geese

- 8 species in North America

General Characteristics

- Have shorter necks than swans
- Sexes are similar-size not a good guideline because of number of races and interbreeding
- Highly social – very strong pair bonds

- More adapted for walking on land than ducks

Species

Snow Goose	*Chen caerulescens*
Brant	*Branta bernicla*
Canada Goose	*Branta canadensis*

Figure 10. 12 Snow Goose.

Whistling Ducks

- 3 species in North America

General Characteristics

- Long necks and legs
- Whistling calls
- Goose-like body

Species

Fulvous Whistling-Duck	*Dendrocygna bicolor*
Black-bellied Whistling-Duck	*Dnerocygna autumnalis*

SUBFAMILY ANATINAE –Ducks

- This subfamily includes the dabbling or surface-feeding ducks, the fresh water diving ducks, the sea ducks, the stifftail ducks, and the perching ducks

The Dabbling Ducks

- 14 species in North America

General Characteristics

- Prefer inland waters of marshes, lakes and ponds for breeding
- Dip for food instead of diving
- Have brightly coloured wing patches called a speculum
- Go through a complete molt in early summer which leave them temporarily flight-less
- Take off in a direct leap from the water

Species

Wood Duck	*Aix sponsa*
Green-winged Teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Northern Pintail	*Anas acuta*
Norther Shoveler	*Anas clypeata*
America Wigeon	*Anas americana*
Gadwall	*Anas strepera*

Figure 10.13 Mallard Duck – female left, male right.

Fresh water Diving Ducks

- 6 species in North America

General Characteristics

- Breed inland on lakes and rivers, winters on coastal bays and river estuaries
- Dive from the surface
- North American species do not have a speculum
- Legs set further back than on dabblers
- Run along water surface to take off
- Courtship displays are spectacular

Species

Canvasback	*Aythya valisnineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Greater Scaup	*Aythya marila*
Lesser Scaup	*Aythya affinis*
Barrow's Goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Harlequin Duck	*Histrionicus histrioninicus*
Common Eider	*Somateria millissima*
Oldsquaw	*Clangula hyemalis*

Surf Scoter *Melanitta perspicillata*

Figure 10.14 Bufflehead.

Mergansers

- 4 species in North America

General Characteristics

- A fish-eating duck whose bill has serrated edges (sawteeth) for holding onto prey
- Dives under water
- Legs placed well back on body
- Moves awkward on land
- Nest inland, winter along coast

Species

Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-rested Merganser	*Mergus serrator*

Figure 10.15 Silhouette of Common Merganser. Note the hook at the end of the bill to help hold onto fish. The bill is also serrated.

Stiff-tailed ducks

- 2 species in North America

General Characteristics

- More aquatic than any other North American duck
- Have dense and shining body plumage
- Can sink slowly below the water
- Use stiff tail as rudder under water
- Male helps care for young

Species

Ruddy Duck *Oxyura jamaicensis*

ORDER: CHARADRIIFORMES – GULLS, SHOREBIRDS AND AUKS

- Spend much of time on or near water
- Long pointed wings
- Consists of three sub-orders:
    - Gulls including Gulls, Terns, Skuas and Skimmers
    - Shorebirds including Jancas, Oystercatchers, Plovers, Thick-knees, Sandpipers, Avocets and Phalaropes
    - Auks

Only a few families are discussed below.

FAMILY LARIDAE – Gulls and Terns

In North America:

- 25 species of gulls
- 15 species of terns

General Characteristics

- Associated with fresh and salt water
- Webbed feet
- Long pointed wings for gliding and flying over long distances
- Hooked bills
- Nest in colonies
- Omnivorous

Species – many species in North America

Gulls: there is no such thing as a "Sea Gull." Gulls are found near coastal areas, in the interior of the continent (the prairies) and at open ocean. Gulls take from two to four years to attain their adult plumage. They are difficult to identify while in the immature plumage.

Terns: Terns plunge dive to feed. Many species have a forked tail. Many migrate long distances.

Figure 10.16 California Gull. Juveniles are brown and take three years to develop adult plumage.

Figure 10.17 Diversity in terns.

SUBORDER: SHOREBIRDS
FAMILY HAEMATOPODIDAE – Oystercatchers

- 2 species in North America

General Characteristics

- Brightly coloured feet and bills
- Three toes – no hind toe
- Bill twice as long as the bird's head
- Bill shaped like a double-edged knife, with a chisel-like tip to pry open prey
- Food includes bivalves, urchins, seastars, and marine worms

Species

American Oystercatcher *Haematopus palliates*

Figure 10.18 Black Oystercatchers have an orange bill and legs.

FAMILY SCOLOPACIDAE – Sandpipers

- 51 species in North America, 36 nest, 24 visitors

General Characteristics

- Long slender bills often curved—used to probe into mud for food
- Young are able to forage when hatched (precocial)
- Some species are often seen in flocks

Species

Marbled Godwith	*Limosa fedoa*
Whimbrel	*Numenius phaeopus*
Greater Yellowlegs	*Tringa melanoleuc*
Spotted Sandpiper	*Actitis macularia*
Wandering Tattler	*Heroscelus incanus*

Figure 10.19 Greater and Lesser Yellowlegs. The lengths of the legs and bills in shorebirds enables them to occupy different niches in feeding on benthic invertebrates.

FAMILY RECURVIROSTRIDAE – Avocets

- 2 species in North America

General Characteristics

- Wading birds known for their extremely long legs
- Stilts have the longest legs in proportion to their body size of any bird
- Live near water; swim and dive readily
- American Avocets feed by sweeping their curved bill from side to side through the water

Species

American Avocet	*Recurvirostra americana*
Black-necked Stilt	*Himantopus mexicanus*

FAMILY PHALAROPODIDAE – Phalaropes

- 3 species in North America

General Characteristics

- Moderate to long bills
- Lobed, semipalmated toes
- In phalaropes the role of the sexes is reversed – the female is larger and more brightly coloured and takes the initiative in courtship
- The male generally builds the nest, and incubates the eggs and rears the young (the male has brood patches – the female does not)
- Feed by spinning on the water to stir up insect larvae

Species

Wilson's Phalarope	*Phalaropus tricolor*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicaria*

FAMILY CHARADRIIDAE – Plovers

- 13 species in North America
- Group includes true plovers and lapwings

General Characteristics

- Distinguished from other shorebirds by pigeon-like bill, dove-like head and relatively large eyes
- Strong flyers, can swim, migratory, sexes alike, travel in large flocks, active day and night
- All plovers use the distraction display to lead predators away from nest site or young

Species

Snowy Plover	*Charadrius alexandrines*
Killdeer	*Charadrius vociferous*
Black-bellied Plover	*Pluvialis squatarola*

Figure 10.20 Diversity in plovers - Black-bellied Plover, Semipalmated Plover, Snowy Plover, Wilson's Plover.

SUB ORDER: AUKS
FAMILY ALCIDAE – Auks

- 20 species in North America

General Characteristics

- Often referred to as alcids
- Are the ecological counterpart of penguins of the Arctic in that they both have dense, water-roof plumages and dive and swim for all their food
- Prefer salt water
- Duck-like with short necks and very rapid wingbeats
- Viewing tip: best time and place to see alcids is in stormy weather, in winter, along the coasts where a few strays may come close

Species

Common Murre	*Uria aalge*
Pigeon Guillemot	*Cepphus columba*
Marbled Murrelet	*Brachyramphus marmoratus*
Ancient Murrelet	*Synthiliboramphus antiquus*
Rhinocerous Auklet	*Cerorhinca monocerata*
Tufted Puffin	*Fratercula cirrhata*

Figure 10.21 Tufted Puffin, Ancient Murrelet and Common Murre.

ORDER: COLUMBIFORMES – DOVES AND PIGEONS
FAMILY COLUMBIDAE- Pigeons

- 17 species in North America

General Characteristics

- Dense feathers of many colours, some metallic or iridescent
- Strong flyers
- Usual habit of immersing bill and sucking up water as a horse drinks
- Adults (both) feed young a milky substance produced in the crop

Species

Band-tailed Pigeon	*Columba fasciata*
Rock Dove	*Columba livia*
Mourning Dove	*Zenaida macroura*

Figure 10.22 Common Pigeon or Rock Dove.

ORDER: FALCONIFORMES – VULTURES, HAWKS, OSPREY AND FALCONS

- Diurnal birds of prey
- Have well developed sense of sight and smell
- Eyes laterally placed in head – use binocular vision for finding prey
- Long wings for gliding and hovering
- Sexes are alike with female generally larger than male
- Hooked beak with a fleshy protuberance on the upper mandible (cere)
- Lower mandible is shorter than upper
- Foot (tarsus) consists of four talons for grasping prey

Figure 10.23 Birds of prey have three distinct body types. The falcon has streamlined pointed wings such as the American Kestrel, the accipiter has a long narrow tail and narrow wings such as the Cooper's Hawk, the buteo has a shorter broad tail such as the Red-tailed Hawk.

FAMILY CATHARTIDAE – New World Vultures

- 4 species in North America

General Characteristics

- Large broad winged birds adapted for soaring long periods of time
- Head naked (no feathers)
- Generally scavengers
- Keen eyesight
- Voiceless birds

Species

Turkey Vulture *Cathartes aura*

Figure 10.24 Turkey Vulture. When soaring the wings are folded slightly over the back in a characteristic dihedral formation.

FAMILY ACCIPITRIDAE – Hawks, Harriers, Eagles

- 26 species in North America (4 eagles, 5 kites, 17 hawks)

General Characteristics

- Heavy scaling on legs and feet (usually yellow)
- Short rounded wings
- Wingbeats short-interrupted by glides
- Neck short and strong
- Turn head to direct vision
- Have binocular/monocular vision to aid hunting
- Interesting courtship behavior
- All members of the Hawk Family are protected by law in Canada and the USA. It is illegal to keep such a bird without a permit from the local government wildlife branch.

HAWKS

- 17 species in North America

Species

Northern Goshawk	*Accipter gentilis*
Cooper's Hawk	*Accipter cooperii*
Sharp-shinned Hawk	*Buteo jamaicensis*
Rough-legged Hawk	*Buteo lagopus*

Figure 10.25 Conservation efforts have increased populations of the Bald Eagle across North America.

Eagles

- 2 species in North America

General Characteristics

- Large sized bird
- Diurnal

Bald Eagle

- Is basically a scavenger feeding on carrion like spawned salmon, it will also take small waterfowl like Bufflehead
- Takes five years to reach adult plumage of white head and tail
- Reaches sexual maturity at seven years
- Nest in tall trees

Golden Eagle

- Generally, a bird of mountains and hilly terrain
- Nests on cliffs or tall trees
- Food includes small mammals, birds, snakes and carrion

Species

Bald Eagle	*Haliaeetus leucocephalus*
Golden Eagle	*Auilla chrysaetos*

Harriers

- 1 species in North America

General Characteristics

- Sexes different colours – (male grey; female brownish)
- Tail long, white rump patch, and long legs
- Nests on ground
- Holds wings in a V while gliding over ground
- Feeds on mice, frogs, small ducks and other prey

Species

Northern Harrier (formerly Marsh Hawk) *Circus cyaneus*

FAMILY PANDIONIDAE – Osprey

- 1 species in North America

General Characteristics

- Fishing birds able to dive under water
- Flies with fish parallel to body for less air friction
- Builds large nest near water
- Migrates to Argentina in winter

Species

Osprey *Pandion haliaetus*

Figure 10.26 Osprey has a diet of 99% fish.

FAMILY FALCONIDAE – Falcons

- 7 living species (1 extinct) and 1 foreign visitor

General Characteristics

- Rapid flyers (100-275 mph)
- Pointed wing tips
- Streamlined bodies
- Strongly hooked bill with small tooth on upper mandible

Species

Gyrfalcon	*Falco rusticolus*
Prairie Falcon	*Falco mexicanus*
Peregrine Falcon	*Falco peregrinus*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*

ORDER: GALLIFORMES – GROUSE, PHEASANTS, TURKEYS

- 50 species in North America

General Characteristics

- Also known as game birds
- Have round chicken-like bodies
- Live mainly on the ground feeding on seeds and insects
- Strong legs for running and walking
- Poor flyers

FAMILY PHASIANIDAE – Pheasant and Grouse

- 14 species in North America, 11 native, 3 introduced

General Characteristics

- Long tail feathers
- Feet and bill adapted to scratching on ground for food
- Feathers on bill, legs and feet
- Flight is strong, rapid but short
- Courtship includes drumming, dancing and displaying

Species

Gray Partridge *1	*Perdix perdix*
Ring-necked Pheasant	*Phasianus colchicus*
California Quail *2	*Callipepla californica*
Ruffed Grouse	*Bonasa umbellus*
Spruce Grouse	*Dendragapus canadensis*
Willow Ptarmigan	*Lagopus lagopus*
Greater Prairie Chicken	*Typanuchus cupido*

*Introduced to North America from 1. Europe and 2. Asia

Figure 10.27 Willow Ptarmigan (left) and Bobwhite Quail (right). Note the short stalky wings of the quail, an adaptation for lifting from the forest floor through trees. Also note the feathers on the feet of the ptarmigan that help it to stand in snow.

Figure 10.28 Ruffed Grouse. During mating season, the Ruffed Grouse will use its wings to generate a drumming sound that attracts mates.

Ruffed Grouse: Did you know that the male ruffed grouse is a great drummer? In the spring, the male rests its tail on a fallen tree and beats its wings faster and faster until they "whirr" and make a hollow sound like the beating of a drum. Males do this to stake out their territory and lure a mate.

Figure 10.29 Ring-necked Pheasant

Figure 10.30 California Quail showing its distinctive curving crest or plume.

FAMILY MELEAGRIDIDAE – Turkey

- 2 species in North America

General Characteristics

- Largest game bird in North America
- Smaller than the domesticated bird
- Forage on ground for seeds, nuts and insects
- Roosts in trees
- Re-introduced in many areas

Species:

Wild Turkey	*Meleagris gallopavo*

ORDER: STRIGIFORMES – OWLS

- Includes 2 families: 1) the Barn Owl and 2) the Typical Owl
- Can be active in daytime (diurnal), night-time (nocturnal) and dusk and dawn time (crepuscular)

General Characteristics

- Broad head on short neck
- Can turn head 270 degrees
- Eyes are fixed to stare forward and are surrounded by a facial disk (must move head to direct vision)
- Plumage very soft to aid in hunting prey
- Food varies from small mammals like mice, shrews, squirrels and rabbits to other birds, insects, reptiles, and amphibians depending on the size of the owl

FAMILY TYTONIDAE – Barn Owl

- 1 species in North America

General Characteristics

- Live in barns, old buildings, caves, burrows or hollow trees
- Facial disk is triangular or heart shaped
- Long, feathered legs with sharp talons
- Longer, narrower wings as compared to other owls
- "dark eyed" owl
- Thought to mate for life
- Relies on hearing rather than eyesight for finding most of its prey

Species

Barn Owl	*Tyto alba*

FAMILY STRIGIDAE – Typical Owl

- 17 species in North America

General Characteristics

- Sight and hearing extremely keen
- Four toes on each foot. The outer toe on each is reversible

Species

Western Screech-Owl	*Otus kennicottii*
Great Horned Owl	*Bubo virginianus*
Snowy Owl	*Nyctea scandiaca*
Northern Pygmy-Owl	*Glaucidium gnoma*
Burrowing Owl	*Athene cunicularia*
Great Grey Owl	*Stix nebulosa*
Short-eared Owl	*Asio flammeus*

Long-eared Owl	*Asio otus*
Northern Saw-whet Owl	*Aegolius acadicus*

Figure 10.31 Barred Owl and Great Horned Owl. Note that two toes point forward and two backward, an arrangement known as zygodactyly that is better adapted for catching prey compared to perching birds that have three toes forward and one toe pointing backward (anisodactyly).

ORDER: CAPRIMULGIFORMES – NIGHTJARS

- Nocturnal
- Insect eaters
- Take insects on the wing
- Small weak feet
- Heads are flat
- Distinctive white patches on wings or tail

FAMILY CAPRIMULGIDAE – Nightjars

- 7 species in North America

General Characteristics

- Also called goatsuckers or mosquito hawks
- Active from dusk to dawn
- One species, the poorwill, hibernates
- Spend much time on the ground and are cryptically coloured for protection

Species

Common Nighthawk	*Chordeiles minor*
Common Poorwill	*Phalaenoptilus nuttallii*
Whip-poorwill	*Caprimulgus vociferous*

Figure 10.32 Feeding Common Nighthawk with its beak open. Note the stiff feathers on either side that help guide insects into the mouth.

ORDER: APODIFORMES – HUMMINGBIRDS and SWIFTS

- Long pointed wings for fast flying
- Feed on insects
- Latin name "apidos" means without feet – BUT they do have tiny feet!

FAMILY APODIDAE – Swifts

- 4 species in North America (with 3 species occur as casual visitors from Asia)

General Characteristics

- Are not songbirds or perching birds
- Strong claws adapted to clinging to walls, cliffs and rocks
- Some swifts become torpid curing cold weather when flying insects are unavailable (i.e. White-throated Swift)

Species

Black Swift	*Cypseloides niger*
Chimney Swift	*Chaetura pelagica*

Figure 10.33 A Chimney Swift. Although swifts look like swallows they are not closely related being in a different order. Swallows are in the Order Passeriformes, perching birds, whereas swifts are in the Order Apodiformes , their tiny feet being in common with hummingbirds.

FAMILY TROCHILIDAE – Hummingbirds

- 21 species in North America
- 5 species in Canada

General Characteristics

- Ability to fly backwards and hover
- Can endure cold weather by becoming dormant
- Iridescent colours
- Spectacular courtship flight in some species

Species

Anna's Hummingbird	*Calypte anna*
Rufous Hummingbird	*Selasphorus rufus*

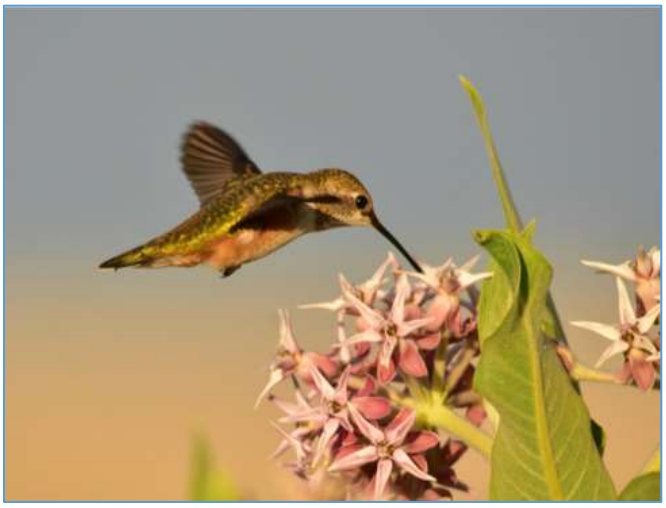

Figure 10.34 The hummingbird can beat its wings 70 times a second and the heartbeat can reach an astonishing 20 times a second.

ORDER CORACIIFORMES – KINGFISHERS
FAMILY ALCEDINIDAE – Kingfishers

- 3 species in North America

General Characteristics

- Compact birds with short necks and large heads
- Long sharp pointed bill
- Three toes forward with one toe pointed back
- Brightly coloured greens and blues
- Dive headlong into the water
- Eat fishes, amphibians, crustaceans, and aquatic insects
- Mainly solitary or in pairs
- Nest in stream banks (burrows)

Species

Belted Kingfisher	*Ceryle alcyon*
Green Kingfisher	*Chloroceryle americana*

Figure 10.35 Belted Kingfisher.

ORDER PICIFORMES – WOODPECKERS
FAMILY PICIDAE – Woodpeckers

- About 23 species in North America

General Characteristics

- Not songbirds
- Adapted to live on tree trunks and branches
- Legs short with toes that are long and strong – sharp clinging nails for holding on to the bark
- Use tail to 'prop' themselves against the trunk or branch while drilling next site, finding food, and for drumming during courtship
- Have extremely long worm-like tongues for finding worms and grubs in trees

- Food: many eat larvae and adults of beetles, ants, aphids, flies, caterpillars; some eat acorns, pine seeds, nuts and berries while others eat fruit, grains and sap

Species

Red-breasted Sapsucker	*Sphyrapicus ruber*
Northern Flicker	*Colaptes auratus*
Pileated woodpecker	*Dryopus pileatus*

Many woodpecker species rely on dead snags for homes and roosting areas. In many states and provinces projects are underway to conserve snags for wildlife. In Germany trees are even girdled to make snags.

Figure 10.36 Male Yellow-bellied Sapsucker. The species makes characteristic parallel straight lines of holes in tree trunks. The Hairy Woodpecker (center) is similar in appearance to the Downy Woodpecker (right) but is larger.

Figure 10.37. Pileated Woodpeckers are crow-sized with a large red crest.

ORDER PASSERIFORMES – PERCHING OR SONG BIRDS

- Large order of birds (29 families in North America)
- Perching birds – three toes forward and one toe facing back, adapted for holding on branches
- Believed to be the most advanced form of birds
- Many species noted for their singing

FAMILY TYRANNIDAE – Tyrant Flycatchers

- 35 species in North America

General Characteristics

- One of the most primitive and successful of the song birds
- Difficult to identify in the field
- Catch insects on the wing
- Head has slight crest

Species

Eastern Kingbird	*Tyrannus tyrannus*
Olive-sided Flycatcher	*Contopus borealis*
Western Wood-Pewee	*Contopus sordidulus*
Hammond's Flycatcher	*Empidonaz hammondii*

Figure 10.38 Western Wood Pewee.

FAMILY ALAUDIDAE – Larks

- 2 species in North America

General Characteristics

- Ground dwelling on open bare land (deserts, beaches, grasslands)
- Walk rather than hop
- Wings long and pointed
- Elaborate and beautiful songs

Species

Horned Lark	*Eremophila alpestris*
Eurasian Skylark*	*Alauda arvensis*

*Eurasian Skylarks were introduced into North America (Vancouver Island, Canada) from Eurasia and Africa at the turn of the century. A small population still exists on the Saanich Peninsula near Victoria.

Figure 10.39 Eurasian Skylark.

FAMILY HIRUNDINIDAE – Swallows

- 11 species in North America

General Characteristics

- Often confused with swifts but not related
- Includes Martins
- Spend more time in daytime flight than other passerine
- Slender, sleek and plumage is iridescent
- Nest in colonies – trees buildings cavities and stream banks

Species

Purple Martin	*Progne subis*
Barn Swallow	*Hirundo rustica*
Cliff Swallow	*Hirundo pyrrhonota*
Tree Swallow	*Tachycineta bicolor*

Figure 10.40 Figure of Tree Swallow (left) and Barn Swallow (right) with its forked tail.

FAMILY CORVIDAE – Crows

- 18 species in North America
- Group includes crows, ravens, jays, magpies and nutcrackers

General Characteristics

- Highest degree of intelligence in the bird world
- Can solve puzzles, have good memories, and can associate objects and can mimic other birds
- Most have complex social structures both as families and flocks
- Omnivorous
- Heavy beaks
- Sexes are generally alike
- Strong flyers

Species

American Crow*	*Corvus brachyrynchos*
Gray Jay	*Perisoreus candensis*
Steller's Jay	*Cyanocitta stelleri*
Black-billed Magpie	*Pica pica*
Clark's Nutcracker	*Nucifraga columbiana*
Common Raven	*Corvus corax*

*formerly the Common Crow, in the coastal area of BC from the border to Alaska the Northwestern Crow (*Corvus caurinus*) replaces the American Crow.

Figure 10.41 Diversity in the Family Corvidae – Steller's Jay, Common Crow, Clark's Nutcracker.

FAMILY PARIDAE – Titmouse (Chickadee)

- 13 species in North America
- Includes chickadees and titmouse
- In 1985 the Bushtits were removed from this group and put in their own Family (Aegithalidae)

General Characteristics

Less than 6 inches in length

- Sexes generally alike
- Soft, thick plumage usually grays and browns
- Short, stout pointed bills
- Strong legs and feet
- Rounded wings
- Cavity nesters
- Often flock when feeding

Species

Black-capped Chickadee	*Poecile atricapillus*
Bridled Titmouse	*Poecile wollweberi*


Figure 10.42 Chickadees are cavity nesters and Bushtits build a pendulous sock-shaped nest.

FAMILY REMIZIDAE – Verdin

General Characteristics

- Small birds with finely pointed bills
- Feeds like a chickadee

Species

Verdin	*Auriparus flaviceps*

FAMILY AEGITHALIDAE – Bushtit

- 1 species in North America
- Formerly a subfamily of the Paridae (Titmouse)

General Characteristics

- Tiny, long tailed gray-brown birds
- Very short bill
- Glean insects and spiders from foliage
- Build gourd-shaped hanging nests of moss, lichens, twigs, and rootlets
- Often flock together with chickadees and kinglets when feeding

Species

Bushtit	*Psaltriparus minimus*

FAMILY SITTIDAE – Nuthatches

- 4 species in North America

General Characteristics

- Moves down the tree head first in search of food
- Short legs with strong claws allowing them to cling to bark
- Move in short hops
- Most are not migratory

Species

Pygmy Nuthatch	*Sitta pygmaea*
Red-breasted Nuthatch	*Sitta canadensis*

FAMILY CERTHIIDAE – Creepers

- 1 species in North America

General Characteristics

- Slender bill, wings and tail
- Very long sharp claws
- Creep on bark in search of insects under the bark

Species

Brown Creeper *Certhia Americana*

Figure 10.43 The Brown Creeper looks for insects on tree trunks.

FAMILY CINCLIDAE – Dipper

- 1 species in North America

General Characteristics

- Solitary except at nesting time
- Territory is usually about ½ mile of stream front
- Soft filmy plumage with thick undercoat of down
- Large preen gland
- Movable flap over nostril (to keep water out)
- Nictitating membrane to protect eyes when in water
- Short stubby wings and tail

- Strong underwater swimmer
- Name derived from its habit of bobbing body rapidly up and down
- Nest along stream or under waterfalls

Species

American Dipper	*Cinclus mexicanus*

Figure 10.44 The American Dipper looks for invertebrates on stream bottoms.

FAMILY TROGLODYTIDAE – Wrens

- 10 species in North America

General Characteristics

- Small, extremely quick
- Brownish-gray plumage
- Sharp pointed bill
- Short rounded wings
- Usually carry tail cocked straight up
- Live close to ground

Species

Bewick's Wren	*Thryomanes bewickii*
House Wren	*Troglodytes adeon*
Marsh Wren	*Cistothorus paulstris*
Rock Wren	*Salpinctes obsoletus*

Figure 10.45 Wrens typically hold their tails straight up.

FAMILY TURDIDAE – Thrushes

- 19 species in North America
- Includes bluebirds, robins, thrushes, solitaires, the veery and wheatear

General Characteristics

- Leg (tarsus) is unscaled, or "booted"
- Perching foot
- Range in size from 2-13 inches in length
- Some of the finest singers
- Eat insects and fruit

Species

Mountain Bluebird	*Sialia currocoides*
American Robin	*Turdus migratorius*
Townsend's Solitaire	*Myadestes townsendi*
Varied Thrush	*Ixoreus naevius*
Veery	*Catharus fuscenscens*
Northern Wheatear	*Oenanthe oenanthe*

Figure 10.46 Diversity in the Family Turdidae. Mountain Bluebird and Varied Thrush.

FAMILY SYLVIIDAE – Old World Warblers

General Characteristics

- Small, very active birds
- Often flock when feeding
- Forest dwellers
- Migratory
- Eat insects and some fruit

Species

Glue-gray Gnatcatcher	*Polioptila caerulea*
Ruby-crowned Kinglet	*Regulus calendula*
Golden-crowned Kinglet	*Regulus satrapa*
Arctic Warbler	*Phylloscopus borealis*

Figure 10.47 Kinglets and warblers typically feed on insects in tree and shrub canopies.

FAMILY BOMBYCILLIDAE – Waxwing

- 2 species in North America
- Tree-dwelling in coniferous and deciduous forests
- Eat berries, small fruit, and insects

General Characteristics

- Soft, silky plumage
- Short, thick bills
- Short legs
- Sleek, strongly crested birds
- Sexes alike
- Small pellets of bright red waxy material form on the secondary featers of wings and tail (purpose unkown)

Species

Bohemian Waxwing	*Bombycilla garrulous*

Cedar Waxwing *Bombycilla cedorum*

Figure 10.48 Bohemian and Cedar Waxwings feeding on berries.

FAMILY LANIIDAE – Shrikes

- 2 species in North America

General Characteristics

- Only predatory songbird
- Prey on vertebrate animal and insects (comparable to hawks and owls)
- Generally solitary except when nesting
- Often hang prey in tree (larder) from where it got its name "butcher bird"
- Hunt by day (diurnal)
- Pattern grey, black and white
- Large heads and bills
- Black band through/behind eyes (giving a masked appearance)
- Strong feet and claws

Species

Loggerhead Shrike *Lanius ludovicianus*
Northern Shrike *Lanius excubitor*

Figure 10.49 Loggerhead and Northern Shrikes. Among other animals shrikes prey on mice and at times "store" their food on thorns.

FAMILY STURNIDAE – Starling

- 3 species introduced into North America from Asia or Europe

General Characteristics

- Strong legs and bills
- Tails short and square cut
- Plumage dark coloured – often with metallic sheen
- Beaks and plumage change colours with season
- Highly social birds – form large flocks

Species

European Starling	*Sturnus vulgaris*
Crested Myna	*Acridotheres cristatellus*

Sixty European Starlings were introduced from Europe into New York City's Central Park in 1890 by Eugene Schieffelin, a Shakespeare enthusiast who wanted to introduce birds mentioned in Shakespeare's plays into North America. Because the European Starling was mentioned only once in all of Shakespeare's works in the year 1597 in Henry IV Part 2, there are now hundreds of millions of these birds in North America today and they pose a significant problem as an invasive species. The population gradually spread across continent reaching the Pacific Northwest in the late 1940s.

The Crested Mynah was introduced into Vancouver, BC from the orient around 1897. The population has been declining during the 1980s and was extirpated in the 1990s. The reason for the extirpation is a mystery. Originally it was thought that the Crested Myna faced serious competition from the European Starling but the most likely scenario is that the population was infected with an avian virus passed on to them by chickens.

Figure 10.50 Juvenile European Starling. In summer plumage the birds are black with yellow bills, in winter they are brown with spots and a dark bill.

FAMILY: VIREONIDAE – Vireos

- 12 species in North America

General Characteristics

- Plain olive, green or gray plumage
- Sexes similar
- Bill short and straight
- Bristle-like feathers partially cover the head
- Eat mostly insects and berries
- Prefer upper branches of tees therefore making them hard to see

Species

Hutton's Vireo	*Vireo huttoni*
Red-eyed Vireo	*Vireo solitarius*

FAMILY PARULIDAE – American Wood Warbler

- 56 species in North America
- Includes some warblers, chats, ovenbirds, redstarts, waterthrushes, and yellowthroats

General Characteristics

- Active, brightly coloured songbirds
- Eat insects
- Toes long and slender
- Bill either slender and sharp pointed or broad and flattened
- Migrator
- Live in woodlands and swampy places

Species

Yellow-breasted Chat	*Icteria virens*
American Redstart	*Setophaga ruticilla*
Yellow-rumped Warbler	*Dendroica coronate*
Northern Waterthrush	*Seiurus novembracensis*
Common Yellowthroat	*Geothlypis trichas*

Figure 10.51 Diversity in Parulidae – Yellow-rumped Warbler and Common Yellowthroat.

FAMILY ICTERIDAE – Blackbirds

- 22 species in North America
- Include blackbirds, grackles, orioles, meadowlarks, cowbirds, bobolinks

General Characteristics

- Small to medium-sized birds
- Sexes generally unlike – males highly coloured
- Some species form large flocks when roosting
- One species (cowbird) lays its eggs in the nest of another species

Species

Red-winged Blackbird	*Agelaius phoeniceus*
Bobolink	*Dolichonyx oryzivorus*
Brown-headed Cowbird	*Molothrus ater*
Common Grackle	*Quiscalus quiscula*
Western Meadowlark	*Sturnella neglecta*
Northern Oriole	*Icterus galbula*

FAMILY THRAUPIDAE – Tanagers

5 species in North America

General Characteristics

- Amongst the most brilliantly coloured birds
- Monogamous
- Rictal bristles around mouth (distinguishes from Orioles)
- Fruit and nectar eaters

Species

Scarlet Tanager	*Piranga olivacea*

Western Tanager *Piranga ludovicians*

Figure 10.52 Scarlet Tanager (left) and Western Tanager (right).

FAMILY CARDINALIDAE – Cardinals, Grosbeaks and Buntings
42 species in North America

General Characteristics

- Strongly sexually dimorphic, brightly coloured males
- All nocturnal neotropical migrants
- Large conical bills
- Mainly solitary or in pairs
- Seed-eating
- Strong bills

FAMILY PASSERELLIDAE – New World sparrows
Examples include Song Sparrows, towhees, juncos, white-crowned sparrow

General Characteristics

- Known for their elaborate songs

The House Sparrow (*Passer domesticus*) is NOT in the Family Passerellidae family of American sparrows but instead is part of the Passeridae or Old World sparrows. It was originally introduced in North America at the turn of the century by Eugene Schieffelin (the same person who introduced the European Starling to New York city), to control insect pests in ornamental gardens.

Species

Song Sparrow	*Melospiza melodia*
Dark-eyed Junco	*Junco hyemalis*
Rufous-sided Towhee	*Pipilo erythrophthalmus*

FAMILY FRINGILLIDAE – Finches

- 83 species plus 8 subspecies in North America
- Largest family of all families in number of species

General Characteristics

- Finest North America songsters
- Most migratory
- Strong flyers
- Gregarious when not nesting
- Cone-shaped strong bills adapted to seed-cracking
- Also eat fruit and insects
- Some have special mouth pouches for carrying food
- Most feed on the ground

Species

This is a very large group – consult field guides for species in your area

Lazuli Bunting	*Passerina amoena*
Northern Cardinal	*Cardinalis cardinalis*
Common Redpoll	*Carduelis flammea*
House Finch	*Carpodacus mexicanus*
American goldfinch	*Cardeulis tristis*
Evening Grosbeak	*Coccothraustes vespertina*
Lapland Longspur	*Calcarius lapponicus*
Pine Siskin	*Cardeulis pinus*

Figure 10.53 House Finch (*Haemorhous mexicanus)*. The thick bills of finches are an adaptation to eating hard seeds.

Figure 10.54 Female Red Crossbill (*Loxia curvirostra*). The beak of a crossbill is adapted for removing seeds from the cones of conifers.

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Unit 11 Mammals

Chapter 11 Mammals

LEARNING OUTCOMES

Successful completion of this unit will enable you to:

1. Compare general features of mammals with other members of the Phylum Chordata.
2. Describe major structural and functional features of mammals with respect to digestion, circulation, reproduction, excretion, sensory perception, and nerve signaling.
3. Apply knowledge of anatomical features to identify mammals, including those that are endangered and threatened.
4. Identify distinguishing characteristics of ten mammalian Orders and the major Families and Genera within.

CHAPTER OUTLINE:

WHAT IS A… MAMMAL?

INTRODUCTION

Mammals are a class of animals of complex organisms which ingest (eat) their food. They all possess mammary or milk glands which produce a secretion used to nourish their young. The mammary glands are modified sweat glands which are usually localized in a breast.

In addition to mammary glands all mammals possess hair or fur. The hair evolved as a modified scale (remember the reptiles) and is used to help insulate the body. Mammals, like birds, are warm-blooded (homeothermic); birds originally evolved feathers from scales to insulate their bodies. The hair may be greatly reduced in mammals found in warm climates (e.g. elephants), or in aquatic environments where the hair is lost to improve streamlining for movement through the water. The hair of mammals is often coloured to camouflage the individual in its surroundings, and may change with the seasons (e.g. snowshoe hare).

The Class Mammalia has many diverse life forms. Originally mammals evolved as land-dwelling (terrestrial) animals walking on four limbs (tetrapods). In some forms the front limbs have been reduced or lost (e.g. whales). In bats, the digits (fingers) of the front limbs have become greatly elongated and support a membranous skin flap for flight.

There are three general groups of mammals. These are:

- Monotremes
- Marsupials
- Eutherians

The **monotremes** have body temperatures of 30-33 C, lay eggs, and do not have milk glands localized in breasts. They include the duck-billed platypus and the spiny anteater.

The **marsupials** have body temperatures of 34-37 C, give birth to live young still in an embryonic stage of development, and have pouches in which the young continue to develop. The kangaroo is in this group.

The majority of mammals are **eutherians**. They have body temperatures of 35-40 C, give birth to well-developed live young, and have a placenta to provide nourishment for the young while still in the uterus of the mother. Humans belong to this group.

Mammalian Anatomy

SKELETAL SYSTEM

The skeletons of mammals are basically similar in structure to our own (human). The bones are heavily ossified (very hard). The skull has a well-developed brain case with bones joined very closely together. The lower jaw is attached directly to the rest of the skull without any connecting bones in between. The bone plate on the back of the skull (occipital) has two projections which joins the skull to the vertebral column (backbone).

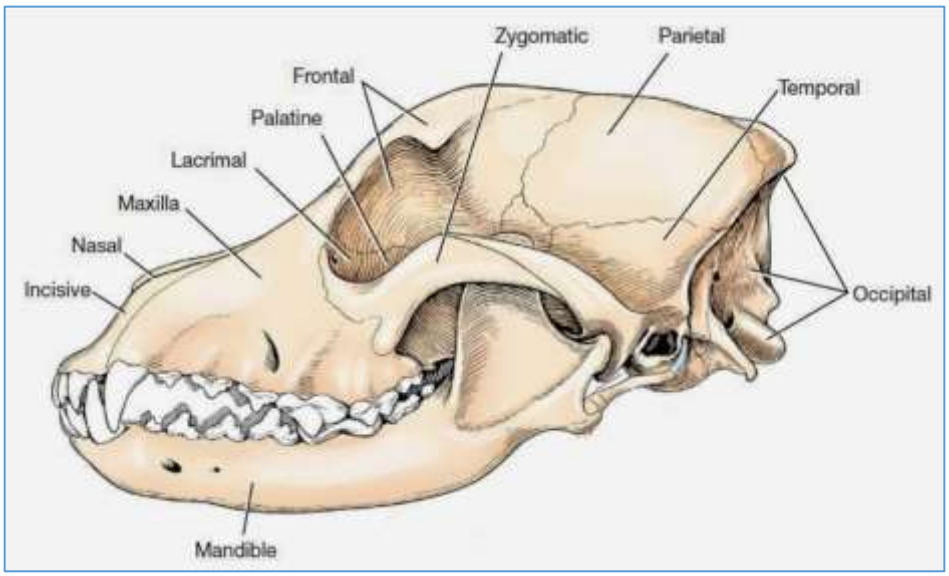

Figure 11.1 Anatomy of the skull of a carnivore.

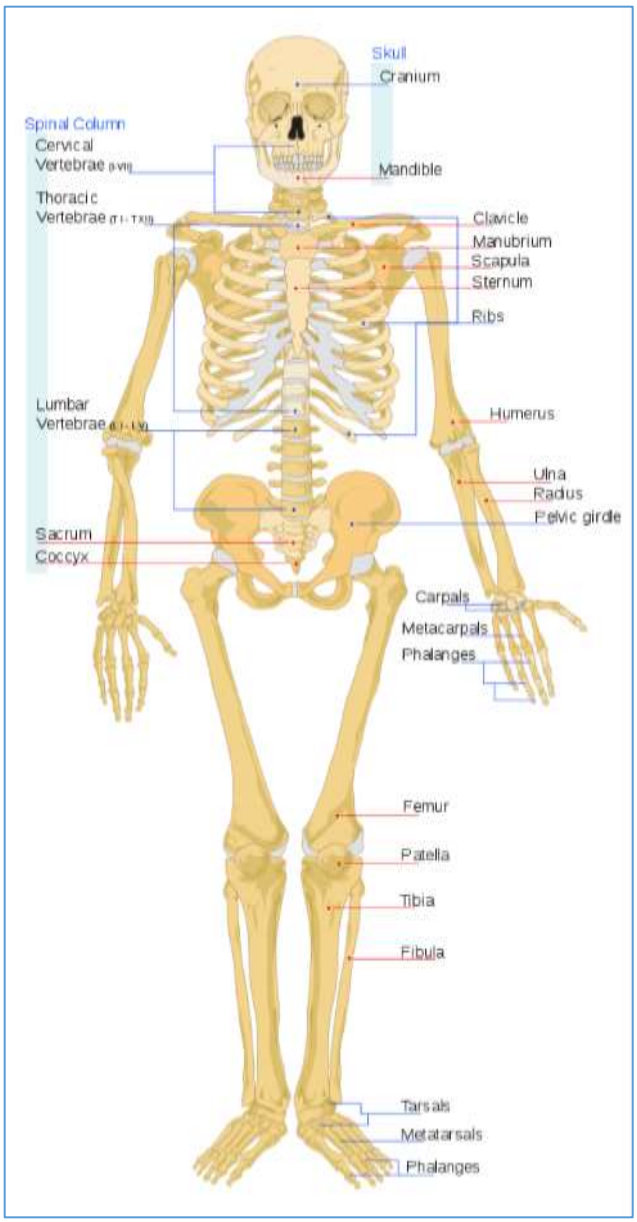

Figure 11.2 Anatomy of the mammalian skeleton.

Most mammals walk on four limbs. In doing so they typically bring the chest over whichever of the front limbs is on the ground. This produces a side-to-side movement as the mammal walks. This type of movement does not require well-developed chest muscles. In the case of reptiles and amphibians the front limbs are kept well to the side as the animal walks; they in turn have well-developed chest muscles. This manner of movement in mammals allows them to have a longer stride for the same length and mass of limbs. As they walk mammals may stand on the soles of their feet (plantigrade, as in humans), or on the toes (digitigrade, as in dogs).

When running a reptile and amphibian use lateral bends of the body, which is suited to increasing their stride because the limbs are placed laterally. The mammalian “gallop” involves bending the back vertically up and down, not side-to-side; the limbs are best extended in this way considering that they

are placed under the body. Forelimbs and hind limbs also move together. Strong back muscles can enhance the action of the legs. The structure of the vertebrae in mammals, with their articulating processes, allows for this necessary vertical movement. The vertebrae of amphibians and reptiles restrict vertical movements.

DIGESTION

The teeth of mammals have different shapes (and functions) in different parts of the jaw. The front teeth, called incisors, are adapted for cutting. The lower incisors may tilt forward to allow them to slide under objects to pick them up. Next to these are canines which in meat-eating mammals are pronounced. They are sharp and curved for tearing a prey. Next to the canines are premolars which are useful in initially cutting food into smaller pieces. The molars are next to these. These break the food into still smaller pieces before it is swallowed. Mammals break up their food before swallowing much more than any other vertebrate group. The larger surface area of the finely chewed food increases the rate of chemical breakdown by enzymes. A rapid rate of digestion is important to mammals because of their high metabolic rate.

Some mammals eat only plants (herbivores), some only other animals (carnivores), and some both (omnivores). The different diets are usually reflected in changes to morphology of the teeth.

Once chewed the food passes into an esophagus down to the stomach. In the stomach proteins are broken down by gastric juice, a mix of hydrochloric acid and enzymes. The food plus the gastric juice (a mixture called chyme), passes into the small intestine where further digestion and absorption of nutrients into the bloodstream occurs. The intestinal surface is thrown into folds of finger like projections that extend into the lumen of the intestine. These folds are called villi and they increase the surface area inside the intestine greatly. The small intestine joins a large intestine with a structure called a caecum occurring at the junction. In the large intestine water and mineral salts are absorbed. The waste (called feces), is formed and stored in a rectum.

Mammals which eat only plants have a problem in obtaining sufficient protein because the cellulose of plant cell walls is difficult to digest. They have solved this problem by using bacteria to digest the cellulose into sugars. Some herbivores like rabbits have an enlarged caecum containing bacteria which can digest cellulose. Because the caecum occurs after the small intestine where most nutrients are absorbed, rabbits eat their own feces to benefit from the material broken down by the bacteria is the caecum. Other mammals, called ruminants, have bacteria in special chambers of the stomach to digest cellulose. Some ruminants, like the cow, have a four chambered stomach. Food goes from the esophagus to the rumen, the largest chamber of the stomach and then into the second chamber called the reticulum (Figure 11.3). Vast numbers of bacteria live in these two chambers and they digest cellulose into sugars. Periodically the food is regurgitated and chewed and goes back to the reticulum. Slowly the sugars produced by microbial digestion, as well some bacteria, enter the next chamber called the omasum and then proceed to the abomasum which is thought to be the true stomach of the cow. (The other three stomachs are thought to be enlarged areas of the esophagus). The food is then passed a little at a time to the small intestine.

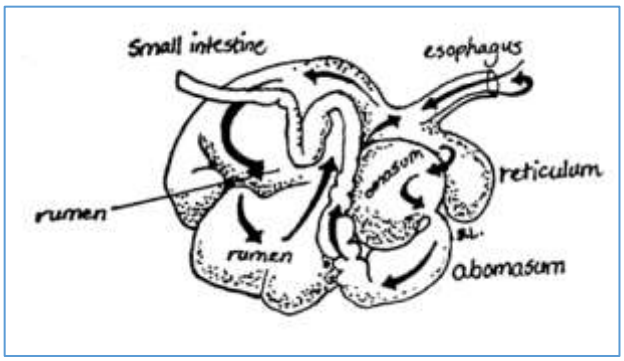

Figure 11.3 The four chambers of the stomach of a ruminant associated with the digestion of cellulose by bacteria – the rumen, reticulum, omasum and abomasum.

Herbivorous mammals without an enlarged caecum or additional chambers in the stomach must consume large amounts of vegetation to compensate for the inefficient retrieval of protein from the diet. The Giant Panda (*Ailuropoda melanoleuca*), for example, eats about 9-14 kg of bamboo shoots in order to compensate for the little energy and protein it derives from its limited diet.

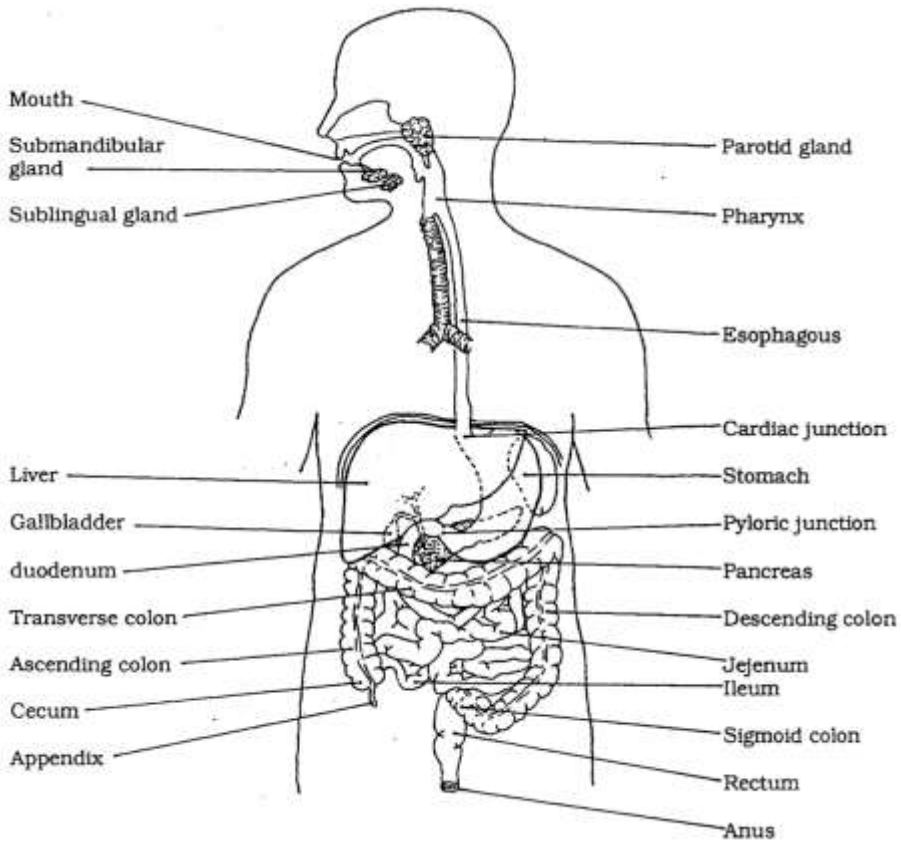

Figure 11.4 The human digestive system

CIRCULATION

As in the case of birds, the only other class of warm-blooded animals, mammals have a 4 - chambered heart (Figures 11.5 and 11.6). They have a complete separation of oxygenated and deoxygenated blood in their bodies. The greater efficiency of oxygen transport is necessary to maintain their body temperature, which requires a higher metabolic rate than cold-blooded animals.

Blood flows from the body into the right atrium, through a valve into the right ventricle, from which it is pumped into the lungs. All mammals breathe through lungs. Blood returns from the lungs back to the left atrium of the heart, through a valve into the left ventricle, and then out to the body. Blood cells contain the pigment hemoglobin which is used to transport oxygen.

An interesting feature of mammalian circulation is the role it plays in maintaining body temperature. This is especially important in aquatic mammals which could lose a deal of body heat through their limbs and skin. In terrestrial mammals the blood supply to the skin and extremities may be increased to reduce body temperature and prevent overheating and vice versa. Notice that people appear more reddish when hot, and blue when cold.

Aquatic mammals also have the veins and arteries in their limbs arranged in a special pattern called a counter current system. This further prevents heat loss. Alternatively, the horns of some mammals are thought to reduce the temperature of the blood before it goes to the brain, preventing heat damage to the delicate brain tissue which can be seriously damaged by heat.

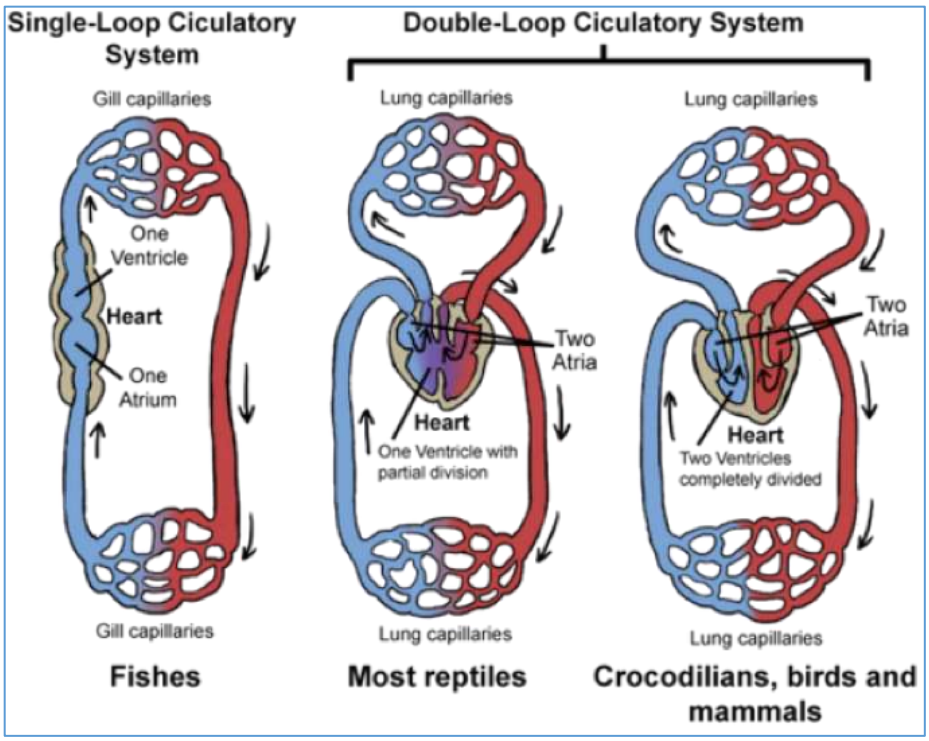

Figure 11.5 The mammalian 4-chambered heart compared with the 2-chambered heart of a fish and 3-chambered heart of amphibians and reptiles. The 4-chambered heart provides for a double circulation where blood returns to the heart after being oxygenated to be pumped again before going out to the body. In the single circulation of a fish the blood goes directly to the body after being oxygenated by the gills. Amphibians and most reptiles have a 3-chambered heart where blood that has been oxygenated mixes with some deoxygenated blood in the ventricle before being pumped to the body.

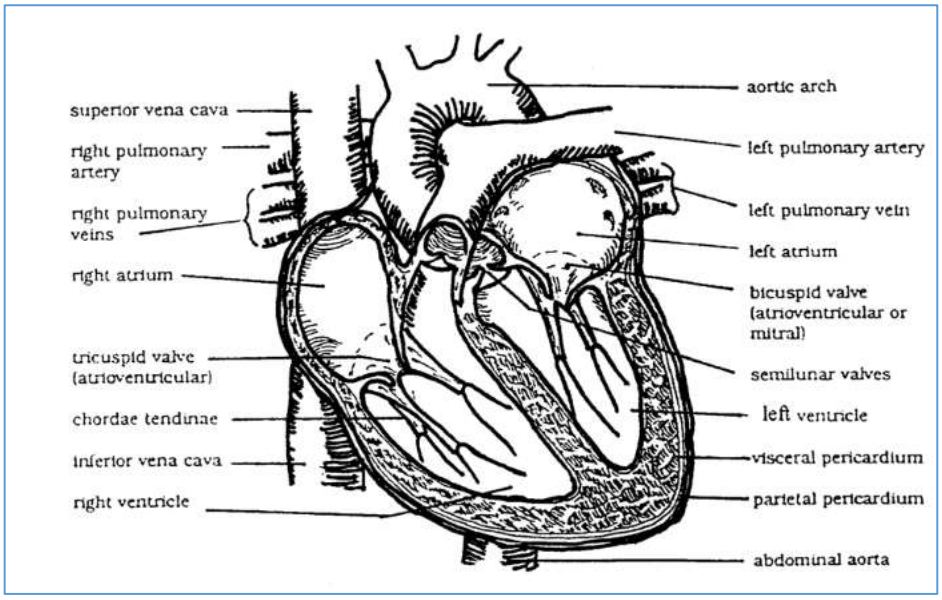

Figure 11.6 Anatomy of the mammalian heart using the human heart as an example.

REPRODUCTION

Most mammals are viviparous – they give birth to live young. The monotremes (platypus and spiny anteater) are exceptions. They lay eggs and are called oviparous.

During development in the marsupials and eutherians the yolk sac and allantois membranes surrounding the embryo (as seen in reptiles) are attached to the wall of the uterus to form the placenta and umbilical cord. In marsupials, usually the yolk sac and chorion form the placenta. In eutherians, the chorion and allantois form the placenta. In the placenta the blood of the mother and the blood of the fetus come close together but never actually mix together.

Young mammals are fed milk after birth. The milk is produced in mammary glands or breasts (except monotremes), which vary in number from 2-20, depending upon the litter size of the species. The milk is a watery substance containing fat globules. The fat content can vary from 1.5% by weight in the case of a horse to 20% in a reindeer, or more in whales. In addition to fat, milk contains sugars, salts, and proteins. The sugar in eutherian mammals is lactose, with additional sugars present in the milk of marsupials.

Mating in most species of mammals, especially in small mammals such as insectivores, rodents, and bats, is promiscuous and indiscriminate. Other mammals such as deer and seals can be polygamous. Monogamous relationships are rare.

Parental care is usually provided by the mother. The degree of parental care usually varies inversely with the number of young produced. In general, the more evolutionarily advanced mammals produce fewer young with a greater degree of parental care.

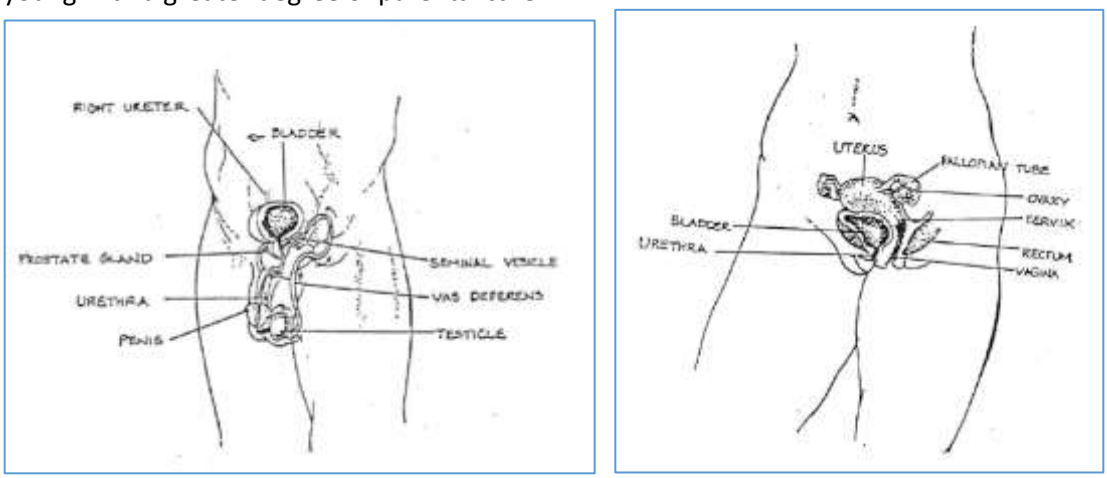

Figure 11.7 Male and female reproductive systems in humans. Mammalian reproductive systems consist of the gonads (male testes, female ovaries), that produce hormones (male testosterone, female estrogen and progesterone) and gametes (male sperm, female ova), the ducts that move the gametes (male vas deferens and urethra, female oviduct), and the glands that produce associated secretions (prostate and seminal vesicles in the male, Bartholin's in the female).

EXCRETION

Birds and mammals are capable of producing urine which is higher in concentration of dissolved substances than their blood. Reptiles are not capable of producing such concentrated urine. Birds and reptiles can excrete their nitrogenous wastes primarily as uric acid, an ability especially important in conserving water.

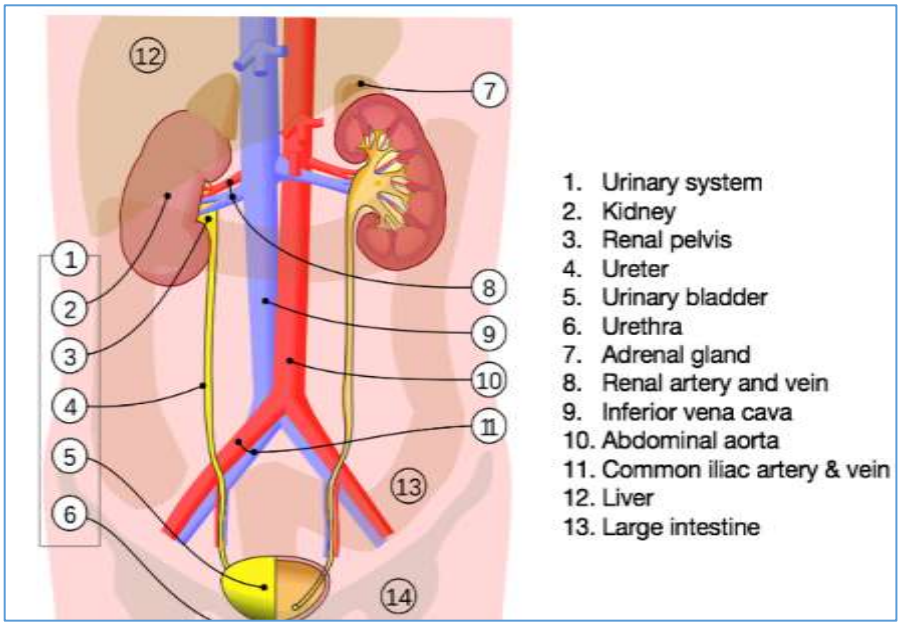

Figure 11.8 Mammalian excretory system using human anatomy as an example.

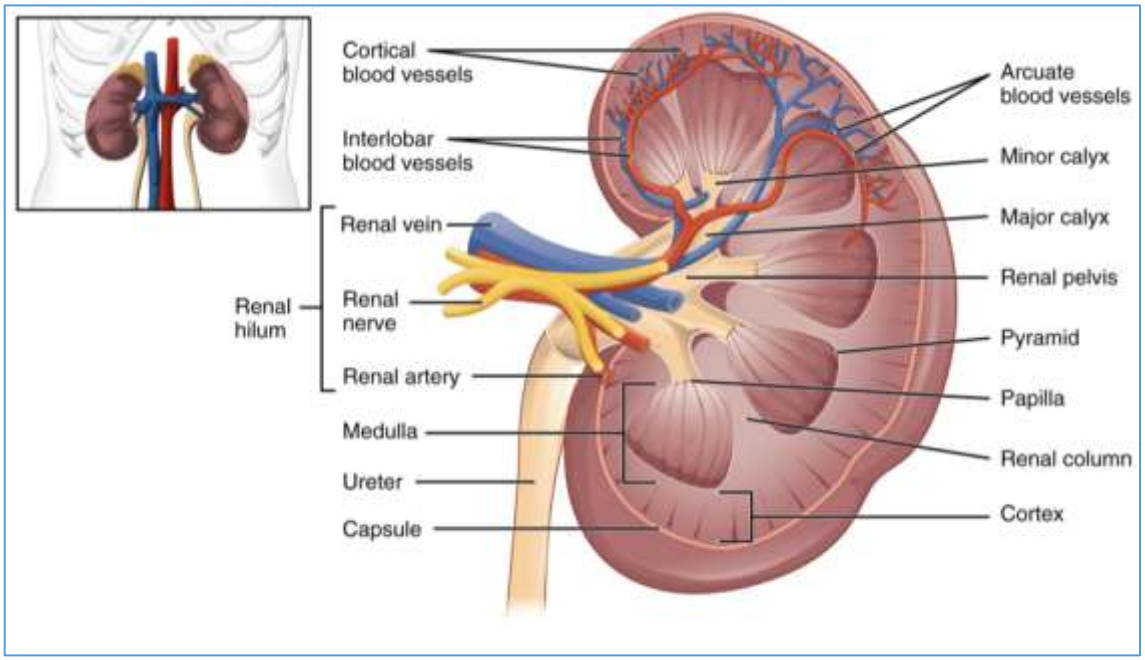

Figure 11.9 Detailed anatomy of the kidney.

SENSE ORGANS

Unlike other vertebrates, mammals have an external ear with a pinna which acts to collect sound waves. In addition to amplifying sound waves the pinna helps to determine the location of a sound source. This is due in part to a comparison of which ear receives the sound first, but is also due to the shape of the pinna. The reflections of sound waves from the pinna onto the eardrum is complex and depends in part on the direction of the sound source.

The middle ear of mammals is peculiar in containing three bones (auditory ossicles) instead of just one. The additional bones further serve to amplify the energy of the sound coming from the external ear. The hearing ability of mammals in general appears to be better than in other vertebrates.

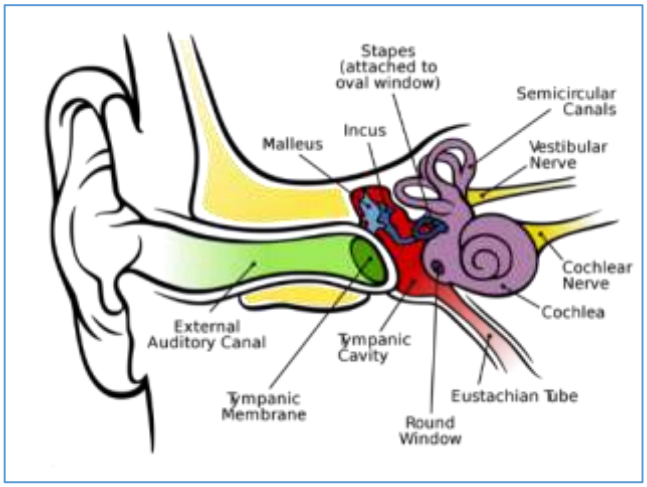

Figure 11.10 Anatomy of the human ear.

The visual acuity is also increased in some mammals by using the lens as a colour filter to absorb the blue end of the spectrum and reduce chromatic aberration on the surface of the retina. For example, red oil droplets appear in the lens of some diurnal marsupials and insectivores; a yellowish colouration appears in the lens of humans and most tree squirrels. Ground squirrels and prairie dogs have orange in the lens.

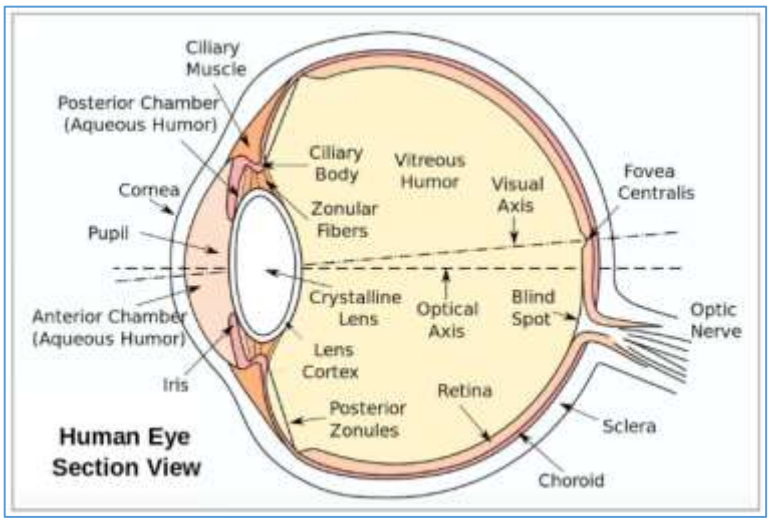

Figure 11.11 Anatomy of the human eye.

Nocturnal mammals often have an additional layer in the eye behind the retina called the tapetum. This contains metallic deposits which reflect light back through the retina a second time, increasing the stimulation of the retina in poor light. An unusually bright light can be reflected back out through the pupil from the tapetum producing eyeshine.

A nocturnal mammal may make use of the length of its rods rather than their diameters in perceiving poor light. If this is the case it can obtain good resolving power in bright light if it can reduce the sensitivity of its eyes to the light. This is done by means of the slit-shaped pupil (either vertical or horizontal) found in many nocturnal mammals.

The position of the eyes is important in determining the field of view and binocular vision. The more the eyes are placed anteriorly with a greater overlap of the field of view, the greater the degree of binocular vision and depth perception. This is especially important for tree-dwelling (arboreal) species which regularly move in three dimensions.

Most fishes, reptiles, and birds can perceive colour, but not mammals. Only the primates and monkeys can perceive colour at all well. Carnivores, rodents and most other mammals are colour blind. Primates and whales have a poor sense of smell. In other mammals smell is used for locating prey or predators, determining the sexual conditions of their partners, determining food quality, and probably recognizing individuals. However, the sense of smell seems to vary considerably from one group to the next.

Figure 11.12 The Blue Whale, the largest mammal, can achieve its massive size because it is aquatic and it does not have to support its body weight as it would have to if it were terrestrial.

NERVOUS SYSTEM

The nervous system of vertebrates is comprised of two main components, the central nervous system and the peripheral nervous system. The central nervous system (CNS) consists of the brain and the spinal cord. Both contain fluid-filled spaces filled with cerebrospinal fluid. The basic nerve cell is called a neuron that consists of a cell body and processes extending from it called axons and dendrites.

Dendrites carry an impulse towards the nerve cell, axons carry impulses away. The brain and spinal cord also have supporting cells called glial cells that are about 10 times more abundant than the neurons. The CNS contains gray matter and white matter. The white matter consists of bundles of the neuron fibres, the axons and dendrites, covered in myelin to improve conductivity. Gray matter consists of the cell bodies and unmyelinated processes. In the brain the white matter is on the inside layer and the gray matter on the outside, in the spinal cord the gray matter is inside and the white matter outside. In humans, the Peripheral Nervous System consists of everything outside the CNS, the nerves that travel through the body and the 12 pairs of cranial nerves coming directly from the brain and 31 pairs of spinal nerves.

The general organization of the vertebrate nervous system is shown in Figure 11.13. The vertebrate nervous system is divided into the central nervous system consisting of the brain and spinal cord and the peripheral nervous systems. The peripheral nervous system in turn has fibres bringing information to the CNS (the afferent nervous system) for processing and the efferent nervous system sending messages from the CNS to the rest of the body for response. The efferent nervous system in turn has fibres in a somatic nervous system going to skeletal muscles for voluntary response, and the autonomic nervous system with fibres going to glands and smooth muscles for involuntary response. The autonomic nervous system has stimulatory and inhibitory fibres innervating the same structures. The dual innervation is sympathetic and parasympathetic.

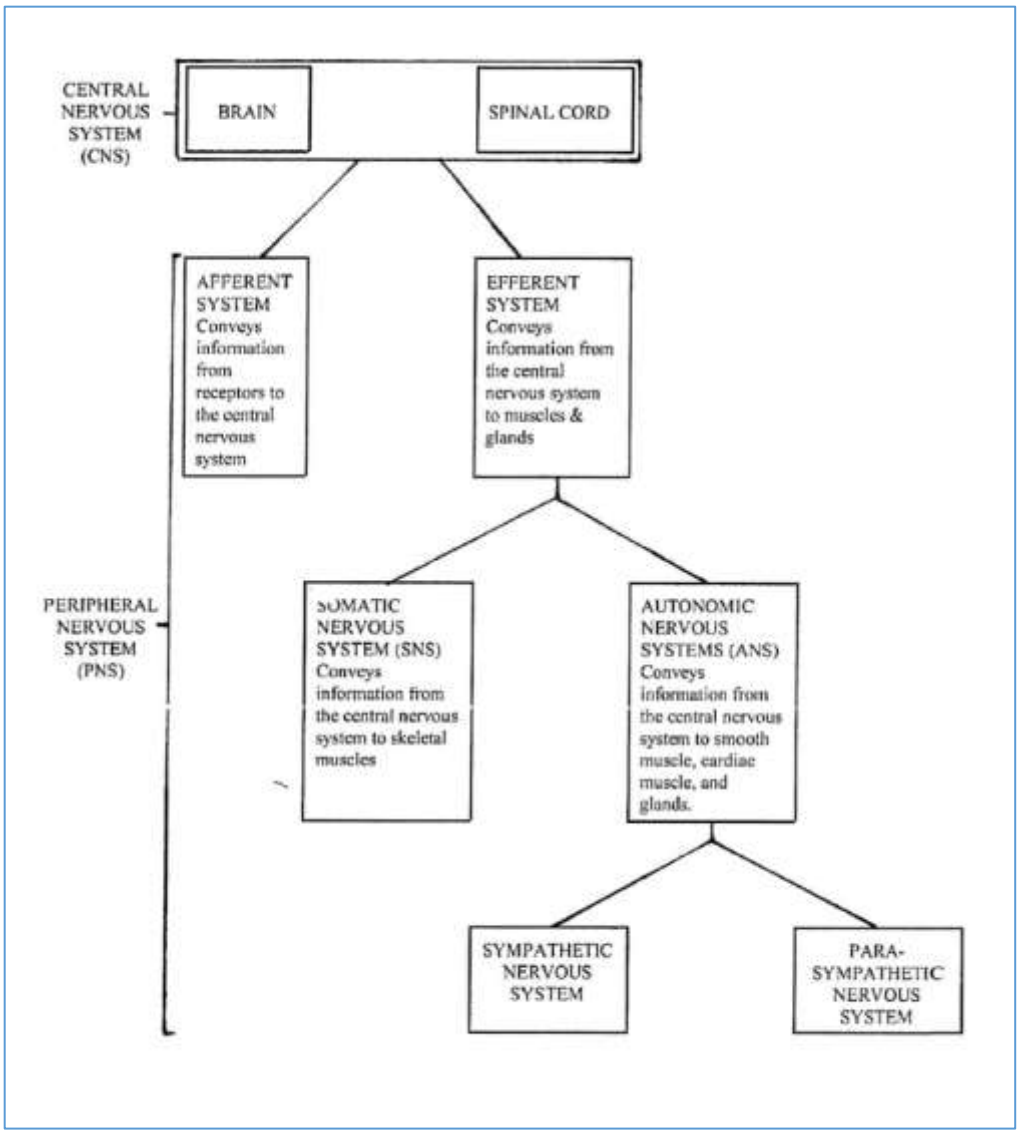

Figure 11.13 General organization of the vertebrate nervous system.

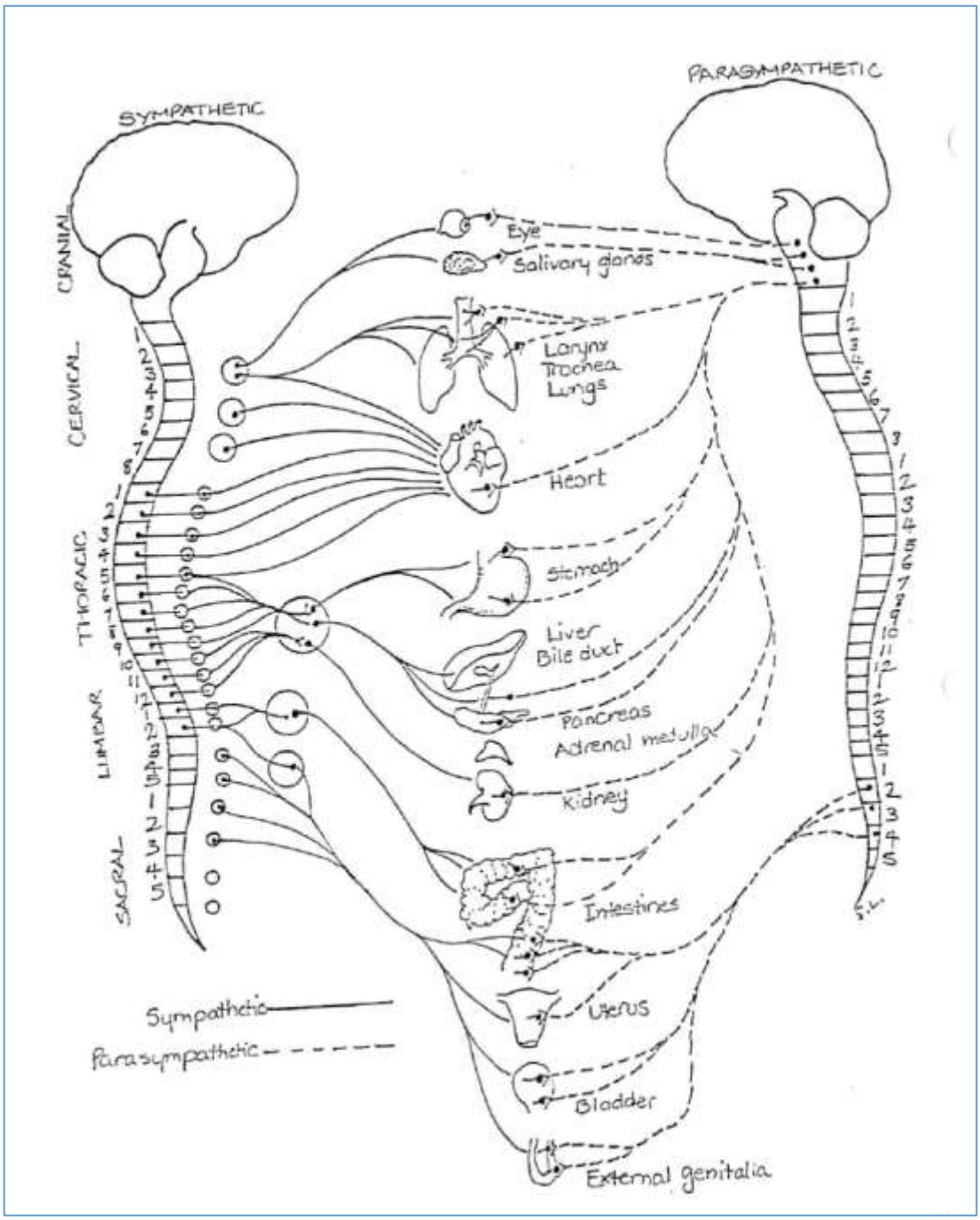

Figure 11.14 Sympathetic and parasympathetic innervation to glands and smooth muscle.

ENDANGERED AND THREATENED ANIMALS

It is estimated that over 50% of the world's species are "endangered," in other words at risk of extinction. Many countries develop strategies to protect endangered species, such as prohibiting or restricting hunting to certain times of the year and protecting the geographic range of threatened species by creating wildlife reserves. The Committee on the Status of Endangered Wildlife in Canada

(COSEWIC) provides a list of wildlife species at risk as well as extirpated and endangered animal species. This list can be accessed online at http://www.sararegistry.gc.ca/species/schedules_e.cfm?id=1

Some examples of endangered animals in Canada include:
Extinct: Dawson Caribou, Sea Mink
Extirpated: Atlantic Gray Whale, Atlantic Whale (St. Lawrence population), Black-footed Ferret, Swift Fox
Endangered: Bowhead Whale, Eastern Cougar, Right Whale, St. Lawrence River Beluga Whale, Sea Otter, Vancouver Island Marmot, Wood Bison
Threatened: Maritime Woodland Caribou, Newfoundland Pine Marten, North Pacific Humpback Whale, Peary Caribou, Prairie Long-tailed Weasel
Rare: Black-tailed Prairie Dog, Blue Whale, Eastern Mole, Fin Whale, Grey Fox, Northwest Atlantic Humpback Whale, Plains Pocket Gopher, Queen Charlotte Island Ermine, Western Woodland Caribou, Wolverine

WATCHING MAMMALS

Mammals are often elusive and are therefore more difficult to see and identify in the field. Mammals can be interpreted by identifying their scats, skeletons or tracks. In order to identify mammals, people should be aware of their habits as well as physical features.

Figure 11.15 The Raccoon (*Procyon lotor*) is sometimes called the "trash bandit" because in urban areas it is a scavenger on garbage.

CLASSIFICATION OF MAMMALS

The Phylum CHORDATA includes all mammals, fishes, birds, amphibians, and reptiles. The phylum is divided into Classes, with mammals in the Class Mammalia. Classes are subdivided into Orders. Worldwide there are 19 Orders with 9 Orders occurring in North America north of Mexico. Orders are divided into Species of which there are 368 in North America.

Order	**Number of Species**
Marsupials	1
Shrews and Moles	37
Bats	40
Edentates	1
Lagomorphs	19
Rodents	200
Carnivores	54
Sea Cows	1
Ungulates	15
Total Species	**368**

ORDER MARSUPIALIA – POUCHED MAMMALS

- 1 species found in North America
- Most primitive group of the mammals that bear their young alive (viviparous mammals)
- Differ in that they lack a true placenta but do have a fur-lined pouch (marsupium) covering the female's mammae.
- Gestation period 1-2 weeks
- Young are born in an undeveloped (embryonic) state and make their way from the base of the mother's tail to the pouch where they attach themselves to a nipple.
- Of the 250 species native to Australia the marsupials fill many niches with species of squirrels, moles, mice, cats, rabbit-like animals, dogs and anteaters

FAMILY DIDELPHIDAE- New World Opossums

- 1 species in North America

General Characteristics

- House cat size
- Greyish-white fur (pelage) – some hairs black-tipped and coarse
- Tail naked, prehensile
- Ears naked with pink tips
- Legs short, first toe of hind foot thumb-like (opposable)
- Average life span – 7 years
- Found in open woods, brushy wastelands and farmlands, occasionally found in urban areas
- Nocturnal and solitary
- When threatened often rolls over and closes eyes – playing possum
- Does not hibernate, but may den up during extreme weather
- Often killed on roadways while scavenging carrion

Species

Virginia Opossum *Didelphis virginiana*

Figure 11.16 The female Opossum raises its young in a pouch. When they are larger the young may travel on the mother's back.

Figure 11.17 Skull of an Opossum.

ORDER INSECTIVORA –SHREWS AND MOLES

- Small mammals with short, dense fur
- 5 clawed toes on fore and hind feet
- Small eyes and ears
- They do eat insects and their larvae but will eat other invertebrates
- Are land-dwellers, burrowers, and some spend life in water

2 families are represented North America:
Shrews (Soricidae)
Moles (Talpidae)

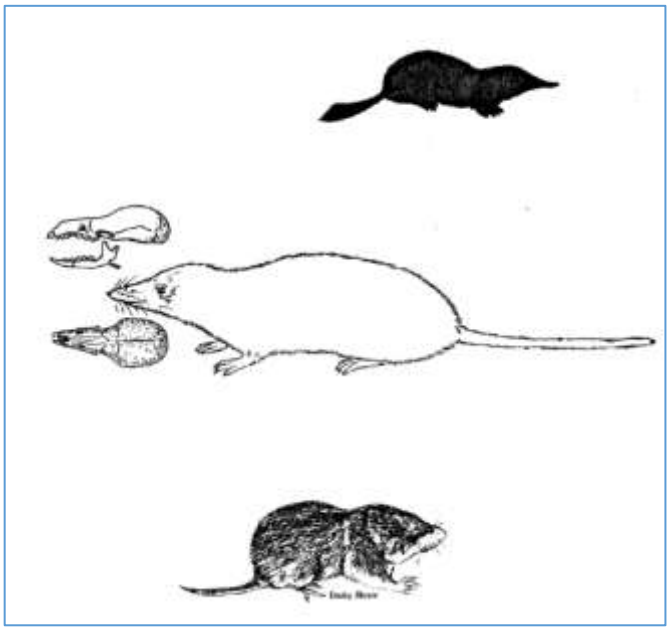

Figure 11.18 A silhouette of a mole on the top (note broad front paws with claws for digging), and shrews below.

FAMILY SORICIDAE – Shrews
General Characteristics

- Are the smallest living mammals
- Often resemble mice but have 5 clawed toes (mice have 4)
- Fur can lay forward or backward – to allow for movement in burrows
- Have high metabolism so that they must feed every three hours day and night
- Eats twice its own body weight each day
- Eats insects, fungi, and small mammals – dead or alive
- Some have squeaky voices, while others echolocate like bats
- Are the prey food of owls, snakes and some mammals
- Average life span 1-2 years
- Usually 1-2 litters per year each with 2-10 young

- Shrews become easily excited and can die from fright when the heart reaches 1,200 beats per minute

Species

Vagrant Shrew	*Sorex vagrans*
Pygmy Shrew	*Microsorex hoyi*
Short-tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Desert Shrew	*Notiosorex crawfordi*

FAMILY TALPIDAE – The Moles

- Larger than shrews

General Characteristics

- Have shorter tails
- Streamlined bodies, narrow pelvis
- Fur is velvety and grainless
- Hearing is well-developed
- Eyes light sensitive, vision poor
- Naked snout, very important in finding food through smell and vibrations picked up through whiskers
- Active day and night
- Can burrow approximately 1 foot per minute in porous soil
- Main food earthworms

Species

American Shrew-mole	*Neurotichus gibbsii*
Townsend's Mole	*Scapanus townsendii*
Hairy-tailed Mole	*Parascalops breweri*
Eastern Mole	*Scalopus aquaticus*
Star-nosed Mole	*Condylura cristata*

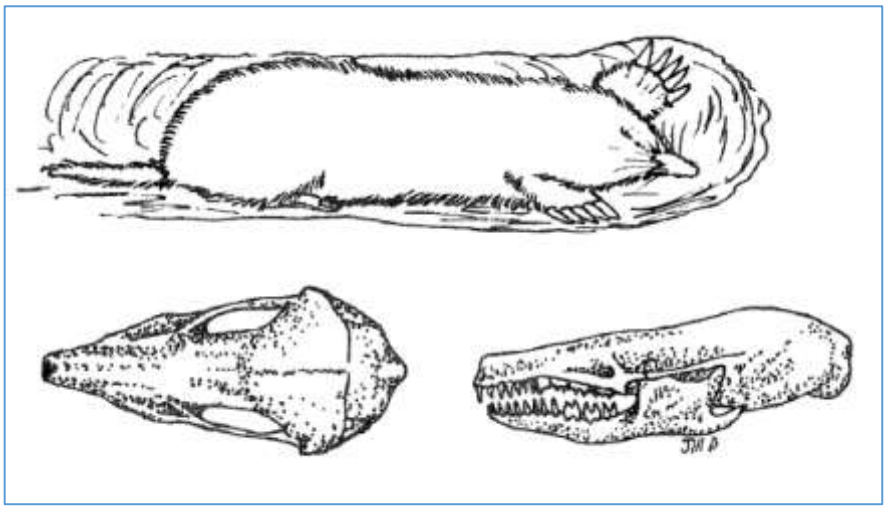

Figure 11.19 Illustration of a mole digging a tunnel and a mole skull below showing the characteristic insectivorous dentition of sharp teeth adapted for breaking through the hard exoskeletons of the insects on which it feeds.

ORDER CHIROPTERA – BATS

- Bats are unique in the mammal world in that they fly
- Other mammals that have "flying" as part of their name actually glide and are not capable of sustained flight (i.e. flying squirrel)
- One of the most numerous mammals next to rodents
- Four families and 39 species occur in North America

General Characteristics

- Well-furred bodies
- Naked wing membranes
- Head has small eyes and large ears
- Chest large, hips narrow
- Most North American bats locate their prey by echolocation which operates by a system similar to sonar
- A high frequency sound is emitted from the bat and is returned when the signal hits the prey object
- Some prey are able to confuse the bat by sending back false signals
- Most bats are nocturnal
- In winter some bats migrate while others hibernate

FAMILY MORMOOPIDAE – The Leaf-chinned Bats

- 8 species restricted to tropics of new world
- 1 is found north of Mexico (Texas and Arizona)

General Characteristics

- The chin has flaps and grooves which aid with the echolocation

- Ear (tragus) has a horizontal pocket-like fold

Species

Ghost-faced Bat *Moroops megalophylla*

Figure 11.20 A Ghost-faced Bat.

FAMILY PHYLLOSTOMATIDAE – the Leaf-nosed Bats

- 140 species in the tropical regions of the New World
- 5 species reach the south-western limit of the United States

General characteristics

- Nose has a vertical projecting flap which is part of the emission of ultrasonic sounds
- Can hover in flight
- Have large eyes – can see quite well

Species

California Leaf-nosed Bat	*Marcotus californicus*
Long-tongued Bat	*Choeronycteris mexicana*
Mexican Long-nosed Bat	*Leptonycteris nivalis*
Hairy-legged Vampire	*Diphylla ecaudata*

FAMILY VESPERTILIONIDAE – Evening Bats

- Found in temperate and tropical regions throughout the world
- Most North America bats belong to this group
- As the name implies these bats are generally seen in the evening
- Insectivorous
- Some migrate, but most hibernate

General Characteristics

- Most have developed echolocation system that sends out an ultrasonic vibration through their mouth
- Have plain noses
- Earlobes form a tragus
- Tail extends only slightly beyond the back edge of the interfemoral membrane

Species

Little Brown Bat	*Myotis lucifugus*
Silver-haired Bat	*Lasionycteris noctivagans*
Western Pipistrelle	*Pipistrellus hesperus*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Laiurus borealis*
Evening Bat	*Nycticeius humeralis*
Spotted Bat	*Euderma maculatum*
Townsend's Big-eared Bat	*Plecotus townsendii*
Pallid Bat	*Antrozous pallidus*

FAMILY MOLOSSIDAE – The free-tailed Bats

- 80 species in the warmer parts of the world
- 6 species occur in North America north of Mexico

General Characteristics

- Naked tails that extend past the edge of the interfemoral membrane
- Wings are narrow and flight is swift and straight

- Groom themselves with spoon-shaped bristles on hind toe of their broad feet
- Thumbs and toe claws have double talons

Species

Brazilian Free-tailed Bat	*Tadarida braseiliensis*
Western Mastiff Bat*	*Eumops perotis*

*Largest bat in North America

Figure 11.21 Brazilian Free-tailed Bat. Bats hunt insects using echolocation to catch their prey. The skull of a bat shows the characteristic sharp teeth for eating insects.

ORDER EDENTATA – THE EDENTATES

- this group includes the armadillos, sloths and anteaters
- Latin name means toothless – but this incorrect
- Teeth generally pegs
- Found mostly in South and Central America
- Only 1 species in North America

Species

Nine-banded Armadillo	*Dasypus novemicinctus*

ORDER LAGOMORPHA – THE PIKAS, RABBITS AND HARES

General Characteristics

- Possess two pairs of upper incisors
- The first enlarged and chisel-like
- The second small, directly behind the first and lacking in cutting edges
- The incisors continue to grow in most animals but are worn down by constant use
- This group was originally thought to be rodents
- Two families in North America
    - The pikas Ochotonidae
    - The rabbits and hares Leporidae

FAMILY OCHOTONIDAE – The Pikas

- All species belong to one genus
- Live in mountains in central Asia, Japan and western North America

General Characteristics

- Short rounded ears
- Short legs
- No tails
- About 7 inches long and 3 inches in height
- Main food plants, grasses and sedges
- In the late summer collects (harvests) food for winter storage
- Lives generally above the tree line in Rocky Mountains
- Make sharp whistle-like sound to warn off predators
- Originally pronounced pee-ka from the Mongolian, in North America it is usually pronounced Pie-ka

Species

American Pika (pica) *Ochotona princeps*

FAMILY LEPORIDAE – The Rabbits and Hares

- Small grazing animals
- With big ears and long hind legs
- Two pairs of large upper incisors
- Females larger than males
- Often nocturnal

Differences between rabbits and hares

- Rabbits: young are born naked, blind and helpless in underground burrows
- Hares: young are precocious and able to run loose soon after birth
- Unique digestive system called re-ingestion where the re-digested plant food is re-ingested – that is re-chewed and goes through the digestive tract for the second time.

Species

Eastern Cottontail *Sylvilagus floridanus*
Snowshoe Hare *Lepus americanus*

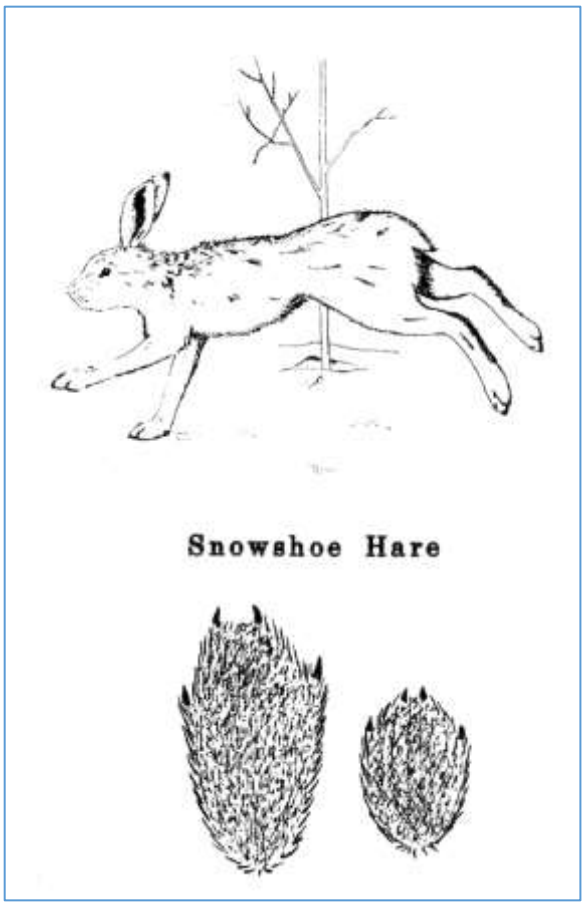

Figure 11.22 Snowshoe Hare with footprints.

Figure 11.23 Eastern Cottontail

ORDER RODENTIA – THE RODENTS

- Largest order of mammals both in number of individuals and number of species 3,000+
- Range in size from mice weighing under 10g to beaver at 110 pounds (50,000g)
- Found throughout the world except Antarctica
- Primarily herbivorous in diet
- An important species in the food chain
- Generally small in size

Generally Characteristics

- Have two pair of specialized incisors in the front of the mouth
- Separated from the cheek teeth by a large gap (no canines)
- Teeth continue to grow throughout the animals life and gnawing keeps the teeth the correct length
- Most have 4 toes on forefeet and 5 on hindfeet
- Most nocturnal
- Most active throughout the year

FAMILY APLODONTIDAE – The Mountain Beaver

- Only 1 living member of this family
- Found only in western North America
- One of the most primitive living rodents

General Characteristics

- Common name is misleading – does not live in the mountains
- Has similar habits of diverting streams and eating bark
- Nocturnal
- Feeds on vegetation such as ferns, bark of conifers, and grasses
- Re-ingests the soft fecal pellets
- Whistles when disturbed

Species

Mountain Beaver *Aplodontia rufa*

FAMILY SCIURIDAE – The Squirrels, Chipmunks and Marmots

- A large and diverse group that occurs in a wide variety of habitats including terrestrial and arboreal
- Most diurnal some nocturnal
- Found worldwide except Australasia, southern South America and Madagascar
- In North America there are 63 species in 9 genera including the chipmunks, tree squirrels, ground squirrels, flying squirrels, woodchucks, marmots, prairie dogs.
- Most diurnal (except flying squirrels)
- Many hibernate, some estivate

General Characteristics

- Internal cheek pouches
- Four toes on forefeet, five on hindfeet

Genus Marmota – The Marmots (Woodchuck)

- Stout body with short bushy tail
- Feed on herbaceous plants and grasses
- Live in burrows under trees or large rocks

Species

Yellow-bellied Marmot *Marmota flaviventris*
Woodchuck *Marmota monax*

Genus Spermophilus – The Ground Squirrels

- Found in North America and Eurasia

General Characteristics

- Small burrowing rodents
- Small ears
- Short tail

Species

Columbia Ground Squirrel *Spermophilus columbianus*
Thirteen-lined Ground Squirrel *Spermophilus tridecemlineatus*

Genus Eutamias – The Chipmunks

- Found in North America and Asia

General Characteristics

- Five blackish and four whitish stripes of approximately equal width give this group a distinctive body markings. They have two pale stripes on head, above and below the eye.
- Tail measures 40% of total length of the animal

Species

Yellow-pine Chipmunk *Eutamias amoenus*

Figure 11.24 The Family Sciuridae contains squirrels, chipmunks and marmots like this Yellow-pine Chipmunk.

Genus Sciurus – Tree Squirrels
General Characteristics

- Larger than the red squirrel
- Tail bushy
- Body colour grey or black

Species

Fox Squirrel	*Sciurus niger*
Grey or Black Squirrel	*Sciurus carolinensis*

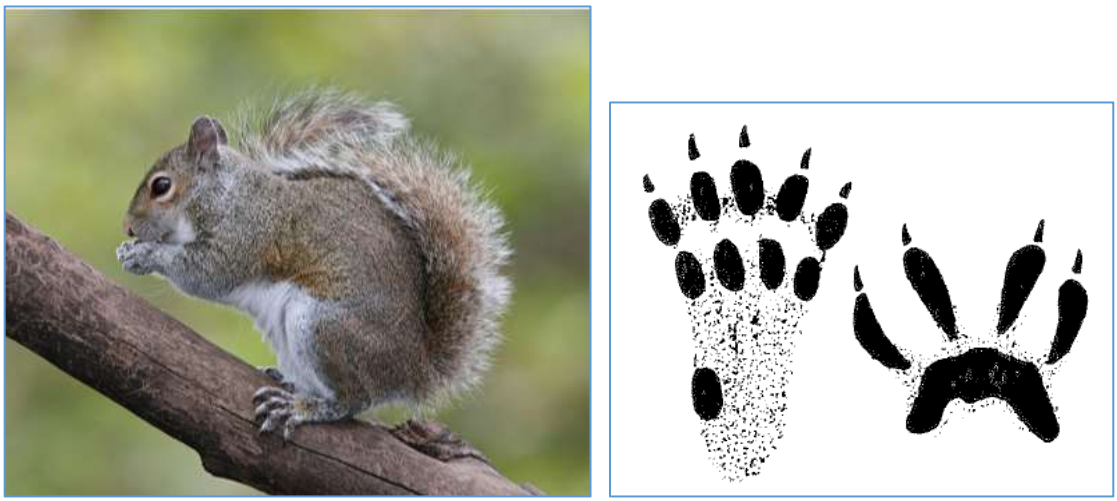

Figure 11.25 The Grey Squirrel also occurs in a black phase.

Genus Tamiasciurus – The Red Squirrels (Chickarees)

- The latin name *tamias* means storer and the ending *us* means true
- Although they do hibernate they do store food
- Highly vocal

Species

Red Squirrel	*Tamiasciurus hudsonicus*
Douglas Squirrel	*Tamiasciurus douglasii*

Figure 11.26 The Douglas Squirrel prefers coniferous habitat.

Genus Glaucomys – The Flying Squirrels

- Inhabits forested areas of North America including Alaska

General Characteristics

- Has loose folds of furred skin connecting the fore and hind limbs on each side of the body – forming a gliding membrane
- Tail is broad and flat
- Eyes large – nocturnal habits
- Soles of the feet are furred

Species

Northern Flying Squirrel *Glaucomys sabrinus*

Figure 11.27 The Northern Flying Squirrel eats truffles and is an important disperser of spores of mycorrhizal fungi.

FAMILY GEOMYIDAE – The Pocket Gophers

- Occur only in North America – 3 genera with 16 species
- Most highly evolved of mammalian burrowers
- Short stocky animal with small eyes and ears
- Fur-lined 'external" pouches (pockets) on cheeks
- Make two kinds of burrows; 1. Near surface for food gathering and; 2 deeper – for storage and shelter
- Usually forage underground – pulling the plant into the burrow
- Liquids are derived from vegetation – do not need water
- Gopher burrows are on angles (moles are vertical)
- Young born in spring – litter 2-11
- Start digging tunnels at 2 months (leave home)
- Sexually mature at 3 months

Species

Northern Pocket Gopher	*Thomomys talpoides*
Plains Pocket Gopher	*Geomys bursarius*
Yellow-faced Pocket Gopher	*Pappogeomys castanops*

FAMILY HETEROMYIDAE – The Pocket Mice and Kangaroo Rats

Members in this group are neither mice nor rats but closely related to the pocket gophers and ground squirrels

General Characteristics

- Nocturnal
- Burrowing animals with fur-lined cheek pouches for carrying food
- Populations subject to periodic fluctuations
- Do not hibernate but become inactive during hot or cold weather
- They are eaten by rattlesnakes, hawks, coyotes, foxes, weasels, badgers and skunks

Species

Great Basin Pocket Mouse	*Perognathuys parvus*
Pale Kangaroo Mouse	*Microdipodops pallidus*
Ord's Kangaroo Rat	*Dipodomys ordii*
Mexican Spiny Pocket Mouse	*Liomys irroratus*

FAMILY CASTORIDAE – The Beavers

- Found in North America Only
- One species

General Characteristics

- Adapted to aquatic lifestyle
- Tail is paddle shaped and covered with scales
- Forefeet are dextrous
- Hind feet are large and webbed which act as paddles when swimming
- Do not hibernate

- Formal family structure with female dominant
- Build lodges or bank burrows for homes

Species

American Beaver *Castor canadensis*

Figure 11.28 Skull of American Beaver. As with all rodents the central incisors grow continually and need to be worn down.

FAMILY CRICETIDAE – The new World Rats and Mice

- Largest family of mammals in North America
- Consists of 19 genera of 70 species
- Found in every habitat
- Mouse-like creatures that are highly adaptable – range in size from 1/8 ounce (Pygmy mouse) to 4 pounds (Muskrat)

General Characteristics

Two groups

1) Cricentines that includes most mice and rats
    - Most have long tails
    - Large eyes and ears
    - Teeth with well developed cusps
    - Most nocturnal are omnivorous
    - Species are so similar that they can only be distinguished by careful examination of their internal bone structure
2) Microtines that includes voles and lemmings
    - Stout bodies with short legs and tails
    - Inconspicuous ears and eyes
    - Teeth adapted for grinding fibrous grasses and leaves

Species

Cricentines:

Marsh Rice Rat	*Oryzomys palustris*
Plains Harvest Mouse	*Peithrodontomys montanus*
Deer Mouse	*Peromyscus maniculatus*
Bush-tailed Woodrat	*Neotoma cinerea*

Southern Red-backed Vole	*Clethrionomys gapperi*
Heather Vole	*Pheacomys intermedius*
Muskrat	*Ondatra zibethicus*
Microtines:	
Meadow Vole	*Mircotus pennsylvanicus*
Northern Bog Lemming	*Synaptomys borealis*

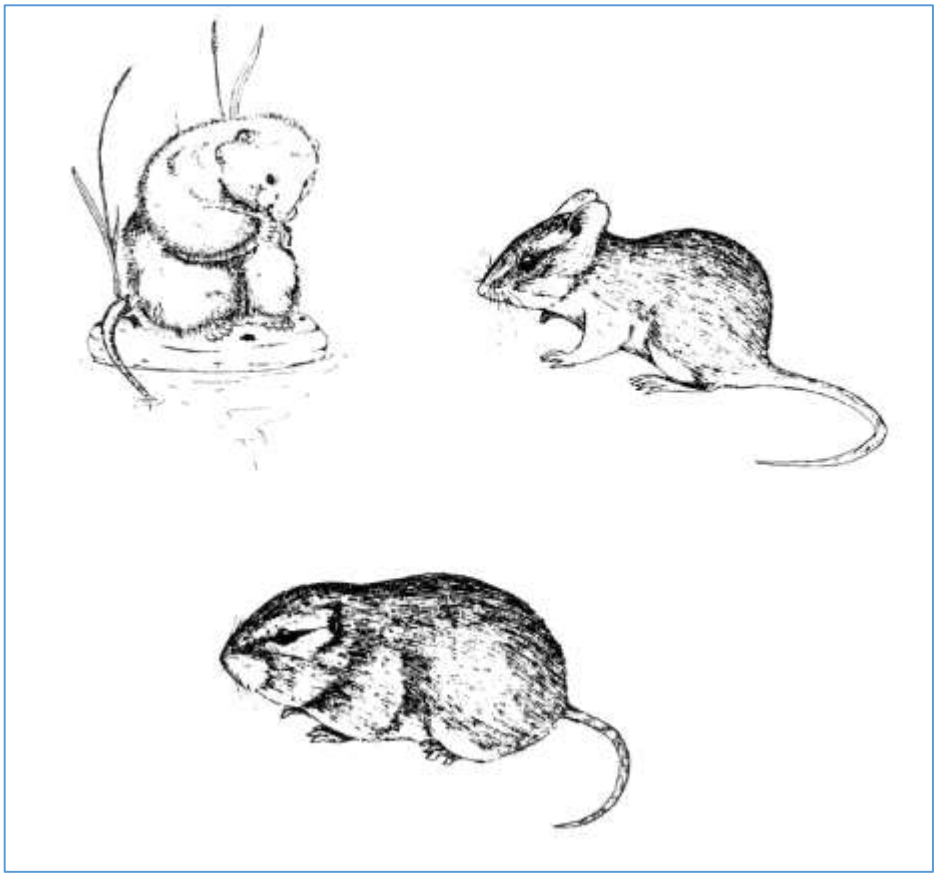

Figure 11.29 Diversity in the Cricetidae.

FAMILY MURIDAE – Old World Rats and Mice

- Very adaptable
- No other mammal family contains more species

General Characteristics

- Long scaly tails
- Large ears
- Active all year
- Nocturnal
- Members of this family carry diseases such as plague, typus and food poisoning, while others destroy crops
- A positive note is that they are used for scientific and medical research

Species

Black Rat	*Rattus rattus*
Norway Rat	*Rattus norvegicus*
House Mouse	*Mus musculus*

Figure 11.30 Black Rat, Norway Rat and House Mouse.

FAMILY ZAPODINAE – Jumping Mice
General Characteristics

- Reddish or yellowish mice
- Very long tails
- Large hindfeet
- Good runners and jumpers
- Plants, berries and insects main food
- Mostly nocturnal
- hibernate up to 6-8 months
- live off body fat – do not store food

Species

Meadow Jumping Mouse	*Zapus hudsonius*

FAMILY ERETHIZONTIDAE – New World Porcupines
One species in North America
General Characteristics

- Large body
- Short legs
- Quills on rump and tail totaling approximately 30,000 per animal
- Unusual soles on feet

- Forefeet have 4 toes
- Hindfeet have 5 toes
- Long curved claws
- Vegetarian

Species
Porcupine *Erethizon dorsatum*

Figure 11.31 Porcupine in a tree.

FAMILY CAPROMYIDAE – Nutria
- Native to South America and the Caribbean
- Two species introduced to North America as a ranch fur-bearer

General Characteristics
- Large aquatic rodent weighing up to 23 pounds
- Small ears and eyes
- Hind feet longer than forefeet
- Similar to muskrat
- Vegetarian
- Colonial and live in burrows
- Marsh dwelling

Species
Nutria (Coypu) *Myocastor coypus*

ORDER CETACEA – THE WHALES, DOLPHINS AND PORPOISES

- Thought to have evolved from terrestrial mammals

General Characteristics

- Under the skin is a thick fibrous layer of fat (blubber) which conserves the body heat (replaces fur)
- Forelimbs short and paddle-like
- Four or five toes
- Hind limbs generally absent
- Ears are small
- Nostrils on top of head

FAMILY ZIPHIIDAE – The Beaked Whales

- Small to medium sized toothed whales

General Characteristics

- Forelimbs short
- Mandibles have many vestigial teeth embedded in gums
- Males have two broad tusks in the mandibles which are characteristics of this group

Species

Giant Beaked Whale *Beraredius bardii*

FAMILY PHYSETERIDAE – The Sperm Whale

- Only member of this family is the Sperm Whale

General Characteristics

- Toothed species
- Large head with small lower jaw containing strong conical teeth
- Dorsal fin is replaced by a series of humps

Species

Sperm Whale *Cachalot macrocephale*

SUBORDER ODONTOCETI

- Have teeth
- One hole blowhole
- Mostly carnivorous

FAMILY DELPHINIDAE – The Dolphins and Porpoises

- Sharp peg-like teeth

Species

Blue Dolphin *Stenella caeruleoalba*
Killer Whale *Orcinus orca*
Dall's Porpoise *Phocoenoides dalli*

Figure 11.32 Killer Whale.

SUBORDER MYSTICETI – THE BALEEN WHALES
FAMILY ESCHRICHTIDAE – The Grey Whale

- Main food is small crustaceans or "krill"
- One member in family

General Characteristics

- Paired nostrils
- Short baleen plates for feeding

FAMILY BALAENOPTERIDAE – The Rorquals

- Members of this family are the largest animals that have ever lived

General Characteristics

- Diagnostic feature is the numberous throat grooves, or pleats which allow enlargement of the mouth capacity

Species

Fin Whale	*Balaenoptera physalus*
Humpback Whale	*Megaptera novaengliae*
Blue Whale	Balaenoptera musculus

ORDER CARNIVORA – THE CARNIVORES

- Generally flesh-eaters
- Some are omnivores
- Range in size from mouse-sized least weasel to the brown bear
- Also included in this order are seals, sea lions, and walrus

General Characteristics

- All have three rows of incisors and strong canines
- One litter per year

FAMILY CANIDAE – The Dogs

- Part of a group consisting of wolves, dogs and foxes called cursorial predators (that is: they chase their prey and kill it by snapping and slashing)

General Characteristics

- Long legs
- Muscular bodies
- Long fluffy tail helps balance
- Long slender snouts
- Acute sense of smell and hearing
- Non retractable claws

Species

Coyote	*Canis latrans*
Wolf	*Canis lupus*
Red Fox	*Vulpes vulpes*

Figure 11.33 Foxes and fox skull.

GRIZZLY BEAR

Did you know that bears are pigeon-toed and flat-footed? Most other large animals like dogs, horses and even elephants walk on their toes. The flat-footed stance of bears makes it easy for them to stand up straight as humans do.

Figure 11.34 Footprints of grizzly bear.

FAMILY URSIDAE – The Bears

- Largest of the terrestrial carnivores
- 3 species in North America

General Characteristics

- Range in size from 600 to 1700 pounds
- Powerful bodies
- Vision is poor
- Bears in Canada hibernate to some extent
- Eat plants and animals
- Bob-tailed

Species

Black bear	*Ursus americanus*
Grizzly Bear	*Ursus arctos*
Polar Bear	*Ursus maritimus*

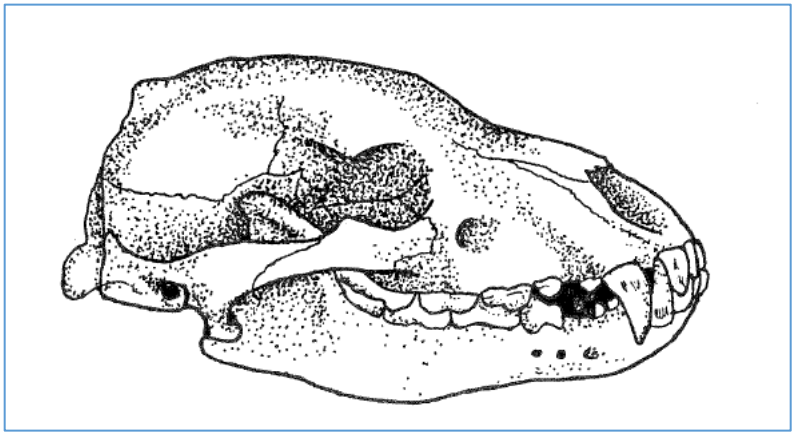

Figure 11.35 Bear skull.

Figure 11.36 Polar Bear

FAMILY PROCYONIDAE – The Raccoons and Their Allies

- Diverse group of animals from lesser pandas of Asia to olingos of South America
- 3 species in North America

General Characteristics

- Long tails with dark and light banding
- Cheek teeth blunt rather than sharp for eating a wide variety of foods
- 5 clawed toes on each foot
- Walks on soles of feet
- Good climbers
- Nocturnal
- Social

Species

Ringtail	*Bassariscus astutus*
Raccoon	*Procyon lotor*
Coati	*Nasua nasua*

Figure 11.37 Raccoon with footprints and skull.

FAMILY MUSTELIDAE – The Weasels, Skunks, Badgers, Otters and allies

- Members of this family vary greatly in appearance and in habitats
- Include tree-living marten, aquatic otters, and burrowing badgers

General Characteristics

- Most are small animals with short legs and long bodies
- All are solitary
- Nocturnal
- Most have paired anal scent glands
- Claws are nonretractable

Figure 11.38 Short-tailed weasel or ermine is known as the stoat in Europe.

Species	
Marten	*Martes americana*
Fisher	*Martes pennanti*
Ermine (Short-tailed Weasel)	*Mustela ermine*
Mink	*Mustela vison*
Wolverine	*Gulo gulo*
Badger	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
River Otter	*Lutra canadensis*
Sea Otter	*Enhydra lutris*

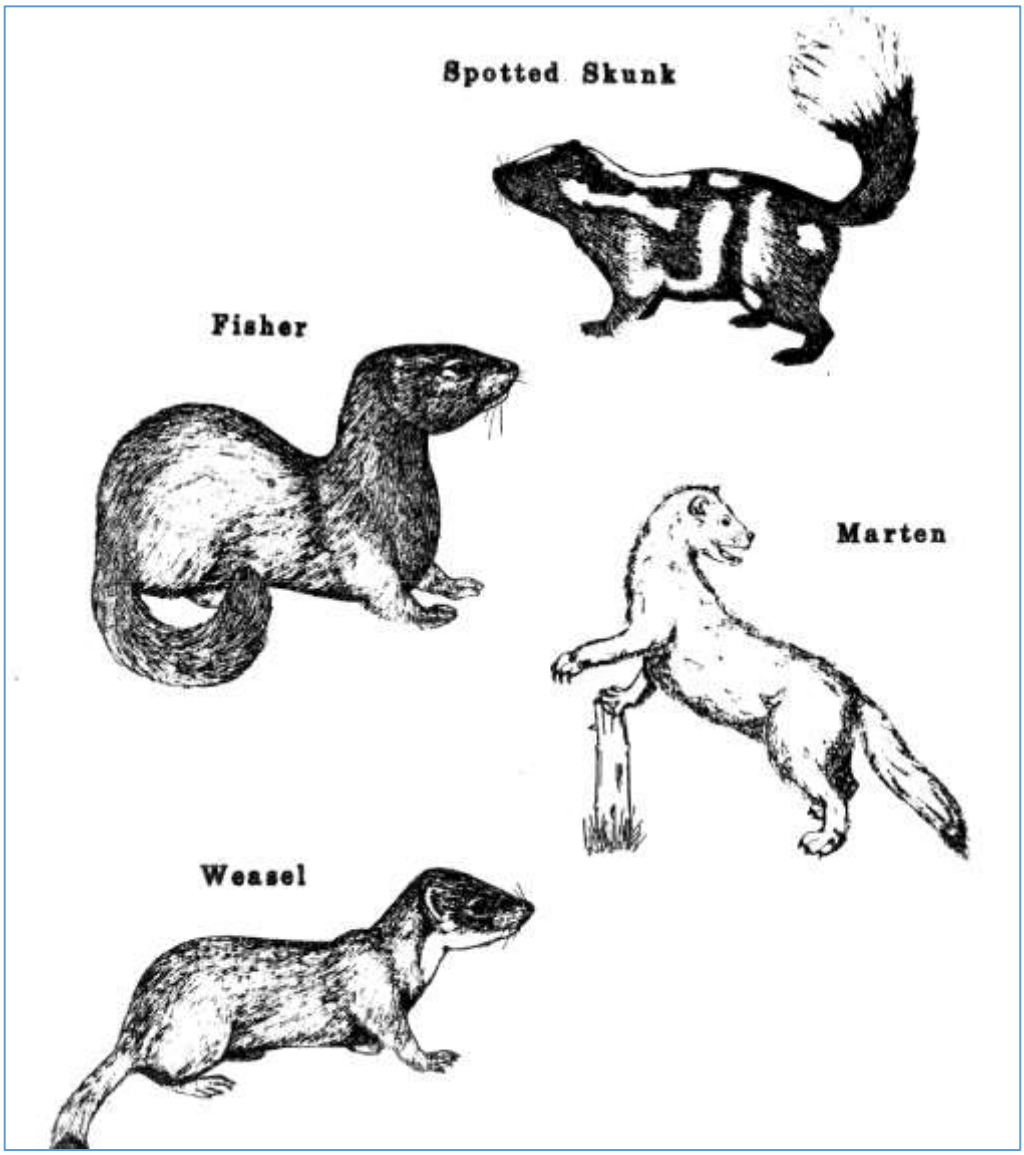

Figure 11.39 Diversity in the Family Mustelidae.

FAMILY FELIDAE – The Cats

- Native to most parts of the world except Australia and New Zealand
- 7 species in North America

General Characteristics

- Long, sleek bodies, powerful legs
- Binocular vision eyes that face forward
- Excellent night vision
- Rough tongue for grooming and tearing meal from bones
- Climb well
- Can swim
- Mark territories with urine and tree scratches

Species

Mountain Lion (Cougar)	*Felis concolor*
Lynx	*Felis lynx*
Bobcat	*Felis rufus*

Figure 11.40 Cougar and cougar skull.

Seals, Sea Lions and the Walrus

Many texts and field guides will list the following as Order Pinnepedia. A recent change has placed these animals in the Order Carnivores. Scientists now believe that these animals have evolved from the same ancestral groups as bears and the mustelids. While physically they are different, their teeth structure is similar, and they feed solely on flesh, mainly fish and aquatic invertebrates.

FAMILY OTARIIDAE – The Eared Seals

- Occur worldwide except Arctic Ocean and Antarctica
- Includes sea lions and fur seals
- Thought to have evolved from the ancestral group as bears

General Characteristics

- Small external ears
- Long, slender bodies
- More agile on land than in the water

- Use for limbs to walk (similar to dog)
- In the water forelimbs for propulsion and rear limbs to steer or as rudders
- Heavy fur and underfur
- Gregarious

Species

Northern Fur Seal	*Callorhinus ursinus*
Northern Sea Lion	*Eumetopias jubatus*
California Sea Lion	*Zalophus californianus*

Figure 11.41 Sea lions like this California Sea Lion are distinguished from seals by their ears and when they dive they hump under the water.

FAMILY ODOBENIDAE – The Walrus

- Evolved from an ancestral eared seal over 7 million years ago
- 1 species in this family

General Characteristics

- Can use hind flippers on land for walking
- Bulls are polygamous
- No external ear
- Has tusks

Species

Walrus	*Odobenus rosmarus*

FAMILY PHOCIDAE – The True Seals

- Most highly specialized
- Most numerous and widespread of seals found throughout the world in freshwater and seas
- Thought to have evolved from otter-like mustelid ancestors

General Characteristics

- Hind flipper permanently turned back (for aquatic use)
- No external ear
- Clumsy on land
- In water use hind flippers for propulsion and front flippers for steering
- Gregarious, but in small groups

- Monogamous

Species

Harp Seal	*Pagophilus groenlandicus*
Harbor Seal	*Phoca vitulina*
Northern Elephant Seal	*Mirouga angustirostris*

Figure 11.42 Harbor seal.

ORDER SIRENIA – MANATEES

- Large aquatic animals that live in coastal waters or rivers in tropical regions of the world
- 2 families; 4 species in world
- 1 species is found in Florida
- Thought to have evolved from the terrestrial hoofed mammals, i.e. elephants

General Characteristics

- Herbivores
- Skeleton is heavy
- Forelegs are rounded flippers
- Hindlegs are absent

Species

Manatee	*Trichechus manatus*

ORDER ARTIODACTYLA – THE EVEN-TOED HOOFED MAMMALS

- The order name means ‘even toed’ each species has 2-4 toes on each foot
- Sometimes referred to as “cloven hoofed” mammals

General Characteristics

- Medium to large sized animals
- Long, slender legs with the third and fourth toes forming a hoof
- The other toes (dewclaws) are higher on the leg
- Most North American species are herbivores which have a cartilaginous pad instead of teeth on the upper jaw
- Molariform teeth are adapted for nipping or tearing off and grinding vegetation
- Stomach is four-chambered

FAMILY SUIDAE – The Old World Swine

- The domestic pig is a member of the family
- Some European species have been released in North America

General Characteristics

- Long, pointed head
- Stocky body

Species

Wild boar	*Sus scrofa*

FAMILY TAYASSUIDAE – The Peccaries

- Related to domestic swine and Wild Boars
- Descended from large pigs that lives 25 million years ago
- 2 living species in world, 1 in Mexico

General Characteristics

- Smaller than domestic and wild pigs
- Straight tusks
- Strong musk gland on upper rump

Species

Collared Peccary	*Dicotyles tajacu*

FAMILY CERVIDAE – The Deer

General Characteristics

- All male members of North American deer species and female Caribou are distinguished by antlers – that are shed annually
- Antlers are replaced each year
- Skull is long and lacks upper incisors
- Stomach has four compartments

Species

Moose	*Alces alces*
American Elk	*Cervus elaphus*
Mule Deer or Black-tailed	*Odocoileus hemionus*
White-tailed Deer	*Odocoileus virginianus*
Caribou or Reindeer	*Rangifer tarandus*

Figure 11.43 Mule deer and barren ground caribou.

Did you know that a deer's foot has four toes? The two small outside toes are called dew claws and the two middle toes form the hoof. The hoof is covered by an extra tough, thick toenail which allows the deer to run on tiptoe.

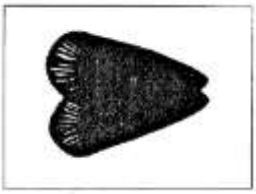

Figure 11.44 Deer footprint.

FAMILY CAMELIDAE – Camels, ilamas, alpacas, vicugnas
General Characteristics

- Six species occur in two groups, camels in Asia and Africa, and llamas, alpacas and vicugnas in South America
- Herbivores with three-chambered stomachs
- Preserved remains found in North America
- Dromedary camel has one hump, Bactrian camel has two
- Humps are filled with fat used when food and water are scarce
- Countercurrent air flow in nasal cavity helps recover moisture to prevent water loss

Species
Dromedary Camel *Camelus dromedaries*

FAMILY ANTILOCAPRIDAE – Pronghorn

- Family has one species
- Found in North America only
- Generic name means "antelope-goat" But it is neither
- Remnant species from 20 million years ago
- Fastest animal in the Western Hemisphere
- Active day and night

General Characteristics

- Horns (not antlers) 12-20 inches in length continue to grow throughout the animals life and the outer layer (keratin) is made of material similar to human finger-nails
- Outer layer of horns is shed twice a year
- Medium size, deer-like

Species

Pronghorn *Antilocapra americana*

FAMILY BOVIDAE – Bison, Goats, Muskox and Sheep

- Domestication of bovids began over 8,000 years ago

General Characteristics

Horns

- Have true horns which are permanent bony outgrowths
- Horns are hollow and never branched which grow throughout the animals life
- Used as defensive weapons against predators
- Present on males, sometimes on females

Species

American Bison or Buffalo *Bison bison*
(largest terrestrial animal in North America)
Mountain Goat *Oreamnos americanus*
Muskox *Ovibos moschatus*
Rocky Mountain Bighorn Sheep *Ovis canadensis*
Dall Sheep *Ois dalli*

Figure 11.45 Bighorn Sheep.

SHEEP

Did you know that some types of domestic sheep in Europe climb low growing trees to feed on the leaves? Mountain sheep have hooves with hard rims round the outer edge and a soft concave area in the middle, giving excellent traction on rocky terrain.

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