قائمة محاضرات الصف الأول بايولوجي باللغتين

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University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

1- Biology

Biology is the study of life. When you study biology you will learn about all of the different kinds of living things. You will learn where they live, what they are like, how they depend on each other, and how they behave.

One of the main ideas in biology is that living things depend on each other. They are part of what is called the balance of nature. All living things interact with other living things and with the world they live in. Without these relationships, nothing would survive.
Humans need plants and animals to supply us with food and raw materials, such as wood, oil, and cotton. Plants provide the oxygen in our air.

Characteristics of Living Things

Sometimes it is difficult to tell the difference between living and nonliving things. At times, nonliving things have one or more of the characteristics of life, but it is necessary to have all of the characteristics of life to be considered living. Things that have all of the characteristics of life are known as **organisms.** All organisms are made of one or more cells. Each cell contains the genetic material DNA that has the information needed to control the life processes of the organism.

What are the characteristics of life?

One of the first things biologists look for when they are searching for characteristics of life is structure, or organization.

Whether an organism is made of a single cell or billions of cells, all of its parts work together in an orderly living system. Another important characteristic of life is reproduction. Reproduction is the ability of an organism to make more of the same

type of organism. The new organisms that are made are called offspring. Although reproduction is not needed for the survival of an individual organism, it must occur for the continuation of the organism's species. A species (SPEE sheez) consists of a group of organisms that can mate with each other and produce offspring that are able to reproduce. For example, there are many species of crocodiles including the American crocodile, the Australian freshwater crocodile, and the saltwater crocodile. American crocodiles reproduce only American crocodiles. Without reproduction, the species would die out. Another characteristic of life is that growth and development must take place. An organism begins life as a single cell. As time passes, it grows and develops. As growth and development take place, the organism takes on the characteristics of its species. Growth results in the formation of new structures and an increase in the amount of living material. Development refers to the changes that occur in each organism's life.

One more characteristic of life is the ability to adjust to surroundings, or the environment. Anything in the environment— air, water, temperature, weather, other organisms—that causes the organism to react is called a stimulus (plural, stimuli). The organism's reaction to the stimulus is called a response. An organism also has the ability to control its internal environment in order to maintain conditions suitable for survival. For example, an organism must make constant adjustments to maintain the right amount of water and minerals in its cells. This ability is called homeostasis (hoh mee oh STAY sus). Without the ability to adjust to internal changes, an organism would die.

How do organisms respond to change?

Organisms use energy to grow, develop, respond to stimuli, and maintain **homeostasis**. Energy is the ability to cause change. Organisms get their energy from food. Any behavior, structure, or internal process that allows an organism to make changes in response to environmental factors and live long enough to reproduce is called an adaptation (a dap TAY shun). For example, the leaves of many desert plants have a thick, waxy coating. This is an adaptation that helps these plants conserve water. Having large eyes is an adaptation that lets owls see well at night. The gradual change in a species over time due to adaptations is called evolution (e vuh LEW shun).

The Methods of Biology
Observing and Hypothesizing

Even though biologists and other scientists study many different types of things, they all use the same basic steps. The common steps they use to do research and answer questions are called **scientific methods.** Scientists often figure out questions to ask and answer just by observing the world around them.

What is a hypothesis?

Forming a **hypothesis** (hi PAHTH us sus) is a research method scientists use often. A hypothesis is an explanation for a question or problem that can be tested. For example, imagine that the number of birds in an area decreased after snakes came into the area. A scientist might make the hypothesis that the snakes were the reason the number of birds decreased. A scientist who forms a hypothesis must be certain that it can be tested. Before testing a hypothesis, scientists make observations and do research. The results of the experiment will help the scientist answer whether or not the hypothesis is supported.

Experimenting

To a scientist, an **experiment** is a test of a hypothesis by collecting information under controlled conditions.

What is a controlled experiment?

Controlled experiments involve two groups—the control group and the experimental or test group. The **control** is the part of an experiment that represents the standard conditions. In other words, the control receives no experimental treatment. The experimental group is the test group that receives experimental treatment. For instance, imagine an experiment to learn how fertilizer affects plant growth. Fertilizer would be used in the experimental group but not in the control group. All other conditions— soil, light, and water—would be the same for both groups. In this experiment, using fertilizer is the independent variable.

The **independent variable** is the one condition in an experiment that is tested. How much the plants grow is the dependent variable.

The **dependent variable** is the condition that changes because of a change in the independent variable. Safety is another important factor that scientists think about when carrying out investigations and experiments. It is important to know about dangers that may exist from doing an experiment before you begin it. Anyone doing an experiment has a responsibility to follow safety procedures. They must keep themselves and others out of danger.

How are theories formed?

The information gathered from experiments is called **data.** A scientist carefully reviews or analyzes experimental results to decide if the data supports the hypothesis. Scientists repeat their experiments in order to gather more data. Data are considered reliable only when repeating the experiment several times produces similar results.

Scientists also compare the results of their experiments with the results of other studies. They research published information in scientific journals and computer databases. It is important to have details of an experiment presented in scientific journals and databases so scientists can compare their results with those of similar studies. It lets other scientists test the results by repeating the experiment. If many scientists get the same results, it helps support the hypothesis. A hypothesis that is supported by many different investigations and observations becomes a **theory.**

The Nature of Biology

Kinds of Information

Scientific information can usually be broken down into two main types—quantitative or qualitative. In quantitative research, results are compared by using numbers. Imagine an experiment to see when different materials begin to melt. The temperature at which wax, iron, and glass each begins to melt is different. Temperatures often are measured in degrees, which are numbers on a scale. These temperatures are a type of quantitative data in quantitative research.

Qualitative research is based on observation. It is also called descriptive research because it describes scientists' observations when they do their research. If a scientist wanted to figure out how a beaver builds a dam, numbers would not be very helpful. The scientist would observe the beaver and see how the dam is built. Then the scientist would describe, in detail, all the steps the beaver takes to build the dam.

Science and Society

Scientific research often provides society with important information. What we learn from scientific research cannot be defined as good or bad. Ethics must play a role in deciding how the information will be used. **Ethics** are the moral principles and values held by humans. Ethics are how we decide what is right or wrong, good or

bad. Suppose scientists develop a new vaccine to cure a disease, but they can only produce 1000 doses each year. Ethics help society decide who should receive those doses. Society as a whole must take responsibility for making sure that scientific discoveries are used in an ethical way.

Some scientific study is done only to learn new things. This type of science is called pure science. Pure science is not done so that the results can be used for a specific need. The research is filed away for later use.
Science that solves a problem is technology. **Technology** (tek NAHL uh jee) means using scientific research to meet society's needs or solve its problems. Technology has helped reduce the amount of manual labor needed to make and raise crops. It has also helped cut down on environmental pollution.

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1- Glencoe science reading essentials for biology the dynamics of life Copyright © Glencoe/McGraw-Hill, a division of The McGraw-Hill Companies, Inc.

2- Campbell, 7th edition

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2- Branches of Zoology

By definition, zoology is the branch of biology dealing with animals and the animal kingdom. Since it is such a large branch of biology, there are many branches of zoology. Below is a list of the most common branches of zoology.

GENERAL BRANCHES

Anatomy	**The study of the internal structure of animals**
Cytology	**The study of cell structure, its organelles, and their functions**
Ecology	**The relationship between the organisms and their surrounding environments**
Embryology	**The study of the development of eggs after fertilization**
Evolution	**The study of the origin of animals and their adaptation to their environments over time**
Genetics	**The study of heredity and its variations**
Geology	**The study of the earth and life as recorded by fossils in rocks**
Histology	**The study of the structure and functions of tissues**
Morphology	**The study of the form and structure of animals**
Neonatology	**The study of new born animals to the age of two months**
Paleontology	**The study of fossils and extinct animals**
Physiology	**The study of the functions and various organs in animals**
Taxonomy	**The study of the classification and the naming of organisms**
Zoogeography	**The study of the distribution of animals all over the world**

APPLIED BRANCHES

Apiculture **The rearing of honey bees**
Aquaculture **The breeding of aquatic animals**
Dairy Science **The study of breeding and rearing of milk yielding cattle**
Genetic Engineering **The study of artificial synthesis of new genes and subsequent alteration of the genome of an organism**
Pisciculture **The culturing and rearing of fish**
Poultry **The breeding and rearing of chicks**
Sericulture **Raising silk worms for production of raw silk**
Veterinary Science **The study of breeding, rearing, and treatment of diseases in animals**

PHYLUM SPECIFIC BRANCHES

Acarology **The study of tics and mites**
Anthropology **The study of apes (and man)**
Carcinology **The study of crustaceans**
Conchology **The study of mulluscan shells**
Entomology **The study of insects**
Helminthology **The study of parasitic worms**
Herpetology **The study of reptiles**
Ichthyology **The study of fish**
Lepidopterology **The study of butter flies and moths**
Malacology **The study of mollusks**
Mammalogy **The study of mammals**
Myrmecology **The study of ants**
Nematology **The study of nematodes**
Ophiology **The study of snakes**
Ornithology **The study of birds**
Protozoology **The study of unicellular organisms**

ORGAN RELATED BRANCHES

Angiology **The study of blood vessels**
Arthrology **The study of joints**
Cardiology **The study of the heart**

Chondrology	**The study of cartilage**
Craniology	**The study of skulls**
Dermatology	**The study of skin**
Endocrinology	**The study of endocrine glands**
Haematology	**The study of blood**
Hepatology	**The study of the liver**
Kinesiology	**The study of the movement of muscles**
Myology	**The study of muscles**
Nephrology	**The study of kidneys**
Neurology	**The study of the nervous system**
Odontology	**The study of teeth and gums**
Ophthalmology	**The study of eyes**
Organology	**The study of organs**
Osteology	**The study of bones**
Otology	**The study of ears**
Rhinology	**The study of noses**
Splanchnology	**The study of visceral organs**
Syndesmology	**The study of bony joints and ligaments**
Trichology	**The study of hair**
Urology	**The study of excretory organs**

HEALTH AND DISEASE RELATED BRANCHES

Actinobiology	**The study of the effects of radiation on organisms**
Bacteriology	**The study of bacteria**
Carcinology	**The study of malignant tumors and cancer**
Cryobiology	**The study of the effects of low temperatures on organisms**
Ethology	**The study of animal behavior**
Etiology	**The study of the cause of disease**
Gerontology	**The scientific study of aging**
Immunology	**The study of immunity to disease**
Oncology	**The study of tumors**
Oology	**The study of eggs**
Pathology	**The study of disease**
Pharmacology	**The study of synthesis and effects of medicine on organisms**
Phenology	**The study of the effect of seasonal changes on animals**

Phrenology	**The study of the mental faculties of the brain**
Teratology	**The study of abnormal growth of embryo or fetal malformations**
Toxicology	**The study of poisons and narcotics in animals**
Traumatology	**The study of wounds**
Virology	**The study of viruses**

reference

https://teachingscienceweb.wordpress.com/2016/09/25/branches-of-zoology/

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3- Characteristics of Animals

All animals have several characteristics in common. Animals are eukaryotic, multicellular organisms. They have ways of moving that help them reproduce, get food, and protect themselves. Most animals have specialized cells. These cells form tissues and organs, such as nerves and muscles.

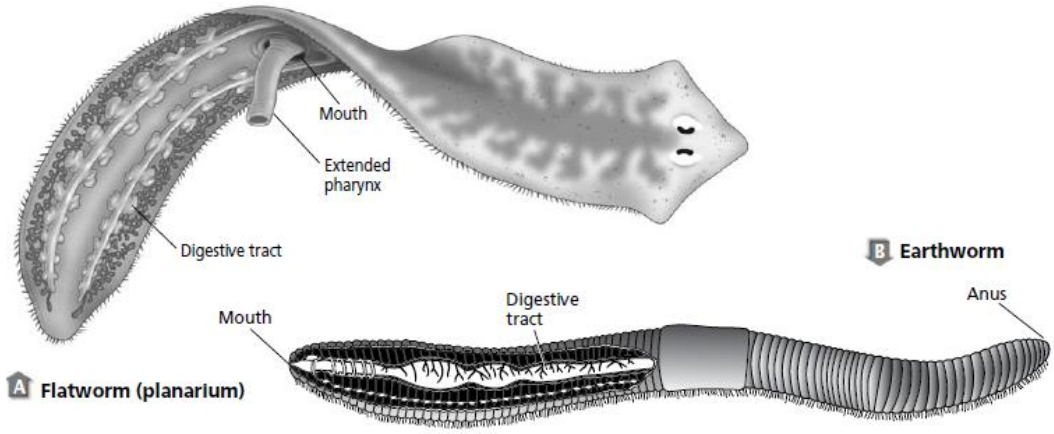
How do animals obtain food?

One characteristic animals share is that they are heterotrophic. That means that they must consume or eat other organisms to get their energy and nutrients. All animals depend either directly or indirectly on autotrophs for food. Remember autotrophs are organisms that make their own food.

Scientists hypothesize that animals first evolved in water. Although water is denser and contains less oxygen than air, it usually has more food suspended, or floating in it. Some animals that live in water, such as barnacles and oysters, do not move from place to place. They have adaptations that allow them to capture food from their environment. Organisms that permanently attach to a surface are called **sessile** (SE sul). They do not use much energy to obtain their food. Some animals that live in water, such as corals and sponges, move only during the early stages of their lives. They hatch from fertilized eggs into free-swimming larval forms. As adults, most of them are sessile and attach to rocks or other objects.
There is very little suspended food in the air. Because of this, land animals need to use more oxygen and energy to find food.

How do animals digest food?

Animals are heterotrophs that ingest, or take in, their food. After they ingest it, they must digest it. In some animals, digestion takes place within individual cells. In other animals, digestion takes place in an internal cavity. Some of the food that an animal ingests and digests is stored as fat or glycogen, which will be used when other food is not available.



Examine the digestive tracts of a flatworm (planarium) and an earthworm in the illustration above. You will notice that there is only one opening to the flatworm's digestive tract, a pharynx. The earthworm has a digestive tract with two openings. There is a mouth at one end and an anus at the other.

What are the functions of some animal cells?

Most animal cells carry out different functions. Animals have specialized cells that allow them to sense and find food and mates. They also have specialized cells that help them to identify and protect themselves from predators.

Development of Animals

Most animals develop from a fertilized egg cell called a zygote. How does a zygote develop into the many different kinds of cells that make up a snail, a fish, or a human? After fertilization, the zygotes of different animal species all have similar, genetically determined stages of development.

What happens during fertilization?

Most animals reproduce sexually. Male animals produce sperm cells and female animals produce egg cells. Fertilization occurs when a sperm cell penetrates an egg cell, forming a new cell called a zygote. Fertilization may occur inside or outside of the body.

How does cell division occur?

The zygote divides by mitosis and cell division to form two cells. This process is called cleavage. Once cell division has started, the organism is called an embryo. Remember that an embryo is an organism at an early stage of growth and development.

The two cells that result from cleavage then divide to form four cells, and so on, until a cell-covered, fluid-filled ball called a **blastula** (BLAS chuh luh) is formed. The blastula is formed early in the development of an animal embryo. In sea urchins, the blastula is formed within about 10 hours of fertilization. In humans, the blastula is formed about five days after fertilization.

What is gastrulation?

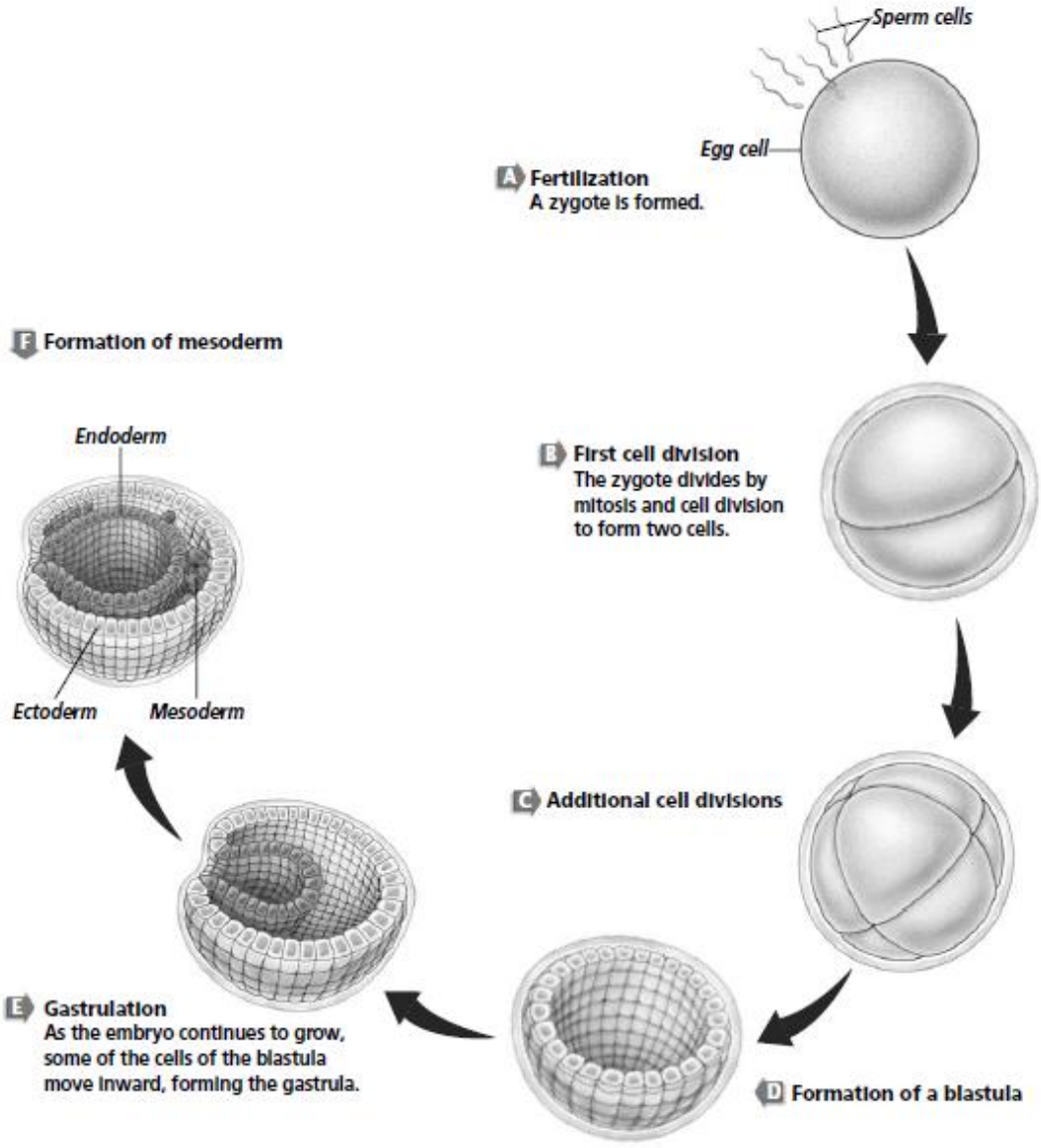
After the blastula is formed, cell division continues. The cells on one side of the blastula move inward to form a **gastrula** (GAS truh luh). This is a structure made up of two layers of cells with an opening at one end.

The way the gastrula forms can be compared to the way a potter makes a bowl from a ball of clay. By pushing in on one side of the clay ball, the potter forms a cavity that becomes the interior of the bowl. Similarly, the cells at one end of the blastula move inward, forming a cavity lined with a second layer of cells. The layer of cells on the outer surface of the gastrula is called the **ectoderm.** The layer of cells lining the inner surface of the gastrula is called the **endoderm.** The cells continue to grow and divide. Eventually the ectoderm cells develop into the skin and nervous tissue of the animal. The endoderm cells develop into the lining of the digestive tract and into organs that aid digestion.

How is the mesoderm formed?

In some animals, the development of the gastrula progresses until a layer of cells called the mesoderm forms as shown in the illustration on page 299. Mesoderm is found in the middle of the embryo. The term “meso” means middle.

The **mesoderm** (MEZ uh durm) is the third cell layer found in the developing embryo between the ectoderm and the endoderm. The mesoderm cells develop into the muscles, circulatory system, excretory system, and, in some animals, the respiratory system. When the opening in the gastrula develops into the mouth, the animal is called a protostome (PROH tuh stohm). Snails, earthworms, and insects are examples of protostomes.



In other animals, such as sea stars, fishes, toads, snakes, birds, and humans, the mouth does not develop from the gastrula's opening. When the mouth develops from cells on another part of the gastrula, the animal is called a deuterostome (DEW tihr uh stohm).

Scientists hypothesize that protostome animals were the first to appear in evolutionary history, and that deuterostomes followed later. Biologists today often classify an unknown organism by identifying its phylogeny, the evolutionary history of an organism. Determining whether an animal is a protostome or deuterostome can help biologists identify its group.

What changes occur during growth and development?

Cells in developing embryos continue to differentiate, which means they become specialized to perform certain functions. Most animal embryos continue to develop over time. They become juveniles that look like smaller versions of the adult animal. In some animals, such as insects and echinoderms, the embryo develops inside an egg into an intermediate stage called a larva (plural, larvae). A larva often does not look like the adult animal. Inside the egg, the larva is surrounded by a membrane formed right after fertilization.

When the egg hatches, the larva breaks thorough the membrane. Animals that are generally sessile as adults, such as sea urchins, often have a free-swimming larval stage.

Once the juvenile or larval stage has passed, most animals continue to grow and develop into adults. This growth and development may take only a few days in some insects. In some mammals it can take up to fourteen years. Eventually the adult animals reach sexual maturity, mate, and the cycle begins again.

Body Plans and Adaptations

What is symmetry?

You have learned that animals share certain characteristics. When you look at a sponge and a leopard, it's hard to see what they have in common. Shape is not something all animals have in common. All animals do have some kind of shape, however. Each animal can be described in terms of symmetry. **Symmetry** (SIH muh tree) describes how an animal's body structures are arranged. Different kinds of symmetry allow animals to move in different ways.

What is asymmetry?

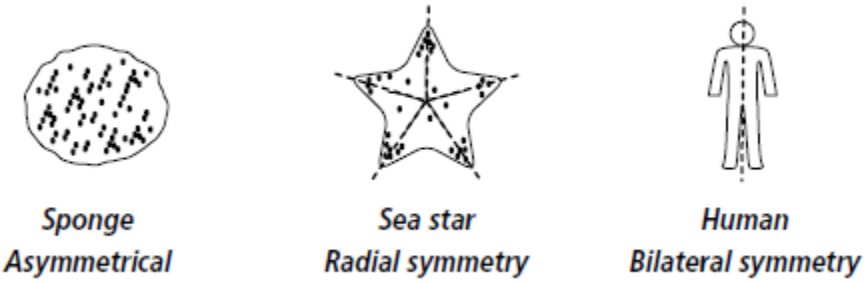
Many sponges have irregularly shaped bodies. An animal that is irregular in shape has no symmetry. It has an asymmetrical body plan. Animals with no

symmetry are often sessile organisms, meaning they do not move from place to place. Most adult sponges are sessile organisms.

The bodies of most sponges consist of two layers of cells. Unlike all other animals, a sponge's embryonic development does not include the formation of an endoderm and mesoderm, or the gastrula stage. Fossil sponges first appeared in rocks dating back more than 700 million years. They represent one of the oldest groups of animals on Earth. This is evidence that their two-layer body plan suits their aquatic environment.

What is radial symmetry?

An animal with **radial** (RAY dee uhl) **symmetry** can be divided along any plane, through a central axis, into almost equal halves. Radial symmetry is an adaptation that enables an animal to detect and capture prey coming toward it from any direction. Hydra are examples of animals with radial symmetry.



Sponge
Asymmetrical

Sea star
Radial symmetry

Human
Bilateral symmetry

What is bilateral symmetry?

An organism with **bilateral** (bi LA tuh rul) **symmetry** can be divided down its length, along one plane, into similar right and left halves. Butterflies have bilateral symmetry. In animals with bilateral symmetry, the **anterior,** or head end, often has sensory organs. The **posterior** of these animals is the tail end. The **dorsal** (DOR sul), or upper surface, also looks different from the **ventral** (VEN trul), or lower surface. In animals that are upright, or nearly so, the back is on the dorsal surface and the belly is on the ventral surface. Animals with

bilateral symmetry can find food and mates and avoid predators because they have sensory organs and good muscular control.

Bilateral Symmetry and Body Plans

Animals that are bilaterally symmetrical also share other important characteristics. All bilaterally symmetrical animals developed from three embryonic cell layers—ectoderm, endoderm, and mesoderm. Some bilaterally symmetrical animals also have fluidfilled spaces inside their bodies called body cavities. The internal organs are found inside the body cavities. These cavities make it possible for animals to grow larger because they allow for the efficient circulation and transport of fluids, and support for organs and the organ systems.

What are acoelomates?

Animals that develop from these same three cell layers but do not have body cavities are called **acoelomate** (ay SEE lum ate) animals. They have a digestive tract that extends throughout the body. Acoelomate animals may have been the first group of animals in which organs evolved. Flatworms are bilaterally symmetrical animals with solid, compact bodies. Like other acoelomate animals, the organs of flatworms are surrounded in the solid tissues of their bodies. A flattened body and branched digestive tract allow for the diffusion of nutrients, water, and oxygen to supply all body cells and to eliminate wastes.

What are pseudocoelomates?

The roundworm is another animal with bilateral symmetry. Unlike the flatworm, the body of a roundworm has a space that develops between the endoderm and mesoderm. It is called a **pseudocoelom** (soo duh SEE lum)—a fluid-filled body cavity partly lined with mesoderm.

Pseudocoelomates have a one-way digestive tract that has regions with specific functions. The mouth takes in food, the breakdown and absorption of food occurs in the middle section, and the anus expels wastes.

What are coelomates?

A **coelom** (SEE lum) is a fluid-filled space that is completely surrounded by mesoderm. The body cavity of an earthworm develops from a coelom. Humans, insects, fishes, and many other animals have a coelomate body plan. In fact, the greatest diversity of animals is found among the coelomates.

In coelomate animals, specialized organs and organ systems develop in the coelom. The digestive tract and other internal organs are attached by double layers of mesoderm and are suspended within the coelom. Like the pseudocoelom, the coelom cushions and protects the internal organs. It provides room for them to grow and move independently within an animal's body.

Animal Protection and Support

Over time, the development of body cavities resulted in a greater diversity of animal species. These different species became adapted to life in different environments. Some animals, such as mollusks, evolved hard shells that protected their soft bodies. Sponges and some other animals evolved hardened spicules, small, needlelike structures, between their cells that provided support.

exoskeleton is a hard covering on the outside of the body. Exoskeletons provide a framework for support, protect soft body tissues, prevent water loss, and provide protection from predators. An exoskeleton is secreted, or formed, by the epidermis and extends into the body where it provides a place for muscle attachment. As an animal grows, it secretes a new exoskeleton and sheds the old one.

Exoskeletons are often found in invertebrates. **Invertebrates** are animals that do not have a backbone. Crabs, spiders, grasshoppers, dragonflies, and beetles are examples of invertebrates that have exoskeletons.

Other animals have evolved different structures to give them support and protection. Invertebrates, such as sea urchins and sea stars, have an internal skeleton called an **endoskeleton,** which is covered by layers of cells. It provides support for an animal's body. The endoskeleton protects internal

organs and provides an internal brace for muscles to pull against. Endoskeletons may be made of one of the following:

Endoskeleton Substance	Example
Calcium carbonate	Sea stars
Cartilage	Sharks
Bone	Reptiles, birds, amphibians, mammals, bony fishes

A **vertebrate** is an animal with an endoskeleton and a backbone. All vertebrates are bilaterally symmetrical. Examples of vertebrates include fishes, amphibians, reptiles, birds, and mammals.

Origin of Animals

Most biologists agree that animals probably evolved from protists that lived in groups in water. Scientists trace this evolution back to late in the Precambrian Period. Although evidence suggests that bilaterally symmetrical animals might have appeared later, many scientists agree that all the major animal body plans that exist today were already in existence 543 million years ago— at the beginning of the Cambrian Period. Since then, many new species have evolved but all known species have variations of body plans developed during the Cambrian Period.

References

1- **Glencoe science reading essentials for biology the dynamics of life Copyright © Glencoe/McGraw-Hill, a division of The McGraw-Hill Companies, Inc.**

2- **Campbell, 7th edition**.

4-Sponges, Cnidarians, Flatworms and Round worms

What is a sponge?

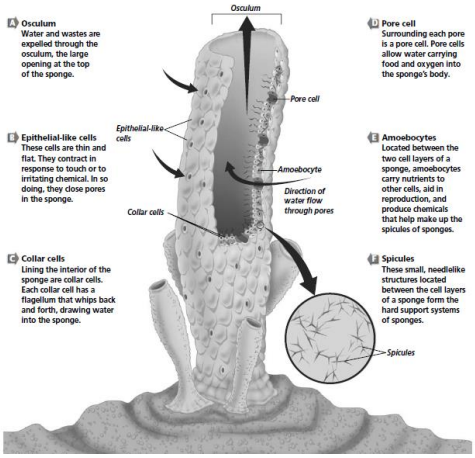
Sponges can be brightly colored, shaped like balls or branches. Sponges are invertebrates, which means they do not have backbones. There are more than 5000 species of sponges. Most live in marine or saltwater environments, but about 150 species live in freshwater.

They get their food by a process called filter feeding. In **filter feeding,** an organism feeds by filtering small particles of food from water that passes by or through some part of the organism.

How are sponge cells organized?

Their cells are differentiated to perform functions that help the sponges survive. Unlike most animals, sponges do not have tissues, organs, or organ systems.

For some sponge species, a living sponge can be torn apart and the cells would still be alive but separate from each other. Over a period of several weeks, the cells would come together, reorganize themselves, and form new sponges.



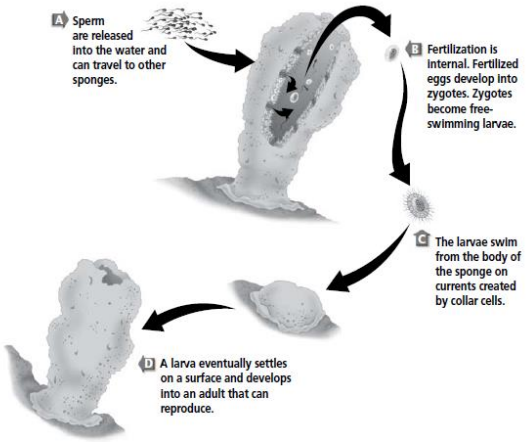
Sponges show a major change in the evolution of animals—the change from a unicellular life to a division of labor among groups of organized cells.

How do sponges reproduce?

Sponges reproduce asexually and sexually. Asexual reproduction can be by budding, fragmentation, or the formation of gemmules. A bud is an external growth on a sponge. If a bud drops off, it floats away, settles, and grows into a sponge. Sometimes buds do not break off. Then a single sponge becomes a colony of sponges. Often, pieces or fragments of a sponge break off. They can grow into new sponges.

Some freshwater sponges produce seedlike particles, called gemmules. They are produced when the water temperature cools. The adult sponges die in winter, but the gemmules survive. In spring when the water warms, the gemmules grow into new sponges. Most sponges reproduce sexually. Some sponges are separate sexes, but most sponges are hermaphrodites. A **hermaphrodite** is an animal that can produce both eggs and sperm. In sessile animals, hermaphrodism increases the chances that fertilization will occur. During reproduction, sperm released by one sponge can be carried by water currents to fertilize another sponge.

Fertilization in sponges can be external or internal. A few sponges have **external fertilization**—fertilization that occurs outside the animal's body. Most sponges have **internal fertilization.** This means the eggs inside the animal's body are fertilized by sperm from another sponge. The sperm are carried into the sponge by water. Fertilization occurs and the result is the development of free-swimming larvae. The larvae settle and grow into adult sponges. A sponge is able to move about only during its larval stage.



What is the internal structure of a sponge?

Sponges are soft bodied invertebrates. They have an internal structure that gives them support and can help protect them from predators. Some sponges have hard, sharp spicules located between the cell layers. Spicules may be made of glasslike material or of calcium carbonate. Some species have thousands of tiny, sharp, needlelike spicules that make them difficult for animals to eat. Other sponges have an internal framework made of silica or spongin, a fibrous protein like material. Sponges can be classified according to the shape of the spicules and frameworks and what they are made of.

Some sponges contain chemicals that are toxic to fishes and other predators. Scientists are studying sponge toxins to identify those that might be used as medicines.

Cnidarians

What is a cnidarian?

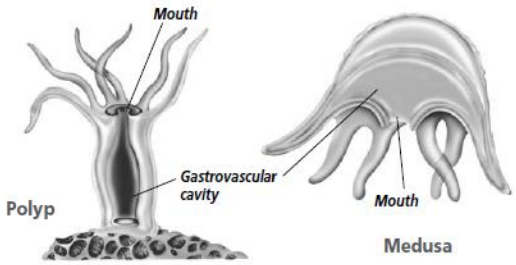
Cnidarians (ni DARE ee uns) are a group of invertebrates made up of more than 9000 species of jellyfish, corals, sea anemones, and hydras. They can be found worldwide and almost all live in marine biomes.

What is the body structure of cnidarians?

All cnidarians have the same basic body structure. Their bodies are radially symmetrical. Cnidarians have one body opening. Their bodies are made up of two layers of cells. The outer layer is protective. The inner layer of cells helps with digestion.

Because a cnidarian's body is only two layers of cell, no cell is ever far from water. Oxygen dissolved in water diffuses directly into body cells. Carbon dioxide and other wastes move out of a cnidarian's body directly into the surrounding water.

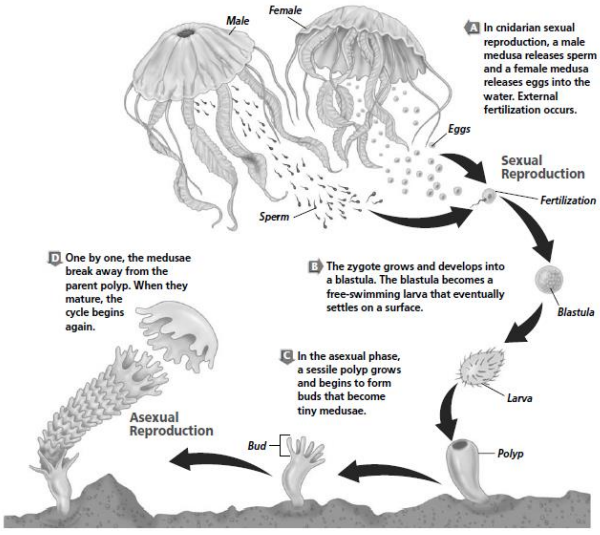
Most cnidarians have two different body forms during their life. The two body forms are the polyp and the medusa. A **polyp** (PAH lup) has a tube-shaped body with a mouth surrounded by tentacles. A **medusa** (mih DEW suh; plural, medusae) has an umbrella-shaped body, called a bell. The tentacles hang down. Its mouth is on the underside of the bell.



In cnidarians, one body form is usually easier to observe than the other. For example, in jellyfishes, the medusa is the body form you observe. The jellyfish polyp is small and not easily seen. In hydras, the polyp is the form that is easier to see. A hydra's medusa form is small and delicate. Corals and sea anemones have only polyp forms.

How do cnidarians reproduce?

All cnidarians have the ability to reproduce sexually and asexually. Sexual reproduction usually occurs in the medusa stage. If there is no medusa stage, then the polyp can reproduce sexually. The illustration of the jellyfish below shows how the sexual medusa stage alternates with the asexual polyp stage.



Male medusae release sperm, and female medusae release eggs into the water. External fertilization occurs. Fertilization results in zygotes. Zygotes develop into embryos, and then into larvae. The free swimming larvae

settle and grow into polyps that reproduce asexually to produce new medusae. This may sound similar to alternation of generations in plant life cycles. However, in plants, the generations alternate between haploid and diploid. In cnidarians, medusae and polyps are diploid animals.

Asexual reproduction can occur in either the polyp or the medusa stage. Polyps reproduce asexually by budding. Cnidarians that remain in the polyp stage, such as corals and sea anemones, can reproduce sexually.

How do cnidarians digest food?

Cnidarians are predators. They capture their prey using nematocysts. A **nematocyst** (nih MA tuh sihst) is a capsule that contains a coiled, threadlike tube. The tube can be sticky or barbed. It also may contain toxic substances. Nematocysts are located in cells on the tentacles. When touched, nematocysts are fired off like toy popguns, but much faster. The barbed tube either sticks to the prey, keeping it from escaping, or poisons the prey. Prey organisms are then pulled in for digestion. The tentacles bring the prey to the mouth by contracting.

The inner cell layer of cnidarians surrounds a space called a **gastrovascular** (gas troh VAS kyuh lur) **cavity.** Cells adapted for digestion line the gastrovascular cavity and release enzymes that break down the captured prey into small particles. Whatever is not digested is ejected back out of the mouth. Cnidarians are classified partly based on whether or not there are divisions in the gastrovascular cavity, and if there are, how many divisions are present.

Do cnidarians have a nervous system?

A cnidarian has a simple nervous system. It does not have a control center or brain such as other animals. The nervous system consists of a **nerve net** that conducts impulses to and from all parts of the body. The impulses from the nerve net cause contractions of musclelike cells in the two cell layers. For example, the movement of the tentacles when a cnidarian captures prey is the result of contractions of the musclelike cells.

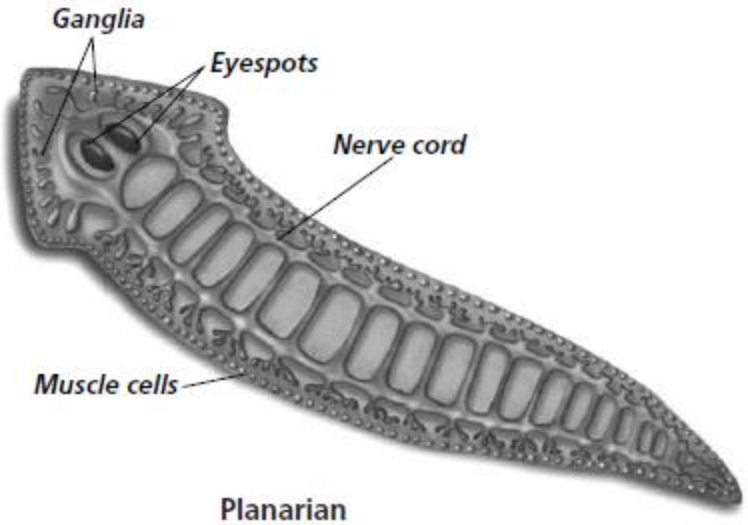
Diversity of Cnidarians

There are four classes of cnidarians: Hydrozoa, Scyphozoa, Cubozoa, and Anthozoa.

Flatworms

What is a flatworm?

Flatworms belong to the phylum Platyhelminthes (pla tee HEL min theez). Flatworms are the least complex worms. The name *flatworm* accurately describes their appearance. They range in size from 1 mm up to several meters. There are approximately 14 500 species of flatworms. They are found in marine and freshwater environments as well as moist habitats on land. Tapeworms and flukes are the most well-known of the flatworms. Both are parasites and cause disease in humans and animals. Parasitic flatworms are discussed at the end of this section. Planarians are free-living flatworms. That means they do not require another organism in order to survive. Planarians are the most commonly studied flatworms.



Planarian

What type of nervous system

do flatworms have?

A planarian is bilaterally symmetrical. Most of its nervous system is located in the head. The nervous system helps the planarian respond to stimuli in its environment. Some flatworms have a nerve net; others have the beginning of a central nervous system. The illustration at left shows the nervous system of a planarian.

The nervous system includes two nerve cords along each side of the body. At the head, eyespots can detect the presence or absence of light. Sensory cells detect chemicals and movement in water. On each nerve cord, near the head, is a small swelling called a ganglion (plural, ganglia). The ganglion receives messages from the eyespots and sensory cells. The ganglion then communicates with the rest of the body along the nerve cords. Messages from the nerve cords trigger responses in a planarian's muscle cells.

How do planarians reproduce?

Planarians are hermaphrodites, meaning they produce both eggs and sperm. During reproduction, individual planarians exchange sperm, which travel along special tubes to reach the eggs. Fertilization happens inside the animals' bodies. The resulting zygotes are released into the water. The zygotes are in capsules and then hatch into tiny planarians.

Planarians also can reproduce asexually. If a planarian is damaged, it has the ability to regenerate, or regrow, new body parts. **Regeneration** is the replacement or regrowth of missing body parts. Missing body parts are replaced through cell division. If a planarian is cut in half horizontally, the section containing the head will grow a new tail, and the tail section will grow a new head. Since a planarian that is cut into two pieces may grow into two new organisms, scientists consider this a form of asexual reproduction.

What do planarians eat?

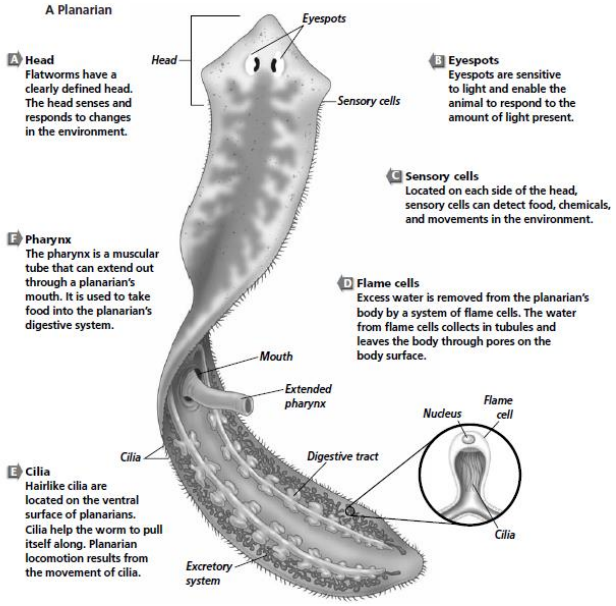
A planarian feeds on dead or slow-moving organisms. It extends a tubelike, muscular organ out of its mouth. The organ is called a **pharynx** (FAHR inx).

Food particles are sucked into the digestive tract, where they are broken up. Cells lining the digestive tract obtain food by endocytosis. Remember that endocytosis is a process in which a cell surrounds materials with a portion

of the cell's plasma membrane and then releases the contents inside the cell. Food is then digested in individual cells.

How do parasitic flatworms obtain nutrients?

Parasitic flatworms live inside the bodies of their hosts. A parasite is an organism that lives on or in another organism. Parasites depend upon the host organism for nutrients. Parasitic flatworms have mouthparts with hooks that keep them firmly attached inside their hosts. Parasitic flatworms such as tapeworms are surrounded by nutrients. They do not need to move to find their food. Parasitic flatworms do not have complex nervous or muscular tissue.



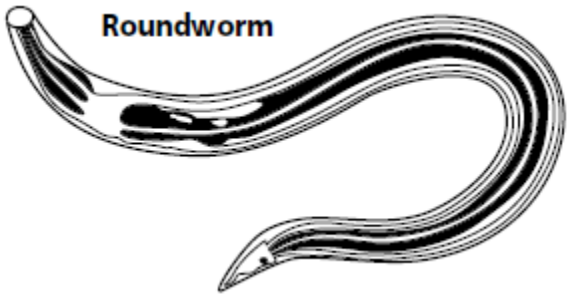
The knob-shaped head of a tapeworm is called a **scolex** (SKOH leks). The tapeworm's body is made of detachable, individual sections called proglottids. A **proglottid** (proh GLAH tihd) contains muscles, nerves, flame cells, and male and female reproductive organs. Some adult tapeworms that live in animal intestines can be more than 10 m in length and consist of 2000 proglottids.

Roundworms

What is a roundworm?

Roundworms belong to the phylum Nematoda. They live in soil, inside animals, in freshwater, and in marine environments. There are more than 12 000 species of roundworms. Some roundworm species are free-living, but many are parasitic. Nearly all plant and animal species are affected by parasitic roundworms. Roundworms are tapered at both ends. They have a thick outer covering that protects them in harsh environments. They shed the outer covering four times as they grow. Roundworms look like tiny, wriggling bits of thread. They do not have circular muscles but they do have lengthwise muscles. As one muscle contracts, another muscle relaxes. Roundworms move in a thrashing fashion due to the alternating contraction and relaxation of the muscles.

Roundworms have a pseudocoelom, a fluid-filled body cavity partly lined with mesoderm. They are the simplest animals with a tubelike digestive system. Unlike flatworms, roundworms have two body openings—a mouth and an anus. The free-living species have well-developed sense organs, such as eyespots. These are less-developed in the parasitic forms.



Diversity of Roundworms

About half of roundworm species are parasites. There are about 50 species that infect humans. Worldwide, the most common roundworm infection is from *Ascaris* (ASS kuh ris). It is more common in tropical and subtropical areas. Children become infected more often than adults. Eggs of *Ascaris* are found in soil. They enter the human body through the mouth. The eggs hatch in the intestines. *Ascaris* moves into the bloodstream and then into the lungs. They are coughed up, swallowed, and the cycle begins again. Pinworms are the most common roundworm parasite in the United States. Children are infected more than adults. Pinworms are highly contagious because eggs can survive on surfaces up to two weeks. The life cycle begins when live eggs are ingested. They mature inside the intestinal tract of the host. Female pinworms exit through the host's anus—usually as the host sleeps—and lay eggs on nearby skin. These eggs fall onto bedding or nearby surfaces.

Trichinella causes a disease called **trichinosis** (trih keh NOH sis). The roundworm enters through the mouth if an individual eats infected pork or wild game that is raw or undercooked. Hookworm infections are common in humans in warm climates where they walk on contaminated soil in bare feet. Hookworms cause people to feel weak and tired due to blood loss.

Can roundworms infect other organisms?

There are about 1200 species of nematodes (roundworm parasites) that cause disease in plants. They are particularly attracted to plant roots, causing a slow decline of the plant. Nematodes can infect fungi and form symbiotic associations with bacteria. Nematodes have been used to control pests. Instead of using chemical pesticides, nematodes can be introduced to kill weevils that damage plants.

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University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

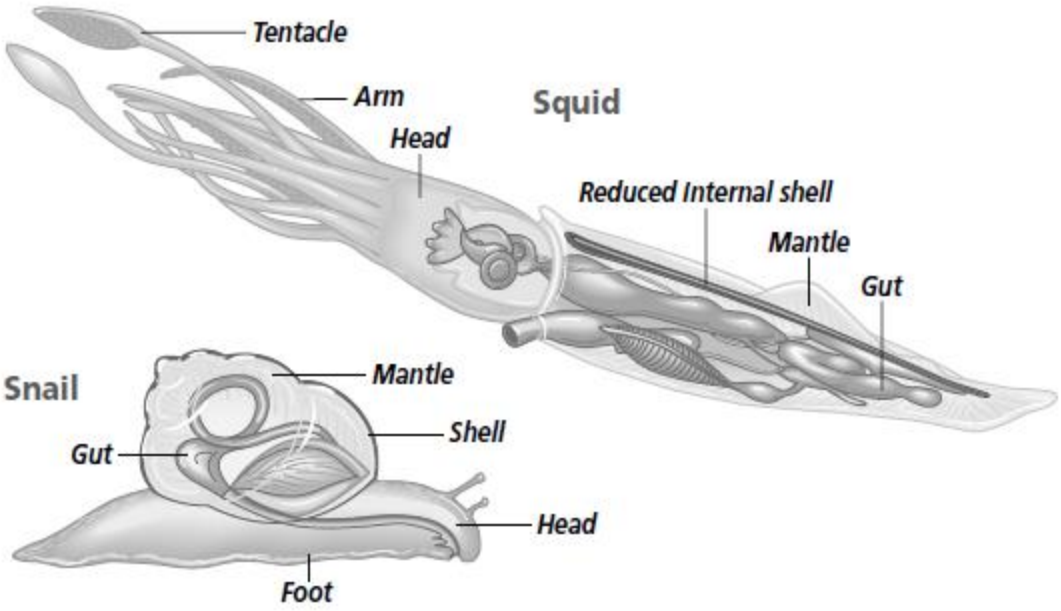
5- Mollusks

What is a Mollusk?

Snails, slugs, squid, octopuses, and some other animals that live in shells either in the ocean or on the beach are mollusks. Members of the phylum Mollusca, or mollusks, include both slow-moving slugs and fast, jet-propelled squid. Some mollusks, like snails and slugs, live in damp areas on land. They can often be found moving over leaves on a forest floor. Some mollusks, including oysters, live most of their lives attached to the ocean floor. Oysters also may attach themselves to the underwater parts of docks or boats. Other mollusks, including the octopus, swim easily in the ocean.

Some mollusks have a shell. Other mollusks, including slugs and squids, do not have a hard outer covering. All mollusks have bilateral symmetry, a coelom, a digestive tract with two openings, a muscular foot, and a mantle. A coelom is a fluid-filled body cavity that is completely surrounded by the mesoderm. The **mantle** (MAN tuhl) is the membrane that surrounds the internal organs of the mollusk. In mollusks that have shells, the mantle secretes the shell. Some mollusks, like snails, have adapted to life on land.

Although mollusks look different from one another on the outside, they are similar inside. Refer to the figure at the right. Compare the similarities and differences in the structures of a snail and a squid. Notice that both the snail and the squid have a mantle, shell, head, and gut. The foot area of the squid has been modified into tentacles and arms.



do mollusks obtain food?

Snails and many other mollusks use a **radula** (RA juh luh) to obtain food. A radula is a structure located in the mouth of mollusks. Similar to a rough file, the radula is a tonguelike organ with rows of teeth. Mollusks use their radulas to drill, scrape, grate, and even to cut food. Octopuses and squids capture food with their tentacles. They use their radulas to tear up the food they have caught. Some mollusks are grazers. Others, including bivalves, are filter feeders. They do not have radulas. Instead, they filter their food from the water.

How do mollusks reproduce?

Mollusks reproduce sexually and most mollusks have separate sexes. For most mollusks that live in water, eggs and sperm are released at the same time. External fertilization then takes place. Many mollusks that live on land are hermaphrodites. Hermaphrodites are plants or animals that have both female and male reproductive organs. Many gastropods, the largest class of mollusks, produce both eggs and sperm, and fertilization takes place within the animal. Some bivalves also are hermaphrodites, producing both sperm and eggs.

Mollusks have different appearances as adults but they develop in similar ways. In one larval stage, most mollusks resemble spinning tops with tufts of

cilia. Cilia are tiny hairlike structures that beat in order to produce movement. Most of these larvae will swim freely in the water until they settle down on the ocean floor. They will spend their adult lives on the ocean floor.

Most sea snails and bivalves have another stage before reaching adulthood called a veliger. In this stage, the beginnings of the foot, shell, and mantle are visible.

Do mollusks have nervous systems?

Mollusks have simple nervous systems. The function of the nervous system is to coordinate movement and behavior. The more advanced mollusks have brains. Most mollusks have paired eyes. The eyes can range from simple cups that detect light to complex eyes with irises, pupils, and retinas. Octopuses have complex eyes that are similar to the eyes of humans.

Do mollusks have a circulatory system?

Mollusks have well-developed circulatory systems that include either a two- or three-chambered heart. In most mollusks, the heart pumps blood through an open circulatory system. In an **open circulatory system,** blood moves through vessels and into open spaces around the body organs. In an open circulatory system, body organs are directly exposed to blood that contains nutrients and oxygen. The blood removes metabolic waste from the organs. Other mollusks, like octopuses, have closed circulatory systems. In a **closed circulatory system,** blood moves through the body, but the blood is entirely enclosed in the blood vessels. The blood moves nutrients and oxygen through the closed blood vessels. A closed system provides an efficient means for gas exchanges within the animal.

Respiration and excretion in mollusks

Most mollusks have respiratory structures called gills. Gills are specialized parts of the mantle. They are a system of tiny strands that contain a rich supply of blood for transporting gases. Gills increase the surface area where carbon dioxide and oxygen are exchanged. In snails and slugs that live on land, the mantle cavity appears to have become a primitive lung.

The excretory structures are called nephridia. **Nephridia** (nih FRIH dee uh) are organs that remove metabolic wastes from the animal's body. Mollusks have one or two nephridia that collect waste from the coelom. The coelom is located around the heart only. Wastes pass from the coelom into the mantle cavity and are expelled from the body by the pumping of the gills. Remember that the gills are respiratory structures.

Diversity of Mollusks

There are many kinds of mollusks. Three classes, Gastropoda, Bivalvia, and Cephalopoda include the most common and the best-known species.

Which mollusks belong to the class Gastropoda?

The largest class of mollusks is Gastropoda, or gastropods. Gastropods are stomach-footed mollusks. The name gastropod comes from the way the animal's large foot is positioned under its body. Most gastropods, such as snails, abalones, conches, periwinkles, whelks, limpets, cowries, and cones have a shell. They can be found in freshwater, in saltwater, or in moist land habitats. Gastropods with shells may be plant eaters, predators, or parasites. Other gastropods, like slugs, do not have shells. They have a thick layer of mucus that protects their bodies. Nudibranches are colorful sea slugs. Nudibranches are protected from predators in another way. When these sea slugs feed on jellyfish, the poisonous nematocysts of the jellyfish are taken into the tissues of the sea slug. When a fish tries to eat the sea slug, the nematocysts are discharged into the predator and the predator is repelled. The bright colors of nudibranches warn predators of the danger before they attack.

Which mollusks belong to the class Bivalvia?

Clams, oysters, and scallops belong to class Bivalvia. Bivalves have two shells. The two shells are connected with a ligament, called a valve. The valve works like a hinge. Strong muscles allow the valves to open and close over the soft body of the bivalve. Most bivalve mollusks live in saltwater, but a few species live in freshwater. Some bivalves are tiny, measuring less than 1 mm in length. Others, such as the tropical giant clam, can be as large as 1.5 m long.

Bivalves do not have a distinct head. They use their large, muscular foot for digging and hiding in the sand.

Bivalves do not have radula, the rough tonguelike organ of many mollusks. They are filter feeders. They obtain their food by filtering small particles of food from the water in which they live. Bivalve mollusks have several features that help them filter feed. They have gill cilia that beat so water can be drawn through the shells. Water and particles in the water move over the gills. Food is trapped in the bivalve's mucus. The cilia that line the gills push food particles to the mouth. The cilia also sort out food from large particles and sediment. These and other items that are rejected are carried to the bivalve's mantle. These rejected particles are pushed out. Rejected particles also may be carried to the foot where they are eliminated from the animal's body.

Which mollusks belong to the class Cephalopoda?

Cephalopoda means head-footed. Cephalopods live in oceans. Octopus, squid, cuttlefish, and the chambered nautilus are cephalopods. The only cephalopod that has a shell is the chambered nautilus. Some species, such as the cuttlefish, have reduced internal shells, but they do not have external shells. Scientists consider the cephalopods to have the most complex structure. Scientists also think the cephalopods are the most recently evolved mollusk.

In the cephalopods, the foot has evolved into tentacles with suckers, hooks, or sticky adhesive structures. Cephalopods swim or walk over the ocean floor to catch their food. They catch food in their tentacles, bring it to their mouths, and bite it with strong, beaklike jaws. Like many other mollusks, they have radulas. They use their radulas to tear food and pull it into their mouths.

Cephalopods, like bivalves, have siphons that push water out. They can expel water in any direction, and they can move quickly by jet propulsion. Using the force of expelled water, squids can travel up to 20 m per second. Squids and octopuses use jet propulsion to escape danger. They also can release a dark fluid, or "ink," that darkens the water around them. This "ink" helps to confuse their predators because the cephalopod can no longer be easily seen.

Segmented Worms

What is a segmented worm?

Segmented worms include leeches, bristleworms, and earthworms. They are classified in the phylum Annelida. Segmented worms are bilaterally symmetrical, the same on both sides. Like mollusks and other animals you have studied, they have a coelom. Segmented worms also have two openings on their bodies. One opening is for taking in food and the other opening is for releasing wastes. Some segmented worms have a larval stage similar to larval stages of certain mollusks. This similar larval stage suggests that mollusks and segmented worms may have a common ancestor.

The basic body plan of a segmented worm is a tube within a tube. The internal tube, which is suspended within the coelom, is the digestive tract. The worm takes food in through the mouth, which is the opening in the front, or anterior, end of its body. The worm releases its waste through the anus, an opening at the back, or posterior, end of its body.

Most segmented worms have tiny bristles called **setae** (SEE tee) on each segment. These bristles help the worms move. Using the setae, the worm anchors its body in the soil. Each segment then helps move the animal along its path.

You can find segmented worms almost everywhere except in the frozen soil of the polar regions and in the dry sand and soil of the deserts. There are about 15 000 species of segmented worms that live in soil, freshwater, and saltwater. Earthworms are just one of the many species of segmented worms that live on our planet.

Why is segmentation important?

The body of a segmented worm is cylindrical, long and round. The body is divided into ringed segments. The giant earthworm of Australia can grow to more than 3 m long and the ringed segments are easily seen. The segmentation on the outside of a worm is repeated inside the worm. Internally, each segment is separated from others by a body partition. Each segment has its own muscles. By using these separated muscles, a worm can shorten and lengthen its body to move.

Segmentation also allows for specialization of body tissues. Groups of segments work together for a particular purpose or function. Certain segments have adaptations or modifications for sensing surroundings and for reproduction.

What kind of nervous system does a segmented worm have?

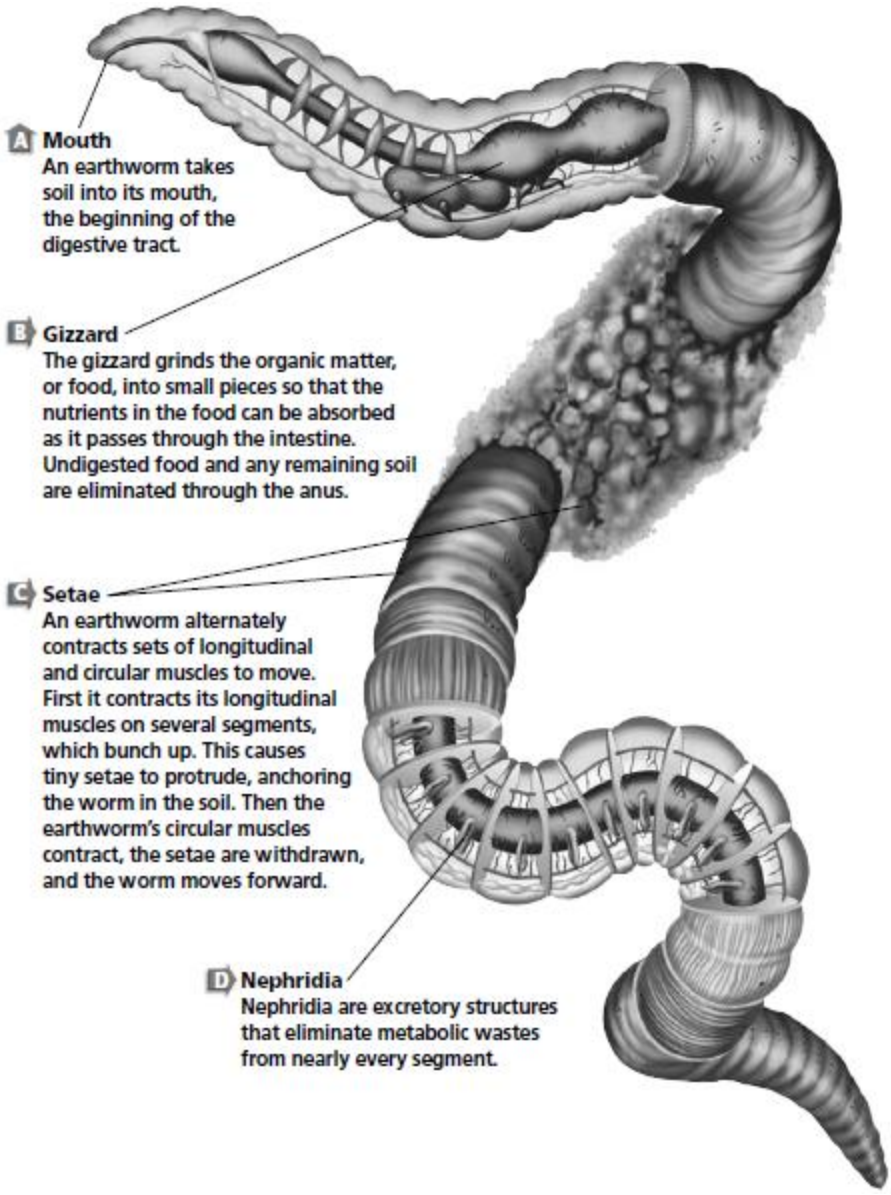
Segmented worms have simple nervous systems. Organs in the front segments are able to sense the environment. Other sensory organs in the front segments detect light. Some segmented worms have eyes with lenses and retinas. Some species have a brain in the front segment. Nerve cords connect the brain to nerve centers that are found in each segment of the worm. These nerve centers are called ganglia.

What type of circulatory system do segmented worms have?

Segmented worms have a closed circulatory system. As you learned in the first section of this chapter, a closed circulatory system means that blood flows through closed vessels. Blood that carries oxygen to the body cells also carries carbon dioxide away from body cells. In a segmented worm, blood flows to all parts of the worm's body. Segmented worms must live in water or in wet areas on land because they exchange oxygen and carbon dioxide directly through their moist skin.

Do segmented worms have a digestive system?

Segmented worms have a complete internal digestive tract that runs from the front of the worm to the end of the worm. When a worm eats, food and soil that go into the mouth eventually pass into the **gizzard.** A muscular sac and hard particles in the gizzard help grind the soil and the food before they are passed into the intestine. Material that cannot be digested and solid wastes pass out of the worm's body through the anus. The anus is the opening in the worm's body that is located at the posterior end. Like mollusks, segmented worms also have nephridia as shown in the illustration below. In a segmented worm, there are two nephridia in almost every segment. The nephridia collect wastes and move them through the coelom and out of the worm's body.



How do segmented worms reproduce?

Some segmented worms, including earthworms and leeches, are hermaphrodites. Hermaphrodites produce both sperm and eggs. When worms mate, two worms exchange sperm. Each worm forms a capsule for the eggs and the sperm. The sperm fertilize the eggs in this capsule. The capsule slips off the worm, and the capsule stays behind in the soil. Two to three weeks later, young worms emerge from the eggs.

Bristleworms and other closely related species have separate sexes. They reproduce sexually. Eggs and sperm are usually released into the seawater

where they live. Fertilization takes place in the water. Bristleworm larvae hatch in the sea. They become part of the plankton. When a larva begins to develop segments, the worm will settle to the bottom of the ocean.

Diversity of Segmented Worms

There are three classes of segmented worms in the phylum Annelida. Earthworms belong to the class Oligochaeta. Bristleworms and their relatives belong to the class Polychaeta. Leeches belong to the class Hirudinea.

What are earthworms?

Earthworms are probably the best-known Annelids because they can be seen easily by most people. Earthworms belong to the class Oligochaeta. Earthworms have anterior and posterior sections, but lack distinct heads. They have only a few setae on each of their segments. As you can see in the illustration, earthworms have a brain, a pharynx, an esophagus, blood vessels, and nephridia. Notice that a single segment contains muscle layers, blood vessels, the esophagus, nephridia, and the ventral nerve cord.

Earthworms improve garden soil. As they eat, they create new spaces for air and water to flow through the soil. As soil passes through the worm's digestive tract, nutrients are extracted. The undigested materials pass out of the worm's digestive tract. These wastes, called castings, help fertilize the soil.

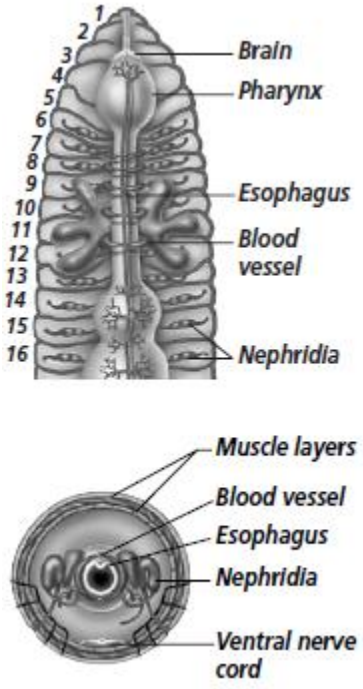
What are bristleworms and their relatives?

Bristleworms and their relatives, including fanworms, lug worms, plumed worms, and sea mice, belong to the class Polychaeta. Most live in the oceans. Most body segments of these worms have many setae. Their class name Polychaete means "many bristles."

Most body segments of Polychaetes have pairs of appendages, similar to tiny limbs. The appendages are called parapodia. Polychaetes use parapodia for swimming or crawling over corals and the bottom of the sea. The parapodia also help in gas exchange. Polychaetes have heads with well-developed sense organs, including eyes.

What are leeches?

Leeches belong to the class Hirudinea. Leeches are segmented worms with flattened bodies. Usually they do not have setae. Most leeches live in freshwater streams or in rivers. Many species of leeches are parasites that suck blood or other body fluids from animals called hosts. Host animals include ducks, turtles, fishes, and humans. Leeches have front and rear suckers than enable them to attach themselves to their hosts.

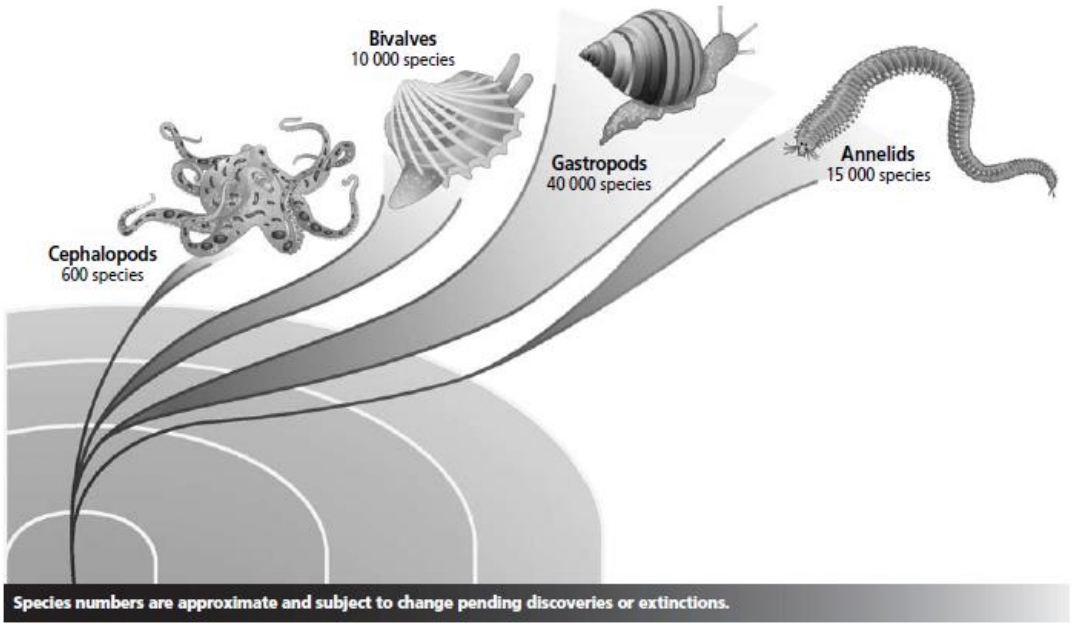


The bite of a leech is not painful. The saliva of the leech contains chemicals that act as an anesthetic, a pain killer. Other chemicals stop the host's blood from clotting. A leech can ingest two to fives times its own weight in a single meal. Once a leech has finished eating, it lets go and drops off its host. The leech may not need to eat again for several months.

Origins of Mollusks and Segmented Worms

Fossil records show that there were great numbers of mollusks 500 million years ago. Fossils of gastropods, bivalves, and cephalopods, the three classes of mollusks, have been found in Precambrian deposits. Some species of mollusks, such as the chambered nautilus, have not changed much from their

ancestors that lived long ago. Because mollusks lived so long ago, scientists use fossil mollusks to help determine the ages of rocks.



Annelids, segmented worms, probably evolved from the sea. They may have originated from the larvae of ancestral flatworms. The fossil records for segmented worms are much more limited than for mollusks because segmented worms have almost no hard body parts. Little remains from their soft bodies in the fossil records. Tubes constructed by Polychaetes are the most common fossils for this phylum. Some of these tubes appear in the fossil record as early as 540 million years ago.

References

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6- Arthropods

What is an arthropod?

A typical arthropod is a segmented, coelomate invertebrate animal. A coelom is a fluid-filled cavity completely surrounded by mesoderm. Arthropods have bilateral symmetry, an exoskeleton, and jointed structures called appendages. An exoskeleton is a hard, thick outer covering. An **appendage** (uh PEN dihj) is any structure, such as a leg or an antenna that grows out of the body of an animal. In arthropods, appendages are adapted for a variety of purposes. There are appendages for walking, sensing, feeding, and mating.

Arthropods are the earliest known invertebrates to have jointed appendages. Joints allow more flexibility in animals that have hard, rigid exoskeletons. Joints allow powerful movements of appendages. Joints allow appendages to be used in many different ways. For example, the second pair of appendages in spiders is used for mating. In scorpions, the second pair is used for seizing prey.

How does an exoskeleton provide protection?

Arthropods as a group have been successful partly because they have exoskeletons. The exoskeleton is made of protein and chitin (KI tun). In some species, the exoskeleton is a continuous covering over most of the body. In other species, it is made of separate plates held together by hinges. The exoskeleton protects and supports internal tissue and provides a place for the attachment of muscles. In many species that live on land, a waxy layer on the exoskeleton protects against water loss. In aquatic species, the exoskeleton may be reinforced with calcium carbonate.

What are the disadvantages of an exoskeleton?

One disadvantage of an exoskeleton is that it is a relatively heavy structure. The larger an arthropod is, the thicker and heavier its exoskeleton must be to support its larger muscles. The weight of the exoskeleton limits the size of arthropods. Some land dwelling and flying arthropods have adapted by having thinner, lighter exoskeletons. A thinner exoskeleton offers less protection but allows the animal to fly or jump.

Another disadvantage is that the exoskeleton does not grow. An exoskeleton must be shed periodically. Shedding the old exoskeleton is called **molting.** Before an arthropod molts, a new, soft exoskeleton forms under the old one. When the new exoskeleton is ready, the animal contracts muscles and takes in air or water. This causes the animal's body to swell. The old exoskeleton splits open and the animal sheds it. The new exoskeleton is soft. Before it hardens, the animal puffs up as a result of increased blood circulation to all parts of the body. Many insects and spiders also increase in size by taking in air. The new exoskeleton hardens in a larger size, allowing some room for the animal to continue growing.

Most arthropods molt four to seven times in their lives before they become adults. During molting, they are at risk from predators. While the new exoskeleton is soft, arthropods cannot protect themselves from danger. Many species hide or remain motionless for a few hours or days until the new exoskeleton hardens.

How is fusion related to movement and protection?

Most arthropods are segmented but they do not have as many segments as worms. In most groups of arthropods, segments have become fused into three body sections—head, thorax, and abdomen. In other groups, even these segments may be fused. Some arthropods have a head, but the thorax and abdomen are fused. Others have a head fused with a thorax, and an abdomen. A fused head and thorax is called a **cephalothorax** (se fuh luh THOR aks). Fusion of the body segments is related to movement and protection.

Less fusion means more movement, but less protection. Beetles and some other arthropods that have separate head and thorax sections are more flexible

than those with fused sections. Shrimps, lobsters, and crayfishes have a cephalothorax, which protects the animal but limits its movement.

What kinds of respiratory structures do arthropods have?

Arthropods are quick, active animals. They crawl, run, climb, dig, swim, and fly. In order to have oxygen delivered quickly to the cells, they need efficient respiratory structures.

Three types of respiratory structures have evolved in arthropods: gills, tracheal tubes, and book lungs. Aquatic arthropods use gills to get oxygen from the water and release carbon dioxide into the water. Land arthropods either have a system of tracheal tubes or book lungs. Most insects have **tracheal** (TRAY kee ul) **tubes,** a network of hollow air passages that carry air throughout the body. Muscle activity helps pump the air through the tracheal tubes. Air enters and leaves the tracheal tubes through openings on the thorax and abdomen called **spiracles** (SPIHR ih kulz).

Most spiders and their relatives have **book lungs,** air-filled chambers that contain leaflike plates. The folded membranes increase the surface area of tissue exposed to air. The stacked plates of the book lungs are arranged like pages in a book.

What senses do arthropods have?

Arthropods use antennae to detect movement, sound, and chemicals with great sensitivity. Antennae are stalklike structures that allow arthropods to detect changes in the environment. Antennae also are used for sound and odor communication. Ants and other arthropods are able to communicate with each other by pheromones.

Pheromones (FER uh mohnz) are chemical odor signals given off by animals. For an ant to communicate the presence of food to another ant, the first ant releases a pheromone. Antennae sense the odor, which signals to the second ant that food is present. Pheromones signal animals to engage in a variety of behaviors. Some are used in scent trails. Others are important for mating behavior.

A Tracheal tubes are inside the body, thereby reducing water loss through the respiratory surface while carrying air close to each cell.

B Gills, with their large surface area, enable a large amount of blood-rich tissue to be exposed to water containing oxygen.

Accurate vision is important to arthropods. Most arthropods have one pair of large compound eyes and three to eight simple eyes. A **simple eye** is a visual structure with only one lens that is used for detecting light. A **compound eye** is a visual structure with many lenses. Each lens registers light from a tiny portion of the field of view. The total image that is formed is made up of thousands of parts. The multiple lenses of a flying arthropod, such as a dragonfly, help it to analyze a fast-changing landscape during flight.

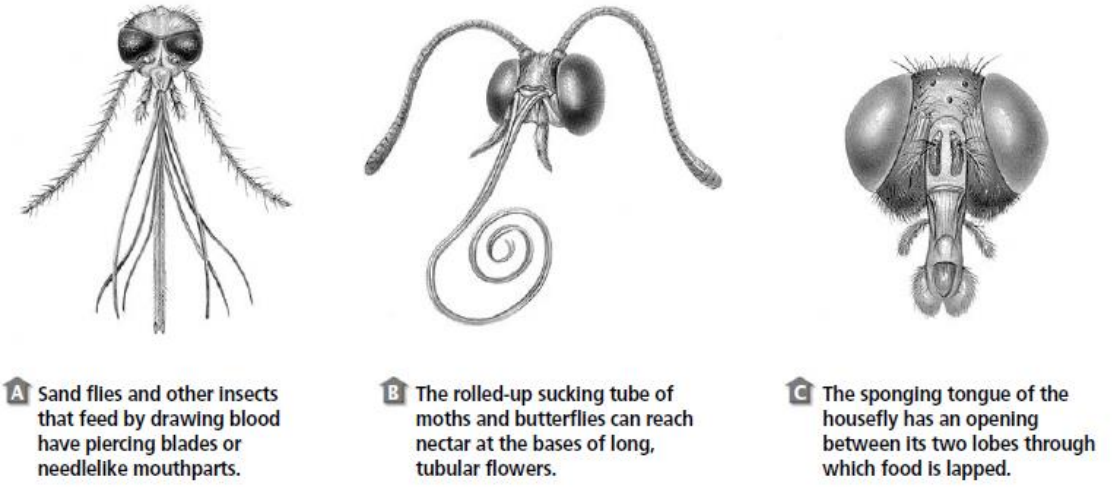
Arthropods have well-developed nervous systems. The nervous system processes information coming in from the sense organs. The nervous system consists of a double ventral nerve cord, an anterior brain, and several ganglia.

Arthropods have ganglia that have become fused. These ganglia act as control centers for the body section in which they are located.

What are other arthropod body systems?

Arthropod blood is pumped by a heart in an open circulatory system. Vessels carry blood away from the heart. The blood flows out of the vessels, bathing the tissues of the body. Blood returns to the heart through open body spaces. Arthropods have complete digestive system.

They have a mouth, stomach, intestine, anus, and various glands that produce digestive enzymes. The mouthparts of most arthropods include one pair of jaws called **mandibles** (MAN duh bulz). The mandibles are adapted for holding, chewing, sucking, or biting the different foods eaten by arthropods.



A Sand flies and other insects that feed by drawing blood have piercing blades or needlelike mouthparts.

B The rolled-up sucking tube of moths and butterflies can reach nectar at the bases of long, tubular flowers.

C The sponging tongue of the housefly has an opening between its two lobes through which food is lapped.

Most arthropods that live on land get rid of wastes through **Malpighian** (mal PIH gee un) **tubules.** In insects, the tubules are all located in the abdomen. Malpighian tubules are attached to and empty directly into the intestine.

The muscular system is well-developed in arthropods. In human limbs, muscles attach to bones. In arthropod limbs, the muscles attach to the inner surface of the exoskeleton. An arthropod muscle attaches to the exoskeleton on both sides of the joint.

How do arthropods reproduce?

Most arthropod species have separate males and females and reproduce sexually. For land species, fertilization is usually internal. For aquatic species, fertilization is usually external. A few species, such as barnacles, are hermaphrodites, animals with both male and female reproductive organs. Some species, such as bees, ants, aphids, and wasps, exhibit parthenogenesis. **Parthenogenesis** (par thuh noh JE nuh sus) is a form of asexual reproduction in which a new individual develops from an unfertilized egg.

Reproductive diversity has contributed to the success of arthropods. There are more arthropod species than all other animal species combined.

Diversity of Arthropods

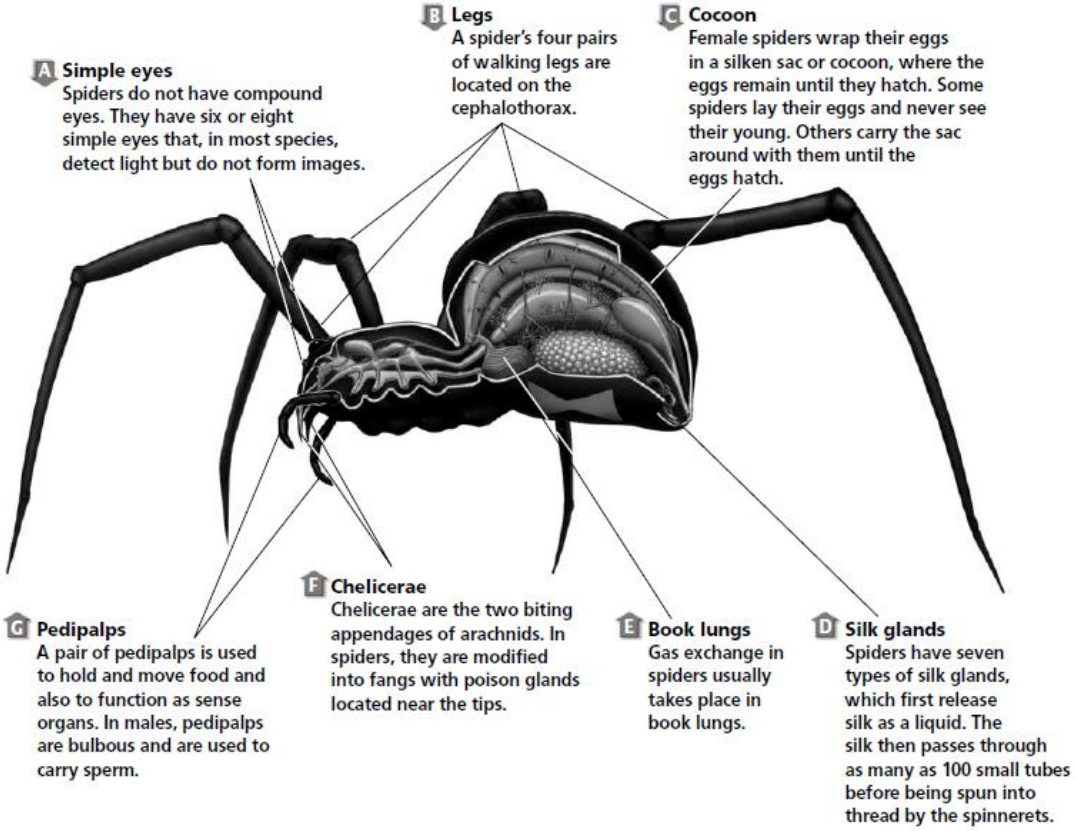
Arachnids

Spiders, scorpions, mites, and ticks belong to the class Arachnida (uh RAK nud uh). Spiders are the largest group of arachnids. Spiders and other arachnids have only two body regions—the cephalothorax and the abdomen. Arachnids have six pairs of jointed appendages.

The first pair of appendages, called **chelicerae** (chih LIH suh ree), is located near the mouth. Chelicerae are often modified into pincers or fangs. Pincers hold food. Fangs inject prey with poison. Spiders do not have mandibles for chewing. Using a process of extracellular digestion, digestive enzymes from the spider's mouth turn the internal organs of the prey into liquid. The spider then sucks up the liquefied food.The second pair of appendages is called the **pedipalps** (PE dih palpz). Pedipalps are adapted for handling food and sensing. In male spiders, pedipalps carry sperm during reproduction. The four remaining appendages in arachnids are adapted as legs. Arachnids do not have antennae.

Most people think of webs when they think of spiders. Although all spiders spin silk, not all make webs. Spider silk is secreted by silk glands in the abdomen. As silk is secreted, it is spun into thread by

structures called spinnerets**,** located at the rear of the spider.



What other animals are arachnids?

Arachnida also includes ticks, mites, and scorpions. Ticks and mites have only one body section. The head, thorax, and abdomen are completely fused. Ticks feed on blood from reptiles, birds, and mammals. They are small but can enlarge up to three times their normal size after feeding.

Mites feed on fungi, plants, and animals. They are so small that they usually cannot be seen without magnification. The bite of a mite can irritate the skin. Both mites and ticks can spread disease.

Scorpions are easy to recognize because of their many body segments and large pincers. They have long tails with stingers at the tips. They use the poison in their stingers to paralyze prey. Scorpions live in warm, dry climates. They eat insects and spiders.

Crustaceans

Crustaceans (krus TAY shuns) are the only arthropods that have two pairs of antennae for sensing. Some crustaceans have three body sections, others have two. All crustaceans have mandibles for crushing food. Crustacean mandibles open and close from side to side. Most crustaceans have two compound eyes, often located on movable stalks. Many crustaceans have five pairs of walking legs. They also use the legs for seizing prey and cleaning other appendages. The first pair of walking legs is often modified into strong claws for defense.

Members of the class Crustacea include crabs, lobsters, shrimps, crayfishes, water fleas, pill bugs, and barnacles. Most crustaceans live in water. They use feathery gills to obtain oxygen from the water and to release carbon dioxide. Land crustaceans, such as sow bugs and pill bugs, must live where there is moisture. Moisture helps with gas exchange. They may be found in damp areas around building foundations.

Centipedes and Millipedes

Centipedes belong to the class Chilopoda. Millipedes are members of the class Diplopoda. Like spiders, centipedes and millipedes have Malpighian tubules for excreting wastes. Unlike spiders, they have tracheal tubes rather than book lungs for gas exchange. Centipedes are carnivorous. They eat soil arthropods, snails, slugs, and worms. The bites of some centipedes are painful to humans. A millipede eats mostly plants and dead material on the forest floor. Millipedes do not bite, but they can spray foulsmelling fluids from their stink glands. Millipedes walk with a slow, graceful motion.

Horseshoe Crabs: Living Fossils

Horseshoe crabs are members of the class Merostomata. One of the three living genera, *Limulus,* is found along the east coast of North America. Horseshoe crabs are considered to be living fossils. *Limulus* has remained relatively unchanged since the Triassic Period about 220 million years ago.

Horseshoe crabs are heavily protected by a large exoskeleton. They live in deep coastal waters. Horseshoe crabs search on sandy or muddy ocean bottoms for algae, annelids, and mollusks. These arthropods migrate to shallow water in the spring, then mate at night during high tide.

Insects

Flies, grasshoppers, lice, butterflies, bees, and beetles are a few of the members of the class Insecta. Insects have three body segments and six legs. There are more species of insects than all other classes of animals combined.

How do insects reproduce?

Insects usually mate once in their lifetime. The eggs are usually fertilized internally. Some insects reproduce from unfertilized eggs, a process called parthenogenesis. In aphids, parthenogenesis produces all-female generations. Most insects lay a large number of eggs. This increases the chances that some offspring will survive long enough to reproduce. Many female insects are equipped with an appendage that can pierce into wood or the surface of the ground. The female insect lays eggs in the hole.

What happens during metamorphosis?

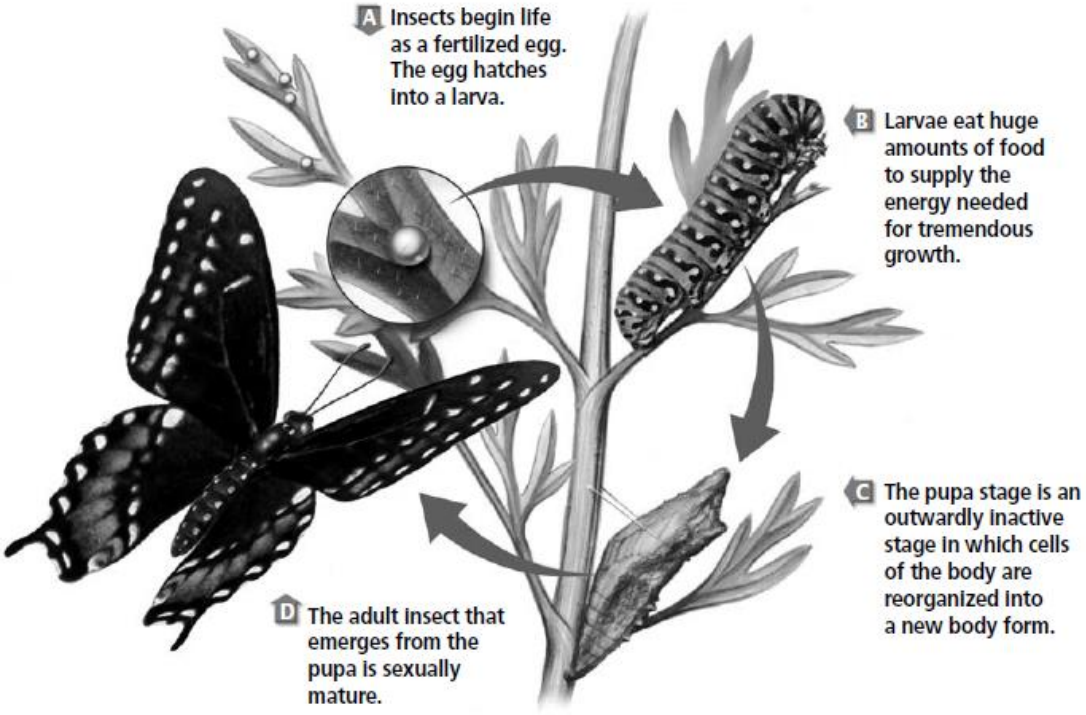
After eggs are laid, the embryos develop and the eggs hatch. In some wingless insects, such as silverfish, the eggs hatch into small forms that look like tiny adults. These insects molt several times until they reach adult size. Many other species of insects go through a series of major changes in body structure as they develop. Often, the adult insect does not resemble the juvenile form of the insect. This series of changes, controlled by chemical substances in the animal, is called **metamorphosis** (me tuh MOR fuh sus).

Insects that undergo metamorphosis usually go through four stages on their way to adulthood: egg, larva, pupa, and adult. The **larva** is the free-living, wormlike stage of an insect, often called a caterpillar. As the larva eats and grows, it molts several times.

The **pupa** (PYEW puh) stage of insects is a period of reorganization. Tissues and organs of the larva are broken down and replaced by adult tissues. Usually the insect does not move or feed during the pupa stage. After a period of time, a fully formed adult emerges from the pupa.

The series of changes that occur as an insect goes through the egg, larva, pupa, and adult stages is called complete metamorphosis. In winged insects that

undergo complete metamorphosis, the wings do not appear until the adult stage. More than 90 percent of all insects undergo complete metamorphosis.



The advantage of complete metamorphosis is that larva do not compete with adults for the same food. For example, butterfly larvae (caterpillars) feed on leaves. Adult butterflies feed on nectar from flowers. The complete metamorphosis of a butterfly is shown above.

What is incomplete metamorphosis?

Some insect species undergo a gradual or incomplete metamorphosis. The insect only goes through three stages of development. The three stages are egg, nymph, and adult. A **nymph,** which hatches from an egg, has the same general appearance as the adult but is smaller. Nymphs may lack certain appendages, or have appendages not seen in adults. A nymph cannot reproduce. With each nymph molt, it looks more like the adult. Wings begin to form and an internal reproductive system develops. Gradually, the nymph becomes an adult. Grasshoppers and cockroaches are insects that undergo incomplete metamorphosis.

Origins of Arthropods

Arthropods live successfully on every surface of Earth. Their ability to survive in just about every habitat is unequaled in the animal kingdom. The success of arthropods is due in part to their varied life cycles, high reproductive output, and structural adaptations, such as small size, hard exoskeleton, and jointed appendages.

How did arthropods evolve?

Arthropods most likely evolved from an ancestor of the annelids. As arthropods evolved, body segments became fused. They adapted for certain functions such as locomotion, feeding, and sensing the environment. Segments in arthropods are more complex than in annelids. Arthropods have more developed nerve tissue and sensory organs such as eyes.

The exoskeletons of arthropods provide protection for their soft bodies. The circular muscles of annelids do not exist in arthropods. Muscles in arthropods are arranged in bands. The muscles are associated with particular segments and appendages. Because arthropods have many hard parts, much is known about their evolutionary history. Trilobites were once an important group of ancient arthropods, but they have been extinct for 248 million years.

References

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7- Echinoderms and Invertebrate Chordates

What is an echinoderm?

Echinoderms belong to the phylum Echinodermata. Echinoderms (ih KI nuh durmz), which means spiny skinned, can be found in oceans all over the world. Echinoderms move using hundreds of suction-cup-tipped appendages. The skin of an echinoderm is covered with tiny, jawlike pincers. These characteristics distinguish echinoderms from other animals.

What kinds of skeletons do echinoderms have?

Echinoderms have hard, spiny, or bumpy endoskeletons. An endoskeleton is an internal skeleton. The skeleton of all echinoderms is mostly calcium carbonate, the compound that makes up limestone. A thin epidermis, or outer layer of skin, covers the endoskeleton. A sea urchin has long, pointed spines. Sea stars, sometimes called starfishes, may not look spiny, but they are. If you look closely at a sea star, you will see that its long arms are covered with short, rounded spines. The arms of a sea star are called **rays.** The skin of a sea cucumber is made of soft tissue that does not appear spiny. The small platelike structures that cover a sea cucumber's skin have replaced true spines.

Some of the spines found on the skin of sea stars and sea urchins have been modified into pincerlike appendages. These appendages are called a **pedicellariae** (PEH dih sih LAHR ee ay; singular, pedicellaria). An echinoderm uses its pedicellariae to protect itself. It also uses the pedicellariae to clean the surface of its body.

How do echinoderms benefit from radial symmetry?

As you will recall, radial symmetry means that the parts of the animal's body are arranged regularly around a central axis. Radial symmetry is an advantage

to animals that move slowly or that do not move freely from place to place. Radial symmetry allows echinoderms to sense possible food or predators that might be nearby. Radial symmetry also allows echinoderms to sense other conditions of their environment from all directions.

What is a water vascular system?

Echinoderms have a water vascular system. A **water vascular system** is a hydraulic system that operates under water pressure. Water comes in and goes out of a sea star through the water vascular system. This system allows sea stars to move, to catch their food, to exchange gases, and to excrete wastes.

As the water goes through the sea star, it passes through the madreporite. The **madreporite** (mah druh POHR ite) is a diskshaped opening on the upper surface of the animal. It functions like a strainer that fits into a kitchen sink drain and keeps large bits of material from going into the drain pipes. The madreporite prevents large particles from entering the echinoderm's body.

Sea stars and other echinoderms have tube feet. **Tube feet** are hollow tubes with thin walls. They look like tiny medicine droppers. The end of a tube foot works like a tiny suction cup. The round, muscular structure is called an **ampulla** (AM pew lah). It looks like the bulb of the dropper. The ampullae contract and relax, creating a strong suction action. The total suction action of ampullae in tube feet is so strong that a sea star can open a clam shell. Each tube foot works independently of the other tube feet. Echinoderms move by pushing out and then pulling in their tube feet.

Tube feet also carry out gas exchange and excretion. Gases are exchanged and some wastes are excreted by diffusion through the thin walls of the tube feet.

What does an echinoderm eat?

All echinoderms have a mouth, stomach, and intestines. The way echinoderms catch their food differs from one species to another. Sea stars are carnivores, or meat-eaters. They eat worms and mollusks such as clams and oysters. Most sea urchins are herbivores. They eat algae. Brittle stars, sea lilies, and sea cucumbers feed on dead and decaying matter on the ocean floor.

Do echinoderms have a nervous system?

An echinoderm has a simple nervous system. It consists of a nerve ring that surrounds the mouth. Echinoderms do not have heads or brains. Nerves extend from the nerve ring down into each ray. Nerves in the rays are called radial nerves. The radial nerves branch out into a network of nerves. This nerve network provides sensory information to the animal.

Most echinoderms do not have sensory organs. They have cells that detect touch and light. Sea stars, however, do have sensory organs. A sea star's body is composed of long rays that extend from the animal's central disk. On the underside of each arm or ray is an eyespot. Eyespots consist of a cluster of light-detecting cells. They help sea stars detect the intensity of light. Most sea stars use their eyespots to help them move toward light. The tube feet of sea stars have chemical receptors. When a sea star senses a chemical signal from a prey animal, it moves in the direction of the ray that most strongly senses the chemical.

Do echinoderm larvae have radial or bilateral symmetry?

The larval stages of echinoderms have bilateral symmetry. The larvae are free swimming, and they go through metamorphosis. During metamorphosis, the larvae undergo many changes both in their body parts and in their symmetry. Remember that the adult forms of echinoderms have radial symmetry.

Are echinoderms protostomes or deuterostomes?

A protostome is an animal with a mouth that develops from the opening in the gastrula. A deuterostome is an animal with a mouth that develops from cells elsewhere on the gastrula. Echinoderms are deuterostomes. Echinoderms have a close relationship to chordates because chordates also are deuterostomes.

Diversity of Echinoderms

About 6000 species of echinoderms exist today. About 1500 of these belong to the class Asteroidea (AS tuh ROY dee uh). Sea stars belong to this class.

The six classes of echinoderms and an example of a species in each class are as follows:

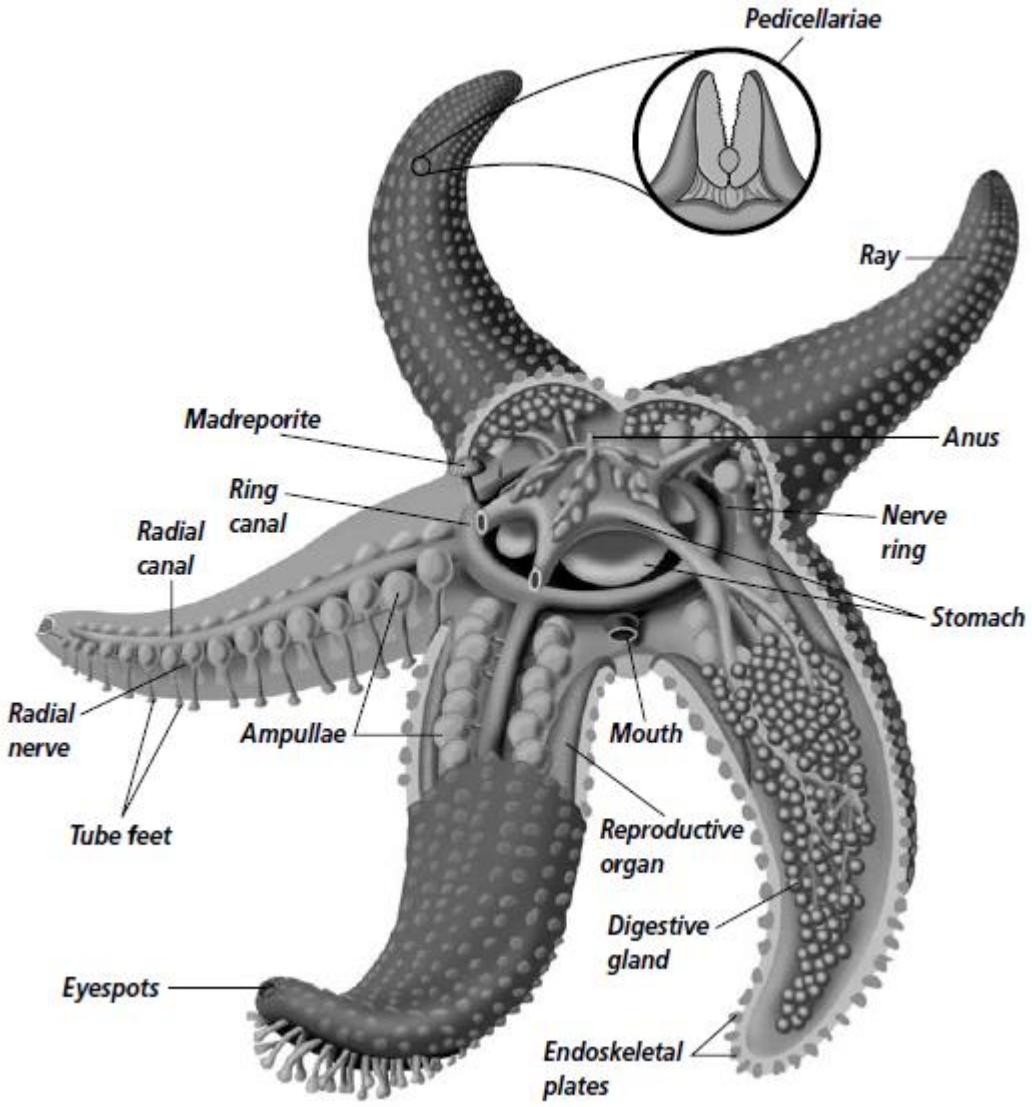
Class	Example of Species in Class
Asteroidea (AS tuh ROY dee uh)	Sea stars
Ophiuroidea (OH fee uh ROY dee uh)	Brittle stars
Echinoidea (eh kihn OY dee uh)	Sea urchins
Holothuroidea (HOH loh thuh ROY dee uh)	Sea cucumbers
Crinoidea (cry NOY dee uh)	Sea lilies
Concentricycloidea (kon sen tri sy CLOY dee uh)	Sea daisies

What are sea stars?

Sea stars are probably the best-known echinoderm. Most sea stars have only five rays. Some sea stars, however, have more than 40 rays. Sea stars have all the common characteristics of echinoderms. They have an endoskeleton made of calcium carbonate plates. The sea star can change from a rigid structure to a flexible one by contracting or relaxing the muscles that connect the plates.

As shown in the illustration on page 355, they have tube feet with ampullae and use eyespots on each ray to distinguish between light and dark. Sea stars have a stomach. In order to eat, a sea star pushes its stomach out of its mouth and spreads its stomach over the food. Enzymes secreted by the digestive gland turn solid food into liquid. The stomach absorbs this liquid. The sea star then pulls its stomach back into its body. The sea star has an anus for ridding

its body of waste. It also has pedicellariae that it uses to keep the surface of its body clean.



What are brittle stars?

Brittle stars are fragile. If you pick up a brittle star, parts of its rays will break off in your hand. That is how this star got its name. If a predator tries to attack a brittle star, rays will break off and the brittle star can escape. New rays will develop to replace those that break off.

Brittle stars do not use their tube feet for movement. They move with a snakelike, slithering motion of their flexible rays. The brittle star uses its tube

feet to move bits of food along the rays and into its mouth. The mouth is located in the star's central disk.

What are sea urchins and sand dollars?

Sea urchins and sand dollars do not have rays. Their shapes resemble globes or disks, and they are covered with spines. Sea urchins often burrow into rocks to protect themselves from predators and from rough water. A sea urchin resembles a pincushion because of its long, pointed spines. The spines help protect the sea urchin from predators. Sea urchins have long and slender tube feet that help them move.

A sand dollar has a flat surface with a petal-like flower pattern. A living sand dollar is covered with tiny, hair-like spines that are lost when the animal dies. Like other echinoderms, a sand dollar has tube feet. The tube feet are found on both the upper and lower surface of a sand dollar. The feet on the upper surface stick out from the petal-like marks on the sand dollar's top surface. They are gills used for respiration. Tube feet on the sand dollar's bottom surface help bring food particles into the sand dollar's mouth.

What are sea cucumbers?

Sea cucumbers and vegetable cucumbers have a similar shape. Sea cucumbers have a leathery outer covering that allows them the flexibility needed to move along the ocean floor. When a predator threatens a sea cucumber, it can protect itself in two ways. It can expel a tangled, sticky mass of tubes through the anus. A sea cucumber also may rupture, releasing some of its internal organs. The sticky mass of tubes or the rupturing organs confuse a sea cucumber's predators. This allows the sea cucumber to move away from its predator. The ruptured internal organs regenerate in a few weeks. Sea cucumbers reproduce by shedding sperm and eggs into the water, where fertilization occurs.

What are sea lilies and feather stars?

Sea lilies and feather stars are echinoderms. They resemble plants because they have feathery rays. Sea lilies are the only stationary, or sessile, echinoderms. Feather stars are sessile only in the larval stage. The adult

feather star uses its feathery arms to swim from place to place. Sea lilies and feather stars feed by capturing downward-drifting particles with their feathery rays.

What are sea daisies?

Two species of sea daisies were discovered in 1986 in deep waters off New Zealand. Sea daisies are flat, disk-shaped echinoderms less than 1 cm in diameter. Sea daisies have tube feet. The feet are located around the edge of the disk, not along radial lines.

Origins of Echinoderms

The earliest echinoderms may have been bilaterally symmetrical as adults. They may have been attached to the ocean floor by a kind of stalk. Another view suggests that echinoderms swam freely in the oceans.

Most invertebrates show protostome development. Echinoderms are the only major group of deuterostome invertebrates. Deuterostome development appears mainly in chordates. For this reason some biologists suggest that echinoderms are the closest invertebrate relatives of the chordates.

Because the endoskeletons are made of calcium carbonate, echinoderms easily turn into fossils. There is a good fossil record of the phylum. Echinoderms, as a group, date from the Paleozoic Era. More than 13 000 fossil species have been identified.

Invertebrate Chordates

What is an invertebrate chordate?

You are probably most familiar with the vertebrate chordates. They have backbones and include animals such as birds, fishes, and mammals. The phylum Chordata (kor DAH tuh) also includes invertebrates. The three subphyla are listed below.

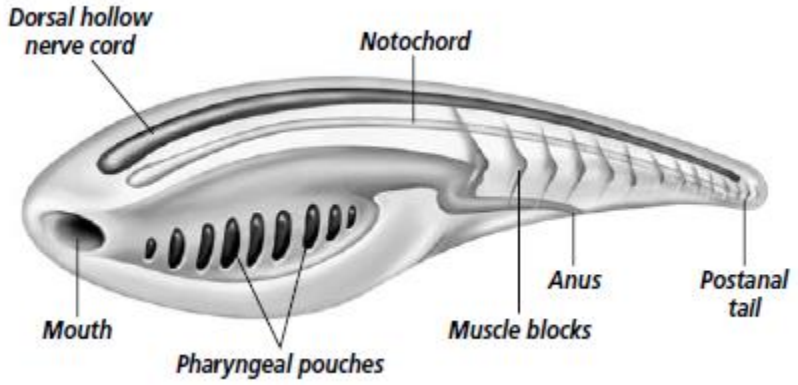
Subphyla	Members of Subphyla

Urochordata	Tunicates
Cephalochordata	Lancelets
Vertebrata	Fishes, reptiles, amphibians, birds, mammals

This section examines tunicates and lancelets, invertebrate chordates that do not have backbones. Invertebrate chordates do not look much like fishes, reptiles, or humans. However, all of these animals have the characteristics common to all chordates. At some time during their development, they all have a notochord, a dorsal hollow nerve cord, and pharyngeal pouches. In addition, at some time during their development, all chordates have a postanal tail. All chordates have bilateral symmetry, a well-developed coelom, and segmentation.

What is a notochord?

The embryos of all chordates have a notochord. The **notochord** (NOH tuh kord) is a long, semirigid structure that resembles a rod. The notochord is made of large, fluidfilled cells. These cells are held within stiff, fibrous tissues.



The notochord is located between the digestive system and the dorsal hollow nerve cord. Invertebrate chordates may keep their notochords in their adult stages. In vertebrate chordates, the notochord is replaced by a backbone. Invertebrate chordates do not develop a backbone.

The notochord develops on what will be the dorsal side of the embryo. It develops after the formation of a gastrula from mesoderm. The gastrula is the embryo development stage in animals where cells on one side of the blastula move inward, forming a cavity of two or three layers of cells with an opening at one end. The mesoderm is the middle cell layer in the gastrula, between the ectoderm and the endoderm. The notochord holds internal muscles in place. This makes it possible for invertebrate chordates to move their bodies quickly.

What is a dorsal hollow nerve cord?

All chordates have a dorsal hollow nerve cord. In chordates, the **dorsal hollow nerve cord** develops from a plate of ectoderm that rolls itself into a hollow tube. This tube is made of cells that surround a fluid-filled canal. The tube lies above the notochord.

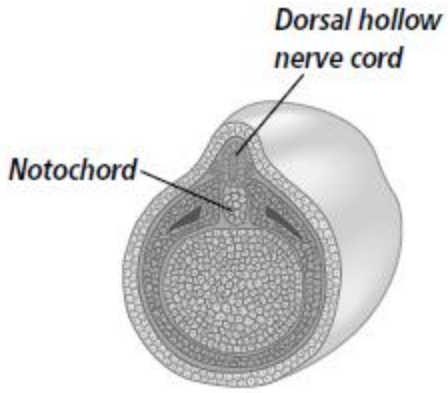
In most adult chordates, the cells in the posterior or back portion of the dorsal hollow nerve cord develop into the spinal cord. The cells in the anterior or front portion develop into the brain. A pair of nerves connects the nerve cord to each block of muscles.

What is a pharyngeal pouch?

All chordates have pharyngeal pouches. The **pharyngeal pouches** of a chordate embryo are paired openings that are located in the pharynx. The pharynx is located behind the mouth. Many chordates have these pouches only during their embryonic stages. In chordates that live in the water, pharyngeal pouches develop openings called gill slits. The gill slits filter food and gas exchange occurs as water flows through them. In chordates that live on land, the pharyngeal pouches develop into other structures.

What is a postanal tail?

All chordates have a postanal tail. In some chordates the tail disappears during the early developmental stages. For example, during the early development of the human embryo, the embryo has a postanal tail. The tail disappears as development continues. In most animals that have tails, the digestive system extends to the tip of the tail. This is where the anus is located. In chordates, however, the tail extends beyond the anus.



Muscle blocks help the tail move. Muscle blocks are modified body segments that consist of stacked layers of muscle. Muscle blocks are held in place by the notochord. The notochord gives the muscles a firm structure to pull against. As a result, chordates generally have stronger muscles than members of other phyla.

How do homeotic genes control development?

Homeotic genes outline body organization. They also direct the development of tissues and organs in the embryo. Scientists have studied chordate homeotic genes. These studies have helped scientists understand the development of chordates and the relationship between invertebrate and vertebrate chordates.

Diversity of Invertebrate Chordates

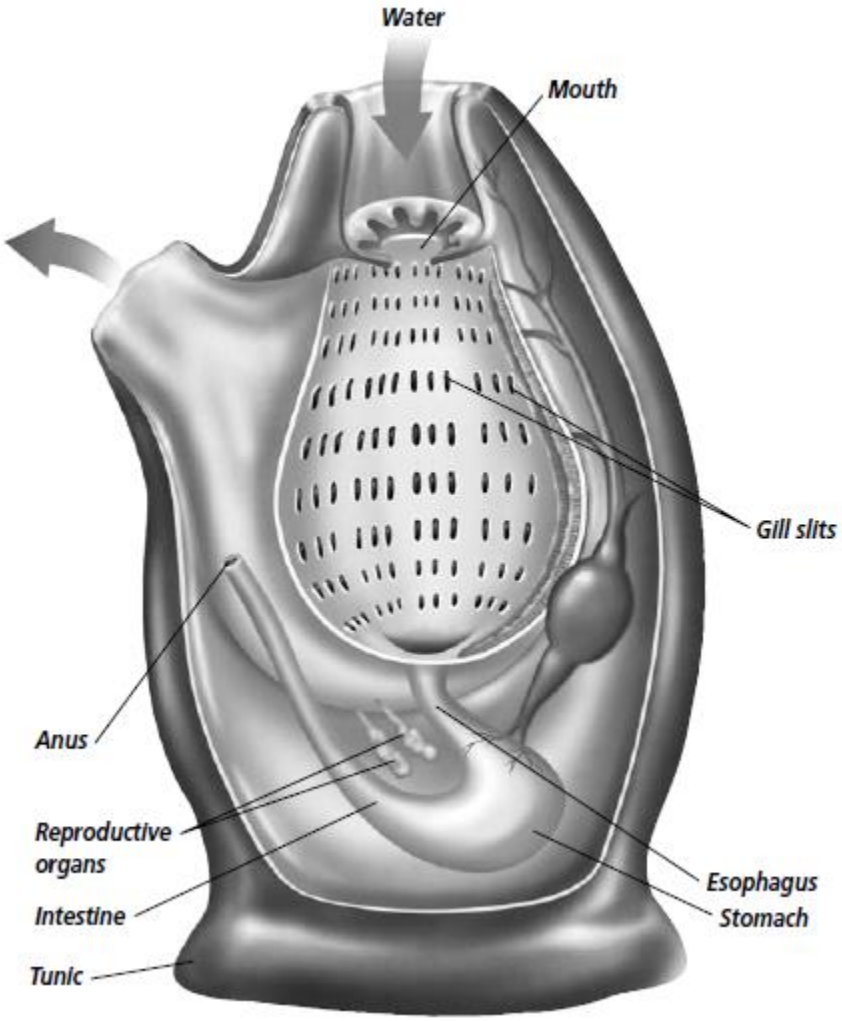
The invertebrate chordates belong to two subphyla in the phylum chordata. One subphylum is called Urochordata. Tunicates (TEW nuh kaytz), or sea squirts, belong to this subphylum. The other subphylum is called Cephalochordata. Lancelets belong to this subphylum.

What are tunicates?

Tunicates are members of the subphylum Urochordata. Adult tunicates, or sea squirts, do not seem to have any of the common chordate features. In the larval stage, a sea squirt has a tail that makes it look similar to a tadpole. Sea squirt larvae do not feed. After they hatch, the larvae are free swimming. They soon settle and attach themselves with a sucker to boats, rocks, and the ocean floor.

Many adult sea squirts secrete a tunic, a tough covering, or sac, made of cellulose. It surrounds their bodies. The figure at right shows the parts of a tunicate.

Sometimes tunicates form a group or a colony. A colony of tunicates sometimes secretes one big tunic that will have one opening to the outside.

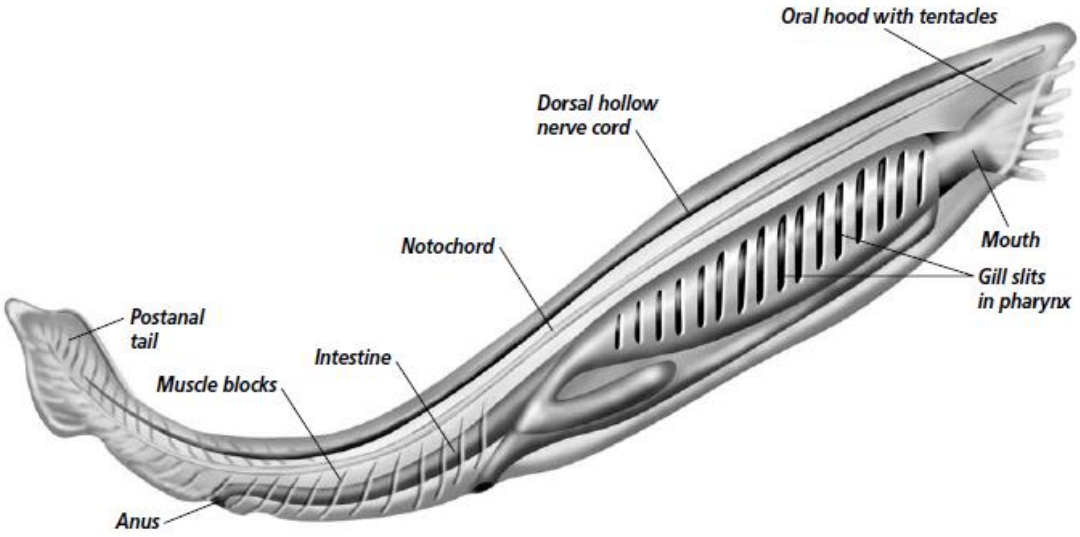


The gill slits in adult sea squirts show that they are chordates. The adult animals are small, tube-shaped animals. They may be microscopic in size, or they may be several centimeters long. If you take an adult tunicate from its home, it may squirt water at you. This is how the tunicate got the name sea squirt.

What are lancelets?

Lancelets are similar to fishes. They are small, common animals that live in the sea. Lancelets belong to the subphylum Cephalochordata. Lancelets spend most of their time buried in the sand with only their heads sticking out. Like tunicates, lancelets are filter feeders. Unlike tunicates, lancelets keep all their chordate features for their entire lives.

Although lancelets look similar to fish, there are some differences. Lancelets have only one layer of skin. They do not have pigment or color. They do not have scales or a distinct head. Lancelets can sense light because they have light-sensitive cells on the anterior or front end of their bodies. They have a mouth that is surrounded by sensory tentacles. Lancelets have a hood that covers the mouth and these tentacles.



Origins of Invertebrate Chordates

Sea squirts and lancelets do not have bones, shells, or other hard parts. Because they do not have hard parts, their fossil record is incomplete. Biologists do not know exactly where sea squirts and lancelets fit in the phylogeny of chordates.

It is possible that echinoderms, invertebrate chordates, and vertebrates came from ancestral, stationary animals that caught food in their tentacles. Modern

vertebrates may have come from free-swimming larval stages of ancestral invertebrate chordates. Scientists have recently found fossil forms of organisms that are similar to present-day lancelets. These fossil forms are in rocks that are 550 million years old. These fossils tell us that invertebrate chordates probably existed before vertebrate chordates.

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1- **Glencoe science reading essentials for biology the dynamics of life Copyright © Glencoe/McGraw-Hill, a division of The McGraw-Hill Companies, Inc.**

2- **Campbell, 7th edition**

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8-Fishes and Amphibians

What is a fish?

Fishes are vertebrates. This means that they have backbones. Fishes are members of the phylum Chordata. There are three subphyla in Chordata. The Urochordata include the tunicates or sea squirts. The Cephalochordata include the lancelets. Vertebrata are the vertebrates. Fishes, amphibians, reptiles, birds, and mammals are all vertebrates. Remember that vertebrates are chordates. All chordates have a notochord, pharyngeal pouches, a postanal tail, and a dorsal hollow nerve cord. In vertebrates the notochord that is found in the embryo becomes a backbone in the adult animal.

All vertebrates are bilaterally symmetrical. They are coelomates and have endoskeletons. Their closed circulatory systems flow blood through the body in enclosed blood vessels. Vertebrates have complex brains, sense organs, and efficient respiratory systems.

How many classes of fishes are there?

There are four classes of fishes. Fishes that do not have jaws belong to the superclass Agnatha. Agnatha means *without jaws.* Within the superclass Agnatha, there are two classes. Hagfish belong to the class Myxini (mik SEE nee). Lampreys belong to the class Cephalaspidomorphi (se fa LAS pe do MOR fee). Sharks and rays, whose skeletons are made of cartilage, not bone, belong to the class Chondrichthyes (kahn DRIHK theez). Fishes whose skeletons are made of cartilage are called cartilaginous fishes. Cartilage is a tough, flexible material. Fishes with bone skeletons belong to the class called Osteichthyes (ahs tee IHK theez).

Fishes live in almost every kind of water environment on Earth. They live in salt water and freshwater. They live in shallow, warm water, as well as deep, cold water that has very little or no light.

How do fishes breathe?

Fishes breathe by using their gills. Notice in the figure to the right that gills are made up of filaments, which are feathery, thread-like structures. These filaments contain tiny blood vessels called capillaries. As a fish takes water in through its mouth, the water flows over the gills. The water goes out through slits in the side of the fish. Oxygen and carbon dioxide are exchanged through the tiny blood vessels, or capillaries, in the gill filaments.

What kind of hearts do fishes have?

All fishes have two-chambered hearts. Blood that no longer has oxygen flows into one chamber of the heart from the body tissues. The second heart chamber pumps blood directly to the capillaries located in the fish's gills. Oxygen is picked up from the water passing over the gills. Carbon dioxide is released. The oxygen is carried from the gills to the fish's body tissues. Blood flows through a fish's body slowly. The flow of blood is shown in the figure to the right. Most of the heart's pumping action is used to push blood through the gills, not through the body tissues.

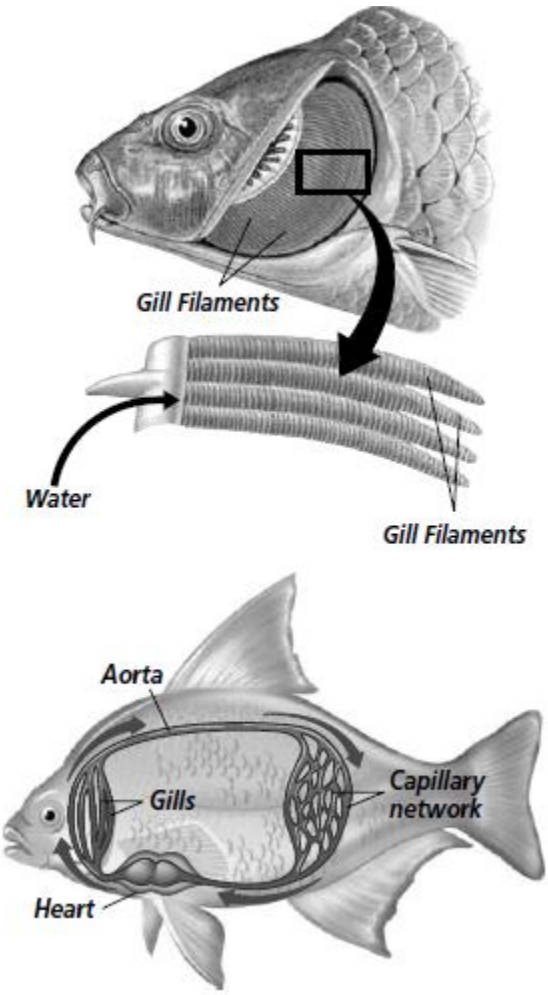
How do fishes reproduce?

All fishes reproduce sexually. The method of reproduction varies from one fish species to another. For most fishes, fertilization and development of the embryos is external. Eggs and sperm are released directly into the water. Some species of fishes leave their eggs and sperm in a more protected area, such as on plants floating in the water. Most fishes produce large numbers of small eggs at one time. Hagfishes produce small numbers of large eggs.

Fishes whose skeletons are made of cartilage have internal fertilization. Skates leave fertilized eggs on the ocean floor. Some female sharks and rays carry developing young inside their bodies. These young fishes are well developed when they are born. This increases their chance for survival.

Most bony fishes have external fertilization and development. This type of external reproduction is called **spawning.** Fishes that spawn, such as cod, may produce as many as 9 million eggs. Most of these fishes provide no care for their young after they spawn.

Only a few of the young will live to be adults. In some bony fishes, such as guppies and mollies, fertilization and development take place internally. Some fishes, such as the mouth-brooding cichlids, stay with their young after they hatch. When young cichlids are threatened by predators, the parent fishes collect their young in their mouths to protect them.



What kind of fins do fishes have?

Fishes that belong to Chondrichthyes and Osteichthyes have paired fins. The **fins** are fan-shaped membranes. Fins are used for balance, swimming, and steering. Fins are attached to and supported by the endoskeleton. Fins

foreshadowed the development of limbs for moving on land and wings for flying.

Do fishes have developed sensory systems?

All fishes have well-developed sensory systems. Cartilaginous and bony fishes have a lateral line system that helps them sense objects and changes in their environment. The **lateral line system** is a line of fluid-filled canals that runs along the sides of a fish. These canals make it possible for the fish to detect movement and vibrations in the water.

Fishes have eyes that allow them to see objects. The eyes also help fishes see contrasts between light and dark in the water. Some fishes see well. Other fishes that live deep in the ocean where there is little or no light have little vision or their eyes do not function at all.

Some fishes have a developed sense of smell. These fishes can smell even small amounts of a chemical in the water. Sharks can follow a trail of blood for several hundred meters. This ability helps sharks find their prey.

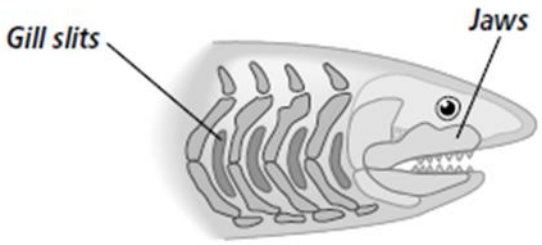
What are fish scales?

Cartilaginous fishes and bony fishes have scales. Fish **scales** are thin bony plates formed from the skin. On some species, the scales are intermittent. This means that the fish body is not completely covered in a continuing pattern of scales. Some species have overlapping rows of scales. Scales have various shapes. They can be toothlike, shaped like diamonds, shaped like cones, or they may be round. Shark scales resemble teeth that are found in other vertebrates.

Do fishes have jaws?

The development of jaws in ancestral fishes was an important event. Jaws, such as those shown in the figure to the right, enable a fish to grasp and crush its food. Jaws allowed early fishes to eat a greater variety of organisms. This is one of the reasons that early fishes grew very large.

Sharks have jaws. They also have up to 20 rows of teeth that are continually replaced. The teeth of a shark point backward. This prevents prey from escaping from the shark’s mouth.



Fish with jaws

What kinds of skeletons do most fishes have?

Most fishes have bony skeletons. They belong to the class Osteichthyes, the bony fishes. The other two classes of fishes have skeletons made of cartilage, not bone. Bone is the hard, mineralized living tissue that makes up the endoskeleton of most vertebrates. There are many differences among species of bony fishes.

They live in different habitats, eat different organisms, and have different shapes. Their bony skeletons allow them to adapt to a variety of water environments.

Are bony fishes flexible?

Bony fishes have a backbone composed of separate, hard segments. These segments are called vertebrae. The evolution of a backbone made of separate vertebrae in the vertebrate skeleton was important. Vertebrae provide the major support structure of the vertebrate skeleton. Because the vertebrae are separate, the animal is flexible. It can bend its back and its body. This is especially important for fish movement. When a fish swims, it continually flexes its backbone. Some fish can swim fast because of their flexible skeletons.

What is a swim bladder?

A **swim bladder** is a thin-walled internal sac. It is located just below the backbone in most bony fishes. The swim bladder can be filled with mostly oxygen or nitrogenous gases that diffuse out of a fish's blood. If a fish has a

swim bladder, it can control its depth by regulating the amount of gas in the bladder. The gas works like the gas in a blimp that adjusts the height of the blimp above the ground. Some fishes have a special duct that attaches the swim bladder to the esophagus. Fishes use this duct to expel gases from the swim bladder. In fishes that do not have this duct, the swim bladder empties when the gases from the bladder diffuse back into the fish's blood.

Diversity of Fishes

Fishes can be tiny. The dwarf goby is less than 1 cm long. Fishes also can be huge. The whale shark can grow to 15 m—about the length of three cars.

What are Agnathans?

Hagfishes and lampreys are members of the superclass Agnathans. The skeleton of an Agnathan is made of cartilage, not bone. **Cartilage** is a tough, flexible material. Agnathans do not have jaws. A hagfish has a toothed mouth. It feeds on dead or dying fish. The hagfish can drill a hole into a fish and suck out the blood and the insides. Lampreys are parasites. Lampreys have sharp teeth and suckerlike mouths. They use their mouths to attack other fishes. They use their teeth to scrape away the flesh from their prey. Then they suck out the blood.

Which fishes are cartilaginous?

Sharks, skates, and rays all have skeletons that are composed of cartilage, not bone. They are called cartilaginous fishes. They belong to the class Chondrichthyes. These fishes are similar to the sharks, skates, and rays that lived more than 100 000 years ago. Because of this similarity, sharks, skates, and rays are considered living fossils. Sharks are probably the best-known predator in the ocean.

Rays also are predators. They feed on or near the ocean floor. Rays have flat bodies and broad pectoral fins. A pectoral fin begins near the fish's chest. Rays flap their fins up and down slowly. This creates a gliding motion that rays use as they look for mollusks and crustaceans on the ocean floor. Some species of rays have sharp spines with poison glands on their tails. They use these glands to protect themselves. Other species of rays have organs that

generate electricity so that the rays can stun or kill their prey and their predators.

Are there any subclasses of bony fishes?

There are two subclasses of bony fishes—lobe-finned fishes, including lungfishes, and ray-finned fishes. There are seven living species of lobe-finned fishes. Six species of lobe-finned fishes are lungfishes. They have both gills and lungs. The other species is the coelacanth (SEE luh kanth). Ray-finned fishes include catfish, perch, salmon, and cod. The fins of these fishes are fan-shaped membranes. Stiff spines called rays support the fins.

Origins of Fishes

Scientists have found fossils of fishes that existed during the late Cambrian Period, 500 million years ago. At that time, early jawless fishes called ostracoderms (OHS trah koh durmz) were the main vertebrates on Earth. Most ostracoderms became extinct at the end of the Devonian Period, about 354 million years ago. Presentday agnathans appear to be descendants of ostracoderms.

Ostracoderms swam slowly over the seafloor. They had cartilaginous skeletons and heavy, bony, external armor. Shields of bone covered their heads and necks. In ancestral fishes, bone formed into plates, or shields, that protected the fishes. The development of bone in early vertebrates was important because bone provides a place for muscles to attach. This enabled the fishes to move more quickly and efficiently.

Ostracoderms may have been the common ancestor of all fishes. Modern cartilaginous and bony fishes evolved during the Devonian Period. Lobe-finned fishes, such as the coelacanths, are another ancient group. They appear in the fossil record about 395 million years ago. They had lobelike, fleshy fins, and they lived in deep places in the ocean. This makes them hard to find. The skeletal structure of fleshy fins is believed to be an ancestral trait of all animals that have four limbs, called tetrapods. The earliest tetrapods had gills and were aquatic.

Amphibians

What is an amphibian?

Amphibia (am FIHB ee uh) means double life. Animals that belong to the class Amphibia change from aquatic to semiterrestrial during their life cycles. This is how they got the name amphibian. As larvae, almost all of these animals are completely aquatic. When most amphibians reach the adult stage, they breathe air. Amphibians can be found on land, but they must live near water or other moist areas. Therefore, these animals are called semiterrestrial. There are three orders in the class Amphibia. Salamanders and newts belong to the order Caudata (kaw DAH tuh). Frogs and toads belong to the order Anura (uh NUHR uh). Caecilians, amphibians that do not have legs, belong to the order Apoda (uh POH duh).

Amphibians have thin, moist skin. Most amphibians have four legs. Most adult amphibians can exist on land, but nearly all of them need water for reproduction. Fertilization in most amphibians is external, and water is needed to carry the sperm to the eggs. The eggs do not have a membrane or a shell to protect them. They must be laid in water or in other damp areas.

What is an ectotherm?

An **ectotherm** (EK tuh thurm) is an animal that has a variable, or changing, body temperature. Amphibians cannot regulate their own body temperature or maintain their temperature at a stable level as humans do. An ectotherm gets its heat from external sources. Amphibians are more common in areas that have warm temperatures all year round because they are ectotherms. Many biological processes require certain temperature ranges. Because of this, amphibians are dormant, or completely inactive, when they live in areas that are too hot or too cold for them during certain parts of the year. During these hot and cold times, many amphibians burrow into the mud and stay buried in the mud until the temperature changes.

How does an amphibian change during metamorphosis?

Most amphibians go through metamorphosis. Fertilized frog and toad eggs hatch into tadpoles. This is the totally aquatic stage. Tadpoles have fins, gills,

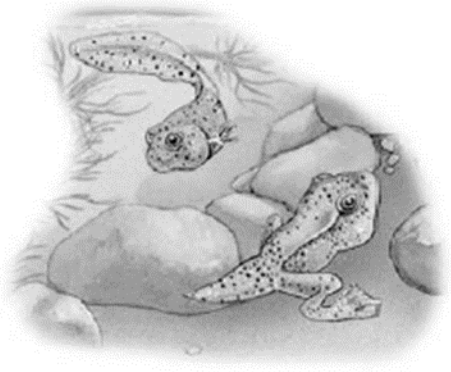
and a two-chambered heart like fishes. As tadpoles grow into adult frogs and toads, they develop legs, lungs, and a three-chambered heart.

Young salamanders resemble adult salamanders. Most salamander larvae also are aquatic. In this stage they have gills, and they usually have a tail fin. Most adult salamanders do not have gills or fins. They breathe through their skin or with their lungs. Some salamanders do not have lungs. They can only breathe through their moist skin. Salamanders that live completely on land do not have a larval stage. When these young salamanders hatch, they look like small adults. Most salamanders have four legs, but some have only two front legs.

What kind of hearts do amphibians have?

Amphibians have a three-chambered heart. When early amphibians began to walk, walking required a great deal of energy from food. It also required a large amount of oxygen for respiration. The evolution to a three-chambered heart helped to ensure that the amphibian's cells would receive enough oxygen. The change from a two- to a three-chambered heart was an important evolutionary change.

In the three-chambered heart, one chamber receives oxygenrich blood from the lungs and the skin. Another chamber receives oxygen-poor blood from the body tissues. Blood from both of these two chambers goes into the third chamber of the heart. This third chamber pumps oxygen-rich blood into the body tissues. It also pumps oxygen-poor blood back to the lungs and the skin. This blood then picks up oxygen. The three-chambered heart mixes some oxygen-rich and some oxygen-poor blood.



Oxygen-rich and oxygen-poor blood also are mixed in blood vessels that lead away from the heart. This is why the skin in amphibians is more important than the lungs for gas exchange. The skin of an amphibian must stay moist to exchange gases. This means that most amphibians have to live on the water's edge or in other, very moist areas. Some newts and some salamanders spend their entire lives in the water. Toads, which have a thicker skin, live primarily on land. They return to water to reproduce.

Amphibian Diversity

Because most amphibians depend on water to reproduce, they must live on the edges of ponds, streams, and rivers, or in areas that remain damp during parts of the year. Amphibian species are found worldwide.

How are frogs and toads different from other amphibians?

Frogs and toads are members of the order Anura. Frogs and toads do not have tails. Frogs have long back legs and smooth, moist skin. Toads have short legs and bumpy, dry skin. Frogs and toads have jaws and teeth. They are predators. They eat insects and worms. To defend themselves from predators, many frogs and toads secrete chemicals through their skin.

Frogs and toads have vocal cords. **Vocal cords** are bands of tissue located in the throat. As air passes over the vocal cords, they vibrate. This makes molecules in the air vibrate, and a wide range of sounds is produced. In many male frogs, air passes over the vocal cords, and then goes into a pair of vocal sacs that are underneath the throat. This enlarges these sacs, making them look like small balloons.

Most frogs and toads spend part of their lives in water and part of their lives on land. They breathe through lungs or through their skins. Because they breathe through their skins, they are exposed to pollutants in the air, on land, or in the water.

How are salamanders different from other amphibians?

Salamanders belong to the order Caudata. Salamanders have long, slender bodies. They have necks and tails. Salamanders look like lizards, but they

have smooth, moist skin. They do not have claws. Some salamanders spend their entire life cycle in water.

Others live on land in damp places. Salamanders can be small, a few centimeters long, or they can be up to 1.5 m long. When young salamanders hatch from eggs, they look like small adults. Salamanders are carnivores, or meat-eaters.

How are caecilians different than other amphibians?

Caecilians belong to the order Apoda. They do not have limbs. Caecilians are burrowing amphibians. Some have short tails; others have no tail at all. They have small eyes, but are often blind. Caecilians eat earthworms and other invertebrates that live in the soil. All caecilians have internal fertilization. They live primarily in tropical areas.

Origins of Amphibians

Tetra pods, animals with four legs, evolved over 360 million years ago. One type of tetrapod developed gills for breathing and a finned tail for swimming. These tetra pods may have used their limbs to move along the bottom of marshlands. Later fossils show the four limbs located further below the body. These limbs could lift the body off the ground. Amphibians probably arose as they developed the ability to breathe air through well-developed lungs. The ability to live on land depended on adaptations, or changes, that would provide support for the body, protect the membranes involved in respiration, and provide for efficient circulation.

What were the benefits and challenges of living on land?

There were many benefits to living on land. There was a large food supply and good shelter. At the time, there were no predators. There was more oxygen on land than in the water. However, life on land was dangerous. Air temperature varied. When the body was out of the water, it was heavy and clumsy. Movement was more difficult.

Amphibians first appeared about 360 million years ago. They probably evolved from an aquatic tetrapod around the middle of the Paleozoic Era. The climate on Earth was warm and wet. Because these early amphibians could

breathe through their lungs, gills, or skin, they became the dominant vertebrates on the land.

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2- **Campbell, 7th edition**

University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

9- Reptiles and Birds

What is a reptile?

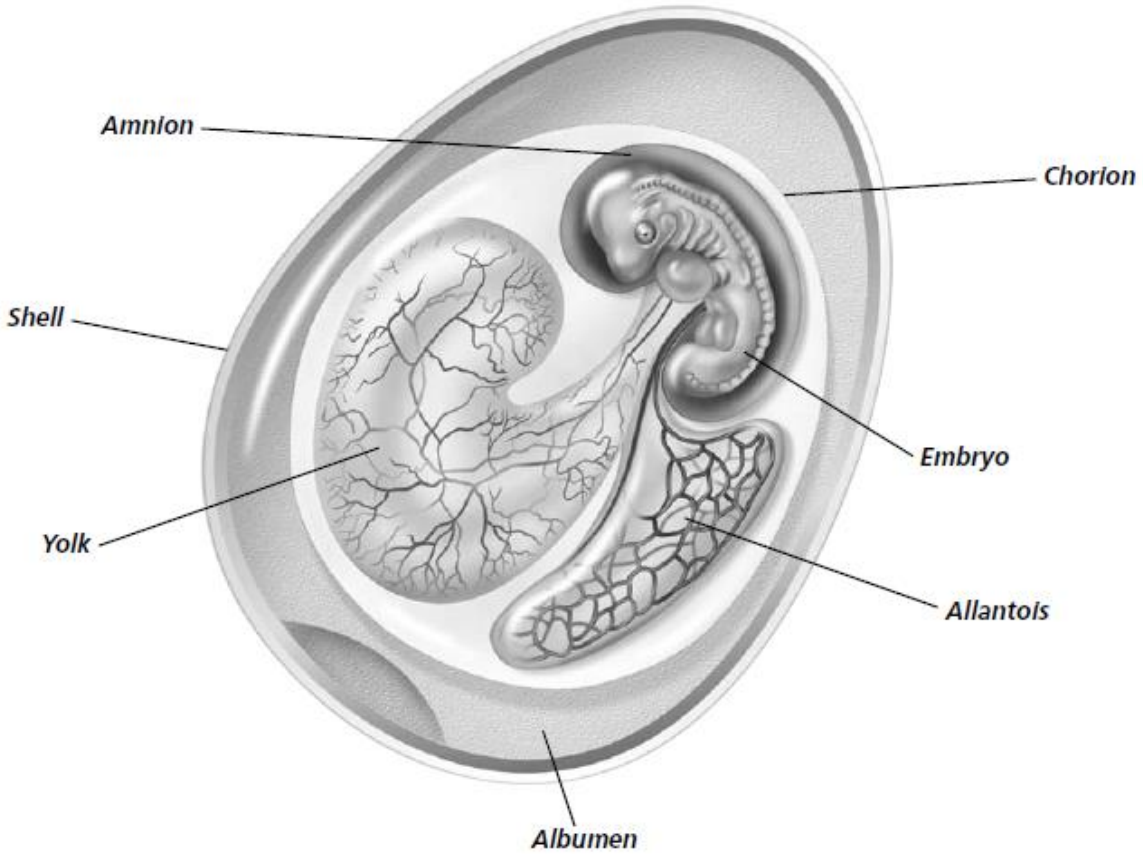
Snakes, turtles, alligators, and lizards belong to the class Reptilia. Early reptiles, called stem reptiles, were the first animals that adapted to life on land. Unlike the amphibians, reptiles can complete all their life cycles on land. They do not need a watery environment to reproduce.

How does scaly skin protect reptiles?

Reptiles have a dry, thick skin. The skin is covered with scales. The scales are made of protein and are part of the skin itself. Scales prevent the loss of moisture from the body and provide protection from predators. Gas exchange cannot occur through scaly skin. The lungs are the primary organs for gas exchange in reptiles.

How do reptiles reproduce?

Most reptiles reproduce by laying eggs on dry land. Some snakes give live birth to well-developed young. All reptiles have internal fertilization. Usually, eggs are laid after fertilization occurs. Reptile eggs are amniotic (am nee AH tihk). An **amniotic egg** provides nourishment, or food, for the embryo. An embryo is the earliest stage of growth and development of both plants and animals. The amniotic egg, shown in the figure on page 377, contains membranes that protect the embryo while it develops on land. An amniotic egg serves as the embryo's total life-support system. The evolution of the amniotic egg was the adaptation that enabled reptiles to reproduce on land rather than in water.



The embryos develop after the eggs are laid. Most reptiles lay their eggs under rocks, tree bark, or grass. Some reptiles dig holes or prepare a nest for the eggs. Most reptiles provide no care for the young, but female crocodiles may guard their nests from predators.

How have body changes helped reptiles?

The legs of amphibians are set at right angles to the body. The legs of early reptiles were placed more directly under the body. This under-the-body positioning provided better body support. It also made running and walking easier. Because reptiles with legs could run and walk, they could catch their prey more easily. They could also better avoid their predators. Reptiles with legs also have claws. Sharp claws help them catch food and protect themselves. Other evolutionary changes in the jaws and teeth of early reptiles helped them to use other resources found on land.

What kind of hearts do reptiles have?

Most reptiles, like amphibians, have three-chambered hearts. Some reptiles, including crocodiles and alligators, have four chambered hearts. A four-chambered heart completely separates the supply of blood with oxygen from the blood that does not have oxygen. This separation allows more oxygen to reach body tissues. Land animals require more energy than aquatic animals. Delivering more oxygen to body tissues was an important adaptation that enabled reptiles to live on land.

Are reptiles ectotherms?

Reptiles are ectotherms. They depend on external heat to maintain their body temperatures within the range that they need for their bodies to function. Reptiles may sun themselves to get warm and then find shade when they get hot.

Because reptiles depend on their environment to provide warmth for their bodies, they do not live in extremely cold regions. Reptiles are commonly found in warmer or tropical regions. They also live in hot desert climates. Many species of reptiles become dormant, or inactive, during the colder months if they live in areas such as the northern United States.

How do reptiles obtain their food?

Some reptiles are herbivores, and some reptiles are carnivores. All reptiles, however, have adaptations that make it possible for them to find food. Most turtles and tortoises are too slow to be effective predators. Most of these species are herbivores, but the turtles and tortoises that are predators eat worms and mollusks. Snapping turtles are aggressive predators. They attack fish and amphibians and will even pull ducklings under the water.

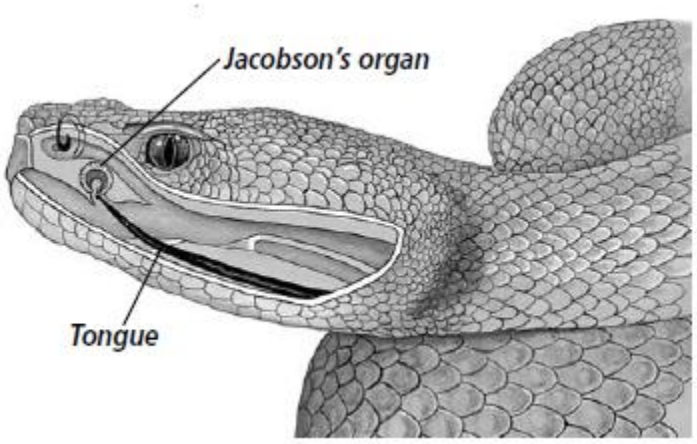
Lizards mainly eat insects but some species of lizards are herbivores. The marine iguana of the Galpagos Islands eats marine algae. The largest lizard, the Komodo dragon, lives on several islands in Indonesia. The Komodo dragon is a strong predator and will attack humans. Although lizards, especially the large ones, may look slow or clumsy, they are able to run for short periods of time. They use this ability to catch their prey.

Snakes are also effective predators. Some species, including rattlesnakes, have poison fangs that they use to subdue or kill their prey. A constrictor wraps its body around its prey to prevent the prey from breathing.

How do reptiles use their sensory organs?

Reptiles have several sensory organs that help them detect danger. The sensory organs also help them detect food. The heads of some snakes have heat-sensitive organs. These organs or pits enable snakes to detect tiny changes in air temperature. These changes are brought about when a warm-bodied animal comes into a snake's environment.

Snakes and lizards also have a keen sense of smell. A snake will flick its tongue out. The tongue picks up molecules of air. The snake then pulls its tongue back into its mouth and moves its tongue into its Jacobson's organ. The **Jacobson's organ** is a pitlike structure located in the roof of the mouth in both snakes and lizards. Special cells in the Jacobson's organ help the animal identify and differentiate the smells found in the air molecules.



Diversity of Reptiles

There are four orders in the class Reptilia. Snakes and lizards belong to the order Squamata. Turtles belong to the order Chelonia. Crocodiles and alligators belong to the order Crocodilia. Tuataras, lizard like reptiles, belong to the order Rhynochocephalia.

How are turtles different from other reptiles?

Turtles are the only reptiles that have a shell made up of two parts. The dorsal, or top, shell of the turtle's body is called the carapace. The ventral, or bottom, shell is called the plastron. The vertebrae and the expanded ribs of turtles are connected to the inside of the carapace. Most turtles have a two-layer shell. The inner layer is hard and bony. The outer layer is made of horny keratin. Keratin is a protein found in the exterior portion of the epidermis. Keratin helps to protect the living cells that are found in the interior epidermis. In a few species of turtles, the shell is made of tough, leathery skin. Most turtles can draw their limbs, their tails, and heads into their shells. They do this to protect themselves against predators. Turtles do not have teeth. They do have powerful jaws that have a beaklike structure. Turtles use their jaws to crush their food.

Not all turtles live on land. Some are aquatic. Turtles that live on land are called tortoises. Tortoises eat fruit, berries, and insects. The largest tortoises in the world live on the Galapagos Islands. Some adult marine turtles swim long distances to lay their eggs. For example, green turtles travel from the coast of Brazil to Ascension Island in the Atlantic Ocean, more than 4000 km, to lay their eggs.

How are crocodiles different from other reptiles?

Crocodiles and alligators belong to the order Crocodilia. They are excellent, fast hunters. When they float in the water, only their eyes and nostrils remain above water. Crocodiles have long, slender snouts, while alligators have short, broad snouts.

Both crocodiles and alligators have powerful jaws and sharp teeth. They catch their prey in their jaws and teeth, drag it underwater, and hold it there until it drowns. Crocodiles and alligators can breathe air with their mouths full of food and water. This makes them especially efficient predators. The American alligator lives in freshwater. It can be found in the southeastern regions of the United States. The American alligator can grow up to 5 m long. The American crocodile lives only in salt water, and it can be found in the estuaries of

southern Florida. Crocodiles, such as the Nile crocodile of Africa, can grow longer than alligators.

Crocodiles and alligators do not migrate to reproduce. They lay their eggs in nests on the ground. They stay close to their nests and guard them from predators. Several species hold their newly hatched young in their mouths and carry the young alligators or crocodiles to the safety of the water.

How are lizards and snakes different from other reptiles?

Most lizards have four legs. Many species are adapted to hot, dry climates. Lizards are found in many places throughout the world. Some lizards live on the ground while others burrow. Some lizards live in trees, and some lizards are aquatic. Snakes, unlike most vertebrates, do not have limbs. They do not have the bones to support limbs. Pythons and boas, however, do have bones of the pelvis. Snakes have many vertebrae, which permit them to move quickly over grass and rough land. Some snakes swim and climb trees.

Snakes usually kill their prey in one of three ways. Constrictors, including boas, pythons, and anacondas, wrap themselves around the prey and suffocate it. Venomous snakes use poison to paralyze or kill their prey. These include rattlesnakes, cobras, and vipers. When these snakes bite their prey, they inject poison from their venom glands. Most snakes are neither constrictors nor poisonous. They grab food with their mouths and swallow it whole. Snakes eat rodents, amphibians, insects, fishes, eggs, and other reptiles.

What are Rhynchocephalia?

There are two living species of this order. Both of the species are tuatara, and they are found only in New Zealand. Tuataras are the only survivors of a primitive group of reptiles. Tuataras have ancestral features including teeth that are fused to the edge of their jaws. Most of the other species of this order died out 100 million years ago.

Origins of Reptiles

The ancestors of snakes and lizards are traced to a group of early reptiles, called scaly reptiles. Scaly reptiles branched off from stem reptiles. Although the evolutionary history of turtles is not complete, scientists have suggested

that they may also be descendants of stem reptiles. Dinosaurs and crocodiles are the third group to descend from stem reptiles.

Scientists used to think that birds arose as a separate group from this third branch. Now there is fossil evidence that leads biologists to suggest that birds are the living descendants of the dinosaurs.

Birds

What is a bird?

There are more than 8600 species of modern birds in the class Aves. Biologists sometimes refer to birds as feathered dinosaurs. Fossil evidence may indicate that birds evolved from small twolegged dinosaurs called theropods. Birds have clawed toes and protein scales on their feet. Fertilization is internal, and birds produce amniotic eggs that have shells. Amniotic eggs provide nourishment for the embryo developing inside. The shells offer some protection for the embryo. All birds have feathers and wings, but all birds do not fly. Birds live all around the world, including Antarctica, deserts, and tropical rain forests.

What are feathers?

Feathers are lightweight, modified protein scales. Feathers provide insulation and enable a bird to fly. Birds frequently run their bills or beaks through their feathers. This process, called preening, keeps the feathers in good condition for flight. When it preens, a bird also rubs oil from a gland located near the tail onto the feathers. Water birds must do this in order to waterproof their feathers.

Bird feathers wear out and are replaced. Birds shed their old feathers and grow new ones in a process called molting. Most birds molt in late summer. They do not lose all their feathers at once and can continue to fly while they molt. Wing and tail feathers are usually lost in pairs. This enables a bird to maintain its balance while flying.

How do birds fly?

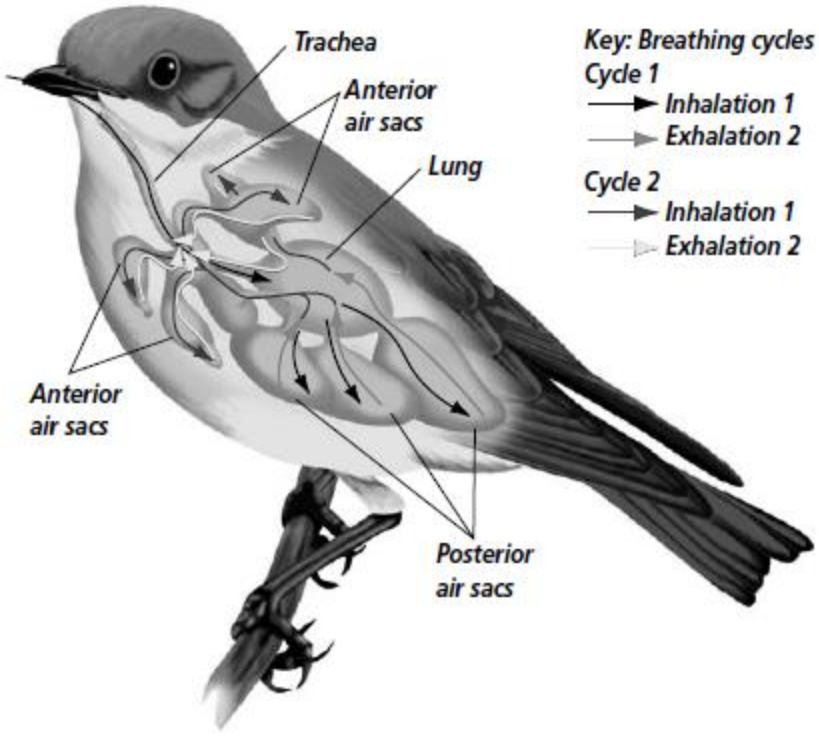
The front limbs of birds have changed into wings. Strong muscles that are used while a bird flies are attached to a large breastbone and to the upper bone

of each wing. The breastbone is called the **sternum.** The sternum supports the thrust and power that the muscles produce when the wings move to get the bird off the ground. Feathers and wings are adaptations that allow birds to fly.

Why do birds need strong circulatory and respiratory systems?

Birds need high levels of energy to fly. Several factors are involved in maintaining these high energy levels. Birds' four chambered hearts beat quickly. The rapid heartbeat moves oxygenated blood quickly through the body. The quick movement of blood keeps birds' cells supplied with the oxygen they need to produce energy.

Birds have two breathing cycles. A bird's respiratory system brings oxygenated air to the lungs both when the bird inhales and when it exhales. The respiratory system consists of lungs and anterior, or front, and posterior, or back, air sacs. Air follows a one-way path in birds. When a bird inhales in Cycle 1, oxygenated air passes through its trachea and into the lungs. The trachea is located in the throat portion of the bird. Gas exchange occurs in the lungs. Most of the inhaled air passes directly into the posterior air sacs. When a bird exhales the deoxygenated air from the lungs, oxygenated air goes into the lungs from the posterior air sacs. At the next inhalation in Cycle 2, the deoxygenated air in the lungs flows into the anterior air sacs. Then, at the next exhalation, air flows from the anterior air sacs out of the trachea.



What is an endotherm?

Birds are endotherms. An **endotherm** is an animal that maintains a nearly constant body temperature. It does not depend on the environment to change its body temperature. Because they are endotherms, birds can maintain the high energy levels they need to fly. Birds have different ways to retain and release body heat to maintain a constant body temperature. When it is cold, feathers help reduce heat loss. Feathers fluff up and trap a layer of air around the bird's body. This limits the amount of heat that the bird loses. When it is hot, birds flatten their feathers and hold their wings away from their bodies to release heat. Birds also pant to increase respiratory heat loss.

Because birds are endotherms, they can live in all environments. Birds are found in the arctic regions and in the hot tropics. In order to maintain the high energy levels, birds and other endotherms must eat large amounts of food.

How do birds reproduce?

Birds, like reptiles, reproduce by internal fertilization and they lay amniotic eggs. Bird eggs have a hard exterior shell. Birds usually make a nest and lay

their eggs in the nest. Nests may be made of bits of straw and twigs or may be a depression in the sand.

Some birds build nests that they add to every year. Birds **incubate** or sit on their eggs to keep them warm. Birds turn the eggs in the nest so that the eggs will develop properly. In some species, both parents, male and female birds, take turns incubating the eggs. In others, only one parent incubates the eggs. Bird eggs do not all look the same. Often the species of bird can be identified by the color, size, and shape of an egg.

Diversity of Birds

The basic form and structure of all birds are similar. They do show differences, or adaptations, depending on where they live and what they eat. Ptarmigans have feathered legs and feet, which serve as snowshoes in the winter, making it easier for them to walk in the snow. Penguins do not fly. Their wings and feet are modified for swimming. They have a thick layer of insulating fat on their bodies to help keep them warm. Owls have large eyes, a keen sense of hearing, and sharp claws, which make them successful predators of the night. They can swoop down on their unsuspecting prey.

The shape of a bird's beak or bill indicates what kind of food the bird eats. Hummingbirds have long beaks used to obtain nectar from flowers. Hawks have curved beaks that tear apart their prey. Pelicans have large bills with pouches. They use the pouches as nets for capturing fish. A cardinal has a short, stout beak for cracking seeds.

Origins of Birds

Scientists hypothesize that today's birds come from an evolutionary line of dinosaurs that did not become extinct. They evolved. *Archaeopteryx* is the earliest known bird in the fossil record.

Archaeopteryx was about the size of a crow and had feathers and wings similar to a modern bird. It also had teeth, a long tail, and clawed front toes. Fossil finds in China support the idea that birds evolved from a theropod dinosaur. It did not fly and it ran to capture its prey. It was about 1 m tall and had feathers. The feathers may have helped to insulate the animal or they may have been used for camouflage. Scientists suggest that feathers evolved before

flight. The figure at the left pictures how a theropod dinosaur may have looked.

Modern birds and theropods have other features in common. Both have a sternum, a wishbone, shoulder blades, flexible wrists, and three fingers on each hand.

References

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University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

10- Mammals

What is a mammal?

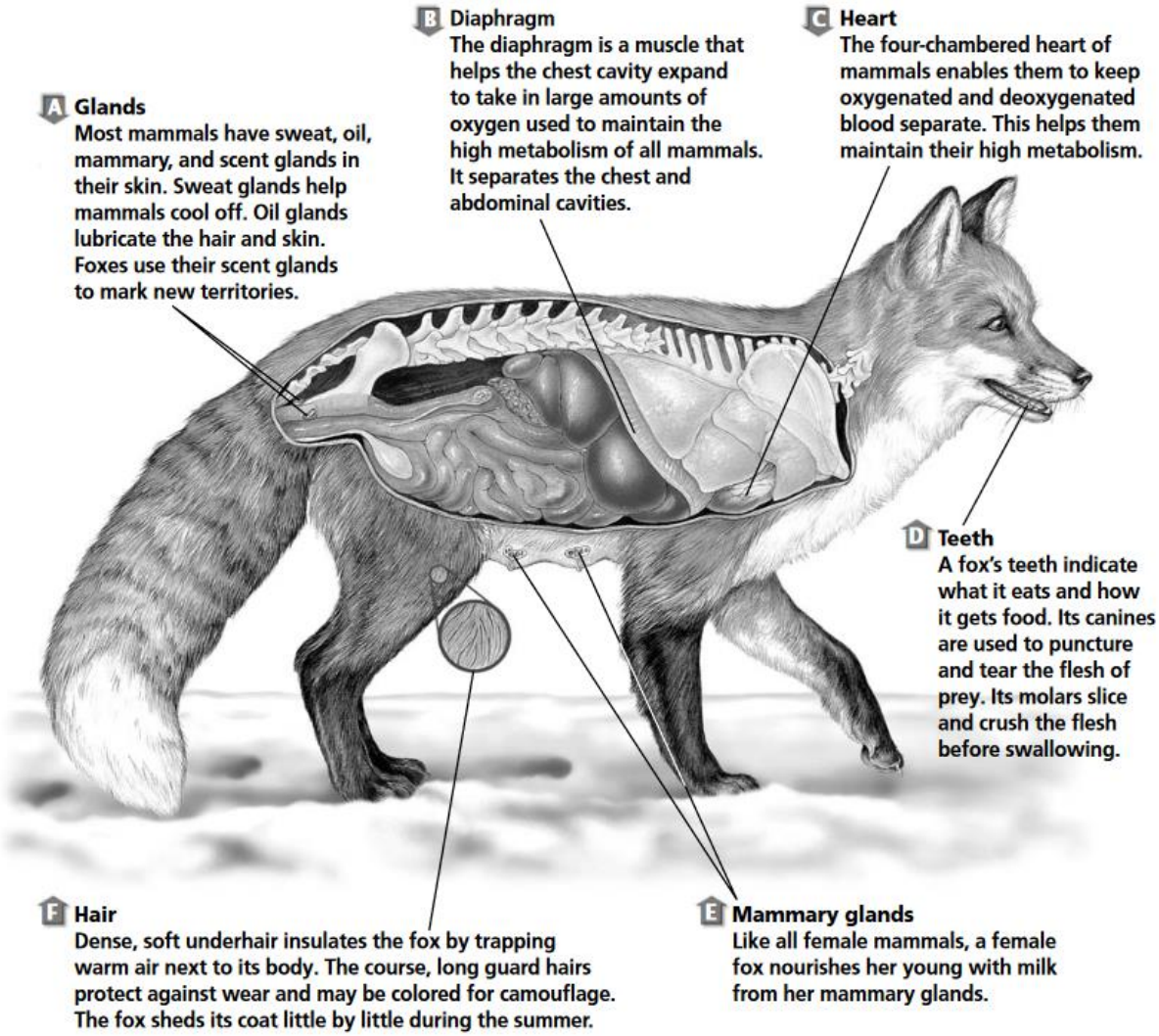
Mammals are endotherms. They have the ability to maintain a fairly constant body temperature. This enables mammals to live in almost every possible environment on Earth. Mammals have characteristics not found in other animals. Mammals have hair and produce milk to feed their young. Mammals have diaphragms, four-chambered hearts, specialized teeth, modified limbs, and highly developed brains. The major structures of a fox, a mam-mal, are illustrated on page 389.

What is the purpose of hair?

Mammal hair is made of the protein keratin. Hair may have evolved from scales. Hair provides insulation and water proofing,which conserve body heat. If body heat becomes too high, mam-mals have internal mechanisms that signal the body to cool off.Mammals cool by panting and through the actions of sweat glands. Panting releases water from the nose and mouth, which results in a loss of body heat. Sweat glands secrete moisture on to the surface of the skin. As the moisture evaporates, it transfer sheat from the body to the surrounding air.

How do mammals feed their young?

Mammals have several types of glands,which are groups of cells that secrete fluids. Glands produce saliva, sweat, oil, diges-tive enzymes, milk, and scent.Mammals feed their young from mammary(MA muh ree)glands.These may be modified sweat glands, which produce



and secrete milk. Milk is a liquid rich in fats, sugars, proteins,minerals, and vitamins. Mammals nurse their young until theyoung are able to digest and absorb nutrients from solid food

How do the processes of respiration andcirculation work in mammals?

Mammals need a high level of energy to maintain their endothermic metabolism. Remember that metabolism is all the chemical reactions that occur in an organism. The energy level is maintained when large amounts of nutrients and oxygen enter the body and reach the cells.

The diaphragm of mammals helps expand the chest cavity to allow the flow of oxygen into the lungs. A diaphragm(DI uh fram)is the sheet of muscle located beneath the lungs that separates the chest cavity from the abdominal cavity, where other organs are located. Once in the lungs, oxygen diffuses into the blood. As the chest cavity returns to its resting position, air is released.Like birds, mammals have a four-chambered heart. The blood with oxygen is kept completely separate from the blood without oxygen. This delivers a good supply of nutrients and oxygen to cells, supporting endothermic metabolism. Circulation also removes waste products from cells and helps regulate body tem-perature. Blood helps keep a constant cellular environment, maintaining homeostasis.

Why do mammals have varied teeth?

Teeth are a distinguishing feature of most mammals. Although fishes and reptiles have teeth, their teeth are all about the same.Mammals with teeth have different kinds that are adapted to the type of food the animal eats. The pointed incisors of moles grasp and hold small prey. The chisel-like incisors of beavers are modi-fied for gnawing. A lion’s canines puncture and tear the flesh of its prey. Premolars and molars are used for slicing or shearing,crushing, and grinding. By examining the teeth of a mammal, ascientist can determine what kind of food it eats.Many hoofed mammals have an adaptation called cud chewing.Cud chewing breaks down the cellulose in plant walls into nutrients that can be absorbed and used. When plant material is swallowed,it moves into the first two of four pouches. Bacteria break down cellulose in the cell wall. The partially digested food, called cud, is brought back into the mouth. After more chewing, the cud is swal-lowed again. When the food particles are small enough, they are passed on to the other stomach areas where digestion continues.

What are the benefits of limb adaptations?

Mammals have several adaptations for gathering food to meet their energy needs. For example, primates use their opposablethumb to grasp objects, such as fruits and other foods. Mammals have other limb modifications. Moles have short powerful limbs with large claws that help them dig. Bats have long finger bones that support the flight membrane of their wings.

Do mammals learn and remember?

One reason mammals are successful is that they protect their young, sometimes fiercely. They also teach their young survival skills. Mammals can accomplish complex behaviors, such as learn-ing and remembering what they have learned.Primates, including humans, are perhaps the most intelligent animals. For example, chimpanzees can use tools, operate machines, and use sign language to communicate with humans. The intelligence of mammals is a result of complex nervous sys-tems and highly developed brains. The outer layer of a mam-malian brain often is folded, forming ridges and grooves. These ridges and grooves increase the brain's active surface area.

Diversity of Mammals

Mammal Classification

Scientists place mammals into one of three subclasses based on their method of reproduction. The first subclass you will study is placental mammals. About 90 percent of all mammals are placen-tal. Placental mammals give birth to young that have developed inside the mother's uterus. Birth occurs when the body systems of the young are fully functional and they can live outside their mother's body. The uterus(YEWT uh rus) is a hollow, muscular rorgan in which offspring develop. The young are nourished inside the uterus through an organ called the placenta(pluh SEN tuh).The placenta develops during pregnancy. Nutrients and oxygen pass through the placenta to the developing embryo. Wastes from the embryo are removed through the placenta.The time during which placental mammals develop inside the uterus is called gestation(jeh STAY shun). The length of gesta-tion varies from species to species. Developing inside the mother's body is an adaptation that has helped mammals succeed. This is because the offspring are protected from predators and the envi-ronment during the early stages of development.

How is reproduction different in marsupials?

Marsupials make up the second subclass of mammals. A mar-supial(mar SEW pee uhl) is a mammal in which the young havea short period of development within the mother's body, followedby a period of development inside a pouch made of skin and hair on the outside of the mother's body

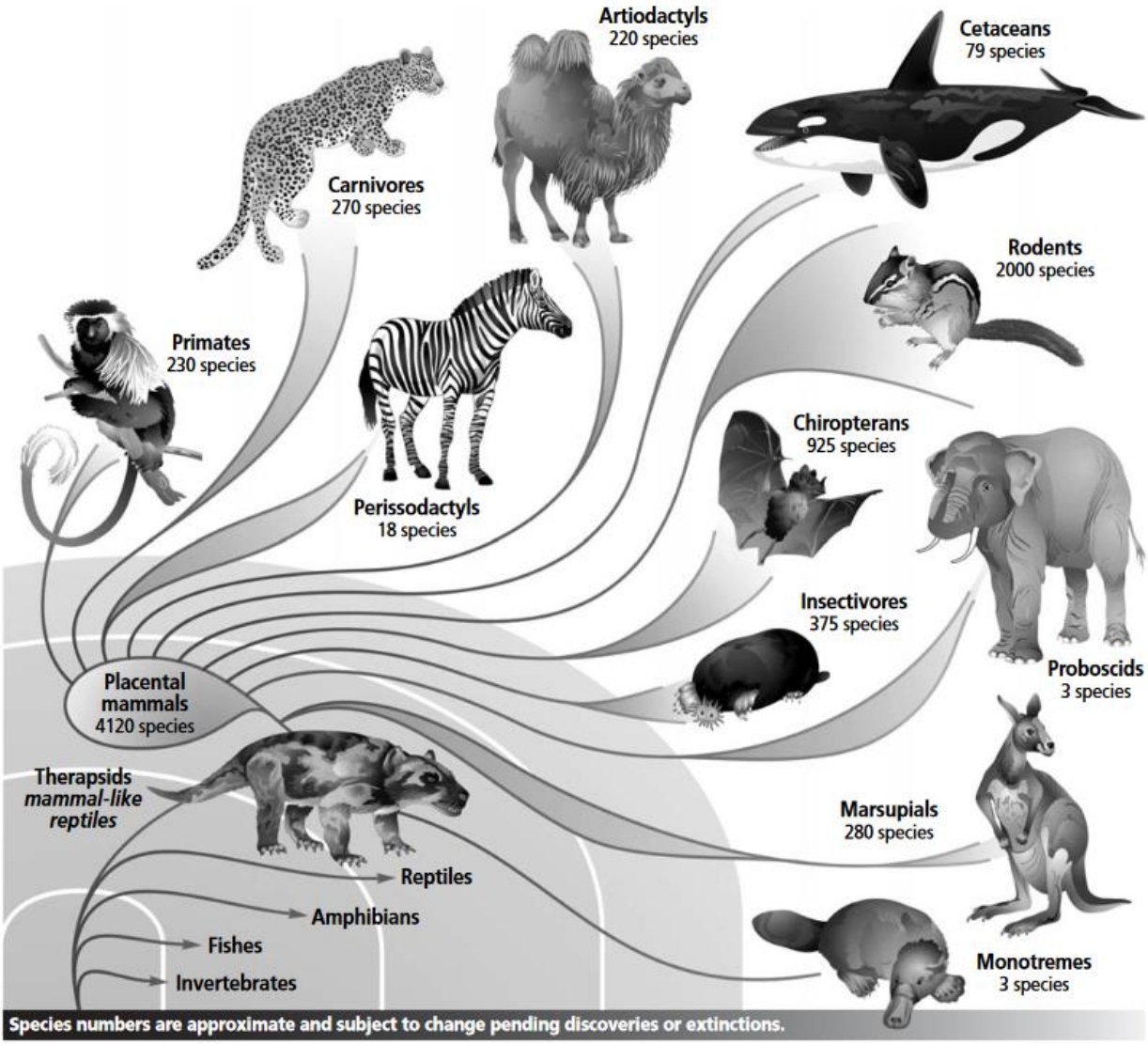
There is only one North American marsupial, the opossum.Most marsupials are found in Australia and surrounding is lands.The theory of plate tectonics explains why most marsupials are found in Australia. Scientists have found fossil marsupials on con-tinents that once made up Gondwana (a prehistoric super conti-nent made up of Australia, South America, Africa, India, andAntarctica). These fossils support the idea that marsupials origi-nated in South America, moved across Antarctica, and populatedAustralia before Gondwana broke up.

What effect have placental mammals had on marsupials?

Ancestors of today's marsupials did not have to share the land-mass that became Australia with the competitive placental mam-mals. Placental mammals evolved in other places. Marsupials were able to spread and fill niches similar to those occupied by placen-tal mammals in other parts of the world. For example, the giantanteater of Mexico, a placental mammal, has a long, sticky tongue that it uses to collect ants and termites from their nests. Thenumbat of Australia, a marsupial, fills the same niche. The num-bat has a long, sticky tongue that it uses to eat termites and ants.Since the introduction of placental mammals, such as sheep and rabbits, to Australia, many native marsupial species have become threatened, endangered, or even extinct. Remember that endan-gered means that the number of individuals falls so low that extinction is possible.

Which mammals lay eggs?

A mammal that reproduces by laying eggs is called a monotreme(MA nuh treem). Only three species of monotremes are alive today. Monotremes are found only in Australia, Tasmania, and New Guinea. The platypus is a mostly aquatic monotreme with a broad, flat tail much like that of a beaver. Its rubbery snout looks like the bill of a duck. The platypus has webbed front feet for swimming. All four feet have sharp claws for digging and burrowing. Much of the body is covered with thick, brown hair. Like all mammals, the platypus has mammary glands.There are two species of spiny anteaters, or echidnas, in the monotreme subclass. The spiny anteater has coarse, brown hair.Its back and sides are covered with sharp spines that it can raise to defend itself when threatened by enemies. From its mouth, the anteater extends its long, sticky tongue to catch insects.



Origins of Mammals

The first placental mammals appeared in the fossil record about 125 million years ago. The oldest placental mammal fossilis Eomaia,a group of mouse-sized animals. Scientists trace the origins of placental mammals to a group of reptilian ancestorscalled therapsids. Therapsids(ther AP sidz) had features of bother ptiles and mammals. They existed between 270 and 180 million years ago.

The mass extinction of the dinosaurs at the end of the Mesozoic Era, the breaking apart of Pangaea (all the continents formed a single land mass), and changes in

climate opened up new niches for early mammals to fill. Flowering plants appeared at the end of this era. They provided new living areas, food sources, and shel-ter. Some mammals that moved into the drier grasslands became fast-running grazers, browsers, and predators. The Cenozoic Era is sometimes called the golden age of mammals because of the dramatic increase in their numbers and diversity.

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11- Behavior

What is behavior?

A peacock displaying his colorful tail, a whale spending the win-ter months in the ocean off the coast of southern California, and alizard seeking shade from the hot desert sun are all examples ofanimal behavior. Behavioris anything an animal does in responseto a stimulus. A stimulus is an environmental change that directly influences the activity of an organism. The presence of a peahenstimulates the peacock to open its tail feathers. A change in thelength of daylight hours may cause the whale to leave its summer-time arctic habitat. Heat stimulates the lizard to seek shade.

Inherited BehaviorInheritance

plays an important role in the ways animals behave.You would not expect to see a hummingbird tunnel undergroundor a mouse fly. Yet, why does a mouse run away when a catappears? Why does a hummingbird fly south for the winter?These behaviors are genetically programmed. An animal's geneticmakeup determines how that animal reacts to certain stimuli.

Does natural selection favor certain behaviors?

Often, a behavior exhibited by an animal species is the result ofnatural selection. A variety of behaviors among individuals affectstheir ability to survive and reproduce. Individuals with behaviorthat makes them more successful at surviving and reproducingusually produce more offspring. These offspring inherit the geneticbasis for the successful behavior. Individuals with less successfulbehavior produce fewer offspring or none at all.

nherited behavior of animals is called innate(ih NAYT)behavior.A toad captures prey by flipping out its tongue. To capture prey, a toad must first be able to detect and follow theprey's movement. Toads have "insect detector" cells in the retinasof their eyes. As an insect moves across the toad's line of sight, the "insect detector" cells signal the brain, causing an innateresponse; the toad's tongue flips out. This is an innate behaviorknown as a fixed-action pattern. A fixed-action pattern is anunchangeable behavior pattern that, once begun, continues until completed.

What is the basis of innate behavior?

Scientists have found that an animal's hormonal balance and its nervous system affect how sensitive the individual is to certainstimuli. The sense organs responsible for sight, sound, touch, and odor identification are especially important. In fire antcolonies, a single gene influences the acceptance or rejection ofthe ant queen, thereby controlling the colony's social structure.Innate behavior includes fixed-action response, automaticresponse, and instincts.

Automatic Responses

What happens if something is thrown at your face? Your firstreaction is to blink and jerk back your head. Even if a protectiveclear shield is placed in front of you, you cannot stop yourselffrom behaving this way. This reaction is called a reflex, the simplest form of innate behavior. A reflex(REE fleks) is a simple,automatic response to a stimulus that involves no conscious con-trol. If you accidentally touch a hot stove, you will automaticallyjerk your hand away. Before you even have time to think about it,the reflex movement saves your body from serious injury.Another automatic response, called fight-or-flight response, has adaptive value. Think about a time when you were suddenlyscared. Your heart began to beat faster. Your skin got cold andclammy and your breathing rate increased. You were having afight-or-flight response. A fight-or-flight responsemobilizes thebody for greater activity. Your body is being prepared to eitherfight or run from the danger. A fight-or-flight response is auto-matic and controlled by hormones and the nervous system.

Instinctive BehaviorThe

fixed-action response of the toad capturing prey, the reflex response to a hot stove, and the fight-or-flight response arequick, automatic responses to stimuli. Some behaviors, however,take a longer time because they involve more complex actions. An instinct(IHN stingt) is a complex pattern of innate behavior.Instinctive behavior begins when the animal recognizes a stimulusand continues until all parts of the behavior are completed. Forexample, a female greylag goose instinctively retrieves an egg thatshe sees has rolled out of the nest.

Much of an animal's courtship behavior is instinctive. Courtshipbehavioris the behavior that males and females of a species carryout before mating. Like other instinctive behaviors, courtship has evolved through natural selection. Courtship behavior helpsmembers recognize other members of the same species. That isimportant for the survival of the species. In courtship, behaviorensures that members of the same species find each other andmate. Such behavior has adaptive value for the species. For exam-ple, different species of fireflies can be seen at dusk flashing dis-tinct light patterns. Female fireflies of one species respond only to those males flashing the species-correct patterns. Some courtship behaviors prevent females from killing malesbefore they have had the opportunity to mate. For example, insome spider species, the male is smaller than the female and risksbeing eaten if he gets close to her. Before mating, the male in some species presents the female with an object, such as an insectwrapped in a silk web. While the female is unwrapping and eatingthe insect, the male is able to mate with her without being attacked.Sometimes, after mating, the female eats the male anyway

Can instinctive behavior reduce aggression?

A territoryis a physical space an animal defends against othermembers of its species. It may contain the animal's breeding area,feeding area, potential mates, or all three. Animals that have territories will defend their space. They will drive away other

individuals of the same species. For example, a male sea lionpatrols the area of beach where his harem of female sea lions islocated. He does not bother a neighboring male that has a haremof his own. Both males have marked their territories and eachrespects the boundaries. However, if a young, unattached maletries to enter the sea lion's territory, the owner of the territorywill attack and drive the intruder away.Setting up territories reduces conflicts, controls populationgrowth, and provides for efficient use of environmental resources.When animals space themselves out, they don't compete for thesame resources within a limited space. This behavior improvessurvival rates. If the male has selected an appropriate site and theyoung survive, they may have inherited his ability to select anappropriate territory. Territorial behavior has survival value, notonly for individuals, but also for the species. Pheromones are chemicals that communicate informationamong individuals of the same species. Many animals producepheromones to mark territorial boundaries. For example, wolfurine contains pheromones that warn other wolves to stay away.Pheromones work day and night, and they work whether or notthe animals that made the marks are present.

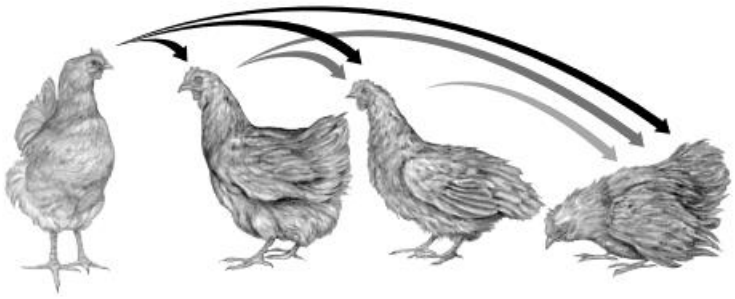
What is the purpose of aggressive behavior?

Animals sometimes act aggressively. Aggressive behaviorisused to intimidate another animal of the same species. Animalsfight or threaten one another in order to defend their young,their territory, or another resource, such as food. Aggressivebehavior includes bird calling, teeth baring, or growling. It is amessage to "keep away".Animals of the same species rarely fight to the death. Thefights are usually symbolic.

Why does aggressive behavior rarelyresult in serious injury?

It may be that the defeated individualshows signs of submission. These signs stop further aggression by the victor.What is a dominance hierarchy?Sometimes, aggressive behavior among several individuals resultsin a grouping in which there are different levels of dominant andsubmissive animals. A dominance

hierarchy(DAH muh nunts •HI rar kee) is a form of social ranking in which some individualsare more subordinate than others. Usually one animal is the top-ranking, dominant animal. This animal may lead others tofood, water, and shelter. A dominant male often sires most or all of the offspring. There might be several levels in the hierarchy.Individuals in each level are subordinate to the one above. Theability to form a dominance hierarchy is innate. However, the posi-tion each animal assumes may be learned. You may have heard theterm pecking order.It describes adominance hierarchy formed bychickens. The top-ranking chickencan peck any other chicken. Thechicken lowest in the hierarchy ispecked by all the other chickens inthe group.



What are some behavioral cues?

Sometimes behavior is a response to internal biologicalrhythms. Behavior based on a 24-hour day/night cycle is oneexample. Many animals, humans included, sleep at night and areawake during the day. Other animals, such as owls, have theopposite pattern. They sleep during the day and are awake atnight. A 24-hour, light regulated, sleep/wake cycle of behavior iscalled a circadian(sur KAY dee uhn) rhythm.Circadian rhythmskeep you alert during the day and help you relax at night. Even ifyou forget to set your alarm clock, they may wake you. Circadianrhythms are controlled by genes. They are also influenced by factors such as jet lag and shift work.Rhythms also occur on a yearly or seasonal cycle. Migration,for example, occurs on a seasonal cycle. Migrationis the instinc-tive, seasonal movement of animals. In North America about two-thirds of bird species fly south in the fall. There is food availablein areas such as South America. The birds fly north in the springto areas where they breed during the summer. Whales migrateseasonally too. Scientists hypothesize that change in day lengthstimulates the onset of migration in

the same way that it controlsthe flowering of plants. Butterflies, salmon, and caribou are just afew of the animals that make seasonal migrations. Migration requires remarkable strength and endurance. Thearctic tern migrates between the arctic circle and the Antarctic, aone-way flight of almost 18 000 km.Animals navigate in a variety of ways including:

•sing the positions of the sun and stars

- using geographic clues such as mountain ranges
- using Earth's magnetic field

It is possible that some animals migrate in response to coldertemperatures and shorter days, as well as hormones. Young animalsmay learn when and where to migrate by following their parents.

What happens to animals that do not migrate?

It is easy to see why some animals migrate from a colder placeto a warmer place, yet most animals do not migrate. The ways inwhich many animals cope with winter is another example ofinstinctive behavior.In preparation for winter, some animals store food in burrowsand nests. Other animals survive winter by undergoing changes intheir bodies that reduce the need for energy. Many mammals,some birds, and a few other types of animals go into a deep sleepduring the cold winter months. This period of inactivity is calledhibernation. Hibernation(hi bur NAY shun) is a state in whichthe body temperature drops. Oxygen use decreases and thebreathing rate falls to a few breaths per minute. Hibernation con-serves energy. Animals that hibernate typically eat large amountsof food to build up body fat before entering hibernation. The fatprovides fuel for the animal's body.What about an animal that lives in a climate that is hot year-round? Some animals respond to heat in a way that is similar tohibernation. Estivation(es tuh VAY shun) is a state of reducedmetabolism that occurs in animals living in conditions of intenseheat. Desert animals appear to estivate in response to lack of foodor periods of drought. On the other hand, Australian long-neckedturtles will estivate even when they are kept in a laboratory withconstant food and water. That means that estivation is an innatebehavior that depends on internal and external cues.

Learned Behavior

What is learned behavior?

Learning, or learned behavior, takes place when behaviorchanges through practice or experience. The more complex ananimal's brain, the more complicated the patterns of its learnedbehavior. Innate behaviors are more common in invertebrates.Learned behaviors are more common in vertebrates. In humans,many behaviors are learned.Learning has survival benefits for all animals. In changing envi-ronments, learning permits behavior to change in response to var-ied conditions. Learning allows an animal to adapt to change.Learned behavior has adaptive value. This ability is especiallyimportant for animals with long life spans. The longer an animallives, the greater the chance that its environment will change.

Kinds of Learned Behavior

Just as there are several types of innate behavior, there are sev-eral types of learned behavior. Some learned behavior is simpleand some is complex.

What is habituation?Horses normally shy away from an object that suddenly appearsfrom the trees or bushes, yet after awhile they disregard noisy carswith honking horns that speed by their pasture. This lack ofresponse is called habituation. Habituation(huh bit choo AY shun)occurs when an animal is repeatedly given a stimulus. However, the stimulus is not associated with any punishment or reward. Ananimal has become habituated to a stimulus when it stops respond-ing to the stimulus.

What is imprinting?

You may have seen young ducklings following their mother.This behavior is the result of imprinting. Imprintingis a form oflearning in which an animal forms a social attachment to anotherobject. This occurs at a specific, critical time in the animal's life.Many kinds of animals do not innately know how to recognizemembers of their own species. Instead, they learn how to do thisearly in life. Imprinting takes place only during a specific periodof the animal's life. It is usually irreversible. For example, birdsthat leave the nest immediately after hatching, such as geese,imprint on their mother. They learn to recognize her within a dayof hatching. Imprinting also

occurs in ducks. Ducklings quicklylearn to recognize and follow the first highly visible moving objectthey see. Normally that object is the ducklings' mother. Learningto recognize their mother and following her helps ducklings sur-vive. Their mother means that food and protection will be nearby.

Do animals learn by trial and error?

You may remember learning how to ride a bike. You probablytried it several times before you were able to do it successfully.Some animal abilities are acquired the same way. For example,nest building may be a learning experience. The first time a jack-daw builds a nest, it uses grass, bits of glass, stones, empty cans,old lightbulbs, and anything else it can find. With experience, thebird finds that grasses and twigs make better nests than lightbulbsand empty cans. The animal has used trial-and-error learninginwhich an animal receives a reward for making a particularresponse. When an animal tries one solution and then another inthe course of obtaining a reward, in this case a suitable nest, it islearning by trial-and-error.Learning happens more quickly if there is a reason to learn orbe successful. Motivationis an internal need that causes an ani-mal to act. In most animals, motivation often involves satisfying aphysical need such as hunger or thirst. If an animal is not moti-vated, it will not learn. Usually, animals that are not hungry willnot respond to a food reward.

Do animals learn by association?

Suppose you have a new kitten. Each time it smells the aromaof cat food in the can you are opening, it begins to meow. After afew weeks, the sound of the can opener attracts the kitten, causingit to meow. The kitten has become conditioned to respond to astimulus other than the smell of food. Classical conditioningislearning by association. You can see a well-known example of anearly experiment in classical conditioning in the illustration below.

A Pavlov noted that dogs salivate when they smell food. Responding to the smell of food is a reflex, an example of innate behavior.

B By ringing a bell each time he presented food to a dog, Pavlov established an association between the food and the ringing bell.

C Eventually, the dog salivated at the sound of the bell alone. The dog had been conditioned to respond to a stimulus that it did not normally associate with food.

What is the most complex type of learning?In a classic study of animal behavior, a chimpanzee was giventwo bamboo poles. Neither of the poles was long enough to reachsome fruit placed outside its cage. The chimpanzee connected thetwo shorter poles to make one longer pole. The chimpanzeesolved the problem of how to reach the fruit. This type of learn-ing is called insight. Insightis learning in which an animal usesprevious experience to respond to a new situation. It is the mostcomplex type of learning.Much of human learning is based on insight. When you were ababy you learned a great deal by trial-and-error. As you grewolder, you relied more on insight. Solving math problems is anexample of insight. Most likely your first math experience waslearning to count. Based on your understanding of numbers, youthen learned to add, subtract, multiply, and divide. Years later, youcontinue to solve math problems based on your past experiences.When you encounter a problem or a situation you have neverexperienced before, you use insight to solve it.

The Role of Communication

When you think about interactions among animals, you realizethat some sort of communication has taken place. Communicationis an exchange of information that results in a change of behavior.Black-headed gulls visually communicate their availability for mat-ing with instinctive courtship behavior. The pat on the head froma dog's owner after the dog fetches a stick signals a job well done.

Do most animals communicate?

Animals have several ways to communicate. They signal eachother by sounds, sights, touches, or smells. Sounds vibrate in alldirections. They can be heard a long way from their sources.Sounds such as songs, roars, and calls communicate a lot of infor-mation quickly. For example, the song of a male cricket tells hislocation, his sex, and his social status. Communication by soundusually varies according to species, so the male cricket also com-municates his species. Signals that involve odors may be spread over a wide area andcarry a general message. Ants leave odor trails that are followedby other members of their nest. These odors are specific to eachant species. As you know, pheromones such as those used bymoths may be used to attract mates. Because only small amountsof pheromones are needed, other animals, especially predators,may not be able to detect the odors.Some communication combines innate and learned behavior. In some species of songbirds, males automatically sing when theyreach sexual maturity. Their songs are specific to their species,and singing is an innate behavior. Sometimes members of thesame species that live in different regions learn variations of thesong. They learn to sing with a regional dialect. In other species,birds raised in isolation never learn to sing their species song

References

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2- **Campbell, 7th edition References**

University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

12-Skin, Bones and Muscles

The Body's Protection

Structure and Functions of theIntegumentary SystemSkin is your body's largest organ. It is also the main organ ofthe integumentary (inh TE gyuh MEN tuh ree) system. Hair,nails, and some glands are also part of the system. Skin covers ourbodies. It is composed of layers of the four types of body tissues.The four types of tissues are epithelial, connective, muscle, andnervous. Epithelial tissue is found in the outer layer of the skin. It covers body surfaces. Connective tissue consists of both toughand flexible protein fibers. Connective tissue holds your bodytogether. Muscle tissues interact with hairs on the skin to respondto stimuli, such as cold and fright. Nervous tissue helps humanssense external stimuli, such as pain or pressure.

What is the epidermis?

The epidermisis the outermost layer of the skin. It has twoparts—the exterior, or outside, part and the interior, or inside,part. The exterior layer of the epidermis consists of 25 to 30 layers of dead, flattened cells. These cells are continually shed.Although the cells are dead, they serve an important function.They contain a protein called keratin(KER uh tin). Keratinhelps protect the living cell layers underneath from exposure tobacteria, heat, and chemicals.The interior layer of the epidermis contains living cells. Theliving cells continually divide so that they can replace the deadcells. As new cells are pushed toward the skin's surface, the nuclei

in the cells degenerate, and the cells die. Then these cells are shed.This process takes about 28 days. So, every four weeks, all of thecells of the epidermis are replaced by new cells.Some of these cells in the interior layer contain melanin.Melaninis a pigment that colors the skin. Differences in skincolor are due to the amount of melanin produced by the cells.Melanin helps protect the underlying body cells from solar radia-tion, or sun damage, by absorbing ultraviolet light. If ultravioletlight damages cells, skin cancer could develop.The epidermis on the fingers and palms of

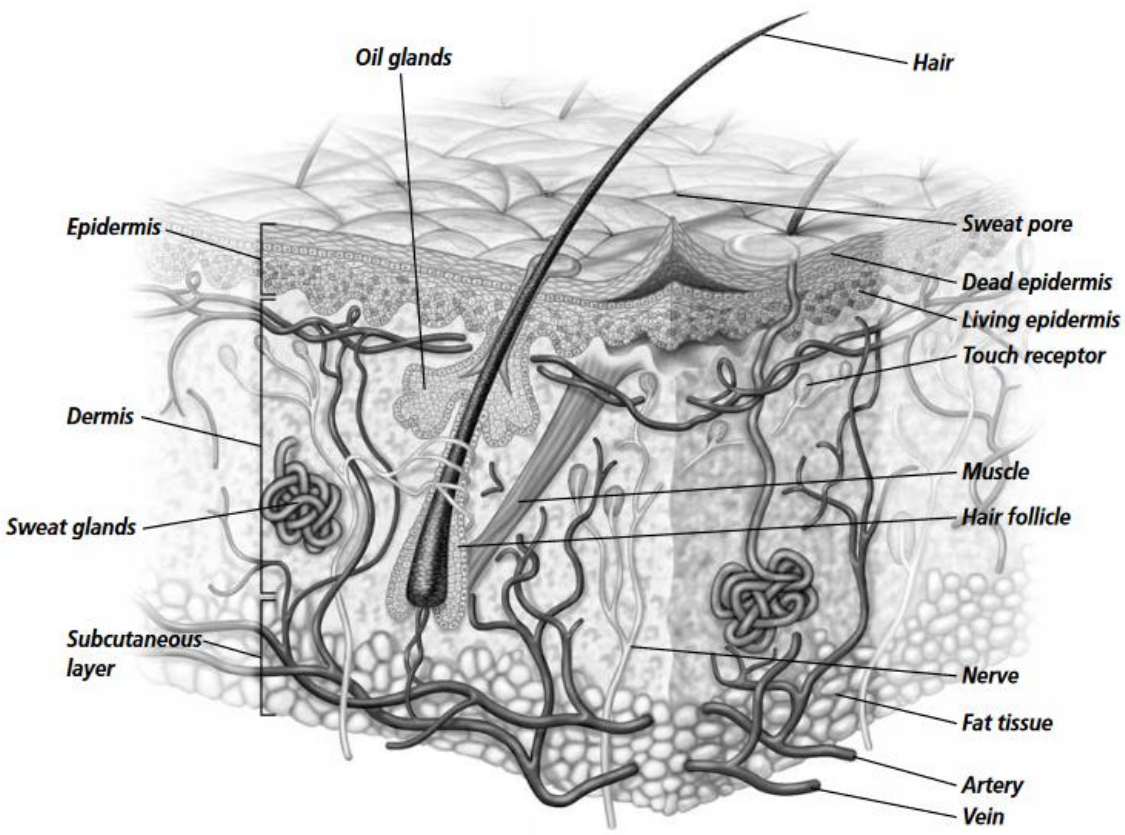
your hands and onthe toes and soles of your feet contains ridges and grooves thatare formed before birth. These ridges increase friction, whichimproves the skin's grip. Each person has a unique pattern ofridges and grooves. Because these patterns are unique, footprintsand fingerprints can be used to identify individuals.

What is the dermis?

The second principal layer of the skin is the dermis. The dermisis the inner, thicker portion of the skin. The thickness ofthe dermis changes from body part to body part. The thicknessdepends on how that body part is used.As shown in the illustration on page 411, the dermis containsstructures such as blood vessels, nerves, nerve endings, hair folli-cles, sweat glands, and oil glands. Underneath the dermis, theskin is attached to the underlying tissues by the subcutaneouslayer. This layer consists of fat and connective tissue. Fat depositshelp the body absorb impacts, retain heat, and store food. Hair is another structure of the integumentary system. It growsout of hair follicles,narrow, hollow openings in the dermis. Theprimary function of hair is to protect the skin from injury anddamage from the sun. Hair also provides an insulating layer of airjust above the surface of the skin. As hair follicles develop, theyare supplied with blood vessels and nerves. These follicles becomeattached to muscle tissue. Most hair follicles have an oil gland.Oil prevents hair from drying out and keeps the skin soft. Oil alsohelps prevent the growth of certain bacteria. When oil and deadcells block the opening of the hair follicle, pimples may form.

What are the functions of the integumentarysystem?

One function of skin is to help maintain homeostasis. Home-ostasis is the regulation of an organism's internal environment to maintain conditions suitable for its survival. Skin helps

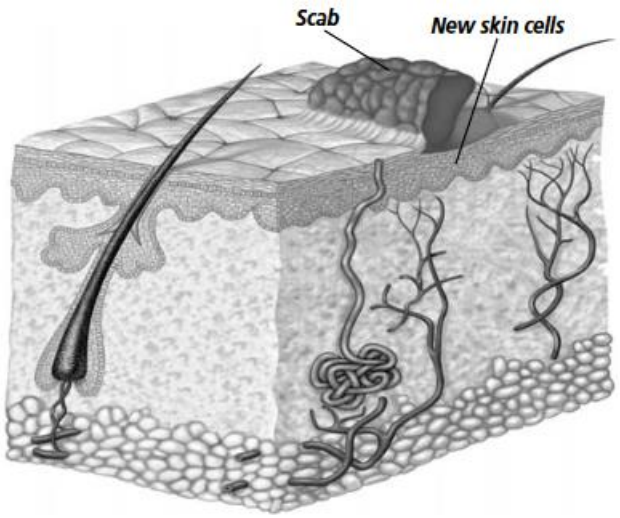


regulate your internal body temperature. When your temperaturerises, blood vessels in the dermis dilate. This dilation causesincreased blood flow. Body heat is transferred from the blood vessels to the surface of the skin. From the skin, the heat is lost by radiation. When you are cold, the blood vessels in the skincontract, and the body conserves heat.Glands in the integumentary system help cool the body. Whenthe body heats up, glands in the dermis produce sweat. The wetskin helps reduce body temperature. As the sweat evaporates, thewater changes from liquid to vapor. Heat is lost, and the bodycools itself. The skin also is a sense organ. Nerve cells in the dermis receivestimuli from outside the body. Nerve cells provide informationabout pressure, pain, and temperature to the brain.Skin helps produce essential vitamins. When exposed to ultra-violet light, or sunlight, skin cells produce vitamin D. Vitamin Dhelps the body absorb calcium into the bloodstream. Because too much sunlight can damage the skin, people may need to take vitamin D supplements or eat foods that are enriched withthis vitamin. Skin serves as a protective layer for the tissues beneath it. It protects the body from physical and

chemical damage. It alsoprotects the body from invasion by bacteria. Cuts or other open-ings in the skin need to be repaired quickly or bacteria will enterthe body.

Skin Injury and Healing

t does not take the skin long to heal after a minor injury orwound. If the skin receives a minor scrape, cells in the deepestlayer of the epidermis divide. The cells quickly fill in the gap onthe skin. If the injury to the skin extends into thedermis, bleeding usually occurs. The skin thengoes through a series of stages to heal the dam-aged tissue. The body's first reaction is to closethe break in the skin. Blood flows out onto theskin until a clot forms. A scab develops on theskin to close the wound. The scab creates a bar-rier that prevents bacteria on the skin fromreaching the underlying tissues. Dilated bloodvessels allow white blood cells to move to thewound site. White blood cells fight infections.New skin cells begin to form beneath the scab.These cells eventually push the scab off, and newskin can be seen. If a wound to the skin is large,dense connective tissue used to close the woundmay leave a scar



How are burns rated?

Burns result from exposure to the sun, contact with chemicals,or contact with hot objects. Burns are rated according to howsevere they are.A first-degree burn, such as a mild sunburn, results in the deathof epidermal cells. When the skin receives a first-degree burn, theskin turns red, and you feel mild pain. A first-degree burn heals in about a week. It will not leave a scar. A second-degree burndamages the skin cells of both the epidermis and the dermis. Asecond-degree burn can result in blisters and

scars. The mostsevere burn is a third-degree burn. A third-degree burn destroysboth the epidermis and the dermis. With a third-degree burn, theskin loses its function. The cells will not be replaced by new cells.Skin grafts may be required to replace the lost skin.

How does skin change?

As people get older, their skin changes. It becomes drier becausethe glands produce smaller amounts of skin oils. Skin oils are amixture of fats, cholesterol, proteins, and inorganic salts. Wrinklesappear as the skin loses its elasticity. These changes happen morequickly when the skin has been repeatedly exposed to ultravioletsun rays.

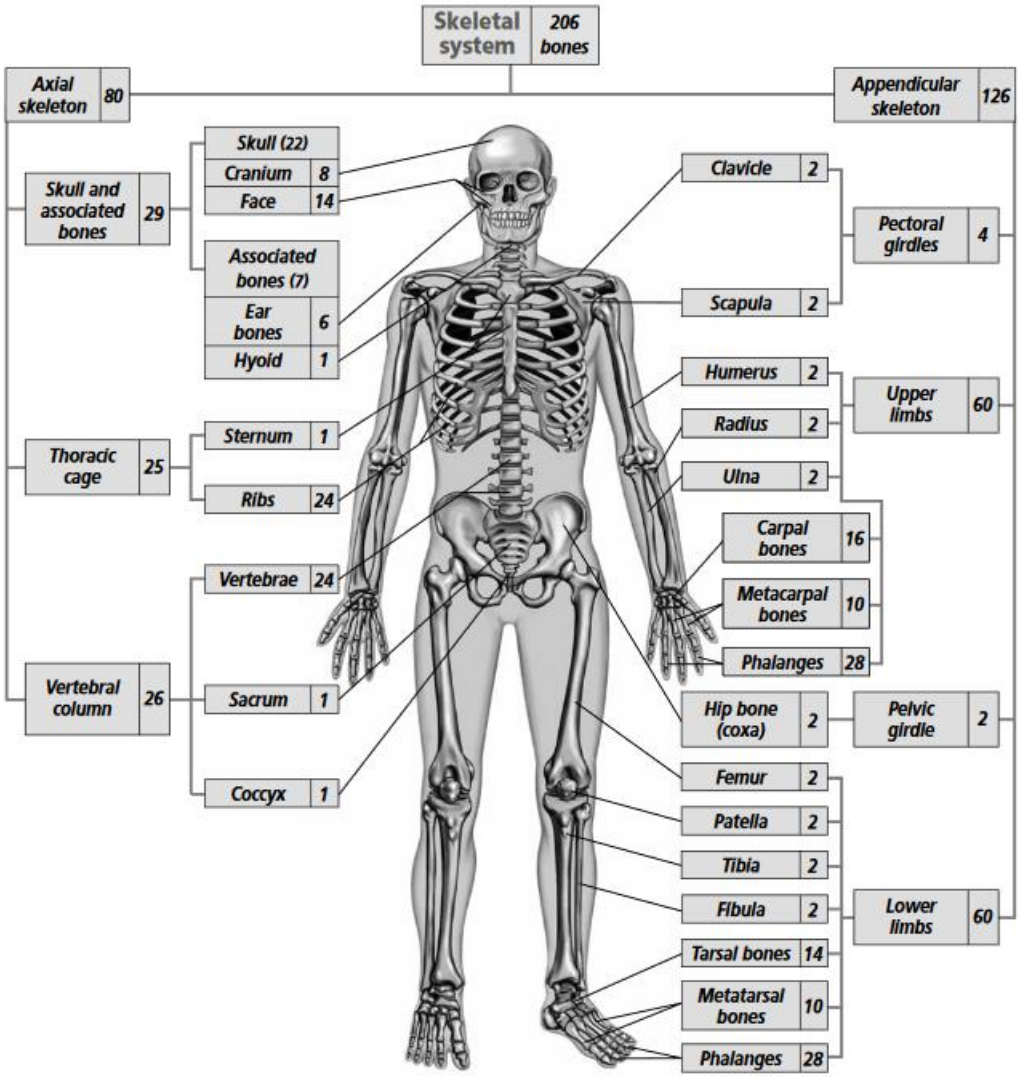
Bones: The Body's Support

Skeletal System Structure

The adult human skeleton contains about 206 bones as shownin the illustration on page 415. The skeleton has two main parts.The axial skeletonincludes the skull and the bones that supportit. These bones include the vertebral column, the ribs, and thesternum. The sternum is the breastbone. The other main part of the human skeleton is the appendicular(a pen DI kyuh lur)skeleton.It includes the bones of the arms and legs, the shoulderand hip bones, wrists, ankles, fingers, and toes.

How are bones joined together?

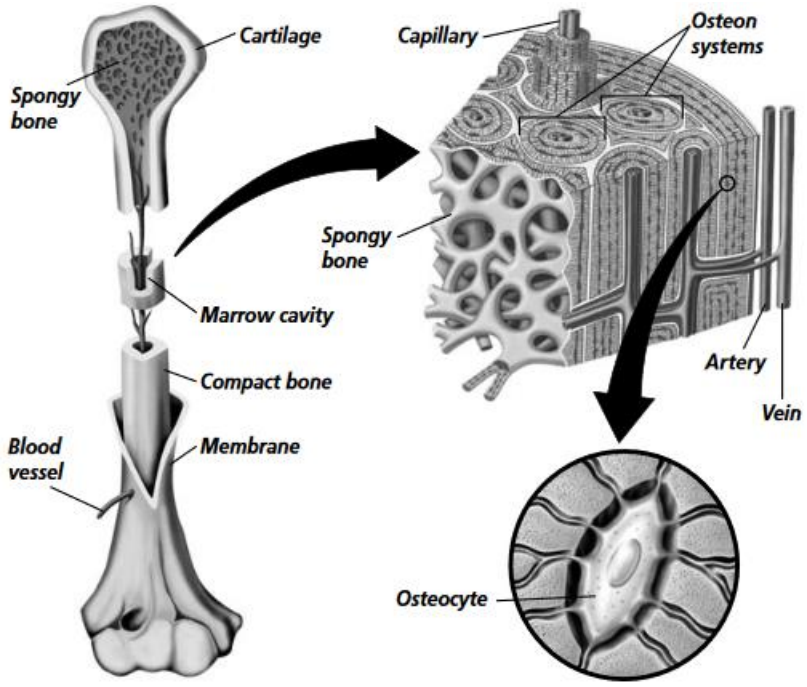
In vertebrates, jointsare found where two or more bones meet. Most joints help bones move in relation to each other, andin several different directions. For example, ball-and-socket jointsallow legs to swing freely from the hip and arms to move freelyfrom the shoulders. Hinge joints allow back-and-forth movementfrom knees, elbows, and fingers. The joints in the skull, however,are fixed. The bones of the skull do not move. Skull joints areheld together by bone that has grown together, or by fibrous cartilage. Recall that cartilage is not bone. It is a tough, flexiblematerial that makes up portions of the skeletons of bony animals. Joints are often held together by ligaments. A ligamentis atough band of connective tissue that attaches one bone to another.Joints with large ranges of motion, such as the knee, usually havemore ligaments surrounding them. In movable joints, the ends of the bones are covered in cartilage. This layer of cartilage allows for smooth movement between the bones. In some joints



ncluding the shoulder and the knee, there are fluid-filled sacslocated on the outside of joints. These sacs are called bursae.The bursae decrease friction and keep bones and tendons fromrubbing against each other. Tendonsare thick bands of connec-tive tissue that attach muscles to bones.When a joint is twisted with force, an injury called a sprain canresult. Sprains usually occur in joints that have a wide range ofmotion, such as the wrist, ankle, and knee.Diseases also can harm joints. One common joint disease isarthritis. Arthritis is an inflammation, or serious irritation, of thejoint that causes swelling or deformity. One kind of arthritiscauses bony growths inside the joints. These growths, or bonespurs, make it painful to move because bone is rubbing on bone.

What are the two types of bone tissue?

Notice that bones are made of two different types of bone tis-sue: compact bone and spongybone. Every bone is covered in a layer of hard bone called com-pact bone.Tubular structuresknown as osteon or Haversian (ha VER zhen) systems run downthe entire length of compact bone.Osteocytes(AHS tee oh sitz) areliving bone cells that receive oxy-gen and other nutrients fromsmall blood vessels running withinthe osteon systems. Nerves in thecanals of the osteon system con-duct impulses to and from eachbone cell Compact bone surrounds spongy bone.Spongy bone gets its name from its appearance. Like a sponge, it has many holesand spaces.



Formation of Bone

The skeleton of a vertebrate embryo is made of cartilage. Inthe human embryo, bone begins to replace cartilage by the ninthweek of development. Blood vessels penetrate the membrane cov-ering the embryo's cartilage. The blood vessels stimulate the embryo's cartilage cells to become potential bone cells. Thesepotential bone cells are called osteoblasts(AHS tee oh blastz).Osteoblasts secrete a protein called collagen. Minerals from thebloodstream begin to deposit themselves in the collagen. Calciumsalts and other ions harden the newly formed bone cells. Thesenew living

bone cells are osteocytes. The skeleton of an adult human is almost all bone. Cartilage isfound only where flexibility is needed. Regions with cartilageinclude the nose tip, the external ears, discs between individualvertebrae, and movable joint linings.

How do bones grow?

Bones grow in both length and in diameter. In bones that endin cartilage, bone growth occurs at both ends of the bones. Duringthe teen years, increased production of sex hormones causes theosteoblasts, the cells that form bone, to divide more rapidly. Thisresults in a growth spurt. These hormones also cause the growthcenters at the ends of the bones to slow production. As these cellsbegin to die, growth slows. After growth stops, bone-formingcells repair and maintain the bones.

Skeletal System Functions

The primary function of the skeleton is to provide a frameworkfor the body tissues. The skeleton also protects internal organs,such as the heart, the lungs, and the brain.The human skeleton allows for efficient movement. Musclesthat move body parts need to be firmly attached to a strong struc-ture that the muscles can pull against. The skeleton providesthese attachment points.Bones also produce blood cells. Red blood cells, white bloodcells, and cell fragments that are needed for blood clotting areproduced in the red marrowof a bone. Red marrow is found inthe humerus, the femur, the sternum, the ribs, the vertebrae, andthe pelvis. Yellow marrowis found in many other bones. Yellowmarrow consists of stored fat. The stored fat can be used in timesof need.

What other functions do bones have?

Your bones store minerals. Minerals stored in bones includecalcium and phosphate. Calcium is needed to form strong, healthybones. It is important to eat foods that are rich in calcium. Thesefoods include milk, yogurt, cheese, lettuce, spinach, and otherleafy vegetables.

What are some common bone injuries and diseases?

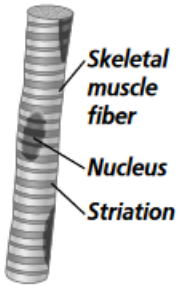
As people get older, their bones age and change. A diseasecalled osteoporosis (ahs tee oh puh ROH sus) involves a loss ofbone volume and minerals. These losses cause the bones tobecome more porous and brittle. Osteoporosis is most commonin older

women because they produce less estrogen, a hormonethat helps bones form.When bones break, a doctor can move them back into position.The doctor will put a cast or a splint over the bone to hold it inplace until the bone tissue regrows.

Muscles

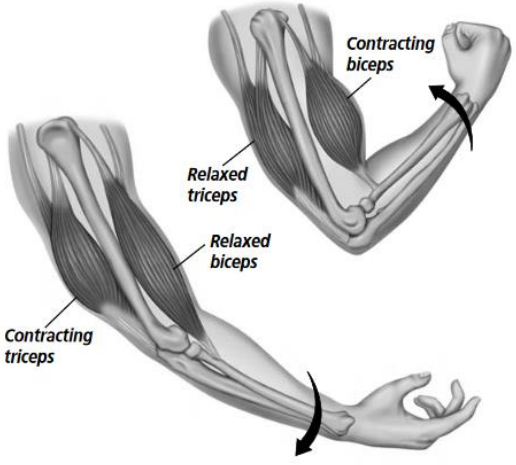
Three Types of Muscles

Almost half of your body mass is muscle. A muscle is groups offibers, or cells, that are bound together. Almost all the musclefibers you will ever have were present at birth. There are threemain types of muscle tissue in your body.Smooth muscleis found in the walls of your internal organsand in blood vessels. Smooth muscle is made of sheets of cellsthat line organs, such as the digestive tract and the reproductivetract. The most common job of smooth muscle is to squeeze. Asmooth muscle applies pressure on the space inside the tube ororgan it surrounds. This pressure moves material through theorgan. For example, food moves through the digestive tract becausesmooth muscles squeeze the material as it moves through the tract.Gametes move through the reproductive system because they aresqueezed by smooth muscle. You do not consciously control asmooth muscle and its contractions. Therefore, smooth muscle isconsidered an involuntary muscle.It contracts by itself.Cardiac muscleis also an involuntary muscle. Cardiac musclemakes up your heart muscle. Cardiac muscle fibers are connected,forming a network that helps the heart muscle contract efficiently.Cardiac muscle can generate and conduct electrical impulses.These impulses are necessary for the regular, rhythmic contrac-tions of the heart—your heartbeat. Cardiac muscle is found onlyin the heart. Skeletal muscleis the third type of muscle tissue. Skeletalmuscle is attached to and moves your bones. Most of the musclesin your body are skeletal muscles. You can control their contrac-tions. When you want to move your arm or your leg, the musclesare under your control. A muscle that contracts under consciouscontrol is called a voluntary muscle.Skeletal muscles are volun-tary muscles



Skeletal Muscle Contraction

Movement occurs because muscles can contract and relax. Most of your skeletal muscles work in opposing pairs. When onemuscle contracts, another relaxes. When you bend your arm, the biceps muscle, which is located on the front of your arm, contracts. Themuscle on the back of your arm, the triceps, relaxes. When you straighten your arm, the biceps relaxes, and the triceps contracts.Muscle tissue is made up of musclefibers. Muscle fibers are long muscle cellsthat are connected. Each fiber is made up of smaller units called myofibrils(mi oh FI brulz).Myofibrils consist of evensmaller protein filaments that can be eitherthick or thin. The thicker filaments aremade of the protein myosin.The thinnerfilaments are made of the protein actin.Each myofibril can be divided into sec-tions called sarcomeres(SAR kuh meerz).Sarcomeres are the functional units of muscles.One of the best explanations for how muscle contraction occursis called the sliding filament theory.The sliding filament theorystates that when a muscle receives a signal from a nerve, the actinfilaments in each sarcomere slide toward each other. This short-ens the sarcomeres in a fiber. This shortening causes the muscleto contract. The myosin filaments do not move.



Muscle Strength and Exercise

Muscle strength does not depend upon the number of fibers ina muscle. The number of fibers in each muscle was fixed before irth. Muscle strength depends on the thickness of the fibers. Italso depends upon how many of the fibers contract at one time.Regular exercise stresses the muscle fibers. This stress increasesthe size of the fibers. When you exercise regularly, your musclefibers increase in diameter by adding myofibrils. Remember that ATP is the energy-storing molecule in cells.ATP is produced during cellular respiration. Muscle cells are con-tinually supplied with ATP from both aerobic and anaerobicprocesses. When adequate oxygen is delivered to muscle cells, theaerobic respiration process dominates. This occurs when a muscleis resting or during moderate activity.During vigorous activity, your muscles may not be able to getoxygen fast enough to sustain aerobic respiration and produceadequate ATP. The amount of available ATP becomes limited.For your muscle cells to get the energy they need, they must relyon lactic fermentation, an anaerobic process. Lactic acid can build up in muscle cells as you exercise. As theexcess lactic acid goes into the bloodstream, the blood becomesmore acidic, rapid breathing begins, and cramping may occur. Asyou catch your breath after vigorous activity or exercise, adequateamounts of oxygen are supplied to your muscles and the lacticacid is broken down.

References

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2- **Campbell, 7th edition References**

University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

13- Digestion, Endocrine and Nervous systems

Functions of the Digestive System

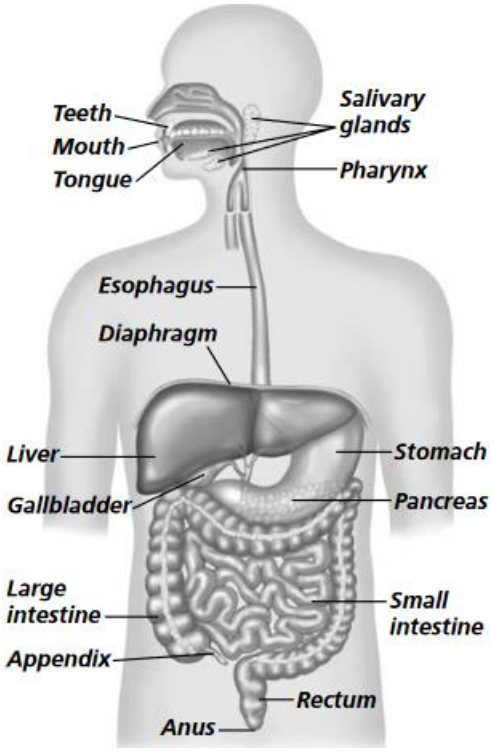
The main function of the digestive system is to change the food you eat into molecules that your body can use for energy. There are a number of steps in the digestive process. Digestion begins when you put food into your mouth. This is called ingestion. The system takes the ingested food and begins moving it through the digestive tract. As food is digested, the complex food molecules are broken down both mechanically and chemically. The digestive sys-tem absorbs the digested food and sends it to your cells. Finally, the materials that cannot be digested are elimi-nated from your body. The digestive system includes several organs.

The Mouth

The first step in the digestive process begins in yourmouth. You bite food, and you chew it.

What happens as you chew?

As you chew food, your tongue moves the food aroundin your mouth. Your tongue helps move the food betweenyour teeth. Chewing is a form of mechanical digestion.It is the physical process of breaking food down intosmaller pieces. Mechanical digestion prepares the foodparticles for chemical digestion. Chemical digestion is theprocess of changing food on a molecular level. Thischange occurs because of the actions of enzymes in yourdigestive system.



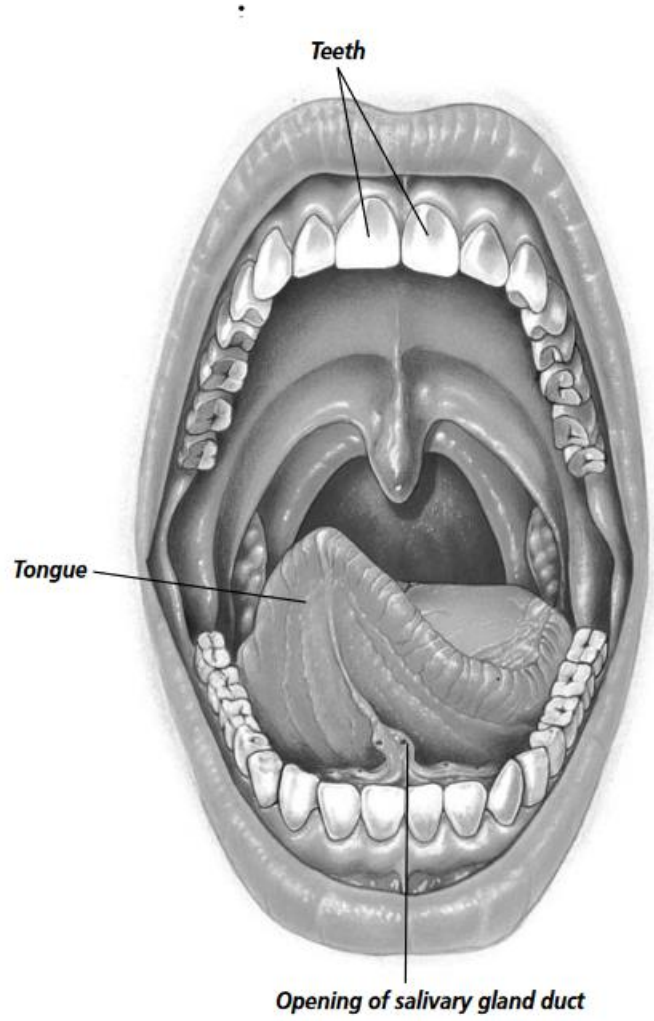
Where does chemical digestion begin?

Chemical digestion begins in the mouth. Salivary glands inyour mouth secrete saliva. Saliva contains a digestive enzymecalled amylase. Amylasebreaks down the starches in food intosmaller molecules. Many of the nutrients in the food you eat con-tain starches, large molecules known as polysaccharides. Thepolysaccharides are broken down into di- or monosaccharides. Inthe stomach, which is a muscular, pouchlike enlargement in thedigestive tract, amylase digests the swallowed starches for about30 minutes.

What happens after you have swallowed your food?

nce food is chewed, the tongue shapes it into a ball. Thetongue moves this ball of chewed food into the back of themouth. The food is swallowed. Swallowing food forces it fromthe mouth into the throat. Food then movesfrom the mouth into the esophagus. Theesophagusis a muscular tube that connectsthe mouth to the stomach. Food moves downthe esophagus by peristalsis. Peristalsis(per uh STAHL sus) is a series of involuntary,smooth muscle contractions along the walls ofthe digestive tract. The contractions occur inwaves called peristaltic waves. First, circularmuscles

relax and longitudinal muscles con-tract. Then, circular muscles contract andlongitudinal muscles relax. Since smoothmuscles are involuntary, you do not con-sciously control these contractions.When you swallow, food enters the esoph-agus. Usually, a flap of cartilage called theepiglottis(ep uh GLAH tus) closes over theopening to the respiratory tract as you swal-low. This prevents food from entering therespiratory tract. If you talk while swallowing,the epiglottis may open, and food can enterthe respiratory tract. The body responds bychoking and coughing, forcing the food outof the respiratory tube and back into the throat.



The Stomach

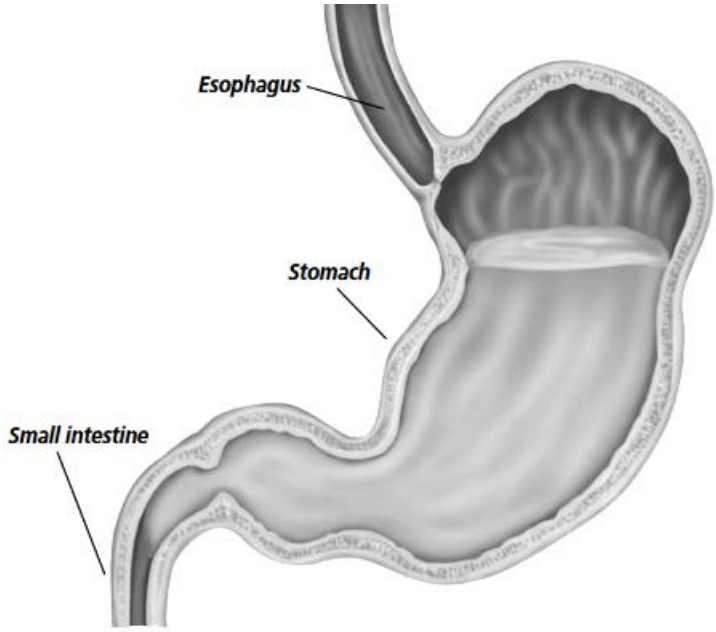
When chewed food reaches the end of the esophagus, it entersthe stomach. The stomachis a muscular, pouchlike enlargement ofthe digestive tract. Both mechanical and chemical digestion takeplace in the stomach.

How do muscles in the stomach break down food?

The stomach contains three layers of involuntary muscles.They lie across each other, and they are located within the stom-ach's walls. When these muscles contract, they physically breakdown swallowed food into smaller pieces. As the muscles continueto work on the pieces of food, the pieces are mixed with digestivejuices produced by the stomach.

How do chemicals in thestomach break down food?

The inner lining of the stomach con-tains millions of glands. These glandssecrete a mixture of chemicals called gastric juice. Gastric juice containspepsin and hydrochloric acid. Pepsinis an enzyme that begins the chemicaldigestion of proteins in food. Pepsinworks best in an acidic environment.This environment is provided byhydrochloric acid. How is the stomach lining protectedfrom powerful digestive enzymes andstrong acids? The stomach lining secretesmucus. This mucus forms a protectivelayer between the stomach lining and theacidic environment of the stomach.Food stays in the stomach for about two to four hours. Whenfood is ready to leave the stomach, its consistency is similar to theconsistency of tomato soup. Peristaltic waves become strongerand force small amounts of the liquid out of the stomach and into the small intestine.



The Small Intestine

The small intestineis a muscular tube about 6 m long. It iscalled smallbecause it has a narrow diameter. Its diameter is onlyabout 2.5 cm. Food digestion is completed in the small intestine.Muscle contractions continue to help break down the foodmechanically. Carbohydrates and proteins undergo additionalchemical digestion. The pancreas and the liver secrete enzymesthat break down the food substances even further.

What is the purpose of the duodenum?

The first 25 cm of the small intestine is called the duodenum(doo ah DEE num). Most of the enzymes and chemicals thatwork in the duodenum enter it through ducts that collect juicesfrom the pancreas, the liver, and the gallbladder. Food does not pass into these three organs, but they all help in the digestion process.

How does the pancreas help in the digestion process?

The pancreasis a soft, flattened gland that secretes both digestive enzymes and hormones. The enzymes that the pancreassecretes break down carbohydrates, proteins, and fats. Alkalinepancreatic juices also help to neutralize the acidity of the liquidfood in the small intestine. This stops any further action of pepsin.

How does the liver help in the digestion process?

The liveris a large, complex organ that has many functions. Itproduces bile. Bileis a chemical substance used in digestion thatbreaks down fats mechanically. Bile breaks large drops of fat intosmaller droplets. After the liver makes bile, the bile is stored inthe gallbladder. The gallbladderis a small organ located just underthe liver. Bile passes from the gallbladder into the duodenum.

How is food absorbed?

After it leaves your stomach, liquid food stays in the small intes-tine for three to five hours. The food moves slowly through thesmall intestine by peristalsis. As digested food moves through the small intestine, it passes over thousand of villi. A villus(plural,villi) is a tiny, fingerlike structure. Villi are projections on the lining of the small intestine that help absorb digested food.Because villi increase the surface area of the small intestine, theyallow the body to absorb more food from the small intestine. Digested food in the small intestine is in the form of smallmolecules. These small molecules can be absorbed into the cellsof the villi. The food molecules diffuse into the blood vessels ofthe villus and enter the body's bloodstream. Villi are the linkbetween the digestive system and the circulatory system.

The Large Intestine

The material that cannot be digested in the small intestinepasses into the large intestine. The large intestineis a musculartube that is also called the colon. The large intestine, or colon, isonly about 1.5 m long, but it is about 6.5 cm in diameter. Thelarge intestine is much wider than the small intestine. The appen-dix is a tubelike extension off the large intestine. It seems to serveno purpose in human digestion.

What does bacteria in the large intestine do?

The human body does not waste water. The walls of the largeintestine absorb water and salts from the indigestible material. A more solid material remains in the large intestine. Anaerobicbacteria in the large intestine produce some B vitamins and

vitamin K. Both these vitamins are absorbed as needed by thebody. Other bacteria in the large intestine stop harmful bacteriafrom colonizing. This helps to reduce the risk of infections in the intestines.

How are wastes eliminated?

After 18 to 24 hours in the large intestine, indigestible material,now called feces, reaches the rectum. The rectumis the last partof the digestive system. Feces are eliminated from the rectumthrough the anus.

Section 35.2 Nutrition

The Vital Nutrients

Six basic kinds of nutrients can be found in foods. They arecarbohydrates, fats, proteins, minerals, vitamins, and water. Thesenutrients are essential for your body to function properly. Usingthe food pyramid, shown on page 430, to shape your diet can helpyou get the essential nutrients your body needs.

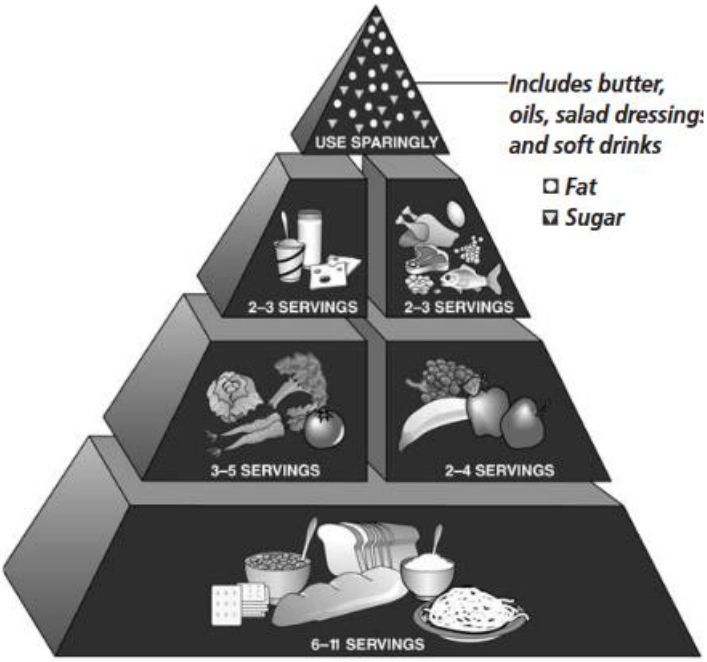
How does your body use carbohydrates?

Carbohydrates are starches and sugars. They are an importantsource of energy for your body cells. Starches are complex carbo-hydrates. They are found in bread, cereal, potatoes, rice, corn,beans, and pasta. Sugars are simple carbohydrates. They arefound mainly in fruits such as plums, strawberries, and oranges.During digestion, complex carbohydrates are broken down intosimple sugars, such as glucose, fructose, and galactose. These sim-ple sugars are absorbed into the bloodstream through the villi ofthe small intestine. These sugar molecules circulate through theblood to fuel body functions. Some sugar is carried to the liverwhere it is stored as glycogen. Cellulose, another complex carbohydrate,is found in all plant cell walls. Even thoughthe human body cannot digest cellulose(also known as fiber), cellulose is importantin the diet. It helps in the elimination ofwastes. Sources of cellulose include bran,beans, and lettuce.

How does your body use fats?

Fats are an essential nutrient. They pro-vide energy for your body. Fats also areessential building blocks of the cell mem-brane. Fats help synthesize hormones,

protect body organs against injury, andinsulate the body from cold.Meats, nuts, and dairy products containfats. Cooking oils are another source ofdietary fat. In the digestive system, fats breakdown into fatty acids and glycerol. They areabsorbed by the villi of the small intestine.Some fatty acids eventually end up in theliver. The liver converts them to glycogen orstores them as fat throughout your body.



How does your body use proteins?

The body uses proteins in many ways. Enzymes, antibodies,many hormones, and substances that help the blood clot are allproteins. Proteins form parts of your muscles. Many cell struc-tures, including cell membranes, are formed of proteins.During digestion, proteins are broken down into amino acids.The amino acids are absorbed by the small intestine, and theyenter the bloodstream. They are carried through the bloodstreamto the liver. The liver can change amino acids to fats or to glucose. Both fats and glucose can be used for energy. Your body uses aminoacids for energy only if other energy sources have been used up. Most amino acids are absorbed by cells and used for protein syn-thesis. The human body needs 20 different amino acids for proteinsynthesis. The body can make only 12 of these,

so the other 8amino acids must come from the food that you eat. Sources of essential amino acids include meats, dried beans, whole grains, eggs, and dairy products.

How does your body use minerals and vitamins?

A mineralis an inorganic substance that serves as a building material for your body. Minerals take part in chemical reactions inyour body. They make up about four percent of your total bodyweight. Most minerals are found in your skeleton. Minerals arenot used as an energy source.Vitaminsare organic nutrients that help maintain growth andmetabolism. Your body needs only small amounts of them. Thereare two main groups of vitamins. One group is water-soluble,which means that they dissolve in water. Water-soluble vitaminscannot be stored in the body and must be included regularly inthe diet. The other main group of vitamins is fat-soluble. Thesevitamins dissolve in fats. Fat-soluble vitamins can be stored in thebody's liver. Excessive amounts of fat-soluble vitamins in the liver,however, can be poisonous.Vitamin D, a fat-soluble vitamin, is synthesized in your skin.The bacteria in your large intestine synthesize vitamin K andsome B vitamins. The rest of the vitamins that your body needsmust be taken in through your food.

How does your body use water?

Between 45 and 75 percent of your body mass is water. Wateris the most abundant substance in your body. Water helps chemi-cal reactions take place in your body. It is necessary for breakingdown foods during digestion. Water is a solvent. Oxygen andnutrients from food cannot enter your cells unless they have beenfirst dissolved in water.Water helps your body maintain its internal temperaturebecause water absorbs and releases heat slowly. The body containsso much water, it takes a lot of added energy to raise your bodytemperature. Every day your body loses about 2.5 L of waterthrough exhalation, sweat, and urine. Therefore, you need todrink enough water every day to replace the water that is lost.

Calories and Metabolism

A calorie is the amount of heat that is needed to raise the tem-perature of 1 mL of water by 1ºC. The energy content of food ismeasured in Calories. The term Calories,written with a capitalletter C, represents a kilocalorie, or 1000 calories. Some foodscontain more Calories than other foods. 1 g of fat generally con-tains nine Calories. 1 g of carbohydrate or protein generally contains only four Calories.

The number of Calories needed each day depends on a person'smetabolism. Metabolism is the rate at which energy is burned. A person's body mass, age, gender, and level of physical activityalso affect how much energy is used. Males usually need moreCalories per day than females. Teenagers use more Calories thanadults, and active people use more Calories than inactive people.

What is the relationship between Calories and health?

If a person takes in more Calories than his or her body canmetabolize, or burn, the extra energy is stored as body fat. Theperson gains weight. If a person eats fewer Calories than the bodycan metabolize, some of the body's stored energy is used. Thatperson will lose weight.Many Americans are overweight. Being overweight increasesthe risk of developing health problems including high blood pres-sure, diabetes, and heart disease. Underweight people can havehealth problems, too. These can include anemia, fatigue, and adecreased ability to fight off infections and diseases.

The Endocrine System

Control of the Body

Internal control of the body is directed by two systems. In thissection you will learn about the endocrine system. Later, you willlearn about the other system, the nervous system. The functionsof all body systems are controlled by the interaction between thenervous system and the endocrine system. As you will recall, inmammals, a gland is a cell or a group of cells that secretes fluid.The endocrine system is made up of a series of glands, calledendocrine glands. Endocrine glandsrelease chemicals directlyinto the bloodstream. These chemicals relay information to otherparts of the body.

How do the nervous and endocrine systems interact?

The endocrine system and the nervous system work togethermuch of the time. The two systems maintain homeostasis in thebody. As you will recall, homeostasis is the ability of a livingorganism to maintain internal equilibrium or conditions thatenable it to survive. Because there are two control systems withinthe human body, the nervous system and the endocrine system,coordination is needed between the two.

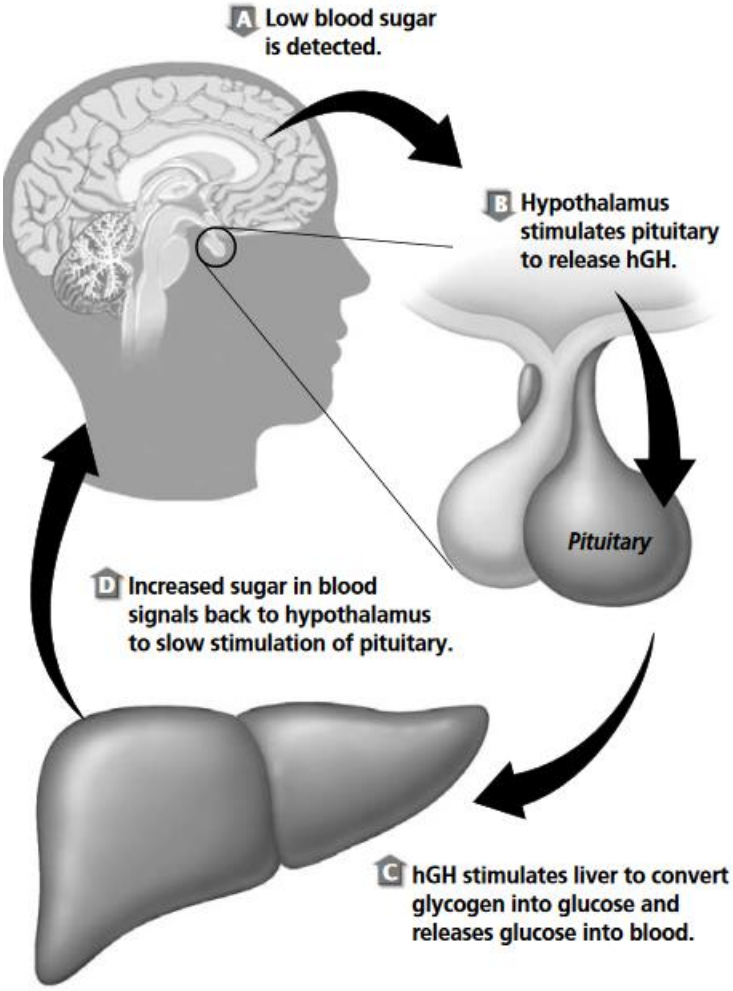
The hypothalamus(hi poh THA luh mus) is the part of the brain that connects theendocrine system and the nervous system. The hypothalamusreceives messages from other areas of the brain. It also receivesmessages from the internal organs. When a change in homeosta-sis is detected, the hypothalamus stimulates the pituitary gland. The pituitary gland(pih TEW uh ter ee) is the main gland ofthe endocrine system.The pituitary gland is located in the skull, just beneath thehypothalamus. The hypothalamus controls the pituitary gland.The two are connected by nerves and by blood vessels. When thehypothalamus receives messages, the pituitary gland releases itsown chemicals, or it stimulates other glands to release theirchemicals. The pituitary gland controls endocrine glands, includ-ing the thyroid gland, the adrenal glands, and glands associatedwith reproduction.

How do hormones travel?

The endocrine glands secrete chemicals called hormones intothe bloodstream. Remember that a hormone is a chemical that isreleased in one part of an organism that affects another part ofthe organism. Hormones carry information to other cells in thebody. Hormones give these other cells instructions regardingmetabolism, growth, development, andbehavior. Once glands release the hor-mones, the hormones travel in thebloodstream. Hormones then attachthemselves to target cells. Target cellshave specific binding sites for hormones.These binding sites are located eitheron the plasma membranes or in thenuclei of these cells. The binding siteson target cells are called receptors.

How does human growthhormone (hGH) work?

Human growth hormone, hGH, pro-vides a good example of an endocrinesystem hormone. When your body isactively growing, blood glucose levelsare slightly lowered because the grow-ing cells use up the sugar. The hypo-thalamus detects this low blood glucoselevel. The hypothalamus then stimu-lates the production and release ofhGH from the pituitary gland into thebloodstream. The hormone hGH bindsto receptors on the plasma membranesof liver cells. This, in turn, stimulates he liver cells to release glucose into your blood. Your cells needthis glucose to keep growing.



Negative Feedback Control

If homeostasis is disrupted, the body responds. The endocrineglands are stimulated. Endocrine glands can be stimulated by thenervous system, by changes in blood chemistry, or by other hor-mones. One type of internal feedback mechanism generally con-trols adjustments to the endocrine system. This is called a negativefeedback system. In a negative feedback system,the hormones,or their effects, are fed back to suppress or slow the original sig-nal. Once homeostasis is reached, the signal stops. The hormoneis no longer released.

How does the feedback system work?

Most of the endocrine glands operate under a negative feed-back system. A gland synthesizes and secretes its hormone. Thehormone travels in the blood to the target

cells. The neededresponse occurs in these target cells. Information concerning thehormone level or its effect on these target cells is fed back. Thefeedback is usually sent to the hypothalamus or the pituitary glandto regulate, or change, the gland's production of the hormone.

How do hormones controlled by the negativefeedback system work?

Antidiuretic hormone, ADH, is one of the hormones that iscontrolled by a negative feedback system. If you have lost waterbecause your body has been sweating, you will feel thirsty. Youfeel thirsty because the water content of your blood is reduced.The hypothalamus is able to sense the concentration of water inyour blood. The hypothalamus determines that your body isdehydrated. It responds by stimulating the pituitary gland torelease antidiuretic (AN tih di yuh reh tihk) hormone (ADH).Antidiuretic hormone (ADH) reduces the amount of water inyour urine. The hormone binds to receptors in the kidney cells.In the kidneys, the hormone ADH promotes the reabsorption of water. ADH also reduces the amount of water that is excretedin urine. Information about the blood water levels is constantlyfed back to the hypothalamus. The hypothalamus can then regu-late the pituitary gland's release of ADH. If the body becomesoverhydrated, or has too much water, the hypothalamus stopsstimulating the release of ADH.

How do hormones that are controlled by a negativefeedback system control blood glucose levels?

Another example of a negative feedback system involves theregulation of blood glucose levels. Unlike most other endocrineglands, the pancreas is not controlled by the pituitary gland. Afteryou have finished eating a meal, your blood glucose levels arehigh. When the blood glucose levels are high, the pancreasreleases the hormone insulin. Insulin signals the liver and musclecells to take in glucose. This lowers the blood glucose levels.When the blood glucose levels become too low, the pancreasreleases another hormone called glucagon. Glucagon signals cellsin the liver to release stored glycogen as glucose.

Hormone ActionOnce

hormones are released by an endocrine gland, they travelto target cells, and they cause a change. There are two basic typesof hormones. They are grouped according

to how they act ontheir target cells. The two groups are steroid hormones andamino acid hormones.

What are steroid hormones?

Hormones that are made from lipids, or fats, are called steroidhormones. Steroid hormones are lipid-soluble. As a result, theycan diffuse freely into a cell through the cell's plasma membrane.The hormones bind to a hormone receptor inside the cell. Thehormone, bound to its receptor, forms a hormone-receptor com-plex. The hormone-receptor complex travels to the cell nucleus.In the cell nucleus, this hormone-receptor complex starts theprocess for making specific messenger RNA (mRNA) molecules.The mRNA molecules move out to the cytoplasm. The mRNAmolecules transport instructions from DNA in the nucleus for thesynthesis of the required proteins while in the cytoplasm.

What are amino acid hormones?

The second group of hormones is made from amino acids.Remember that amino acids can be strung together in chains.Proteins are made from long chains of amino acids. Some hor-mones are short chains of amino acids while other hormones arelong chains. Once amino acid hormones are secreted into thebloodstream, they bind to receptors. These receptors are embed-ded in the plasma membrane of the target cell. From the plasmamembrane, they open ion channels in the membrane. Ions haveelectrical charges. These ion channels route signals down the surface of the membrane to activate enzymes within the cell. Theenzymes change the behavior of other molecules inside the cell.

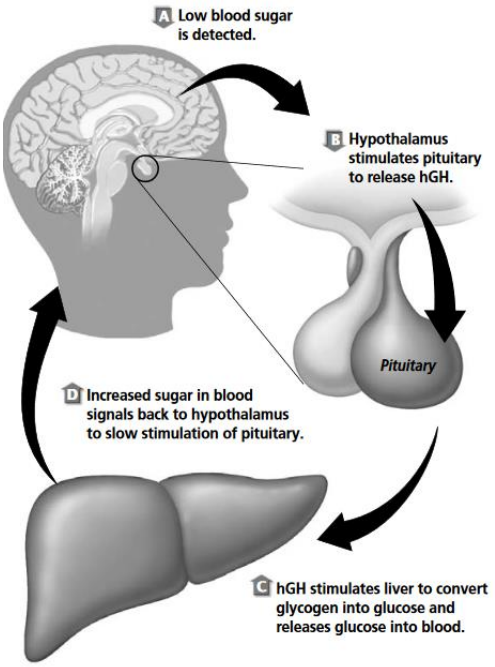
Adrenal Hormones and Stress

The adrenal glands help prepare your body for stressful, diffi-cult situations. The adrenal glandsare located on top of the kidneys. These glands consist of two parts—an inner portion andan outer portion. The outer portion secretes steroid hormones.These include glucocorticoids (glew ko KOR tuh koydz) andaldosterone (ahl DOS tuh rohn).These steroid hormones cause an increase in available glucose.They also raise blood pressure. As a result, they help the bodycombat fear, very hot or very cold temperatures, bleeding, infec-tion, disease, and other common anxieties.The inner portion of the adrenal gland secretes two amino acidhormones. One is epinephrine (eh puh NEH frun). Epinephrineis often called adrenaline. The

other hormone is called norepi-nephrine. Remember the fight-or-flight response? During thisresponse, the hypothalamus relays impulses to the nervous sys-tem. The nervous system stimulates the adrenal glands to increasethe output of both epinephrine and norepinephrine. These twohormones stimulate heart rate, blood pressure, and the rate ofbreathing. They increase the efficiency of muscle contractionsand they also increase blood sugar levels.

Thyroid and Parathyroid Hormones

The thyroid glandis located in the neck. This gland regulatesmetabolism, growth, and development. The main metabolic andgrowth hormone of the thyroid is thyroxine. Thyroxine affectsthe rate at which your body uses energy. It also determines howmuch food you need to eat.The thyroid gland secretes calcitonin (kal suh TOH nun). This hormone regulates cal-cium levels in the blood. The body needs the min-eral calcium for blood clotting, the formation ofbones and teeth, and for normal nerve and musclefunction. Calcitonin binds to the membranes ofkidney cells. Calcitonin then causes the kidneys toexcrete more calcium. Calcitonin also binds tobone-forming cells. It causes these bone-formingcells to increase calcium absorption and to makenew bone.



Parathyroid hormone (PTH) is involved in mineral regulation.This hormone is produced by the parathyroid glands.Parathy-roid glands are attached to the thyroid gland. The release of PTHleads to an increase in the rate that minerals are absorbed in theintestine. The three minerals affected are calcium, phosphate, andmagnesium. PTH causes the release of calcium and phosphatefrom bone tissue. PTH also increases the rate at which the kidneysremove calcium and magnesium from urine and return these twominerals to the blood. Hormones associated with the endocrinesystem control many different body functions. Different hor-mones play more important roles during various stages of growthand development. They are the main biological influence on yourbehavior and on your development.

The Nervous System

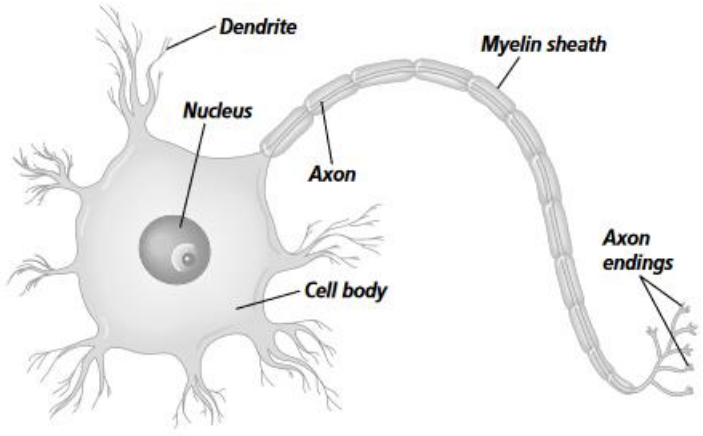
Neurons: Basic Units of the Nervous System

The basic unit of structure and function in the nervous systemis called the neuron, or nerve cell. Neurons(NYU ronz) conductimpulses throughout the nervous system. As shown below, a neu-ron is a long cell that consists of three regions: a cell body, den-drites, and an axon.Dendrites(DEN drites) are branchlike extensions of the neu-ron that receive impulses and carry them toward the cell body.The axonis an extension of the neuron. It carries impulses awayfrom the cell body and toward other neurons, muscles, or glands.Neurons fall into three categories: sensory neurons, motor neurons, and interneurons. Sensory neurons carry impulses fromthe body to the spinal cord and brain. Interneurons are foundwithin the brain and spinal cord. They process incoming impulsesand pass response impulses on to motor neurons. Motor neuronscarry the response impulses away fromthe brain and spinal cord to a muscleor gland.

How are impulses relayed?

Imagine that you are in a crowded,noisy store and you feel a tap on yourshoulder. You turn your head, and yousee a friend standing behind you. Whathappened in your body to cause the tapto get your attention? First, the touchstimulated sensory receptors located in he skin of your shoulder. This produced a sensory impulse whichwas carried to the spinal cord and then to your brain. From thebrain, an impulse was sent to your motor neurons, which trans-mitted the impulse to the

muscles in your neck. The result? Yourneck muscles turned your head in response to the tap.



What occurs when the neuron is at rest?

You have learned that the plasma membrane controls the con-centration of ions in a cell. Because the plasma membrane of aneuron is more permeable to potassium ions (K+) than to sodiumions (Na+), more potassium ions are inside the cell membranethan outside it. Similarly, more sodium ions are outside the cellmembrane than inside it.The neuron membrane also contains an active transport sys-tem, called the sodium/potassium (Na+/K+) pump. The pump usesATP (the cell's energy storing molecules) to pump three sodiumions out of the cell for every two potassium ions it pumps in. Thisincreases the concentration of positive charges on the outside ofthe membrane. In addition, the presence of many negativelycharged proteins and organic phosphates means that the inside ofthe membrane is more negatively charged than the outside.Under these conditions, which exist when the cell is at rest, theplasma membrane is said to be polarized. A polarized membranehas the potential to transmit an impulse.

How are impulses transmitted?

When a stimulus excites a neuron, gated sodium channels inthe membrane open up. That allows sodium ions to enter the cell.As the positive sodium ions build up inside the membrane, theinside of the cell becomes more positively charged than the out-side. This is called depolarization. The change in the chargemoves down the length of the axon like a wave. As the diagram onpage 444 shows, the gated channels and the Na+/K+pump thenreturn the neuron to its resting state.An impulse can only

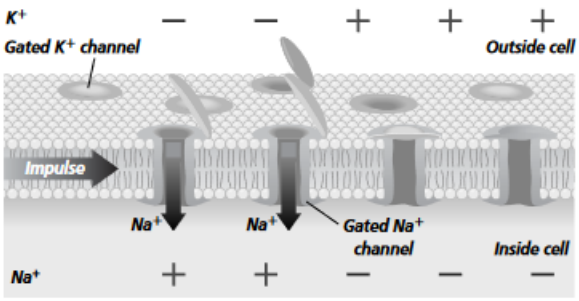
move down the complete length of anaxon when stimulation of the neuron is strong enough. If thethreshold level—the level at which depolarization occurs—is notreached, the impulse will die out quickly.

What are white and gray matter?

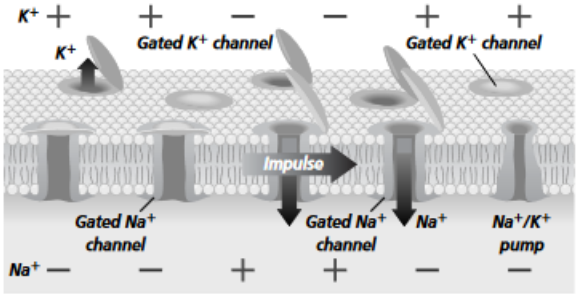
Most axons are surrounded by a white covering of cells calledthe myelin sheath. The myelin sheath is like the plastic coating on an electric wire. It insulates the axon, hindering the movement f ions across its plasma membrane. Theions move quickly down the axon untilthey reach a gap in the sheath. Here, theions pass through the plasma membraneof the nerve cell and depolarizationoccurs. As a result, the impulse jumpsfrom gap to gap, greatly increasing thespeed at which it travels.The myelin sheath gives axons a whiteappearance. In the brain and spinal cord,masses of myelinated axons make up whatis called “white matter.” The absence ofmyelin in masses of neurons accounts forthe grayish color of “gray matter” in thebrain.

What are the spaces betweenneurons called?

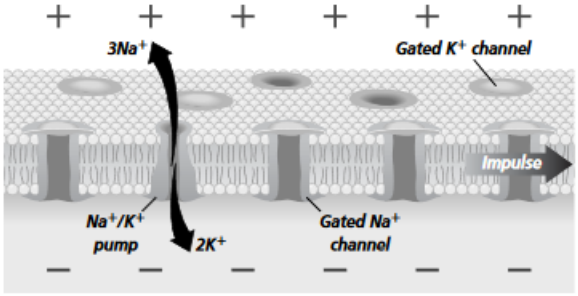
Neurons lie end to end—axons to dendrites—but they do not actuallytouch. There is a tiny space between oneneuron’s axon and another neuron’s den-drites. This space is called a synapse.Impulses traveling to and from the brainmust move across this space. How doimpulses make this leap?As an impulse reaches the end of anaxon, calcium channels open, allowing cal-cium to enter the end of the axon. The cal-cium causes vesicles in the axon to fusewith the plasma membrane, releasing theirchemicals into the synaptic space. Thesechemicals are called neurotransmitters.They diffuse across the space to the den-drites of the next neuron. As the neuro-transmitters reach the dendrites, they signalreceptor sites to open the ion channels.This process is illustrated on page 445.The open channels change the polarityin the neuron, starting a new impulse.Enzymes in the synapse typically breakdown the neurotransmitters shortly aftertransmission. This prevents the continualfiring of impulses.



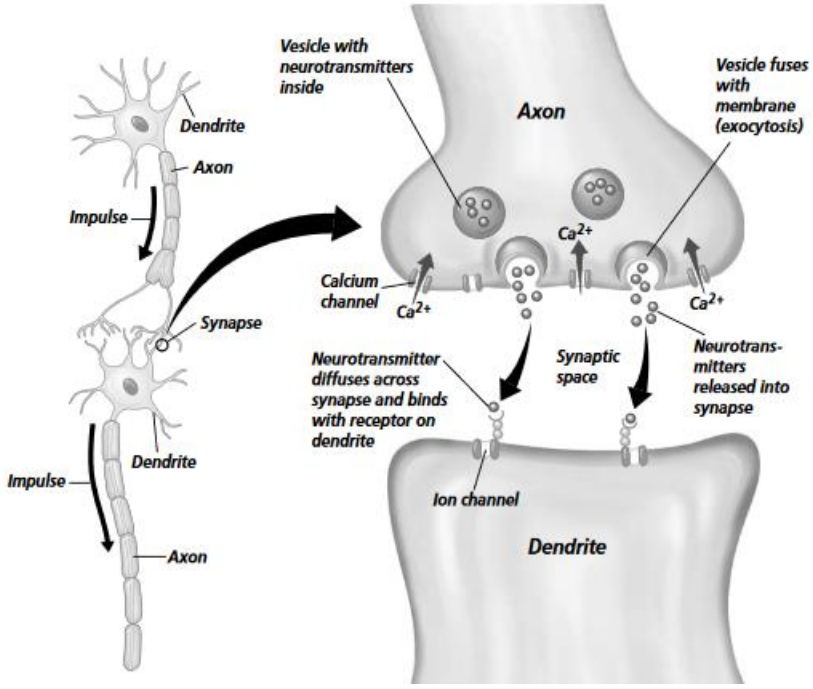
A Gated sodium channels open, allowing sodium ions to enter and make the inside of the cell positively charged and the outside negatively charged.



B As the impulse passes, gated sodium channels close, stopping the influx of sodium ions. Gated potassium channels open, letting potassium ions out of the cell. This action repolarizes the cell.



C As gated potassium channels close, the Na^+/K^+ pump restores the ion distribution.



The Central Nervous SystemWhen you make a telephone call to a friend, your call travelsthrough wires to a control center. There it is switched over towires that connect with a friend's telephone. In the same way, animpulse travels through the neurons in your body. The impulseusually reaches the control center of the nervous system—yourbrain—before being rerouted. The brain and the spinal cordtogether make up the central nervous system,which coordi-nates all your body's activities. Another division of your nervous system is called the peripheral(puh RIH frul) nervous system.It is made up of all the nervesthat carry messages to and from the central nervous system. It issimilar to the telephone wires that run between a phone system'scontrol center and the phones in individual homes. Together, thecentral nervous system (CNS) and the peripheral nervous system(PNS) respond to stimuli from the external environment.

How does the brain work?

The brain is the control center for the entire nervous system.The brain can be divided into three main sections. They are thecerebrum, the cerebellum, and the brain stem.The cerebrum(suh REE brum) is divided into two halves thatare connected by bundles of nerves. The sections are called hemi-spheres. The cerebrum controls all

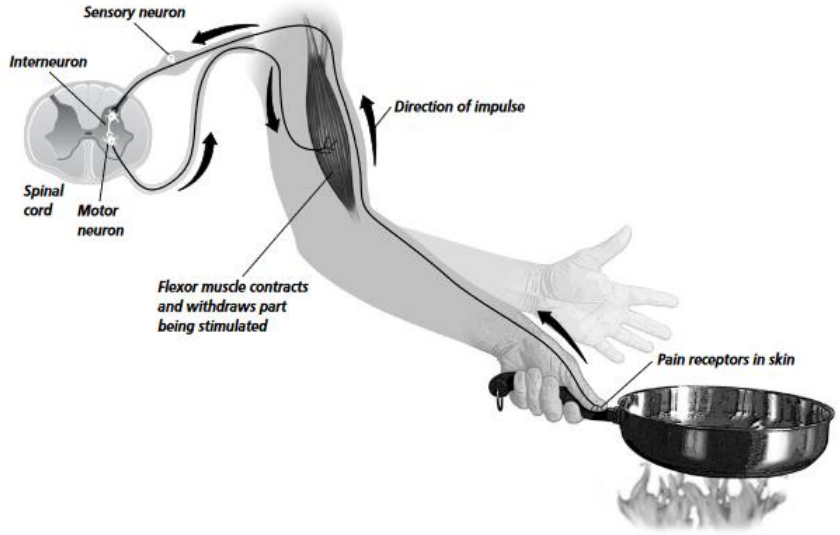
conscious activities, intelli-gence, memory, language, skeletal muscle movements, and senses.The outer surface of the cerebrum, called the cerebral cortex, ismade up of gray matter. The cerebral cortex contains numerousfolds and grooves that increase its total surface area. This increasein surface area played an important role in the evolution ofhuman intelligence. Greater surface area allowed more and morecomplex thought processes.The cerebellum(ser uh BE lum) is located at the back of thebrain. It controls balance, posture, and coordination. If the cere-bellum is injured, movements can become jerky.The brain stem is made up of the medulla oblongata, the pons, and the midbrain. The medulla oblongata(muh DU luh •ah blon GAH tuh) is the part of the brain that controls involun-tary activities such as breathing and heart rate. The pons andmidbrain act as pathways connecting various parts of the brain toeach other.

The Peripheral Nervous System

Remember that the PNS carries impulses between the body andthe CNS. For example, when a stimulus is picked up by receptorsin your skin, it initiates an impulse in the sensory neurons. Theimpulse is carried to the CNS. There, the impulse transfers to themotor neurons, which carry the impulse to a muscle.The PNS can be separated into two divisions—the somaticnervous system and the autonomic nervous system.

What is the somatic nervous system?

The somatic nervous systemis made up of 12 pairs of cranialnerves from the brain, 31 pairs of spinal nerves from the spinalcord, and all of their branches. These nerves are actually bundlesof neuron axons bound together by connective tissue. The cellbodies of the neurons are found in clusters along the spinal col-umn. Most nerves contain both sensory and motor axons.The nerves of the somatic system relay information mainlybetween your skin, the CNS, and skeletal muscles. This pathway



s voluntary, meaning that you can decide whether or not to movebody parts under the control of the system.Sometimes a stimulus results in an automatic, unconsciousresponse within the somatic system. When you touch somethinghot, you automatically jerk your hand away. Such an action is areflex,an automatic response to a stimulus. As illustrated above, areflex impulse travels to the spinal column or brain stem where itcauses an impulse to be sent directly back to a muscle. It does notgo to the brainfor interpretation. The brain becomes aware ofthe reflex only after it occurs.

What is the autonomic nervous system?

Have you ever heard scary sounds in the middle of the night?Maybe your heart began to pound or your palms got sweaty.These internal reactions to being scared are controlled by theautonomic nervous system. The autonomic nervous systemcar-ries impulses from the CNS to internal organs. These impulsesproduce responses that are involuntary, meaning they are notunder conscious control.There are two divisions of the autonomic nervous system—thesympathetic nervous system and the parasympathetic nervous sys-tem. The sympathetic nervous systemcontrols many internal

functions during times of stress. When something scares you, thesympathetic nervous system causes the release of hormones, suchas epinephrine and norepinephrine, which results in a fight-or-flight response. The parasympathetic nervous systemcontrols many of thebody’s internal functions when it is at rest. It is

in control whenyou are reading quietly in your room. Both the sympathetic andparasympathetic systems send signals to the same internal organs.The resulting activity of the organ depends on the intensities ofthe opposing signals.

Section 36.2 The Senses

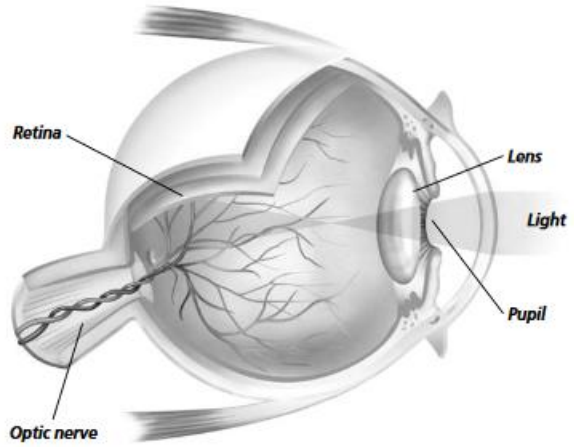
Sensing Chemicals

How are you able to smell and taste an orange? As you sniffand eat the fruit, chemical molecules of the orange touch recep-tors in your nose and mouth. The receptors for smell are hairlikenerve endings located in the upper portion of your nose.Chemicals acting on these nerve endings initiate impulses in theolfactory nerve, which is connected to your brain. The brain theninterprets this signal as a particular odor.The senses of taste and smell are closely linked. Think aboutwhat your sense of taste is like when your nose is all stuffed upand you are not able to smell much at all. Your sense of taste isaffected because much of what you taste depends on your sense of smell.You taste something when chemicals dissolved in saliva contactsensory receptors on your tongue called taste buds.Tastes can be divided into four basic categories: sour, salty, bitter, and sweet.As seen with the sequence of electrochemical changes a neuronundergoes as it is depolarized, each of the different tastes pro-duces a similar change in the cells of taste buds. As these cells aredepolarized, signals from your taste buds are sent to the cere-brum. There the signal is interpreted and you become aware of aparticular taste. A young adult has approximately 10 000 taste buds. As a personages, the sense of smell becomes less sharp and the taste buds maydecrease in number or become less sensitive. A reduced sense oftaste can result.

Sensing Light

How are you able to see? Your sense ofsight depends on receptors in your eyesthat respond to light energy. The retinais a thin layer of tissue made up of lightreceptors and sensory neurons. It is foundat the back of the eye. Light enters theeye through the pupil and is focused bythe lens onto the back of the eye, where itstrikes the retina.The retina contains two types of lightreceptor cells—rods and cones. Rodsare receptor cells adapted for vision indim light. They help you detect shapeand movement. Conesare receptor cellsadapted for sharp vision in bright light.They also

help you detect color.At the back of the eye, retinal tissue comes together to formthe optic nerve. The optic nerve leads to the brain, where imagesare interpreted.



Sensing Mechanical

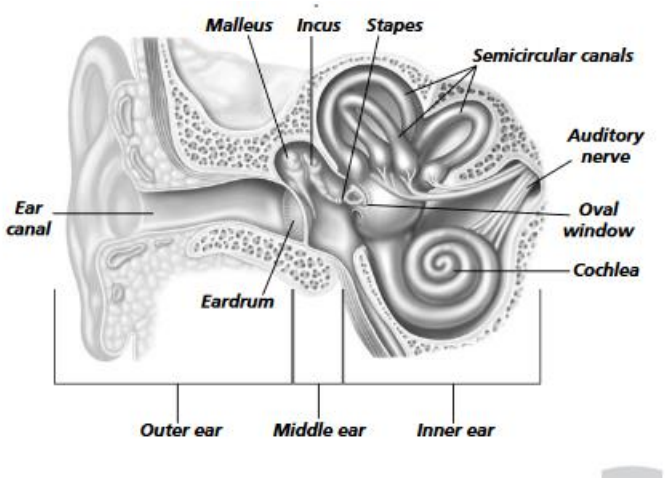
StimulationWhen you walk in a park, how are you able to hear the leavesrustle or feel the things you reach out to touch? Both of thesesenses, hearing and touch, depend on receptors that respond tomechanical stimulation.

How does your sense of hearing work?

Every sound causes the airaround it to vibrate. Thesevibrations travel outward fromthe sources in sound waves.Sound waves enter your outerear and travel down to the endof the ear canal. In the earcanal, they strike a membranecalled the eardrum and cause itto vibrate. The vibrations thenpass to three small bones inthe middle ear—the malleus,the incus, and the stapes. Asthe stapes vibrates, it causes

the membrane of the oval window, a structure between the middleand inner ear, to move back and forth.From here, the vibrations continue to travel deeper into the ear.The movement from the oval window causes fluid in the cochlea,a snail-shaped structure in the inner ear, to move. Inside the cir-cular walls of the cochlea are structures that are lined with haircells. The fluid in the cochlea moves like a wave against the hair cells causing them to bend.The movement of the hairs produces electrical impulses, whichtravel along the auditory nerve to the sides of the

cerebrum. Oncethey reach the cerebrum, they are interpreted as sound. Hearingloss can occur if the auditory nerve or the hair cells in the cochleaare damaged.



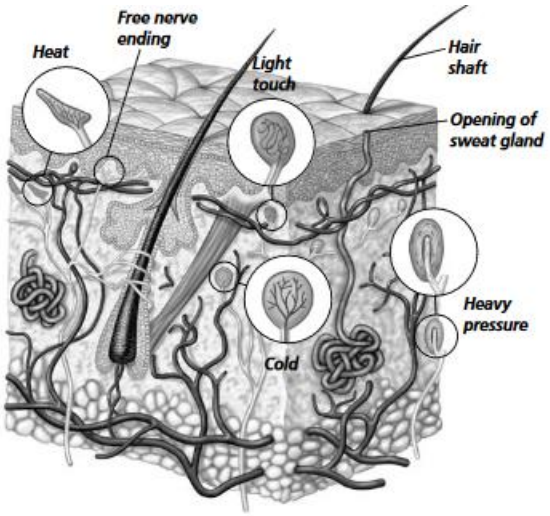
How does your sense of balance work?

The inner ear also converts information about the position ofyour head into nerve impulses, which travel to your brain, inform-ing it about your body's balance.Maintaining balance is the function of your semicircularcanals.Like the cochlea, the semicircular canals are filled with athick fluid and lined with hair cells. When you tilt your head, thefluid moves, causing the hairs to bend. This movement stimulatesthe hair cells to produce impulses. Then neurons from the semi-circular canals carry the impulses to the brain. The brain sends animpulse to stimulate your neck muscles and readjust the positionof your head.

How does your sense of touchwork?

Like the ear, your skin also responds to mechanical stimulation with receptorsthat convert the stimulus into a nerveimpulse. Receptors in the dermis of the skin respond to changes in temperature,pressure, and pain. With the help of thesereceptors, your body can respond to itsexternal environment. Although receptors are found all overyour body, those responsible for respondingto particular stimuli are usually concen-trated within certain areas of your body. Forexample, many receptors that respond tolight pressure are found in the dermis of your fingertips, eyelids, lips, the tip of your tongue, and the palmsof your hands. When these receptors are stimulated, you will feela light touch.Receptors that respond to heavier pressure are found insideyour joints, in muscle tissue, and in certain organs. They also are abundant on the skin of your palms and fingers and on thesoles of your feet. When these receptors

are stimulated, you feelheavy pressure.Free nerve endings extend into the lower layers of the epider-mis. Free nerve endings act as receptors for itch, tickle, hot andcold, and pain sensations. Heat receptors are found deep in thedermis, while cold receptors are found closer to the surface ofyour skin. Pain receptors can be found in all tissues of the bodyexcept those in the brain.



The Effects of Drugs

Drugs Act on the BodyA drugis a chemical that affects the body's functions. Mostdrugs interact with receptor sites on cells, probably the same onesused by neurotransmitters of the nervous system or hormones ofthe endocrine system. Some drugs increase the rate at which neu-rotransmitters are synthesized and released. Drugs also can slowthe rate at which neurotransmitters are broken down. Otherdrugs interfere with a neurotransmitter's ability to interact withits receptor.

Medicinal Uses of Drugs

A medicine is a drug that, when taken into the body, helps pre-vent, cure, or relieve a medical problem. Some of the many kindsof medicines used to relieve medical conditions are discussed here.

How do drugs relieve pain?

Headache, muscle ache, and cramps are common pain sensa-tions. You have just read about how pain receptors in your bodysend signals to your brain. Pain-relieving medicines manipulateeither the receptors that initiate the impulses or the central nerv-ous system that receives them.Pain relievers that do not cause a loss of consciousness arecalled analgesics. Some analgesics, such as aspirin, work byinhibiting receptors at the site of pain from producing nerve impulses. Analgesics that work on the central nervous system arecalled narcotics.Many narcotics are made from the opium poppyflower. Opiates, as they are called, can be useful in controlledmedical therapy because these drugs are able to relieve severepain from illness or injury.

How are circulatory problems treated?

Many drugs have been developed to treat heart and circulatoryproblems such as high blood pressure. These medicines are called cardiovascular drugs. In addition to treating high bloodpressure, cardiovascular drugs may be used to normalize an irreg-ular heartbeat, increase the heart's pumping capacity, or enlargesmall blood vessels.

How are nervous disorders treated

Several kinds of medicines are used to help relieve symptoms ofnervous system problems. Among these medicines are stimulantsand depressants. Drugs that increase the activity of the centraland sympathetic nervous systems are called stimulants.Ampheta-mines (am FE tuh meenz) are synthetic stimulants that increasethe output of CNS neurotransmitters. Amphetamines are seldomprescribed because they can lead to dependence. However,because they increase wakefulness and alertness, amphetaminesare sometimes used to treat patients with sleep disorders.Drugs that lower, or depress, the activity of the nervous systemare called depressants,or sedatives. The primary medicinal usesof depressants are to encourage calmness and produce sleep. Forsome people, symptoms of anxiety interfere with the ability tofunction effectively. By slowing down the activities of the CNS, adepressant can temporarily relieve some of this anxiety.

The Misuse and Abuse of Drugs

The misuse or abuse of drugs can cause serious health prob-lems—even death. Drug misuse occurs when a medicine is takenfor an unintended use. Instances of drug

misuse include givingyour prescription medicine to someone else, not following theprescribed dosage of medication, and mixing medicines.Drug abuse is the inappropriate use of a drug for a non-medicalpurpose. Drug abuse may involve use of an illegal drug, such ascocaine; use of an illegally obtained medicine, such as someoneelse's prescribed drugs; or excessive use of a legal drug, such asalcohol or nicotine. Drugs abused in this way can have powerfuleffects on the nervous system and other systems of the body.

What is addiction to drugs?

When a person believes he or she needs a drug to feel good orto function normally, that person is psychologically dependent onthe drug. When a person's body develops a chemical need for thedrug in order to function normally, that person is physiologicallydependent. Both are forms of addiction.When a drug user experiences tolerance to or withdrawal froma frequently used drug, that person is addicted to the drug.Toleranceoccurs when a person needs a larger or more frequentdose of a drug to achieve the same effect. The need for more isrelated to the body's becoming less responsive to the effects of thedrug. When a person stops taking a drug and actually becomes ill,it is called withdrawal.

Classes of Commonly Abused Drugs

Each class of drug produces its own effect on the body, and itsown particular symptoms of withdrawal.

What are stimulants?

You already know that stimulants increase the activity of thecentral and sympathetic nervous systems. Increased CNS stimula-tion can result in mild elevation of alertness, increased nervous-ness, anxiety, and even convulsions. Cocaine stimulates the CNS by working the part of the innerbrain that governs emotions and basic drives, such as hunger andthirst. When these needs are met under normal circumstances,neurotransmitters—such as dopamine—are released to rewardcenters and the person experiences pleasure. Cocaine artificiallyincreases levels of these neurotransmitters in the brain. As a result,false messages are sent to reward centers signaling that a basicdrive has been satisfied. The user quickly feels a pleasurable highcalled a rush. This feeling does not last. Soon the effects of thedrug change. Physical hyperactivity follows. Often anxiety anddepression set in.Cocaine also

disrupts the body's circulatory system by interfer-ing with the sympathetic nervous system. At first cocaine slowsthe heart rate. However, it soon produces a rapid increase in heartrate and a narrowing of blood vessels, known as vasoconstriction.The result is high blood pressure. Heavy use of this drug weakensthe immune system and often leads to heart abnormalities.Cocaine may affect the unborn babies of addicted mothers.Sometimes the babies are born already dependent on the drug.

Amphetamines are stimulants that increase levels of CNS neu-rotransmitters. Like cocaine, amphetamines also cause vasocon-striction, a racing heart, and increased blood pressure. Otheradverse side effects of amphetamine abuse include irregular heart-beat, chest pain, paranoia, hallucinations, and convulsions.Not all stimulants are illegal. Caffeine—asubstance found in coffee, some carbonatedsoft drinks, cocoa, and tea—is a CNS stimu-lant. Its effects include increased alertness andsome mood elevation. Caffeine also causes anincrease in heart rate and urine production,which can lead to dehydration.Nicotine, a substance found in tobacco, alsois a stimulant. By increasing the release of thehormone epinephrine, nicotine increases heartrate, blood pressure, breathing rate, and stom-ach acid secretion. Nicotine is the addictiveingredient in tobacco. There are many otherharmful chemicals also found in tobacco prod-ucts. Smoking cigarettes leads to an increasedrisk of lung cancer and cardiovascular disease.Use of chewing tobacco is associated with oraland throat cancers.

What are depressants?

Depressants slow down the activities of the CNS. All CNSdepressants relieve anxiety, but most produce drowsiness. One ofthe most widely abused drugs in the world today is alcohol. It iseasily produced from various grains and fruits. Alcohol is distrib-uted throughout a person's body via the bloodstream. Like otherdrugs, alcohol affects cellular communication by influencing therelease of or interacting with receptors for several important neu-rotransmitters in the brain. Alcohol also appears to block themovement of sodium and calcium ions across the cell membrane.That process is important in the transmission of impulses and therelease of neurotransmitters.Tolerance to the effects of alcohol develops as a result of heavyalcohol consumption. Addiction to alcohol—alcoholism—candestroy nerve cells and cause brain damage. Chronic alcohol use contributes to a number of organ diseases. For example, cirrhosis, a hardening of the tissues of the liver, commonly afflicts alcoholics.B arbiturates (bar BIH chuh ruts) are sedatives and anti-anxietydrugs. When barbiturates are used in excess, the user's respiratoryand circulatory systems become depressed. Chronic use results in addiction.

What are narcotics?

Most narcotics are opiates, derived from the opium poppy.They act directly on the brain. Heroin is the most abused nar-cotic in the United States. It depresses the CNS, slows breathing,and lowers heart rate. Addiction develops quickly, and withdrawalfrom heroin is painful.

What are hallucinogens?

Natural hallucinogens have been known and used for thousandsof years, but the abuse of hallucinogenic drugs did not becomewidespread in the United States until the 1960s, when new syn-thetic versions became widely available.Hallucinogens(huh LEW sun uh junz) stimulate the CNS—altering moods, thoughts, and sensory perceptions. The user sees,hears, feels, tastes, or smells things that are not actually there.This disorientation can impair the user's judgment and place him or her in a potentially dangerous situation. Hallucinogensincrease heart rate, blood pressure, respiratory rate, and bodytemperature. They sometimes cause sweating, salivation, nausea,and vomiting. After large enough doses, convulsions may occur.LSD, also called acid, is a synthetic drug. The mechanism bywhich LSD produces hallucinations is not certain, but it mayinvolve the blocking of a CNS neurotransmitter.

What are anabolic steroids?

Anabolic steroids are synthetic drugs that are similar to thehormone testosterone. Like testosterone, anabolic steroids stimu-late muscles to increase in size. Physicians use anabolic steroids totreat hormone imbalances or diseases that result in a loss of mus-cle mass. Abuse of anabolic steroids is associated with infertility inmen, high cholesterol, and extreme mood swings.

Breaking the HabitOnce

a person has become addicted to a drug, breaking thehabit can be very difficult. Remember that an addiction caninvolve both physiological and psychological dependencies.Besides the desire to break the addiction, people usually need

both medical and psychological therapy to be successful in theirtreatment. Support groups such as Alcoholics Anonymousencourage addicts to share their experiences in an effort to main-tain sobriety. Often people going through the same recovery areable to offer the best support.

What is nicotine replacement therapy?

Nicotine replacement therapy is one example of a relativelysuccessful drug treatment approach. People who are trying tobreak their addiction to tobacco often go through stressful with-drawal symptoms when they stop smoking cigarettes. To ease theintensity of the withdrawal symptoms, patients wear adhesivepatches that slowly release small amounts of nicotine into theirbloodstream. Alternatively, pieces of nicotine-containing gum arechewed periodically to temporarily relieve cravings

References

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2- **Campbell, 7th edition References**

University of Anbar
College of science
Department of Biology

1st year Biology
Subject: Zoology
Prof. Dr. Abid A. Thaker

14-The Respiratory, Circulatory and Urinary systems

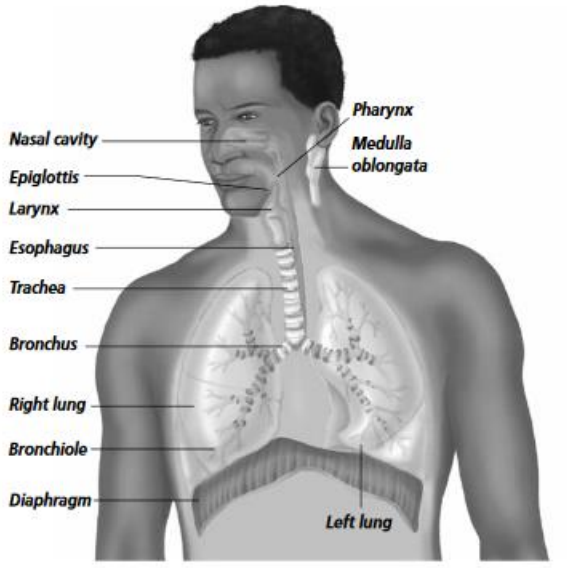
Passageways and LungsYour respiratory system is made of a pair of lungs and a seriesof passageways. The passageways include the nasal passages, the throat, the windpipe, and the bronchi. You probably think of breathing when you hear the term respiratory system. Breathings just one of the functions that the respiratory system carries out.Gas exchange, or respiration, is another important function per-formed by the respiratory system. Respiration includes all of thesteps involved in getting oxygen to the cells of your body and get-ting rid of carbon dioxide. Recall that cellular respiration also involves the formation of ATP within the cells.The first step in the process of respiration involves taking airinto your body. Air enters through the nose or mouth. It flows intothe pharynx, or throat, passes the epiglottis, and moves throughthe larynx. The air then travels down the windpipe, or trachea(TRAY kee uh), a tubelike passageway that leads to two tubes orbronchi (BRAHN ki) (singular, bronchus), which lead into thelungs. Use the illustration on page 463 to trace the steps. Whenyou swallow food, the epiglottis covers the entrance to the tra-chea, which prevents food from getting into the air passages.

What happens if the air is not clean?

The air you breathe is far from clean.Depending on where you live, you maybreathe in as much as a million particlesof foreign matter per day. The nasal cav-ity, trachea, and bronchi are lined withcells that secrete mucous. These cellsalso have tiny hairlike projections calledcilia. The cilia constantly beat in thedirection of the throat. They move the foreign matter to where it can beswallowed or expelled by coughing orsneezing. These cells prevent most of the foreign matter from reaching the lungs.

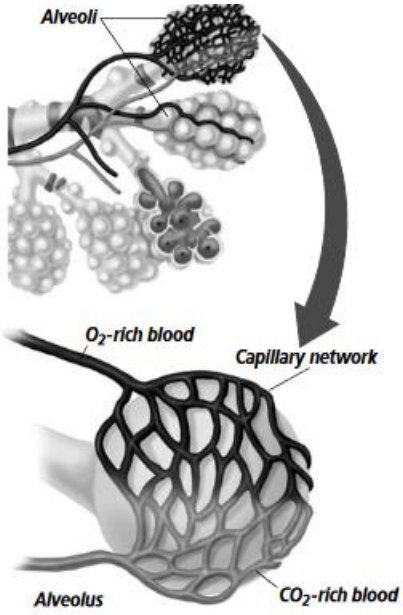
Where does gas exchangehappen?

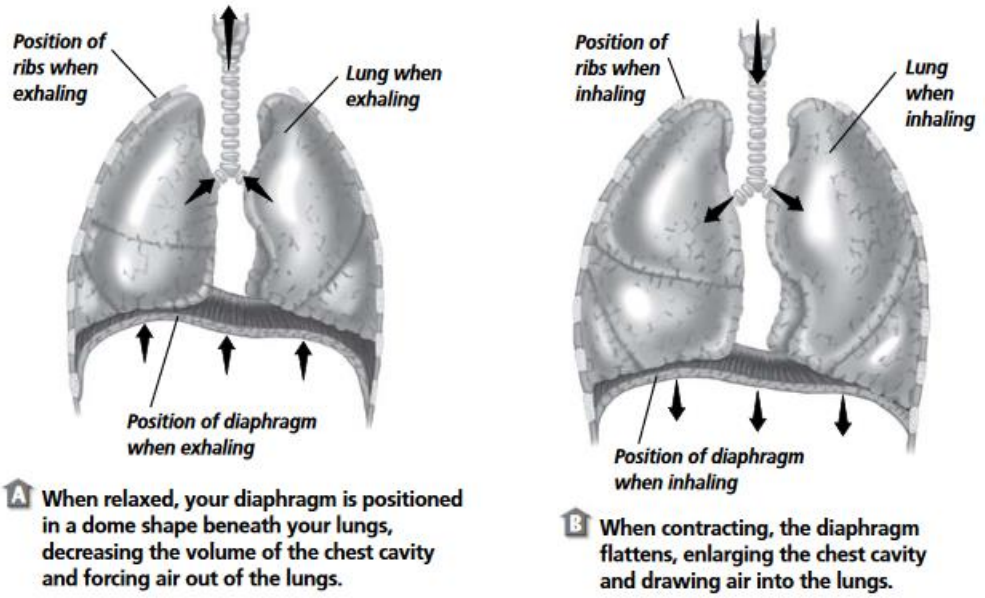
Like the branches of a tree, each bronchus branches into bron-chioles. The bronchioles branch into many microscopic tubulesthat eventually open into thousands of thin-walled sacs called alve-oli. Alveoli(al VEE uh li) (singular, alveolus) are the sacs of thelungs where oxygen and carbon dioxide are exchanged by diffusionbetween air and blood. The clusters of alveoli are surrounded bynetworks of tiny blood vessels, or capillaries. Blood in these ves-sels has come from the cells of the body and contains wastes fromcellular respiration. Diffusion of gases takes place easily becausethe wall of each alveolus and the wall of each capillary are onlyone cell thick. External respiration involves the exchange of oxy-gen or carbon dioxide between the air in the alveoli and the bloodthat circulates through the walls of the alveoli. Once oxygen diffuses into the blood vessels surrounding thealveoli, the heart pumps it to the body cells. There it is used forcellular respiration. Remember that cellular respiration is theprocess by which cells use oxygen to break down glucose andrelease energy in the form of ATP. Carbon dioxide is a wasteproduct of this process. The carbon dioxide diffuses into theblood, which carries it back to the lungs



The Mechanics of BreathingThe action of your diaphragm and the muscles betweenyour ribs allows you to breathe in and out. When youinhale, the muscles between your ribs contract and your ribcage rises. At the same time, the diaphragm muscle contracts.It becomes flattened and moves lower in the chest cavity.This

creates more space in the chest cavity, which creates aslight vacuum. Air rushes into your lungs because the airpressure outside your body is greater than the air pressureinside your lungs.When you exhale, the muscles associated with the ribsrelax, and your ribs drop down in your chest cavity. Yourdiaphragm relaxes, returning to its resting position. As themuscles relax, the chest cavity becomes smaller. This forcesmost of the air out of the alveoli.In healthy lungs, the alveoli are elastic. They stretch as youinhale and return to their original size as you exhale. Evenafter you exhale, the alveoli contain a small amount of air.





Control of Respiration

Breathing is usually an involuntary process. It is partially con-trolled by an internal feedback mechanism. The medulla oblon-gata receives signals about the chemistry of your blood. Itresponds to higher levels of carbon dioxide in your blood bysending nerve signals to the rib muscles and diaphragm. Thenerve signals cause the muscles to contract and you inhale.During exercise you breathe faster. This causes a more rapidexchange of gases between air and blood.

The Circulatory System

Your Blood: Fluid Transport

Blood is a tissue made of fluid, cells, and fragments of cells.The fluid portion of the blood is called plasma.Plasma is strawcolored and makes up about 55 percent of the total volume ofblood. Red and white blood cells and cell fragments are sus-pended in plasma. What do red blood cells do?Red blood cells are round, disk-shaped cells. Red blood cellscarry oxygen to body cells. They make up 44 percent of the total volume of blood. Red blood cells are produced in the redbone marrow of your ribs, humerus, femur, sternum, and otherlong bones.The red blood cells in humans have nuclei in an early stage ofcell development. The nucleus is lost before the cell enters thebloodstream. Red blood cells remain active in the bloodstream forabout 120 days.

Then they break down and are removed as waste.Old red blood cells are destroyed in the spleen and in the liver.How is oxygen carried by the blood?Red blood cells have an iron-containing protein moleculecalled hemoglobin(HEE muh gloh bun). Oxygen becomesloosely attached to the hemoglobin in blood cells that haveentered the lungs. These oxygenated blood cells carry oxygen

From the lungs to the body's cells. As blood passes through bodytissue with low oxygen concentrations, oxygen is released fromthe hemoglobin and diffuses into the tissues. Hemoglobin can also carry some carbon dioxide after it releasesthe oxygen. Remember that once biological work has been donein a cell, wastes in the form of carbon dioxide diffuse into theblood. The bloodstream carries the carbon dioxide to the lungs.About 70 percent of this carbon dioxide combines with water inthe blood plasma to form bicarbonate. The remaining 30 percenttravels back to the lungs dissolved in plasma or attached to thehemoglobin molecules.

What is the function of white blood cells?

White blood cellsplay a major role in protecting the bodyfrom foreign substances and from microscopic organisms thatcause disease. White blood cells make up only one percent of thetotal volume of blood

How does blood clot?

What happens if you cut yourself? If the cut is not deep, youbleed until the blood clots. It usually does not take long for theblood to clot. That's because, in addition to red and white bloodcells, blood contains small cell fragments called platelets.Theyhelp blood to clot after an injury. Platelets help connect a stickynetwork of protein fibers called fibrin. This forms a web over thewound that traps escaping blood cells. Then a dry, leathery scabforms. Platelets are produced from cells in the bone marrow.They have a short life span and are removed from the blood bythe spleen and liver about a week after they are produced.

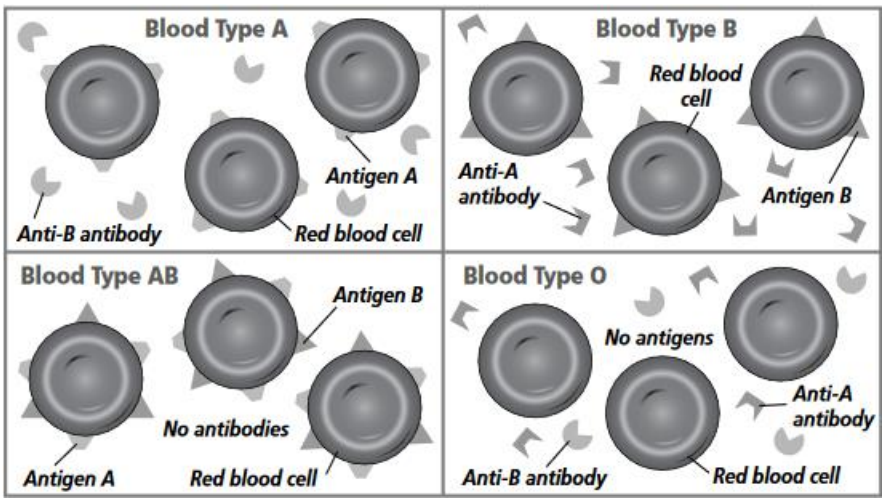
ABO Blood Groups

If a person is injured so severely that a large amount of blood islost, a transfusion of blood from another person may be required.Whenever blood is transfused from one person to another, it isimportant to know the blood group of each person. There are

fourhuman blood groups, A, B, AB, and O. You inherited the charac-teristics of one of these blood groups from your parents. Some-times the term blood typeis used to describe the blood group towhich a person belongs. If your blood group is O, you are said tohave type O blood.

What are the differences between the blood groups?

Differences in blood groups are due to the presence or absenceof proteins on the membranes of red blood cells. The proteins arecalled antigens. Antigensstimulate an immune response in thebody. An immune response defends the body against foreign pro-teins. The letters A and B stand for the types of blood surfaceantigens found on human red blood cells.Blood plasma contains proteins called antibodies(AN tih bahd eez). The antibodies are shaped to correspond withthe different blood surface antigens. The antibody in the bloodplasma reacts with its matching antigen on red blood cells if theyare brought into contact with one another. This reaction resultsin clumped blood cells that can no longer function. That is why atransfusion from the wrong blood group can be so dangerous. Eachblood group contains antibodies for the blood surface antigensthat are found in other blood groups. A blood group does notcontain antibodies for antigens found on its own red blood cells.For example, if you have type A blood, you have the A antigenon your red blood cells. You have the anti-B antibody in yourplasma. Your bloodflows smoothlybecause there isn’tanything for the anti-B antibody to reactwith. What wouldhappen if you receiveda transfusion of type Bblood? This bloodgroup contains anti-Aantibodies, and Bantigens. The resultwould be clumpedblood cells that cannotcarry oxygen or nutri-ents to body cells.



What is Rh factor?

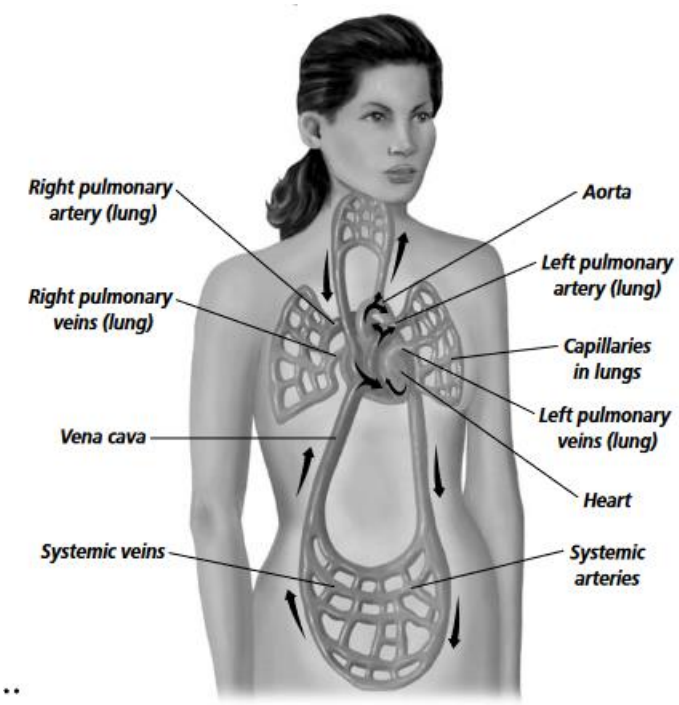
Another characteristic of red blood cells involves the presenceor absence of an antigen called Rh or Rhesus factor. Rh factor isan inherited characteristic. People are Rh positive (Rh+) if theyhave the Rh antigen on their red blood cells. They are Rh nega-tive (Rh-) if they do not.

Rh factor can cause complications in some pregnancies. Theproblem begins when an Rh-mother becomes pregnant with anRh+baby. Sometimes at birth, the blood cells of the baby are mixedwith those of the mother. If the Rh-mother is exposed to the bloodof the Rh+baby, the mother will make anti-Rh+antibodies. If themother becomes pregnant again, the antibodies can cross the pla-centa and enter the fetus. If the new fetus is Rh+, the anti-Rh+anti-bodies from the mother will destroy red blood cells in the fetus.Prevention of this problem is possible. When the Rh+fetus is28 weeks old and again shortly after the Rh+baby is born, the Rh-mother is given a substance that prevents the production ofRh antibodies in her blood. As a result, the next fetus will not be in danger.

Your Blood Vessels: Pathways of Circulation

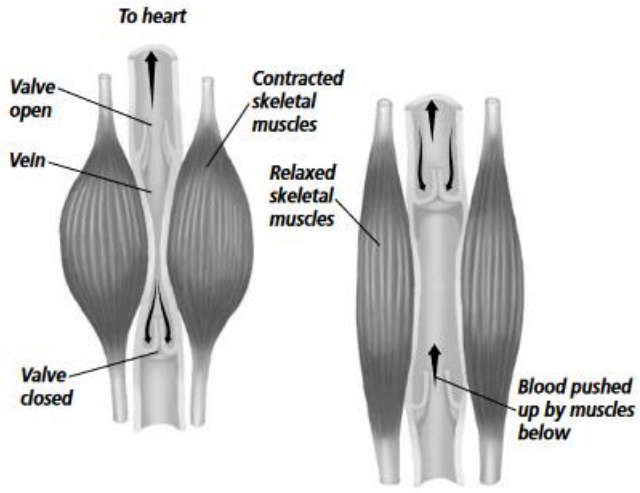
Blood is a fluid channeled through blood vessels. The threemain types of blood vessels are arteries, capillaries, and veins.Each is different in structure and function. Arteriesare large, thick-walled, muscular, elastic blood vesselsthat carry blood away from the heart. The blood that they carry is under great pressure. As the heart contracts, it pushes bloodthrough the arteries. Each artery’s elastic walls expand

slightly. Asthe heart relaxes, the artery shrinks a bit, which helps to push theblood forward. As a result, blood surgesthrough the arteries in pulses that corre-spond with the rhythm of the heartbeat.The arteries branch off from theheart. They divide into smaller arteriesthat, in turn, divide into even smallervessels called arterioles. Arterioles (ar TEER ee ohlz) enter tissues, wherethey branch into the smallest blood vessels, the capillaries. Capillaries(KA puh ler eez) are microscopic bloodvessels with walls that are only one cellthick. These vessels are so tiny that redblood cells must move through them insingle file. Capillaries form a dense net-work that reaches almost every cell inthe body. Thin capillary walls allownutrients and gases to diffuse easilybetween blood cells and surrounding tissue cells.



As the blood leaves the tissues, the cap-illaries join to form slightly larger vesselscalled venules. The venules merge to formveins,the large blood vessels that carryblood from the tissues back toward theheart. Blood in veins is not under pressureas great as blood in arteries. In some veins,especially those in your arms and legs,blood has to travel uphill against gravity.These veins, shown at left, are

equippedwith valves that prevent the blood fromflowing backward. The veins work withskeletal muscles to open and close thevalves. When the skeletal muscles contract, the top valves open, and blood isforced toward the heart. When the skele-tal muscles relax, the top valves close toprevent blood from flowing backward,away from the heart.



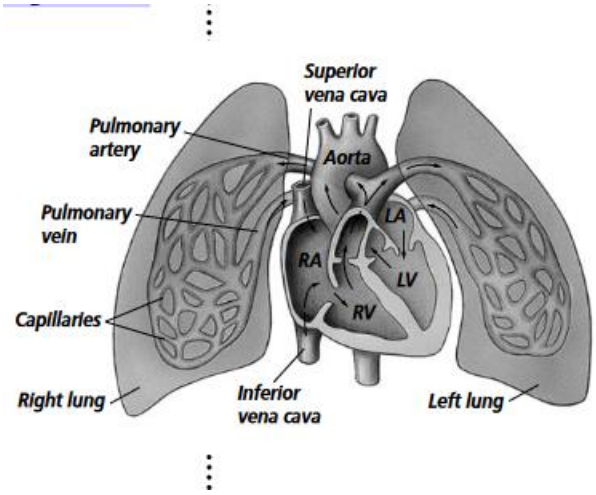
Your Heart: The Vital Pump

The thousands of blood vessels in your body would be of little use if there were not a way to move blood through them.The heart moves blood through the vessels. In fact, the mainfunction of the heart is to keep blood moving constantly throughthe body. The heart is well adapted for its job. It is a large organ made of cardiac muscle cells that are rich in energy-producing mitochondria. All mammals, including humans, have hearts with four cham-bers. The two upper chambers of the heart are the atria.The twolower chambers are the ventricles.The walls of each atrium arethinner and less muscular than those of each ventricle. That'sbecause the ventricles perform more work than the atria. Eachatrium pumps blood into the corresponding ventricle. The leftventricle pumps blood to the entire body. So its muscles arethicker than those of the right ventricle. The right ventricle pumpsblood to the lungs. As a result, the heart is somewhat lopsided.

What is the path of blood through the heart?

Blood enters the heart through the atria and leaves the heartthrough the ventricles. Both atria fill up with blood at the sametime. The right atrium receives oxygen-poor blood from the head and body through two large veins called the venae cavae

(vee nee • KAY vee) (singular, vena cava). The left atrium receivesoxygen-rich blood from the lungs through four pulmonary veins.These veins are the only veins that carry blood rich in oxygen.After the two atria have filled with blood, they contract, pushingthe blood down into the two ventricles. After the ventricles have filled with blood, they contract at the same time. When the right ventricle contracts, it pushes theoxygen-poor blood out of the heart and toward the lungs throughthe pulmonary arteries. These arteries are the only arteries thatcarry blood poor in oxygen. At the same time, the left ventricleforcefully pushes oxygen-rich blood out of the heart through theaortato the arteries of the body. The aorta is the largest bloodvessel in the body.Use the illustration at right to trace a drop ofblood as it travels through the heart. Begin withthe blood coming back from the body througha vena cava. The oxygen-poor drop travels firstto the right atrium, then into the right ventri-cle. The right ventricle pumps it to the lungsthrough a pulmonary artery. In the lungs, theblood drops off its carbon dioxide and picks upoxygen. Then it moves through the pulmonaryveins to the left atrium, into the left ventricle,and finally out to the body through the aorta.Eventually it will return to the heart



What regulates the heartbeat?

Each time the heart beats, a surge of blood flows from the leftventricle into the aorta and then into the arteries. The surge ofblood can be felt in arteries that are close to the surface of thebody. This is called a pulse.The pacemaker sets the heart rate. The pacemaker is a bundleof nerve cells located at the top of the right atrium. It generatesan electrical impulse that spreads over both atria. The impulsesignals the two atria to contract at almost the same time. Theimpulse also triggers a second set of cells at the base of the rightatrium to send the same electrical impulse over the ventricles.This causes the ventricles to contract. The pacemaker causes theatria to contract 70–80 times per minute. What controls the pacemaker?The pacemaker controls the heartbeat. A portion of the braincalled the medulla oblongata regulates the rate of the pacemaker.If the heart beats too fast, sensory cells in arteries near the heart become stretched. These cells send a signal through the nervoussystem to the medulla oblongata. The medulla oblongata sendssignals that slow the pacemaker. If the heart slows too much,blood pressure drops, signaling the medulla oblongata to speed upthe pacemaker and increase the heart rate.

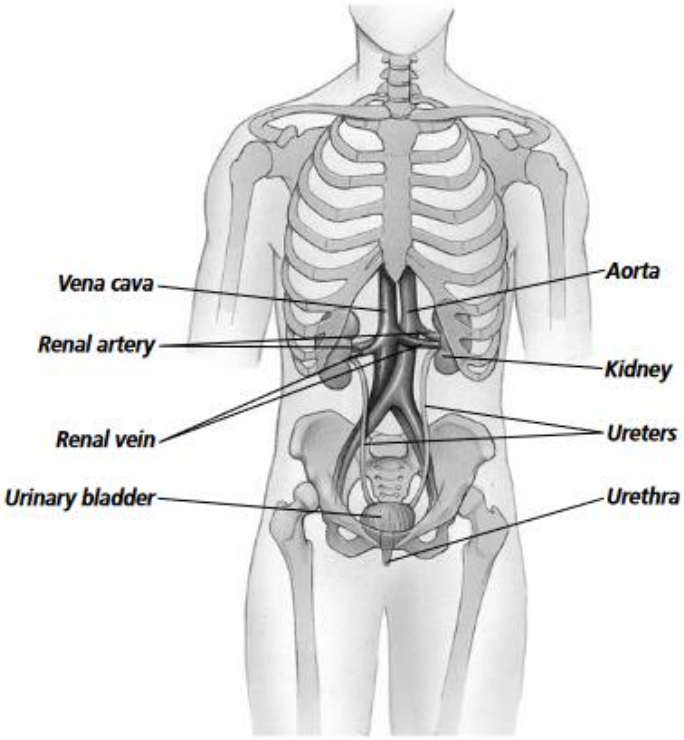
What is blood pressure?

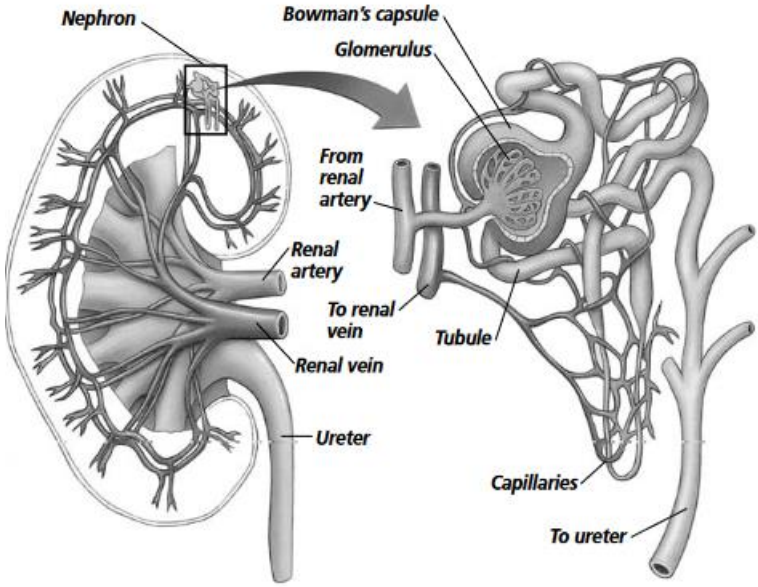
A pulse beat represents the pressure that blood exerts as itpushes against the walls of an artery. Blood pressureis the forcethat the blood exerts on the blood vessels. Blood pressure risesand falls as the heart contracts and then relaxes.Blood pressure rises sharply when the ventricles contract, push-ing blood through the arteries. The high pressure is called systolicpressure. Blood pressure then drops dramatically as the ventriclesrelax. The lowest pressure occurs just before the ventricles con-tract again. It is called diastolic pressure.

The Urinary System

Kidneys: Structure and FunctionThe urinary system is made up of two kidneys, a pair of ureters,the urinary bladder, and the urethra. The kidneysfilter the bloodto remove wastes from it. This maintains the homeostasis of bodyfluids. Homeostasis is the process of maintaining equilibrium.Your kidneys are located just above the waist, behind the stomach.One kidney lies on each side of the spine, partially surrounded byribs. Each kidney is connected to a tubecalled a ureter,which leads to

the urinarybladder. The urinary bladderis a bag madeof smooth muscle. It stores a solution ofwastes. See the illustration at left.What is a nephron?Each kidney is made up of about one million tiny filters. A filter is a device thatremoves impurities from a solution. Eachfiltering unit of a kidney is called a nephron.Blood entering a nephron carries wastesproduced by body cells. The blood enteringthe nephron is under high pressure. Itimmediately flows into a bed of capillariescalled the glomerulus. Because of the pres-sure, water, glucose, vitamins, amino acids,protein waste products (called urea), salt,and ions from the blood pass out of the capillaries into a part of the nephron called the Bowman's cap-sule. Blood cells and most proteins are too large to pass throughthe walls of a capillary, so these components stay within the blood vessels. The liquid forced into the Bowman's capsule passes through anarrow, U-shaped tubule. As the liquid moves along the tubule,most of the ions and water and all of the glucose and amino acidsare reabsorbed into the bloodstream. This reabsorption of sub-stances is the process by which the body's water is conserved andhomeostasis is maintained.Small molecules, includingwater, move back into the cap-illaries by diffusion. Othermolecules and ions move back into the capillaries byactive transport.The liquid that remains inthe tubules, composed ofwaste molecules, excess water,and ions, is urine.Humansproduce about 2 L of urine aday. This waste fluid flows outof the kidneys, through theureter, and into the urinarybladder where it may bestored. Urine passes from theurinary bladder out of thebody through a tube called theurethra(yoo REE thruh).


Vena cava
Aorta
Renal artery
Kidney
Renal vein
Ureters
Urinary bladder
Urethra


Nephron
Bowman's capsule
Glomerulus
From renal artery
Renal artery
To renal vein
Tubule
Renal vein
Ureter
Capillaries
To ureter

The Urinary System and HomeostasisThe major waste products of cells are nitrogenous wastes, whichcome from the breakdown of proteins. These wastes includeammonia and urea. Both compounds are toxic to the human bodyand must be removed from the blood regularly. In addition toremoving these wastes, the kidneys control the level of sodium inblood by removing and reabsorbing sodium ions. This helps con-trol the osmotic pressure of the blood. The kidneys also regulatethe pH of blood by filtering out hydrogen ions and allowingbicarbonate to be reabsorbed into the blood. Glucose is a sugarthat is not usually filtered out of the blood by the kidneys. Indi-viduals with diabetes have too much glucose in their blood

References

1- **Glencoe science reading essentials for biology the dynamics of life Copyright © Glencoe/McGraw-Hill, a division of The McGraw-Hill Companies, Inc.**

2- **Campbell, 7th edition References**