Chapter 11 Human Body Systems:

11.1 Opening Questions: How are animals organized?

- Arrange the following parts of your body into a logical hierarchy:
  - Heart
  - Circulatory system
  - Cardiac (heart) muscle
  - Cardiac (heart) cell

Answer:
- Circulatory system
- Heart
- Cardiac muscle
- Cardiac cell

11.1 Animal bodies can be organized into a structural hierarchy.

- An important principle is that form correlates with function.
- Anatomical structures (form) inform our understanding of physiological action (function), and vice versa.

11.1 Individual cells are organized into larger and larger working units.

11.2 Opening Questions: Body Olympics?

Which organ do you think is your body’s largest?

Which bone in your body is the longest?
11.2 The human body contains several major types of tissues.

- Cells work cooperatively as part of a tissue.
- Each tissue consists of similar cells that work together to perform a specific function.
- Most animal bodies contain a number of tissues.

**Remember: the cell is the fundamental unit of life.**

11.2 Connective tissue supports, connects, or binds different parts of the body.

- Connective tissue consists of cells scattered throughout an extracellular matrix.

11.2 Your skin and nervous system are made of tissue.

- Epithelial tissue (epithelium) covers the whole surface of the body, including your digestive tract.

- Nervous tissue communicates signals between your brain and the rest of the body.

11.2 Your muscular system contains three types of muscles made of tissue.

- Muscle tissue consists of bundles of long cells called muscle fibers, each of which contains specialized proteins that allow it to contract (shorten).

- Epithelial tissue (epithelium) covers the whole surface of the body, including your digestive tract.

11.3 Opening Questions: Human body trivia—you decide: true or false?

For each one, be prepared to explain your choice:

- **True or false?** The average adult takes over 20,000 breaths a day.

- **True or false?** Water makes up more than 50 percent of the average adult’s body weight.

- **True or false?** Adults excrete more than one liter of urine a day.

11.3 An animal’s internal environment remains relatively constant.

- Every organism exchanges chemicals and energy with its surroundings.

- One of the characteristics that distinguishes living organisms from nonliving matter is the ability to detect and react to environmental stimuli.
11.3 Animal bodies tend to maintain relatively constant internal conditions.

- The tendency to maintain a constant internal environment is called **homeostasis**.
- When the external environment changes drastically, the body uses various mechanisms that maintain internal systems.

11.3 Diabetes is an example of a breakdown in homeostasis.

- In a person with **diabetes mellitus**, the body fails to produce enough insulin (type 1) or target cells do not respond normally (type 2).
- Diabetes kills over 3 million people worldwide.

11.3 The integumentary system interacts most directly with the environment.

- The **integumentary system** includes organs such as skin, hair, and nails that protect the body against physical harm.

11.3 How does your body detect and respond to changes in the environment?

- **Negative feedback**, where the results of a process inhibit that very process, is the most common mechanism.

11.4 Opening Questions: Feeling thirsty?

- As you exercise, your breathing and heart rate increase, your skin may flush, and you may sweat.
- If you continue to exercise, you may feel thirsty.

**How is feeling thirsty during exercise an example of a negative feedback loop?**

11.4 The human digestive system is a long tube with specialized organs.

- Your “gut” is called the **alimentary canal**.
- At each stop along the alimentary canal, specific steps in the processing of food occur.
11.4 The alimentary canal starts at your mouth.

1. The mouth, also called the oral cavity, is the site of ingestion.
2. At the pharynx, the epiglottis moves to cover the entrance to the trachea, directing food down the esophagus.

11.4 The stomach has elastic folds and can stretch out.

3. Food moves through the esophagus to the stomach via muscle contractions called peristalsis.
4. Cells lining the stomach secrete gastric juice, containing enzymes (such as pepsin).

11.4 Most digestion occurs in the small intestine.

5. Chemical digestion is completed within the small intestine.
6. Within the colon, the main portion of the large intestine, water is absorbed.
7. Remaining waste is formed into feces and stored in the rectum.

11.4 Waste, as feces, is expelled.

8. Two sphincter muscles, one voluntary and the other not, regulate the opening of the anus.
9. When the voluntary sphincter muscle is relaxed, feces are expelled.

11.4 Your digestive system contains a series of accessory organs.

- Accessory organs secrete specific digestive chemicals into the alimentary canal via ducts.

11.5 Opening Questions: What happened to last night’s dinner?

- Try to remember all the food you have eaten over the past 24 hours.
- Why did you choose the foods you ate?

Take one of those foods and write down its pathway through your digestive system.
11.5 Food processing occurs via four stages:

1. **Ingestion** (eating)
2. **Digestion** (mechanical and chemical)
3. **Absorption** (primarily by cells lining the small intestine)
4. **Elimination**

Why do you chew your food before swallowing it?

11.5 After ingestion, digestion begins.

- **Mechanical digestion** is the use of physical processes to break down food into smaller pieces.
- **Chemical digestion** is the use of enzymes to perform hydrolysis, chemical reactions that use water to break bonds within large molecules.

11.5 After digestion, food molecules are absorbed and waste is eliminated.

- **Absorption** is the uptake of these small nutrient molecules, primarily by the cells that line extensive folds of the small intestine.
- **Elimination** is the disposal of undigested matter from the body.

11.6 Opening Questions: Can you have a zero-calorie energy drink?

- Your friend raves about a new zero-calorie energy drink. Since you are taking biology, you start to wonder whether that type of drink really can contain “energy.”

Is it possible to have a zero-calorie energy drink? Explain your answer.

11.6 Proper nutrition provides energy and building materials.

- Food provides energy (fuel).
  - Every cell requires a constant supply of energy in the form of the molecule ATP.
- Food provides the building materials needed for the body’s structures.
  - **Essential nutrients** are those that cannot be produced by the body itself.

The potential energy in food is held in molecules like glucose.

11.6 USDA Dietary guidelines are meant to remind us to make healthy food choices.

**OTHER RECOMMENDATIONS**
- Avoid sodium
- Drink water
- Eat high-fat foods only occasionally
- Limit empty calories
- Be physically active

Source: USDA’s Center for Nutrition Policy and Promotion
11.6 Four categories of essential nutrients

VITAMINS: A vitamin is an organic (carbon-containing) nutrient required in your diet, but only in very small amounts.

MINERALS: Minerals are inorganic chemical elements required to maintain health.

ESSENTIAL AMINO ACIDS: Essential amino acids are required to build proteins.

ESSENTIAL FATTY ACIDS: Essential fatty acids are required to build important lipid-based molecules.

11.7 Opening Questions: Human body trivia – you decide: true or false?

For each one, be prepared to explain your choice:

- True or false? You cannot digest food if you are turned upside-down.
- True or false? Most of your food is digested in your stomach.
- True or false? The salivary glands in the mouth produce approximately 1.2 liters of saliva daily.

11.7 Many illnesses are caused by infection or malfunction of the digestive system.

- Common ailments include:
  - Acid reflux
  - Gallstones
  - Constipation
  - Appendicitis
  - Cholera
  - Inflammatory bowel disease
  - Ulcer

11.7 Improper diets can cause significant health problems.

- Obesity
  - Contributes to type 2 diabetes, cancer, and cardiovascular disease.
- Malnutrition
  - Is caused by a diet that lacks sufficient calories or essential nutrients.
- Eating disorders
  - Anorexia nervosa and bulimia can cause nutrient deficiencies and death.

11.8 Opening Questions: Does your diet affect your health in multiple ways?

For much of human history, poor nutrition and starvation were major health concerns. In modern human societies, increasing access to high-calorie, processed foods has resulted in rising obesity levels.

Is it possible for a person to be both obese and malnourished?

Explain your answer.

11.8 The respiratory system exchanges gases: O$_2$ into the body and CO$_2$ out.

- Breathing is the alternation of inhalation (in) and exhalation (out) of air from your lungs.

Due the branching of your airways, there is a tremendous surface area in your lungs.
11.8 Air exchange occurs between the lungs and the surrounding blood vessels.

- The **circulatory system** conveys oxygen from the lungs to body cells.
- The exchange of gases occurs between **blood capillaries** and **alveoli** (tiny air sacs) in your lungs.

11.8 What can go wrong with the respiratory system?

- **Emphysema** is often caused by long-term exposure to tobacco smoke or air pollution.
- **Bronchitis** is most commonly caused by a viral infection of the bronchioles.
- **Upper respiratory infections** (URIs) can be caused by either viruses or bacteria.
- **Asthma** is a long-term inflammation of the airway.

11.9 Opening Questions: How much air do you breathe in during a deep breath?

- An adult male can usually hold around 6 liters in the lungs.
- Lung volume is influenced by many things, including size, gender, and elevation.

**How might an athlete’s lung capacity compare to that of a nonathlete? Explain your reasoning.**

11.9 The circulatory system transports materials throughout the body.

- The **heart** pumps blood through a series of **blood vessels**.
- Blood carries nutrients and wastes.
- Your heart and blood vessels working together is your **cardiovascular system**.

11.9 Three types of blood vessels make up the “plumbing” of your circulatory system.

1. **Arteries** (and smaller arterioles) carry blood away from the heart.
2. **Veins** (and smaller venules) carry blood to the heart.
3. **Capillaries** join arterioles to venules.

11.9 The human cardiovascular system can be organized into two circuits.

- The **pulmonary circuit** shuttles blood from the heart to the lungs.
- The **systemic circuit** shuttles blood from the heart to the rest of the body.
11.9 What can go wrong with the cardiovascular system?

- **Hypertension** (high blood pressure) increases the risk of heart attack, heart disease, and stroke.
- **Heart disease** often results from fatty deposits blocking the arteries and is the most common cause of death among Americans.
- **Anemia** occurs when the blood doesn’t carry enough oxygen.

11.10 Opening Questions: Does all blood have the same oxygen level?

- What is the oxygen content (high or low) for blood flowing from your heart to your toes in an artery?
- What is oxygen content (high or low) for blood flowing from your brain to your heart in a vein?

11.10 The heart is the hub of the human circulatory system.

- Blood enters the heart at the **atria**, which pumps it a short distance to the **ventricles**.
- The ventricles then pump it out of the heart to the rest of the body.

11.10 The cardiac cycle, a rhythmic contraction and relaxation of the heart

- In **diastole**, the heart muscles relax.
- In **systole**, the heart contracts.

11.10 The timing of your heartbeat is set by a natural pacemaker.

- The **sinoatrial (SA) node** is nervous tissue that times heartbeats.
- The SA node causes atria to contract and sends the signal to the **atrioventricular (AV) node** to signal the ventricles to contract.

11.10 If coronary arteries become blocked, heart muscle cells quickly die.

- Blockage is called a myocardial infarction, or **heart attack**.

Buildup of fatty deposits, **plaque**, is usually the result of a gradual process called **atherosclerosis**.
11.11 Opening Questions: How does your heart rate change after exercise?

- Your pulse is the rate at which your heart beats.
- Take your resting pulse rate: turn your left hand palm-side up, then place the first two fingers of your right hand along the outer edge of your left wrist.
- Count the number of beats in 15 seconds (use a timer on your watch or cell phone). Multiply this by four to determine the number of heartbeats in 1 minute.
- Do an exercise such as running in place or jumping jacks for 1 minute. Stop and calculate your pulse again.

How did your heart rate change after exercising? What is happening in your circulatory system?

11.11 Blood contains cells in liquid.

- Your blood consists of many small molecules and several types of cells dissolved in a liquid called plasma.
- Red blood cells transport oxygen using hemoglobin.
- White blood cells fight infections.

11.11 Your red blood cells transport oxygen.

- In the lungs, O₂ binds to a protein in your red blood cells called hemoglobin.

Your blood is red because iron is bound to the heme group in the protein hemoglobin.

11.12 Opening Questions: How was the trip?

Imagine you are a red blood cell. You are currently moving along in the blood capillaries that connect with the tiny alveoli in the lungs. So, you've just gotten oxygenated!

Map out your trip as a red blood cell. Where do you go? What do you see?

Estimate how long it will take you to complete one circuit of the body, before you return to the lungs.

11.12 The immune system contains a huge number of defensive elements.

- Your immune system protects against pathogens using a huge number and variety of defenses.
- These include:
  - External barriers
  - The inflammatory response
  - The lymphatic system
  - White blood cells
11.12 External barriers are your first line of defense against infections.
- **Hairs and cilia**
  - Sweep particles outward until they can be expelled.
- **Mucous membranes**
  - Secrete mucus, a sticky fluid that traps particles.
- **Gastric juice**
  - Kills most of the bacteria you swallow.
- **Skin**
  - Forms a protective outer layer that most viruses and bacteria cannot penetrate.

11.12 The inflammatory response is a nonspecific defense against tissue damage.
- Cell damage triggers the **inflammatory response**.
- White blood cells called **phagocytes** engulf and destroy bacteria.

11.12 The lymphatic system kicks into high gear when your body fights an infection.
- The **lymphatic system** is a branching network filled with **lymph fluid**.
- Invading microbes are swept into **lymph nodes**, where they are attacked by **lymphocytes** (white blood cells that reside in the lymphatic system).

11.12 Specific immunity depends on lymphocytes, white blood cells.
- **Specific immunity** must first be primed by exposure to an **antigen**, a molecule that elicits an immune response.
- **Lymphocytes** come in two varieties: **B cells** and **T cells**.

11.12 Lymphocytes have surface receptors that bind to one kind of antigen.
- Once activated, B cells secrete antibodies, proteins that circulate in the blood that are specific for that same antigen.

11.12 The immune system maintain a vast army of white blood cells.
- Antigen exposure will stimulate rapid multiplication of lymphocytes in a process known as **clonal selection**.
11.12 Once antigens are recognized, they must be destroyed.

- **Helper T cells** stimulate the production of several types of immune cells to take on invaders.

11.12 Once exposed to an infectious disease, you may have lifetime immunity.

Memory cells can live for decades!

11.13 Opening Questions: Gesundheit!

- Imagine this scenario: your roommate comes home sneezing and coughing. He has got a cold!
- Unfortunately, your roommate has now exposed you to the cold virus.

What defenses does your immune system have against a cold virus?

Consider all aspects of the immune system: external barriers, the inflammatory response, the lymphatic system, and white blood cells.

11.13 Immune system malfunctions cause a variety of disorders.

- Problems can arise when the immune response is too strong.
- These include:
  - Allergies
  - Autoimmune diseases
  - Immunodeficiency
  - Organ rejection

11.13 The immune system can turn against the body’s own cells and molecules.

- **Autoimmune diseases** occur when the immune system’s self-recognition breaks down.
- Autoimmune diseases include:
  - rheumatoid arthritis
  - type 1 diabetes
  - multiple sclerosis

11.13 Problems can also arise when the immune response is not strong enough.

- **Immunodeficiency diseases** result when one or more components of the immune system are missing or defective.
- These include:
  - Severe combined immunodeficiency (SCID)
  - Immunodeficiency diseases including AIDS
11.13 Vaccination: Outsmarting invaders

• **Vaccination** (also called immunization) involves purposefully exposing the immune system to an antigen, which stimulates the production of memory cells.
• Modern vaccines are created from killed bacteria or viruses, or fragments of proteins from these microbes.

11.14 Opening Questions: Is stress making you sick?

• Evidence suggests that emotional stress can trigger the release of hormones that may suppress the immune system.
• Conversely, during times of happiness, the brain releases chemicals that may enhance immunity.

In your own life, have you seen any link between stress and immunity?

11.14 The endocrine system regulates the body via hormones.

• **Hormones** are chemical signals produced by endocrine tissue that are transported by the bloodstream and affect target cells throughout the body.
• A tiny amount of a hormone is often sufficient to influence many cells.

11.14 Endocrine system: Important players

• **Hypothalamus**
  – Control center of the endocrine system
• **Pituitary**
  – Receives signals from the hypothalamus
• **Parathyroid glands**
  – Help regulate blood calcium levels
• **Thyroid gland**
  – Regulates oxygen consumption, metabolism, blood calcium levels, and body temperature

11.14 Endocrine system: Important players

• **Pancreas**
  – Regulates blood glucose levels through the secretion of hormones
• **Adrenal glands**
  – Regulate metabolism and responses to stress
• **Testes** (males) or **ovaries** (females)
  – Growth and development, promote sexual characteristics, and regulate reproduction

11.14 Glucose regulation is an example of negative feedback maintaining homeostasis
11.15 Opening Questions: Human body trivia—you decide: true or false?

For each one, be prepared to explain your choice:

- **True or false?** All the blood in our body is filtered through the kidneys 400 times every day.
- **True or false** Eating asparagus makes everybody's urine odiferous (but only ~25% of us have the gene to smell it).
- **True or false?** Urinating on a jellyfish sting is not an effective remedy.

11.15 The urinary system rids the body of nitrogen-containing wastes.

- **Osmoregulation** is the control of the gain or loss of water and dissolved ions.
- The **urinary system** disposes of wastes and helps regulate the concentration of water and dissolved substances within the body.

11.15 Urinary system: Important players

- **Kidneys** (pair) — The central organs of the urinary system
- **Renal artery and vein** — Blood supply to and from the kidneys
- **Urinary bladder** — Stores urine
- **Urethra** — A tube through which urine is expelled

11.15 Your kidneys continuously filter your blood, producing urine.

- The filtering of the blood takes place within the **kidney nephrons**.
- Water and solutes are reclaimed and returned to the blood via tiny capillaries.
- At the same time, unneeded substances are moved from the blood into the kidney, forming **urine**.

11.15 Urine is mostly water.

- **3.5% Urea**
- **1% Chloride**
- **0.5% Sodium**
- **0.25% Potassium**
- **0.25% Phosphate**
- **0.15% Creatinine**
- **0.1% Uric acid**

11.15 Dialysis treatment

- A person with one functioning kidney can lead a normal life, but if both kidneys fail, the buildup of toxic wastes will lead to certain and rapid death.
- **Dialysis** is the filtration of the blood by a machine that mimics the action of a kidney.
11.16 Opening Questions: How many chromosomes?

*Fill in the blanks:*

• The correct chromosome number for a human is __________.

• Sperm and egg cells have __________ chromosomes.

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11.16 Males and females both produce, store, and deliver gametes.

• Despite their external differences, both sexes share the following similarities:
  - A pair of gonads, the organs that produce gametes
  - A system of ducts that store and deliver gametes
  - Structures that facilitate copulation (sexual intercourse)

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11.16 Male reproductive anatomy

- Urine and sperm are conveyed through a tube called the urethra.
- The penis contains erectile tissue that, when filled with blood, produces an erection.
- The male gonad is the testis.
- The scrotum is an external sac that holds the testes and keeps them slightly cooler than body temperature.

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11.16 A sperm is a haploid cell formed by the division of a diploid cell.

• Within the testes, diploid cells divide via meiosis to produce haploid sperm cells (23 chromosomes).
• This is the process of spermatogenesis.

Recall that humans have 46 chromosomes.

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11.16 Female reproductive anatomy

- The ovary is the female gonad, where eggs are produced and released.
- The uterus is the site of pregnancy where an embryo develops into a baby.
- The oviduct (fallopian tube) is the site where egg meets sperm.
- The vagina, or birth canal, is where sperm enters and a baby exits.
- The vulva is the collective name for all of the external female reproductive structures.

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11.16 An egg is a haploid cell formed by the division of a diploid cell.

• Within the ovary, during the process of oogenesis, a mature haploid egg called an ovum develops (23 chromosomes).
11.16 The female reproductive cycle

- **Ovulation**, the release of an egg cell from the ovaries, occurs around day 14.

11.17 Opening Questions: Viva la difference

- Human males and females have some important differences in their reproductive systems. Yet, there are also some similarities.

  List three differences and three similarities between the reproductive systems of males and females.

11.17 You, and every human, developed from a single cell.

- The time from human fertilization to birth takes about 38 weeks.
- During this time, a zygote develops into an embryo and then into a fetus.

11.17 The embryo develops along a timeline.

- By day 9 after fertilization, the embryo forms a gastrula, with defined layers that will develop into specific organs and tissues.
- By day 21, the embryo is attached to the wall of the uterus by a placenta.
- By just after week 8, the embryo has developed into a 2-inch-long fetus.

11.17 The fetus progresses until birth.

- **First trimester** is marked by organ formation.
- **Second trimester** is time for growth.
- **Third trimester** is preparing for birth.
- Childbirth is brought about by labor, a series of uterine muscle contractions.

11.18 Opening Questions: Human body trivia—you decide: true or false?

For each one, be prepared to explain your choice:

- **True or false?** The largest cell in the human body is the female egg.
- **True or false?** A fetus acquires fingerprints at the age of three months.
- **True or false?** Sexual reproduction increases genetic variation, which increases the raw material on which natural selection operates.
11.18 Issues of reproductive health affect all of us.

• The anatomy of the human reproductive system can help us to understand issues of reproductive health.
• These include:
  – Contraception
  – Infertility
  – Sexually transmitted diseases (STDs)

11.18 Contraception methods vary based on male and female anatomy.

• Birth control pills (or patches) contain synthetic hormones to prevent the formation of gametes.
• The diaphragm and tubal ligation prevent joining of the egg and sperm.

11.18 Contraception methods vary based on male and female anatomy.

• Currently, the available male contraception depends on preventing the egg and sperm from joining.
• These include condoms and vasectomy.

11.18 Infertility issues affect both males and females, but for different reasons.

• About 15% of couples are infertile—that is, they are unable to conceive a child despite one year of trying.
• There are many potential causes of infertility, and several possible solutions.

11.18 STDs are spread by sexual contact and represent several organism types.

• Sexually active individuals should be screened for sexually transmitted diseases (STDs) annually.

11.19 Opening Questions: Why sex?

• After learning about sexually transmitted diseases (STDs), perhaps cloning yourself doesn’t sound like such a bad idea (asexual reproduction).
• Yet, despite its disadvantages, nearly 99% of all plants and animals reproduce sexually.

From an evolutionary perspective, what might be a benefit of sexual reproduction that is great enough to outweigh the costs?
11.19 The brain is the hub of the human nervous system.

- The nervous system divided into two major parts:
  - The **central nervous system** (CNS) includes the brain and spinal cord.
  - The **peripheral nervous system** (PNS) includes your nerves.

11.19 The central nervous system receives, processes, and sends out information.

- The CNS receives incoming signals from the senses (such as touch).
- It then integrates them to formulate a response and transmits signals that produce reactions, such as moving a muscle.

11.19 Key components of the central nervous system

- The CNS is protected by a layer of connective tissue called the **meninges**.
- The **brain** receives and integrates sensory information, keeps the body functioning, controls the muscles, and is the center of emotion and intellect.

11.19 Key components of the central nervous system

- The **spinal cord** is the central communication conduit between the brain and the body.
- Both the brain and the spinal cord contain spaces filled with **cerebrospinal fluid**, which cushions and supplies nutrients, hormones, and white blood cells.

11.19 The nervous system can be negatively impacted by disease and injury.

- Disorders of the nervous system are difficult to diagnose and treat because of the complexity of this system.
- Some examples include:
  - Depression
  - Alzheimer's disease
  - Paralysis
  - Spinal infections

11.19 The human brain is an incredibly sophisticated system.

- Your brain excels at receiving, processing, and communicating information.
- The brain acts as the central hub for the nervous system.
- The spinal cord acts as the main conduit to the rest of the body.
11.19 Organization of the nervous system

11.20 Opening Questions: Brain needs?

- Your brain represents approximately 3% of your total body mass.

Of all the oxygen you breathe in, what percentage do you think is used by your brain?

A. 1%
B. 3%
C. 10%
D. 20%
E. 50%

11.20 The nervous system receives input, processes it, and sends output.

- The **nervous system** forms a communication and coordination network.
- Your nervous system consists of your brain, spinal cord, and many nerves.
- Neuron networks enable us to move, perceive our surroundings, learn, and remember.

11.20 Nerve signals travel along the axon.

- **Neurons** are nerve cells that carry electrical signals from one part of the body to another.

11.20 The movement of ions into and out of the axon generates the signal.

- A nerve signal involves a temporary reversal of the electric charge, caused by ions flowing into and out of the axon.

11.20 Nerve signals travel to a receiver cell: another neuron or other type of cell.

- At the **synapse**, the signal may be communicated to another cell via chemical neurotransmitters.

A synapse is a gap at the end of a neuron.
11.21 Opening Questions: Can you score?

If you see a soccer ball coming and move to kick it, what is happening in your nervous system?

- Describe what is happening in your nervous system as you see the ball.
- Consider that your action involves the three interconnected functions of the nervous system.

11.21 Your senses use receptors to convey information about the outside world.

- Senses are created when sensory receptor cells detect a stimulus and convert it to an electrical nerve signal that is communicated to the brain.
- The brain then can formulate and convey responses.

11.21 There are several categories of sensory receptors.

- Pain receptors
- Thermoreceptors
  - Detect heat and cold
- Mechanoreceptors
  - Detect touch, pressure, motion, sound, body position
- Electromagnetic receptors
  - Detect energy, including photoreceptors that detect light
- Chemoreceptors
  - Detect chemicals, such as those found in foods and odors

11.21 Your sense of smell is an example of stimulus and response.

1. Odor molecules bind to receptor cells and through signal transduction and create an action potential (electrical signal).
2. The signal is carried to the brain.
3. The brain then creates perceptions from the input.

11.21 The human eye is able to respond to even tiny amounts of stimulus.

- As light strikes the retina, receptor cells convert the stimulus into nerve signals sent to the brain.

11.21 The human ear is capable of hearing a great range of auditory signals.

- Sound vibration is detected by hair cells in a fluid in the inner ear and converted to an electrical signal that travels to the brain.
11.21 Food molecules bind the taste receptor cells located in taste buds.

• There are five different tastes: sweet, salty, sour, bitter, and umami (savory).

11.22 Opening Questions: Fun facts

The human skeleton contains 206 bones.

Where is the smallest bone in your body located?

A. Nose
B. Ear
C. Little finger
D. Big toe
E. Brain

11.22 Your skeletal system supports your body.

• Your skeletal system provides support, protects your vital organs, and anchors your internal structure.
• Like all vertebrates, you have an endoskeleton, a bony skeleton located inside your body.

11.22 The human skeleton contains 206 bones.

Your bones include:
• An axial skeleton, which supports the axis, or trunk, of your body
• An appendicular skeleton, which is all the rest of your bones
• Cartilage that provides flexibility and cushioning

11.22 Your bones contain living tissue that can regenerate after an injury.

• Bones are living organs containing several kinds of tissue.

11.22 Joints allow for complex skeletal movements.

• Ligaments are strong fibrous connective tissue that hold bones together at joints.
• Several types of joints permit movement. These include:
11.22 Skeletal system: What can go wrong?

- **Fractures** (broken bones) result from forces that exceed a bone’s ability to flex.
- **Arthritis** is an inflammation of the joints.
  - Due to aging, immune system disorders, injury, or infection
- **Osteoporosis** is characterized by a low bone mineral density.
  - Bones are thinner, so are more easily broken.

11.23 Opening Questions: Do you smoke?

Tobacco smoking impacts multiple body systems. For each of the effects below, consider which body systems are likely impacted.

<table>
<thead>
<tr>
<th>Effect of Cigarette Smoking</th>
<th>Body System(s) impacted</th>
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</thead>
<tbody>
<tr>
<td>1. Damage to the air sacs of the lungs</td>
<td></td>
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<tr>
<td>2. Raised blood pressure</td>
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<td>3. Reduced white blood cell number</td>
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<td>4. Interference with neurons</td>
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<tr>
<td>5. Lower sperm count and impotence</td>
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<td>6. Reduced ability to smell or taste</td>
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<tr>
<td>7. Decreased bone density</td>
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**Note:** These are just some of the effects!

11.23 Animals move from an interplay of the nervous, skeletal, and muscular systems.

- Your muscular system contains three types of muscles: smooth, cardiac, and skeletal.
- **Skeletal muscles** produce movement when they contract (shorten) and exert a force against the stationary skeleton.

11.23 Each skeletal muscle consists of bundles of parallel muscle fibers.

- Each **muscle fiber** is a single long, cylindrical cell with many nuclei.
  - Most of a muscle cell consists of **myofibrils**, bundles of proteins.
  - Each myofibril consists of a long series of **sarcomeres** arranged end-to-end.

11.23 The sarcomere is the functional unit of contraction in a skeletal muscle.

- Thin filaments
- Thick filaments

The thin filaments slide along and overlap each other and the thick filaments.

11.23 Contraction of the sarcomeres within muscle fibers allows muscles to shorten.

Body movements are produced by the contraction of the sarcomeres within muscle fibers.
11.23 Answers: Do you smoke?

Tobacco smoking impacts multiple body systems. For each of the effects below, consider which body systems are likely impacted.

<table>
<thead>
<tr>
<th>Effect of Cigarette Smoking</th>
<th>Body System(s) Impacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Damage to the air sacs of the lungs</td>
<td>Respiratory system</td>
</tr>
<tr>
<td>2. Raised blood pressure</td>
<td>Circulatory system</td>
</tr>
<tr>
<td>3. Reduced white blood cell number</td>
<td>Immune system</td>
</tr>
<tr>
<td>4. Interference with neurons</td>
<td>Nervous system</td>
</tr>
<tr>
<td>5. Lower sperm count and impotence</td>
<td>Reproductive system</td>
</tr>
<tr>
<td>6. Reduced ability to smell or taste</td>
<td>Sensory and Digestive systems</td>
</tr>
<tr>
<td>7. Decreased bone density</td>
<td>Skeletal system</td>
</tr>
</tbody>
</table>

Note: These are just some of the effects!