Anatomy, Physiology, and the Characteristics of Life

Anatomy and Physiology

Distinct yet interrelated biologic studies

- Anatomy
  - Scientific study of the structures of the body and the relationship of its parts
- Physiology
  - Scientific study of the processes and functions of the body that support life

Anatomy

"Anatomy" = to cut apart

Categories of anatomy:

- Developmental
- Gross
- Regional
- Systemic
- Surface

Physiology

"Physiology" = physis (nature) + logos (science)

Categories of physiology

- Organizational physiology
- Pathophysiology
- Systemic physiology

Organization physiology studies how the body is organized (example: cellular physiology).

Pathophysiology is the study of disease

Systemic physiology is the study of body systems.

Structure (anatomy) and function (physiology) are inseparable; they form a continuum.

Structure and Function

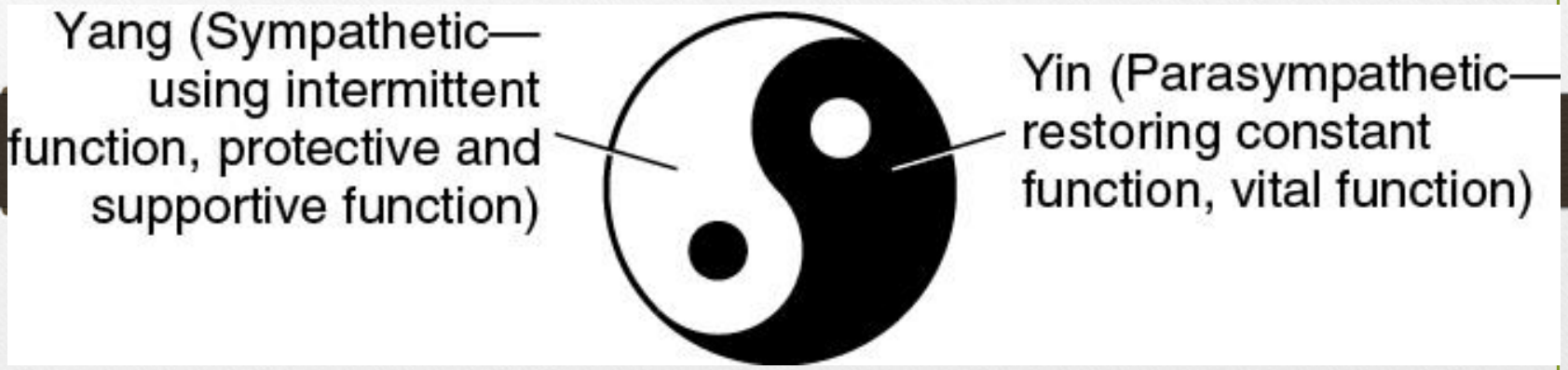
Duality of wholeness

- Structure (anatomy) and function (physiology) cannot be separated.
- Regulatory functions of the body (homeostasis)

The duality of wholeness is often how we make sense of our inner and outer worlds.

Yin and Yang

Duality of wholeness



Yin corresponds to structure, yang to function; they are intertwined.

Yin and Yang

Among other things, yin and yang represent a wholeness divided into two complementary parts. Nothing can be totally yin or totally yang.

Table 1-1 Yang Qualities Versus Yin Qualities

Yang Qualities	Yin Qualities
Day	Night
Immaterial	Material
Produces energy	Produces form
Hot	Cold
Sun	Moon
Expansion	Contraction
Energy	Matter
Above	Below
Fire	Water
Hollow	Solid
Hard	Soft
Superior	Inferior

Characteristics of Life

Maintenance of boundaries

Movement

Responsiveness

Conductivity

Metabolism

Growth

Respiration

Digestion

Maintenance of boundaries: Keeping the internal environment distinct from the external environment

Movement: The ability to transport the entire being, as well as internal components, throughout the body

Responsiveness: The ability to sense, monitor, and respond to changes in the external environment

Conductivity: The movement of energy from one point to another

Metabolism: A chemical reaction that occurs in cells to affect transformation, production, or consumption of energy

Growth: A normal increase in the size and/or number of cells

Respiration: The absorption, transport, and use or exchange of respiratory gases (oxygen and carbon dioxide)

Digestion: The process by which food products are broken down into simple substances to be used by individual cells

Absorption

Secretion

Excretion

Circulation

Reproduction

Metabolism

Absorption: The transport and use of nutrients

Secretion: The production and delivery of specialized substances for diverse functions

Excretion: The removal of waste products

Circulation: The movement of fluids, nutrients, secretions, and waste products from one area of the body to another

Reproduction: The formation of a new being; also the formation of new cells in the body to permit growth, repair, and replacement

Organization of the Human Body

Organization of Body Structure

Chemical level

Organelle level

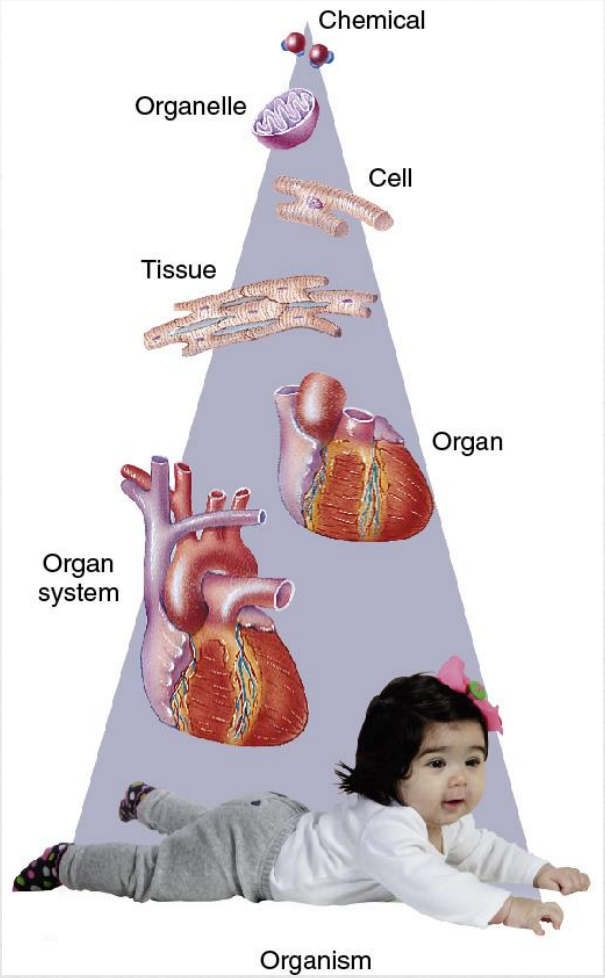
Cellular level

Tissue level

Organ level

System level

Organism level



Chemical Level

Chemical properties

- Demonstrate the way a substance reacts with other substances or the way it responds to a change in the environment.

Physical properties

- Characteristics such as color, taste, texture, and odor

Each substance has chemical and physical properties that give it a unique identity.

Atoms and Molecules

Atom

- Small particle of an element
- Composed of protons, neutrons, and electrons

Element

- Substance composed of single kind of atom

The atoms most commonly found in living things are hydrogen, carbon, nitrogen, and oxygen.

Molecule

- Combination of two or more atoms
- Smallest part of a substance that can exist independently without losing the physical and chemical properties of that substance
- Can form elements or compounds

Compound

- Substance made up of different types of atoms (matter)

Matter exists as solid, liquid, or gas, depending on the attraction of the molecules.

When the molecules exist close together, the substance is solid; conversely, when the molecules are farthest apart, they form a gas.

Chemical Bonds

Ionic bond

- Atom becomes an electrically charged ion with a negative charge (anion) or a positive charge (cation).

Covalent bond

- When two or more atoms share electrons
- Most stable

Polar covalent bond

- Electrically neutral (equal + and – electrons), but arranged so one side is more + or – than the other

Polar molecules attract each other. A strong attraction exists between water molecules, and this attraction is called hydrogen bonding. Hydrogen bonds help to create larger molecules, such as proteins and deoxyribonucleic acid (DNA).

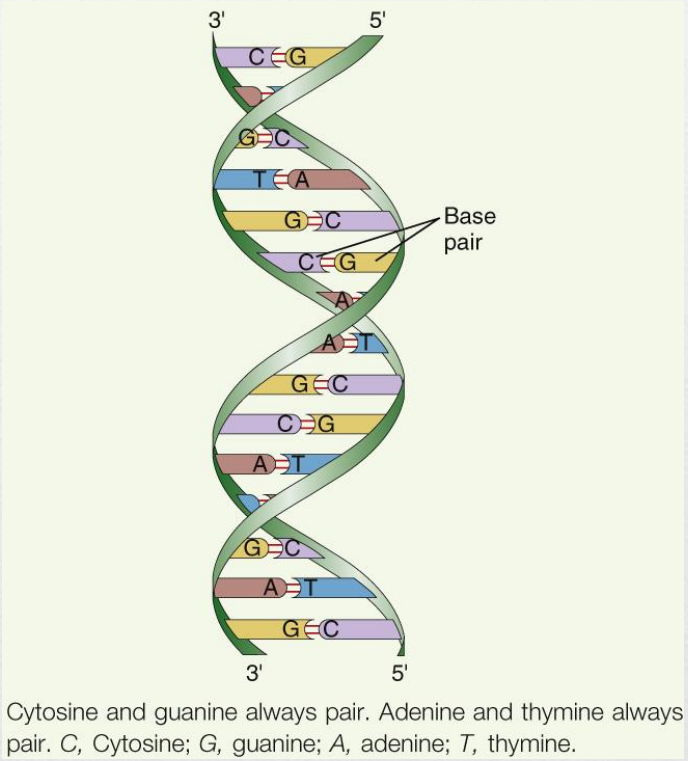
DNA and RNA

DNA (deoxyribonucleic acid)

- Hereditary code for building and maintaining living organisms

RNA (ribonucleic acid)

- Similar to DNA
- Messenger

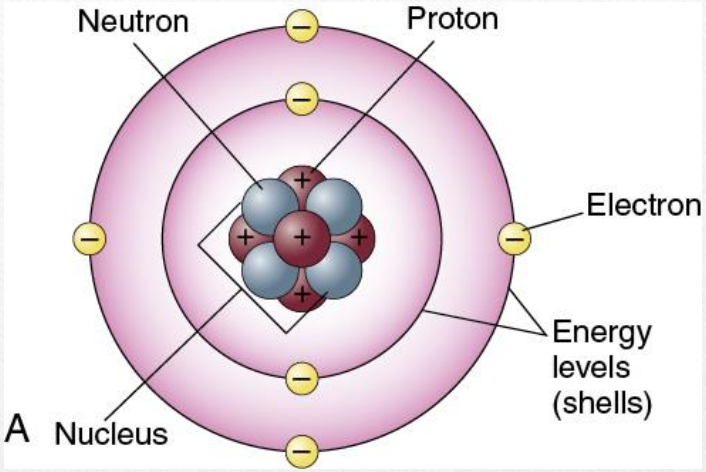


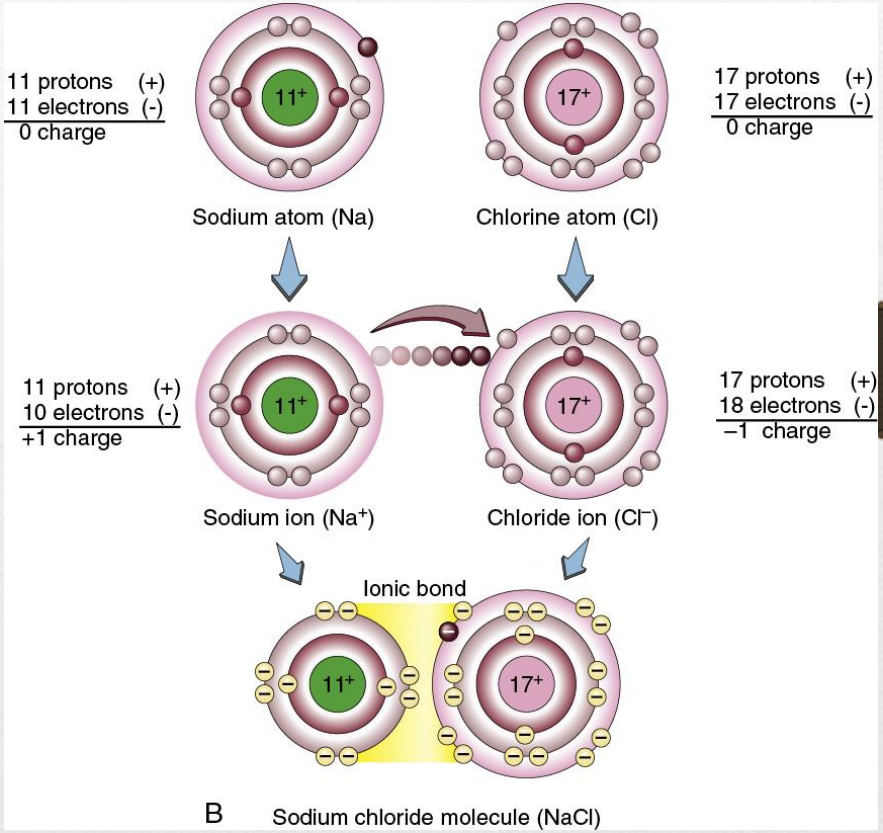
Cytosine and guanine always pair. Adenine and thymine always pair. *C,* Cytosine; *G,* guanine; *A,* adenine; *T,* thymine.

An important property of DNA is that it can replicate or make copies of itself.

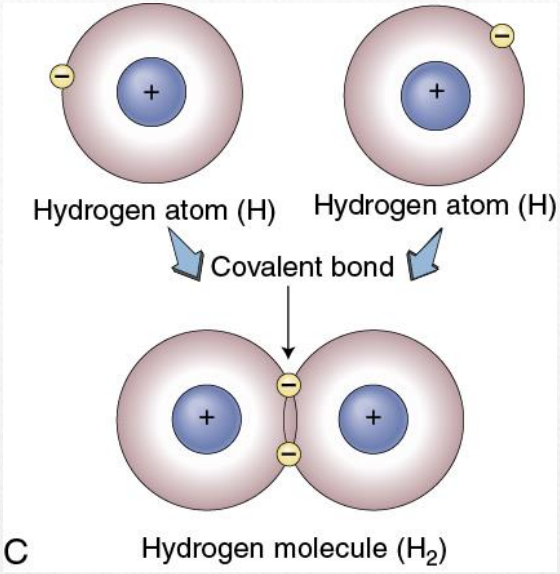
RNA carries information from DNA to organelles called ribosomes that can read RNAs and translate the information so that the cell can make the proteins necessary for body function.

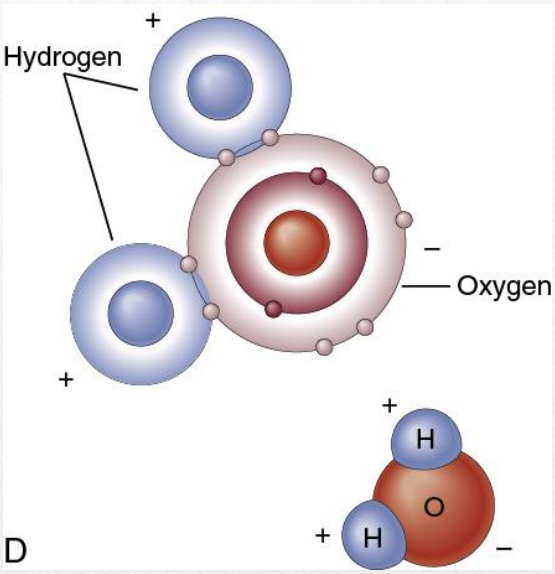
Chemical Bonds





- A, Model of the atom
- B, Ionic bonding





- C, Covalent bonding
- D, Water – a polar molecule

Metabolism

Metabolism

- Converts food and air into energy for our bodies
- Body stores energy as compounds; chemical reactions form and break down the compounds:
  - Anabolism: reactions that use energy to build complex molecules
  - Catabolism: reactions that release energy as they break down complex compounds

Metabolism is the word we use to describe all the physiologic processes that take place in our bodies.

Enzymes speed up the chemical processes that occur during metabolism

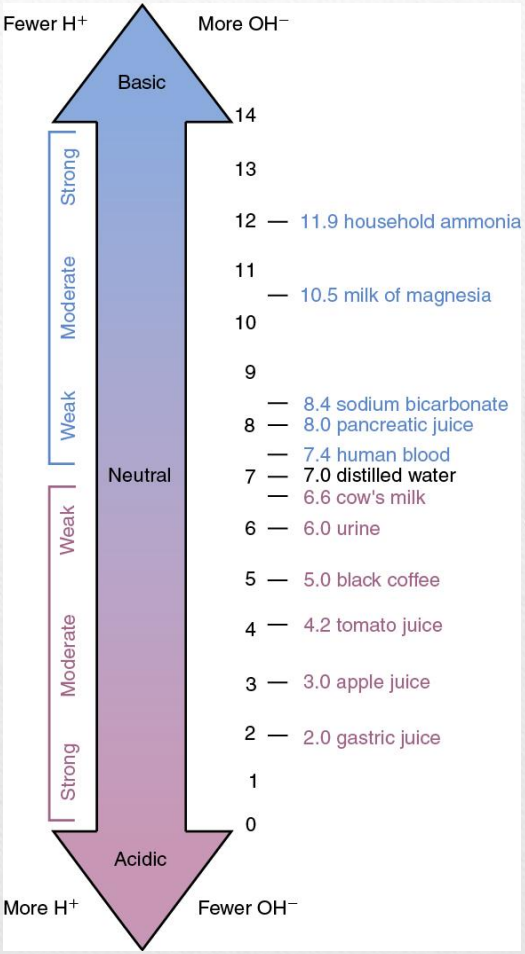
Acidity and Alkalinity

pH scale

Used to measure acidity and alkalinity

The body has to maintain a balance between acidity and alkalinity to support normal function.

The pH of the body is 7.4, which is slightly alkaline. For the enzymes of the body to be active and for the chemical reactions to proceed normally, the pH has to be maintained at this level.



Inorganic and Organic Compounds

Inorganic compounds

Chemical structures that do not have carbon and hydrogen atoms

Organic compounds

Chemical structures that have carbon and hydrogen atoms

Much of our body consists of organic compounds. The food we eat is made mostly of organic compounds called nutrients.

Carbohydrates

- Simple or complex
- Supply most of the energy for body

Lipids

- Fats that form structures and provide energy

Carbohydrates make up 2% to 3% of our body weight.

Lipids make up 10% to 12% of our body weight. When lipid supply exceeds demand, lipids are stored as fat reserves for future use or as important body insulators.

Proteins

- Consist of chains of molecules called amino acids and chains of amino acids called peptides
- Form the structural framework of the body

Nucleic acid

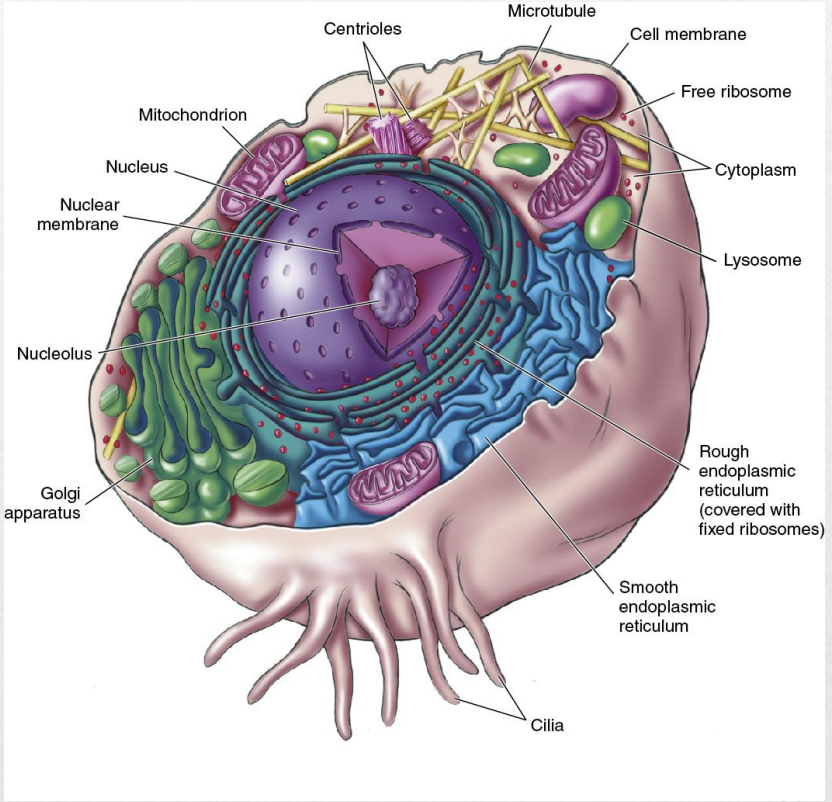
- Major component of ova (eggs) and sperm
- Conveys information about the genetic cycle
- DNA and RNA

Proteins make up about 20% of body weight.

Organelle Level

Organelles: the basic structures found in cells

Each has a specific function to perform.



The nucleus controls the activity of cells and all their reproduction. It contains the DNA and RNA, chromosomes and genes.

The endoplasmic reticulum is the transport network for molecules targeted for certain modifications and specific final destinations. The ribosomes are the sites where amino acids are combined to create various proteins. The mitochondria are responsible for aerobic respiration. The Golgi apparatus modifies molecules and packages them into vesicles. Ribosomes are the sites of protein synthesis.

Cell Membrane

Outer boundary of a cell

Composed of lipids, carbohydrates, and proteins (phospholipid bilayer)

Functions:

- Contain the inside of the cell
- Allow the transport of certain substances into and out of the cell

Can be impermeable or semipermeable

Electrical charge, chemical composition, and the size and shape of a substance determine whether the cell membrane will allow it to pass through.

Passive transport

- Diffusion
- Osmosis
- Filtration
- Carrier-mediated transport
  - Endocytosis
  - Exocytosis

Transport of substances across the cell membrane without use of energy is called passive transport.

Active transport

Active transport of substances across a cell membrane requires energy in the form of ATP. Active transport uses energy to create ion pumps.

Organelle Level

Cytoplasm

- Material enclosed by a cell membrane

Endoplasmic reticulum

- Network distributed throughout cytoplasm
- Rough and smooth

Golgi apparatus

- Processes and packages protein and some carbohydrates for distribution to or for secretion from the cell

Cytoplasm, which is not classified as an organelle, is the medium that surrounds all the organelles.

The cytoskeleton is internal scaffolding that anchors the organelles and allows the cells to move and to maintain or change their shapes.

Lysosomes

Digestive system of cell

Microvilli

Small fingerlike projections of the cell membrane that serve to increase the surface area

Mitochondria

Produce ATP; energy for cell

The mitochondria may be the largest and one of the most numerous of the organelles.

Peroxisomes

- Help detoxify the cell

Ribosomes

- Most numerous of organelles
- Sites where amino acids are combined to create various proteins

Nucleus

- Controls the daily activities of the cell and all cellular reproduction
- Largest of organelles
- Contains chromosomes
- Contains nucleolus
  - RNA forms ribosomes.

The nucleus has the information needed for the manufacture of more than 100,000 proteins, and it controls which proteins are synthesized and in what amounts during a given time.

Cellular Level

Cells

- Basic structural units of an organism
- Determine activities of any organism

Life cycle

- Growth (interphase)
- Reproduction (mitosis)

In the 1660s, an English scientist named Robert Hook, studying cork, suggested that all things are made of cells.

In 1838, Matthias Schlieden, a microscope-wielding German, determined that plants are made of cells. The next year, Theodor Schwann proved the same went for animals.

During reproduction (mitosis), in which the cell reproduces itself, the process of meiosis halves the number of chromosomes in reproductive cells before they combine and multiply.

Atrophy

Decrease in the size of a cell

Hypertrophy

Increase in the size of a cell

Differentiation

Adaptation of a cell to perform specialized duties

Tissue Level

Tissue: group of similar cells specialized for a specific function

Types of tissue

- Epithelial
- Connective
- Muscle
- Nervous (Neural)

The cells of a tissue are embedded in or surrounded by material called the matrix.

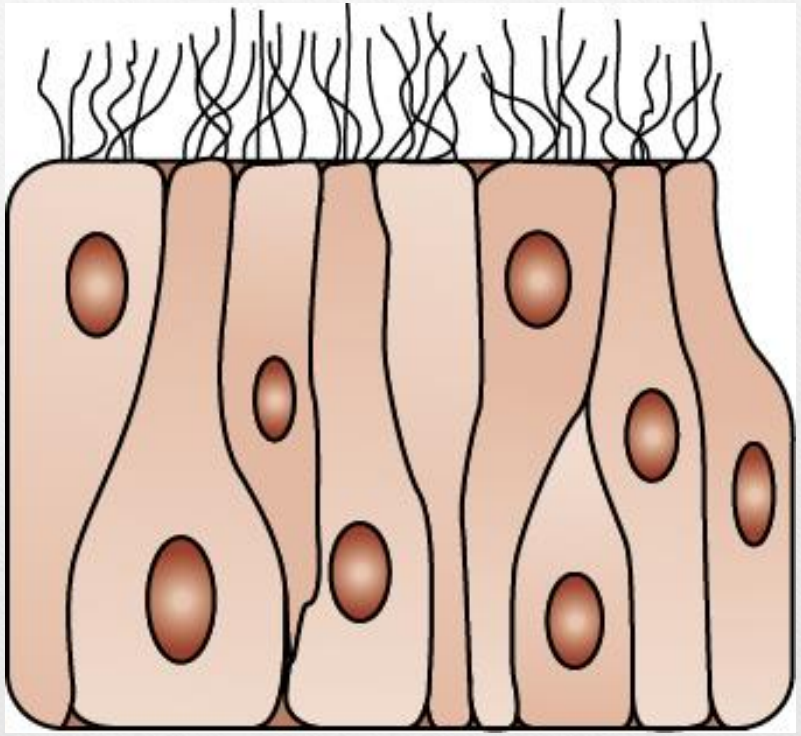
The amount and configuration of matrices differ with the type of tissue and the amount of containment or support needed for the tissue.

Epithelial Tissues

Cover and protect the surface of the body

Form membranes

Many DNA tests rely on epithelial cells, often swabbed from the inside of the cheek.



Membranes:

Cutaneous: cover surface of body

E.g., skin

Serous: line and lubricate internal body cavities

E.g., peritoneal, pleural, and pericardial cavities

Mucous: found on surfaces of tubes that open to exterior; coat and protect underlying cells

E.g., respiratory, digestive, urinary, reproductive tracts

The epithelial tissues make up three types of membranes; each membrane has epithelial tissue on the surface and a specialized connective tissue layer underneath.

A membrane is a thin, sheetlike layer of tissue that covers a cell, an organ, or a structure; lines tubes or cavities; or divides and separates one part from another.

Connective Tissue

Most abundant tissue in body

May be manipulated by heat, cold, stretch, and activity

Matrix may be 90% ground substance; remainder made up of:

- Collagenous fibers
- Reticular fibers
- Elastic fibers

Connective tissue cells are surrounded by nonliving tissues called the matrix.

Very exciting research is being conducted to learn more about the structure and function of connective tissue. This research may eventually explain some of the ways massage provides benefits.

Connective Tissue Cell Types

Table 1-3 Connective Tissue Cell Types

Cell Type	Matrix and Fibers
Fibroblast	Connective tissue
Chondroblast	Cartilage
Osteoblast	Bone
Hemocytoblast (hematopoietic stem cell)	Blood

Each major type of connective tissue has a fundamental cell type that secretes the matrix and fibers.

Connective Tissue

Connective tissue contains cells that help with repair, healing, and storage as well as other cells that help with defense:

- Fibroblasts
- Mesenchymal cells
- Macrophages
- Mast cells
- Adipose cells

Macrophages develop in the bone marrow and move throughout the connective tissue, searching for microorganisms, damaged cells, and foreign particles. When these targets are found, the macrophages dispose of them by ingesting and digesting them, a process known as phagocytosis.

Types of connective tissue

- Dense regular connective tissue
- Dense irregular connective tissue
- Loose (areolar) tissue
- Adipose tissue
- Cartilage, bone, and blood

Connective tissue membranes

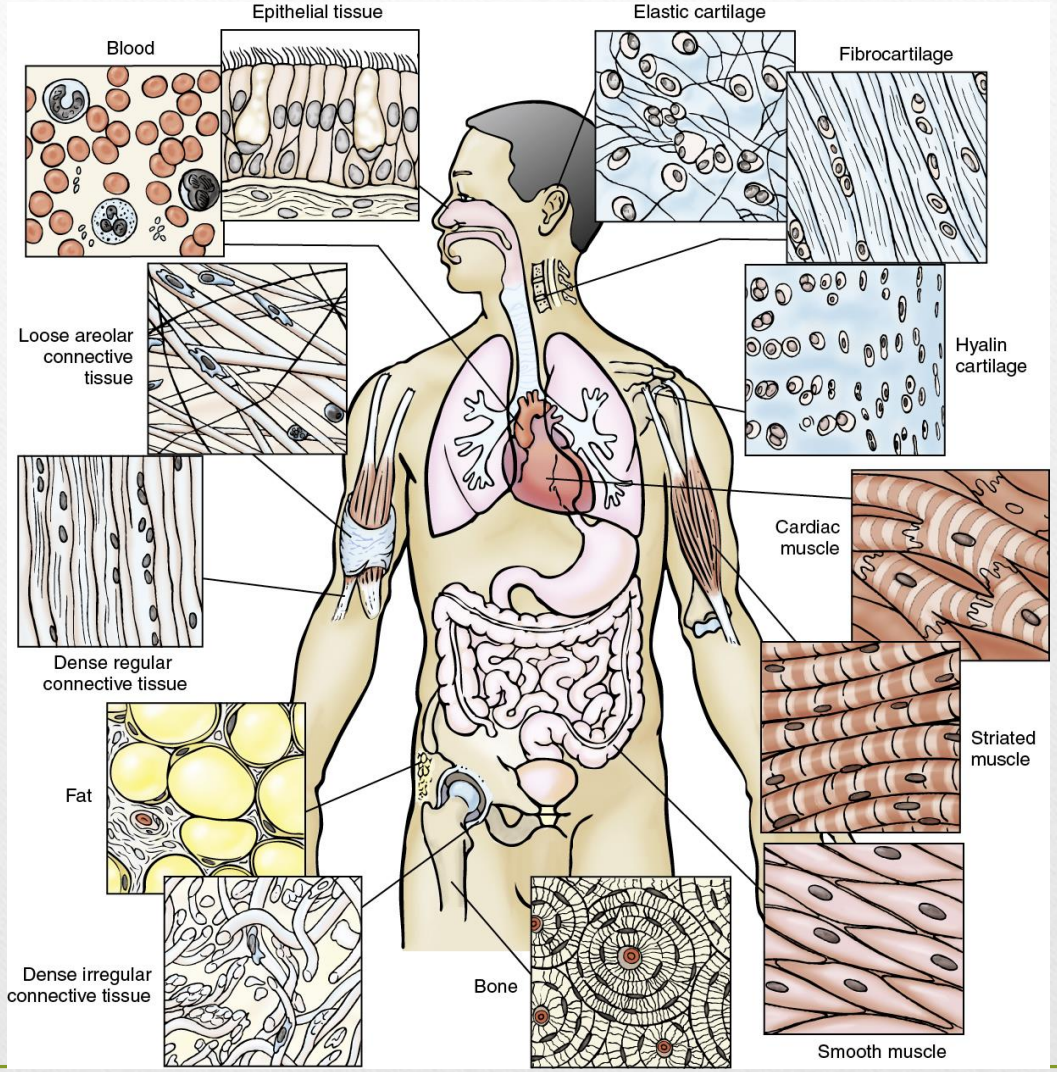
- Synovial membranes

Bone has an extremely rigid matrix.

Blood cells float in a very loose matrix (plasma).

Synovial membranes line the joint spaces in the mobile joints.

Tissues of the Body



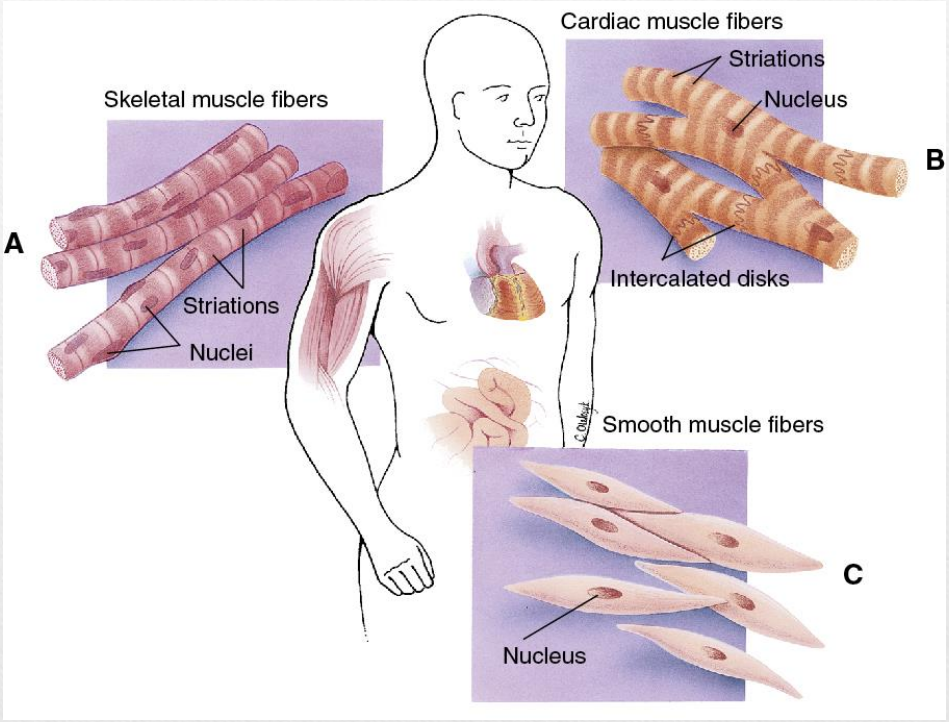
Muscle Tissue

Provides movement through contraction

Skeletal muscle fibers are large cells connected to the skeleton.

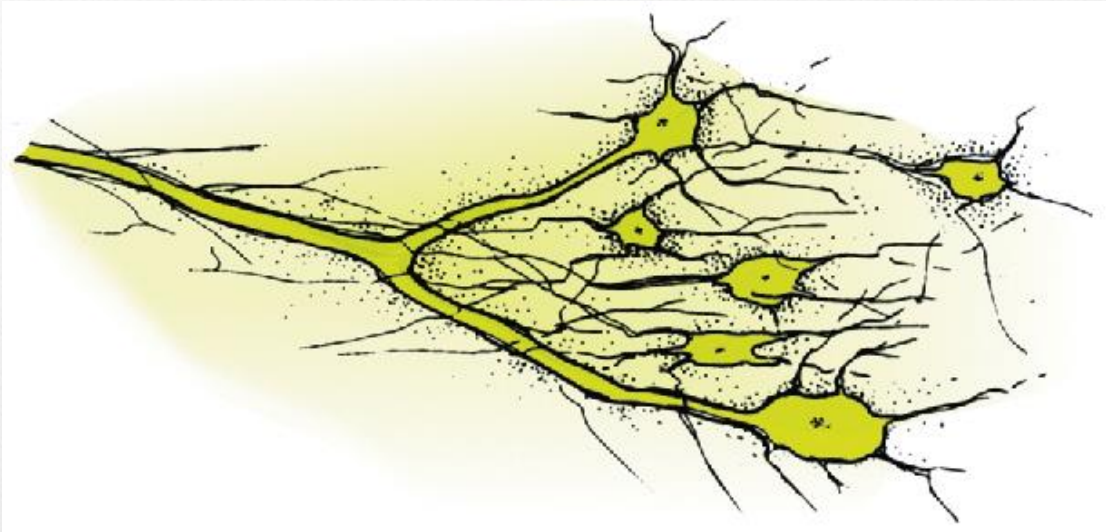
Cardiac muscle fibers are found in the heart, and their movements are involuntary.

Smooth muscle fibers regulate the flow of materials through the body.



Nervous Tissue

Coordinates and regulates body activity



Two types of nerve cells: Neurons and neuroglia. Neurons are the functional units, and neuroglia connect and support them.

Organ Level

Organs: groups of two or more kinds of tissue combined to perform a special function.

Yin organ examples: heart and lungs

Yang organ examples: stomach and bladder

Some Eastern belief systems associate the function of organs with the flow of energy through the body.

Organs that are solid and must work all the time to maintain homeostasis are yin organs.

Yang organs are hollow and work intermittently. Extensions of the yang organs make contact with the exterior of the body.

System Level

System: group of organs combined to perform complex function

- 11 body systems

Nervous and endocrine systems regulate all organ systems.

- Nervous system = main control

All organ systems affect one another.

- E.g., digestive system provides fuel for all other organ systems.

11 systems of the body:

Integumentary

Skeletal, Muscular

Nervous

Endocrine

Cardiovascular

Lymphatic and immune

Respiratory

Digestive

Urinary

Reproductive

Organism Level: The Body as a Whole

More than the sum of our parts

Parts of body are mutually dependent.

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