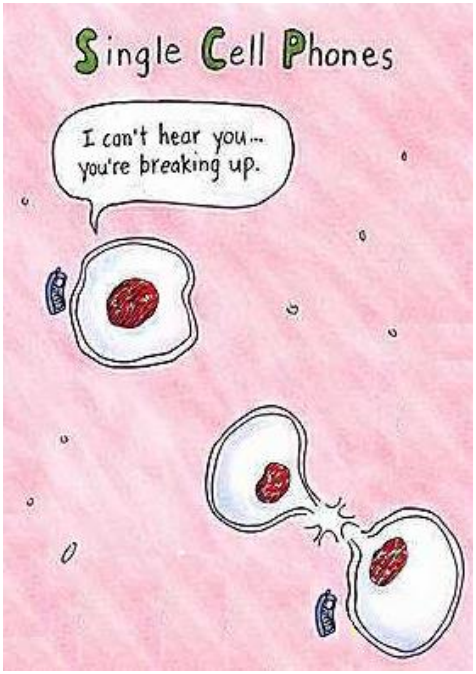


Zoology – Cells

"All living organisms begin life as a single cell… (that) divides repeatedly until it develops into an organism consisting of billions of cells."

I. History

A. Remember that cells are microscopic – they can't be seen with the naked eye

1. We haven't always known that living organisms were made of cells
2. It took time for us to develop the technology to see microscopically

B. 1665—_____, an English physicist, examined cork cells

C. 1676—Anthony van Leeuwenhoek observes "_____"- bacteria & protozoans

D. 1809—Jean Baptist de LaMarck concluded that all animal plant tissues are composed of cells

E. 1831—English botanist _____ discovers the nucleus

F. 1838-1839—Cell Theory developed by two scientists…

1. German Botanist Matthias _____
2. German zoologist Theodor _____
3. Cell Theory states that "all living organisms are composed of cells."

G. Refuting Spontaneous Generation – until the mid-1880s, many people believed that living organisms could arise from nonliving matter.

1. 1668—_____ demonstrates that maggots don't spontaneously originate from rotting meat. This seemed to disprove spontaneous generation. A HUGE controversy (that would last more than 200 years) soon ensued.
2. 1858—Rudolph Virchow argued that every cell comes from a preexisting cell.
3. 1860—Paris Academy of Sciences offers a prize for experimentally proving or disproving spontaneous generation
4. 1862—_____ proved that sterile media remained so if microorganisms in the air were excluded.

II. Cell Terminology

A. _____: cells without nuclei (e.g. bacteria)

B. _____: cells with nuclei

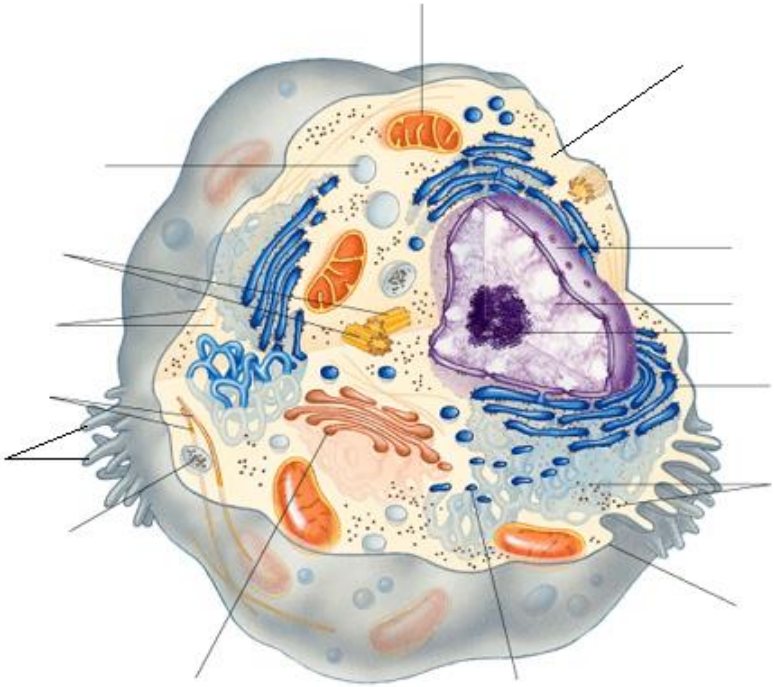
C. _____: the outer boundary of the living components of a cell

D. _____: all cellular components between the plasma membrane and the nucleus (includes the cytosol and organelles)

E. _____: the soup-like fluid in the cytoplasm (composed mainly of water) that the organelles are distributed in

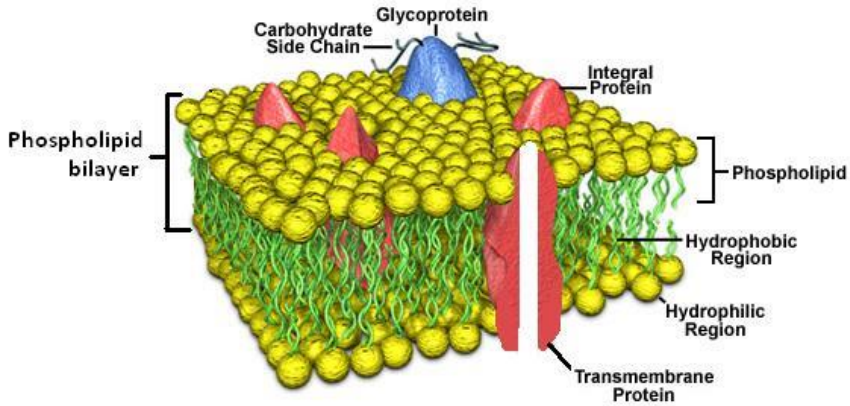
F. _____: structures in the cytoplasm that have various shapes and sizes with specialized functions in the cell, typically they are membrane bound

III. Parts of the Cell & Their Functions



A. The **plasma membrane** - the outermost membrane

1. Why is it important?
    a. It is the gatekeeper to substances that enter and exit a cell.
    b. It maintains cellular integrity.
    c. It separates the interior environment from the exterior and regulates molecule traffic flow.
2. The current model of plasma membrane structure is the _____.



a. It is only 8-millionths of a millimeter thick
b. Composed of a bi-layer of _____ with

partially or wholly embedded _____ interspersed throughout.

1) Phospholipid molecules have their water-soluble (phosphate) ends toward the outsides and fat-soluble (lipid) portions toward the inside of the membrane.

c. The layer is liquid, providing flexibility; embedded cholesterols decrease this fluidity.

d. The membrane also has glycoproteins.

1) Glycoproteins are proteins with carbohydrates attached.

e. Some of the embedded proteins function to transport molecules across the plasma membrane.

f. Some of the surface proteins act as receptors for specific molecules or to identify the cell as "self."

3. Plasma membranes are **differentially or selectively permeable**.

a. Allows some substances to pass freely (_____)

b. Actively moves some substances either out of or into the cell (_____)

c. It inhibits the movement of other substances

d. It is extremely important in maintaining cellular _____

4. **Passive transport** - depends on kinetic energy of molecules and/or pressure gradients (things will move from high to low concentration without the cell expending energy)

a. _____ - Small, fat-soluble, uncharged (nonpolar) molecules (e.g. _____) can flow freely through the phospholipids from high to low concentration until they reach equilibrium.

b. _____ - movement of **water** across a membrane, along a concentration gradient

1) Water always moves from high to low concentration, across the plasma membrane.

2) As the solute concentration increases, the water concentration decreases.

3) **Hypotonic solutions** – "low salt"

a) Water goes into the cell

4) **Hypertonic solutions** – "high salt"

b) Water exits the cell

5) **Isotonic solutions** – "same salt"

c) Water has no net movement

Here is a tutorial video discussing osmosis: http://www.brightstorm.com/science/biology/cell-functions-and-processes/osmosis/

c. _____ – some molecules are too big (e.g. _____), or are polar (e.g. _____), and can't squeeze between the phospholipids.

1) _____ help these molecules across the membrane.

2) These molecules still travel from high to low concentration.

5. **Active transport** – sometimes cells have to move molecules AGAINST the concentration gradient (moving from low to high concentration)

a. This requires the cell to expend energy, as _____

b. Most animal cells require internal potassium levels 20–50 times higher than outside levels

c. Outside sodium levels may be ten times higher than inside levels.

d. In many cells, sodium and potassium pumping are linked using the same transporter molecule, a Na^+-K^+ pump.

6. **Vesicular transport** – the plasma membrane surrounds and moves large amounts of material in an enclosed vesicle
   a. These movements always requires ATP.
   b. _____ encloses a particle in a vesicle that is engulfed. (Material moves into the cell.)
   c. _____ literally means "cell eating."
      1) An area of the plasma membrane forms a pocket to engulf material.
      2) The membrane-enclosed vesicle detaches from the cell surface for internal digestion.
      3) This produces a _____.

Watch this video of an amoeba eating: http://youtu.be/W6rnhiMxtKU

   d. _____: "cell drinking"
      1) Movement of dissolved particles into the cell
   e. _____ - the reverse of endocytosis, it moves materials out of the cell.
      1) Expels indigestible residues
      2) Secretes hormones and transport substances.

B. The _____ (the control center of the cell)
   1. The nucleus is surrounded by a double-layered _____.
      a. This membrane has large pores to let molecules in and out.
      b. The nuclear envelope is continuous with the endoplasmic reticulum.
   2. Inside the nuclear envelope is the _____.
      a. Chromatin is a threadlike material that coils into chromosomes just before cell division occurs; it contains the DNA
      b. **DNA** in the nucleus provides information needed to make proteins, grow, differentiate, and carry on other activities
      c. DNA also stores hereditary information
   3. _____ – darkly-staining body in the nucleus
      a. It produces the ribosomes.

C. _____ **(ER)** (the manufacturing plant of the cell)
   1. A system of interlinked double-membraned channels subdividing the cytoplasm
   2. Primary site of membrane synthesis in the cell
   3. ER comes in two varieties: rough & smooth
      a. _____ is rough because it is studded with ribosomes
         1) _____ –the workbenches upon which proteins are built.
            a) Ribosomes have no bounding membranes and therefore aren't considered to be organelles by many.
         2) Rough ER synthesizes, stores, and secretes _____.
            1) Proteins may be structural & form organelles or membranes.
            2) Proteins may be functional (e.g. enzymes)
         3) Products of the rough ER are transported to the _____ for storage or activation.
      b. _____ has few if any ribosomes
         1) Smooth ER synthesizes _____ and _____.

D. _____ (the warehouse of the cell)

1. Disc-shaped, often branching hollow tubules just outside the ER
2. It receives products from the ER, and does one of three things…
    a. _____ the product for later use by the cell
    b. _____ the product
        1) e.g. It may modify carbohydrates attached to proteins to activate an enzyme
    c. _____ the product for use elsewhere in the cell
        1) Collects product in small vesicles that are pinched off from the margins.
3. It produces _____.
    a. Lysosomes are membrane-bound vesicles that contain digestive enzymes.
    b. They help digest foreign material or engulfed bacteria by fusing with a food vacuole produced by phagocytosis.
    c. They destroy injured or diseased cells.

E. _____ (the Powerhouses of the cell)

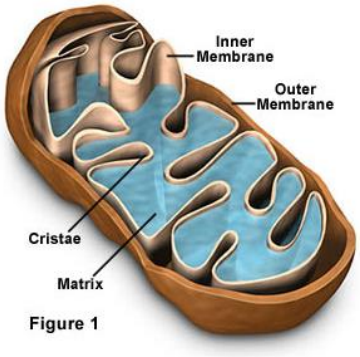


Figure 1

1. The energy (E) stored in sugar is released by the process of _____ here.
    a. The sugar is broken down into water and carbon dioxide, releasing energy.
    b. That energy is stored in a form the cell can then use to do work – _____ (adenosine triphosphate).
2. Mitochondria are shaped like cucumbers, rods, or balls, they move throughout the cell and accumulate where energy is needed.
3. Bounded by 2 membranes, the inner membrane forming platelike folds called _____ which increase the surface area for enzymes to work on.
4. Mitochondria are self-replicating and have their own DNA.

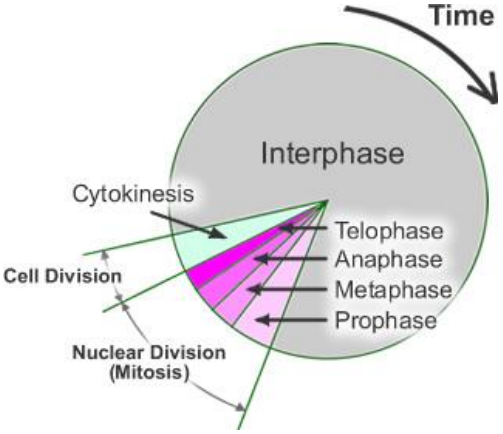
F. _____ - a network of filaments and tubules that maintain support and form.

1. In many cells, they provide locomotion and translocation of organelles.
2. The cytoskeleton forms _____
- short cylinders with 9 triplets of microtubules.
    a. _____ contain two centrioles lying at right angles to each other.

Watch this video review of the organelles and their functions: http://youtu.be/LP7xAr2FDFU

Complete this study guide over organelles: http://www.clarendoncollege.edu/programs/NatSci/Biology/Zoology/zoo%20online%20outlines/animal cell organelles.htm

IV. Cellular Reproduction – A cell's life begins when a parent cell divides into 2 daughter cells, continues as the cell grows and matures, and ends when the cell divides. This is known as the _____.



Cell cycle

A cell's life begins when a parent cell divides into 2 daughter cells, continues as the cell grows and matures, and ends when the cell divides. This is known as the cell cycle.

A. Nearly all multicellular organisms originated from division of a single cell, the _____.

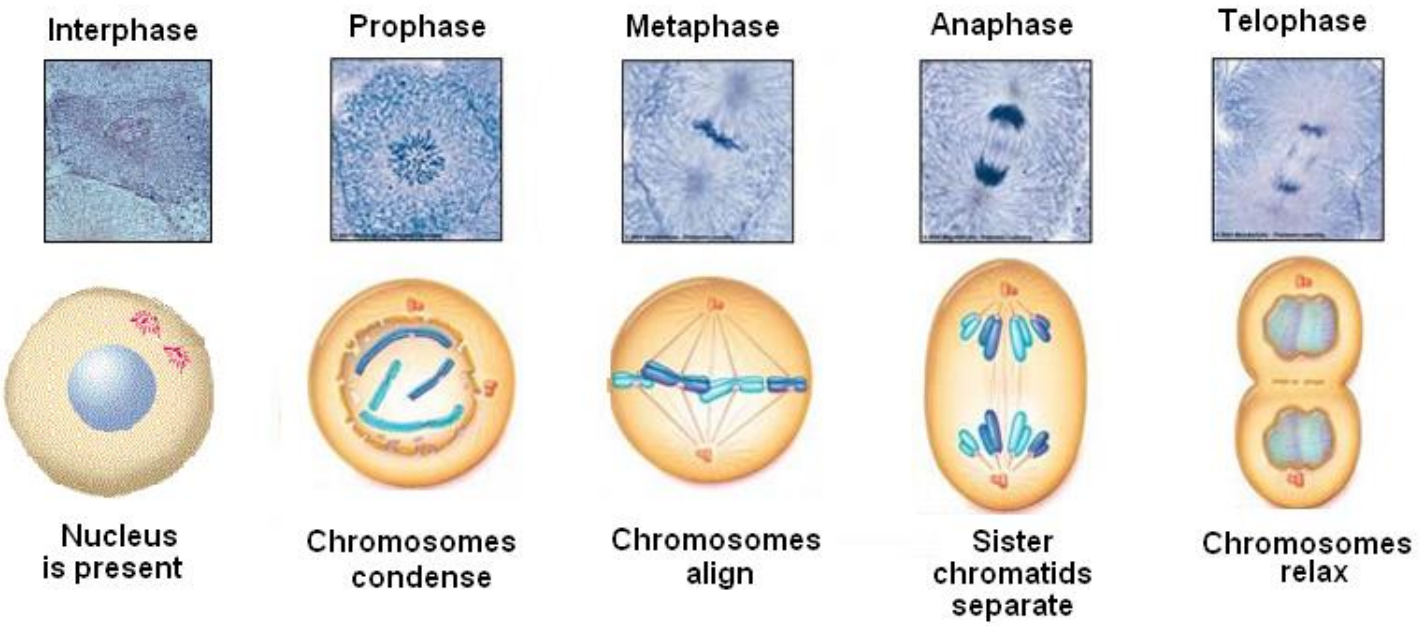
1. A zygote is formed from union of egg and sperm, the _____.
2. This one cell divides repeatedly through the process of _____.
    a) The human infant has 2 trillion cells that originated from one fertilized egg.
        i) This represents 42 cell divisions.
    b) Five more cell divisions produce adult with 60 trillion cells.
3. Mitosis ensures that all cells inherit all of the organism's DNA.
4. Cell lineages differentiate (i.e. they become bone, blood, muscle, etc.) due to selective expression of genes.
5. In animals that reproduce sexually, parents produce sex cells with half the number of chromosomes.
    a. This requires reduction division or **meiosis**.
    b. We will revisit this subject later.

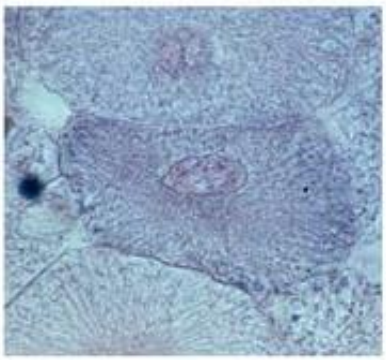
Mitosis is the type of cell division that results in **two daughter cells that are identical** to their parent cell. We want to produce identical cells when we are **growing and repairing an injury**. If you start with a diploid parent cell, the daughter cells will also be diploid.

Watch this tutorial video discussing mitosis: http://youtu.be/pOsAbTi9tHw

After reviewing the notes regarding mitosis, complete this mitosis study guide: http://www.clarendoncollege.edu/programs/NatSci/Biology/Zoology/zoo%20online%20outlines/animal cell mitosis review.htm

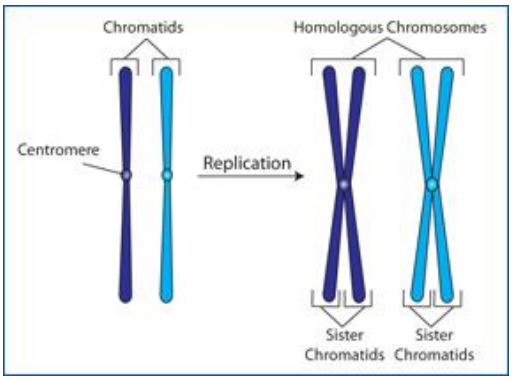
Overview of the events of mitosis:

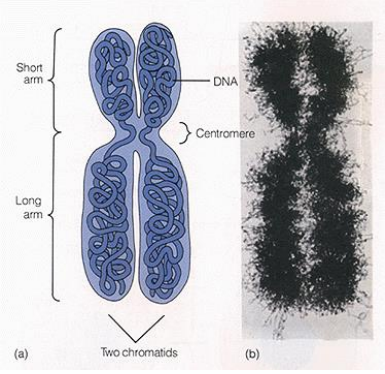




INTERPHASE – the period between cell division.
When cells are not actively dividing, they are in **interphase**. A cell may spend up to 95% of its life in interphase. At this time, the DNA is in a loose, soupy form known as **chromatin**. The chromatin contains the animal's **chromosomes**. Chromosomes are long strands of DNA where **genes** (instructions for specific traits and proteins) are encoded. A species will have a specific number of chromosomes in all cells except gametes. Interphase can be divided into three periods; the G_1 Period, S Period, and G_2 Period.

1. During the **G_1** (Gap 1) **Period** the cell increases in size to adult cell size.
2. During the **S** (Synthesis) **Period**, DNA replication takes place.
3. During the **G_2** (Gap 2) **Period**, mitochondria and other cellular organelles replicate. Also, the chromosomes begin to supercoil and condense. This is done so that the chromosomes can be easily moved without breaking.





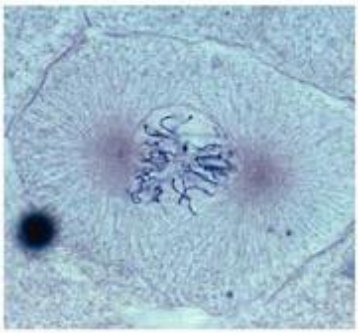
Parts of a replicated chromosome include…

1. **Sister chromatids** – the identical strands of DNA
2. **Centromere** – structure that holds the sister chromatids together
3. **Kinetochore** – structures that develop on the sides of a centromere during late prophase. The spindle fibers attach at this point of the chromosome.

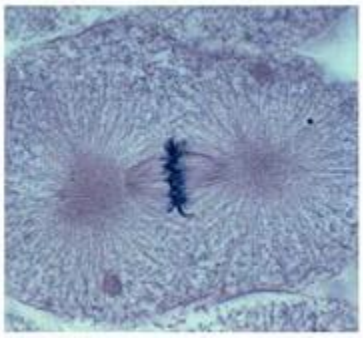
MITOSIS

Mitosis refers to division of the nucleus, normally accompanied by the division of the rest of the cell called cytokinesis. Mitosis is divided into four phases; prophase, metaphase, anaphase, and telophase.

PROPHASE - During prophase, the following events take place:

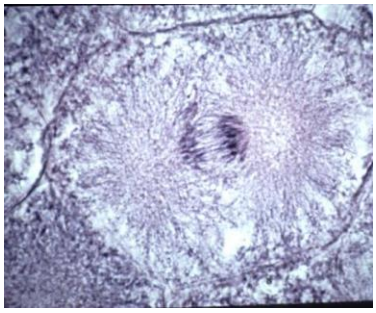


1. The centrosomes replicate and then migrate to opposite poles of the nucleus. Spindle fibers stretch out between them as they move, forming a football-shaped **spindle** between the centrosomes.
2. Microtubules radiate outward from the centrosomes to form **asters**. The asters will push the poles of the cell away from each other during late anaphase and telophase.
3. The nuclear chromatin condenses into visible chromosomes.
4. The nucleolus gradually disappears.
5. The nuclear membrane completely fragments.
6. Some spindle fibers grow from the poles to the center of the cell and attach to the chromsomes at the kinetochores.



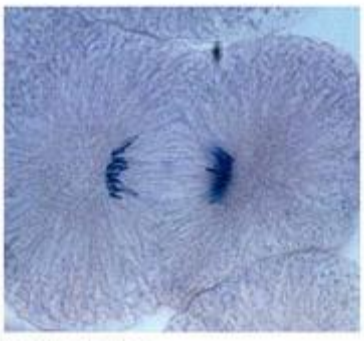
METAPHASE - During metaphase, the following events take place:

1. The spindle fibers pull the chromosomes to the center of the cell.
2. The chromosomes are lined up along an invisible circular plate, perpendicular to the axis of the spindle, called the **equator.**



ANAPHASE - During anaphase, the following events take place:

1. The centrosomes begin reeling in their spindle fibers.
2. The centromeres break, allowing the sister chromatids to separate and be dragged toward opposite poles.
3. The sister chromatids, once separated, are known as **daughter chromosomes**.
4. The aster bodies begin pushing the poles of the cell further apart.



TELOPHASE - During telophase, the following events take place:

1. The daughter chromosomes reach opposite poles.
2. The spindle begins to break down.
3. The chromosomes begin to uncoil and become chromatin once again.
4. Nuclear envelopes form around the two newly formed nuclei.
5. Nucleoli reform

CYTOKINESIS

Cytokinesis is the process whereby the cytoplasm of a single eukaryotic cell is divided to form two daughter cells. This process results in a **cleavage furrow** appearing. The cleavage furrow contracts, "cutting" the parent cell into two, identical daughter cells.

IV. Tissues, Organs, and Organ Systems of Animals

A. **Tissues** are specialized groups of cells adapted for a particular function.

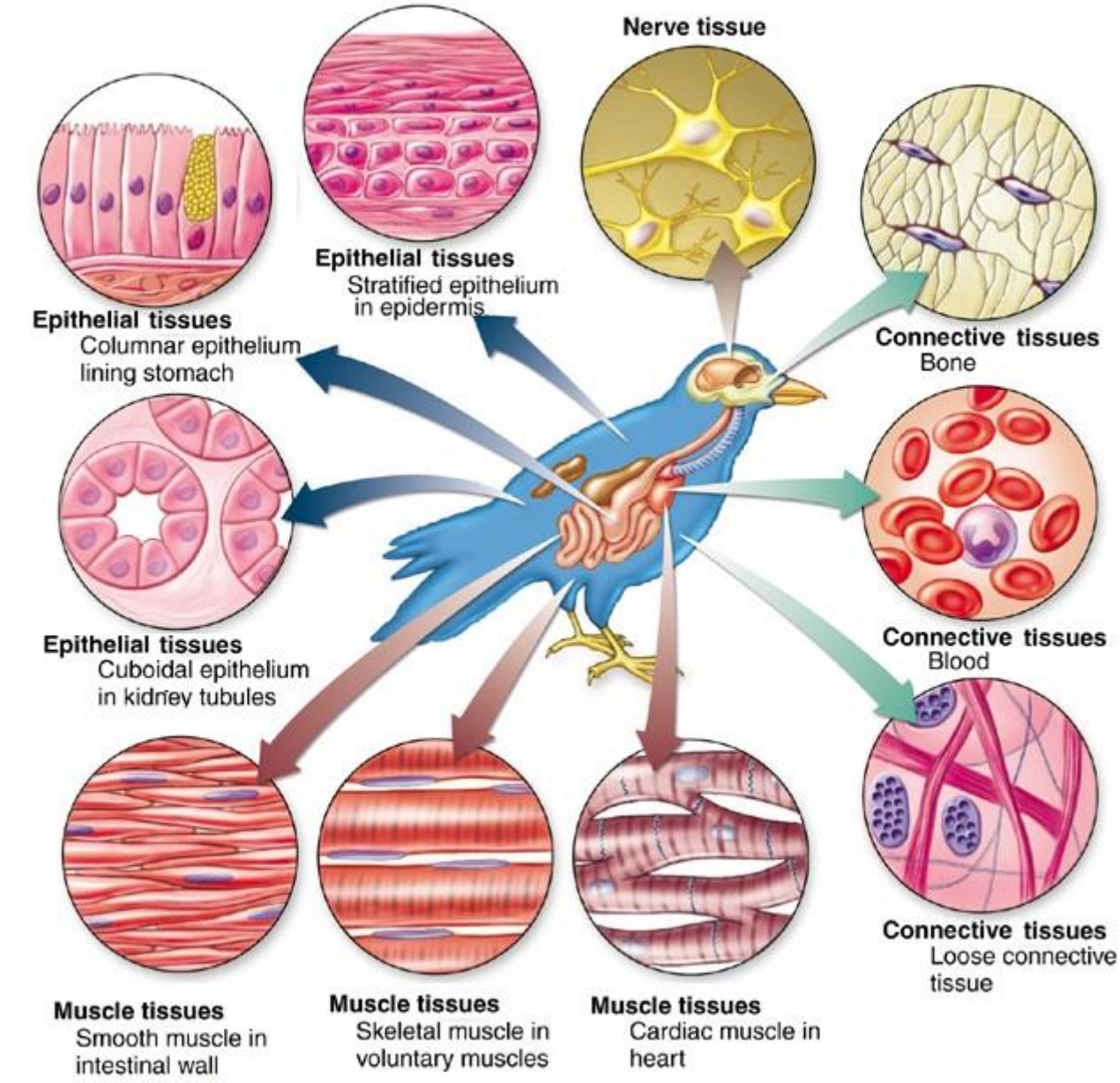


Image modified from The McGraw-Hill Companies, Inc.

1. **Epithelial tissues** – cover openings (internal and externals) and line structures
    a. They are attached to underlying tissues by **basement membranes**.
    b. Functions: absorption, transport, excretion, protection, sensory reception
    c. They are classified by cell shape:

1) Squamous epithelium – flattened
2) Columnar epithelium – cells are taller than they are wide
3) Cuboidal epithelium – shaped like sugar cubes.

d. They are also classified by how many cells thick the tissue is.
1) Simple epithelium – only one cell thick
2) Stratified epithelium – multiple cells thick

2. **Connective tissues** – support and bind other tissues.
a. Cells are embedded in an extracellular matrix, usually the matrix has numerous fibers.
b. Adipose tissue is characterized by cells swollen with lipids.
c. Cartilage and bone tissue is characterized by a relatively solid matrix.
d. Blood is characterized by a fluid matrix called plasma
3. **Muscle tissue** – provides movement, internally and externally
a. Muscle tissue belongs to three types…
1) Skeletal – voluntary, gross movements
2) Smooth – involuntary, propels fluids through organs
3) Cardiac – heart muscle
b. Muscle contractions produce heat.
1) This is necessary to maintain the body temperature needed for enzymes to facilitate metabolic reactions.
4. **Nervous tissue** – tissues that control and regulate the other body tissues through quick control.
a. Composed of neurons, conducting nervous impulses, and glial cells, which support the neurons.

B. **Organs** are functional units composed of different types of tissues.
1. Consider the human heart. It is composed of myocardial tissue (heart muscle), epithelial tissues (e.g. endocardium & epicardium), connective tissue (e.g. the fibrous skeleton of the heart), and nervous tissues (e.g. the SA Node, known as the pacemaker of the heart)

C. **Organ systems** are groups of organs with a particular function.
1. In humans, there are 11 organ systems that have specific functions.
a. **M**uscular – movement
b. **R**espiratory – exchanging gases
c. **R**eproductive – producing offspring
d. **E**ndocrine – hormones, a slow control system
e. **D**igestive – breaking food into usable subunits
f. **I**mmune – protecting the body from invasion by viruses, bacteria, etc.
g. **S**keletal – supporting other tissues, acting as levers for muscles
h. **N**ervous – fast control system of the body
i. **I**ntegumentary – the skin, protection of body
j. **C**ardiovascular – propels fluids to exchange gases and molecules
k. **E**xocrine – urinary system, removes waste products