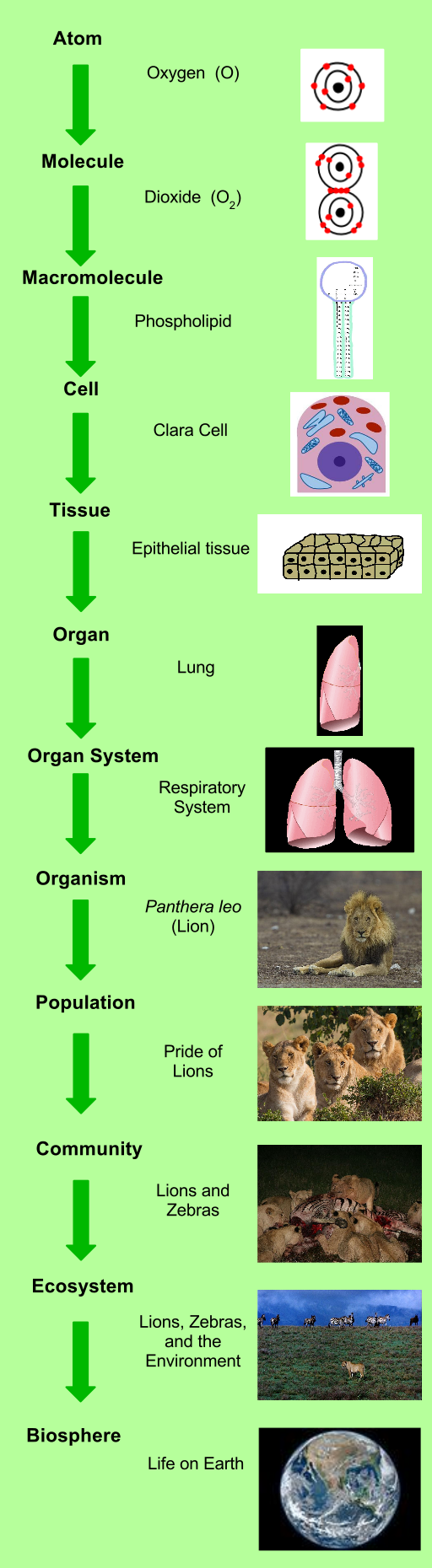
**Cell Specialization and Organ Systems**

***HASPI Medical Biology Lab 03***

**Background/Introduction**

**Organization of Life**

Life on Earth is organized into a hierarchy based on complexity.

Starting at the most basic level, the atom, each level becomes

more complex than the last. Table 1 provides a definition and

example(s) of life at each level.

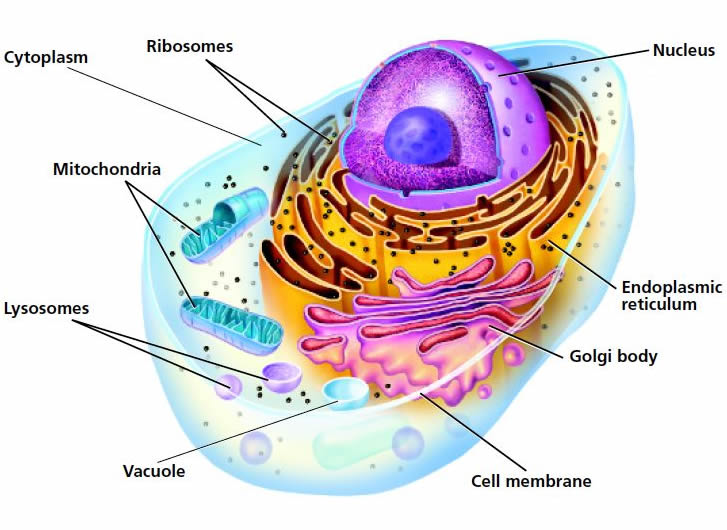
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| **Table 1. The Hierarchy of Life** | | |
| **Level** | **Definition** | **Example(s)** |
| **Atom** | The most basic units of matter | Carbon (C), hydrogen (H), oxygen (O), sodium (Na) |
| **Molecule** | A collection of atoms that are bonded together | Water (H20), carbon dioxide (CO2), table salt (NaCl) |
| **Macromolecule** | Large molecules that perform a function in living organisms | Carbohydrates, proteins, DNA, lipids |
| **Cell** | A collection of macromolecules that combine to form a living organism that performs a specified function | Skin cell, muscle cell, bacteria, plant cell, protist |
| **Tissue** | A collection of cells that works together to perform a specified function | Blood tissue is a collection of different cells capable of transporting materials throughout the body |
| **Organ** | A specialized structure made of tissues that performs a specific function | A muscle, stomach, brain, lung, bone, heart |
| **Organ System** | A specialized system within a living organism made up of organs that perform a unified function | Circulatory, respiratory, and digestive systems |
| **Organism** | A single living individual | The human body |
| **Population** | All individuals of a single species | A population of humans |
| **Community** | All of the species within an ecosystem | Only the living components including all bacteria, fungi, plants, and animals |
| **Ecosystem** | All living organisms and non-living matter within a specific area | Desert, pond, forest, the human mouth |
| **Biosphere** | All of the living organisms on Earth | All bacteria, fungi, plant, and animal life on the Earth |

A disturbance, or disease, in the lowest level of the hierarchy can

greatly impact more complex levels. For example, hemophilia is a genetic disease that prevents the blood from clotting. The mistake occurs in DNA. This leads to a mistake in cells involved in blood clotting. Blood loss can impede the function of organs, and therefore organ systems, which can lead to the death of the human body, or organism.

**Cells**

Cells are the smallest unit of life. All cells are capable of growth, use energy, reproduce, and respond to the environment. The simplest cells that were the first form of life on Earth are called **prokaryotes**. Prokaryotes are primarily bacteria and do not have a nucleus or membrane-bound organelles. More complex cells that contain a nucleus and membrane-bound organelles are called **eukaryotes**. Fungi, protists, plants, and animals are all eukaryotic organisms. Eukaryotic cells may have different organelles depending on their function and the type of organism in which they are found. For example, plant cells contain chloroplasts, while animal cells do not.

Some organisms, such as protists, are made up of only a single cell and are called **unicellular** organisms. Organisms that are made up of more than one type of cell working together, such as the human body, are **multicellular** organisms. In fact, a human adult body contains more than 100 trillion cells. Table 2 provides a description, image, and the types of cells in which some common organelles can be found.

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| **Table 2. Common Organelles** | |
| **Organelle** | **Function** |
| Cell Membrane | Controls substances moving in/out of the cell |
| Cell Wall | Plants only; made of stiff cellulose that maintains cell shape |
| Chloroplast | Plants only; performs photosynthesis |
| Cytoplasm | Liquid substance that fills the cell; location where most chemical reactions occur |
| Cytoskeleton | Strengthens and supports cell shape |
| Endoplasmic Reticulum | Stores and carries materials throughout the cell; participates in protein synthesis |
| Golgi Apparatus | Modifies and transports proteins |
| Mitochondria | Perform cellular respiration |
| Nucleus | Contains and protects the DNA |
| Ribosomes | Location where protein synthesis occurs |
| Vacuole | Plants only; contains and stores water and other substances to maintain cell shape |
| Vesicles | Transport substances, such as proteins, through the cell |

<http://www.stephsnature.com/images/Websitelifescience/plantcell.jpg>

**Cell Specialization or Differentiation**

Why are not all cells within the human body exactly the same if they contain the same organelles and DNA? How and why is a muscle cell different from a brain cell when the instructions to create cells are the same? The answer is entirely about WHICH **genes**, or instructions, are used. If the DNA in all cells is thought of similar to a cookbook, different recipes within the book are used to create different cells. The recipe to make a chocolate cake contains different ingredients than a recipe for beef stew, even though both recipes are in the same cookbook. In the same way, the “recipe” to form a muscle cell is different than the “recipe” to form a brain cell. Cells can look and function differently, because only certain genes in a cell’s DNA are used, or **expressed**, when those cells are formed.

Cell **specialization** or **differentiation** occurs when a less specialized cell, such as a stem cell, becomes a specialized cell, such as a red blood cell. Specialization occurs during the development of a multicellular organism and continues into adulthood. This is caused by a

highly complex system that controls when a gene should be expressed. The genes expressed will create different physical characteristics in the different cell types. Table 3 below summarizes a few examples of specialized cells within the human body and how structural features impact each cell type’s function.

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| **Table 3. Examples of Specialized Cells** | | | | |
| **Type of Cells** | **Function/Features** |  | **Type of Cells** | **Function/Features** |
| Muscle cells    <http://www.mhhe.com/biosci/esp/2001_saladin/folder_structure/su/m4/s13/assets/images/sum4s13_1.jpg> | ***Function to contract and move the body;***  Long and narrow, contain myosin and actin which are able to make the muscle cell shorten (contraction) | Red blood cells    <http://thewhitenetwork.com/wp-content/uploads/2013/03/red-blood-cells.jpg> | ***Function to carry oxygen;***  Hemoglobin on the surface to bind oxygen and large surface area |
| Sperm cells    <http://cdn-imgs-mag.aeon.co/images/2013/07/sperm.jpg> | ***Function to travel to and fertilize an egg;***  Head with enzymes to break into egg and long tail for travel | Osteocytes (bone)    <https://vault.swri.org/cms/upload/cells_500pixels.jpg> | ***Function to build and shape bone;***  Contain proteins capable of building and breaking down minerals surrounding them |
| Neurons (nerve cells)    <http://wileywitch.com/wp-content/uploads/2013/02/173_neurons.jpg> | ***Function to relay messages through the body;***  Long and narrow with strands to form connections with other neurons | Skin cells    <http://cellfunctioning.wikispaces.com/file/view/cheekcells.jpg/210933652/cheekcells.jpg> | ***Function to form a protective layer;***  Flat shape and containing massive amounts of keratin that form a protective outer layer as the skin cell dies |

**Tissues & Organs**

A tissue is made up of a group of cells that work together to perform a specific function. The study of tissues is called histology. The tissues of the human body are grouped into four types based on function:

* ***Connective tissue*** – provides shape and support
* ***Muscle tissue*** – capable of contraction and producing movement
* ***Nervous tissue*** – capable of passing impulses, or messages
* ***Epithelial tissue*** – provides covering and protection

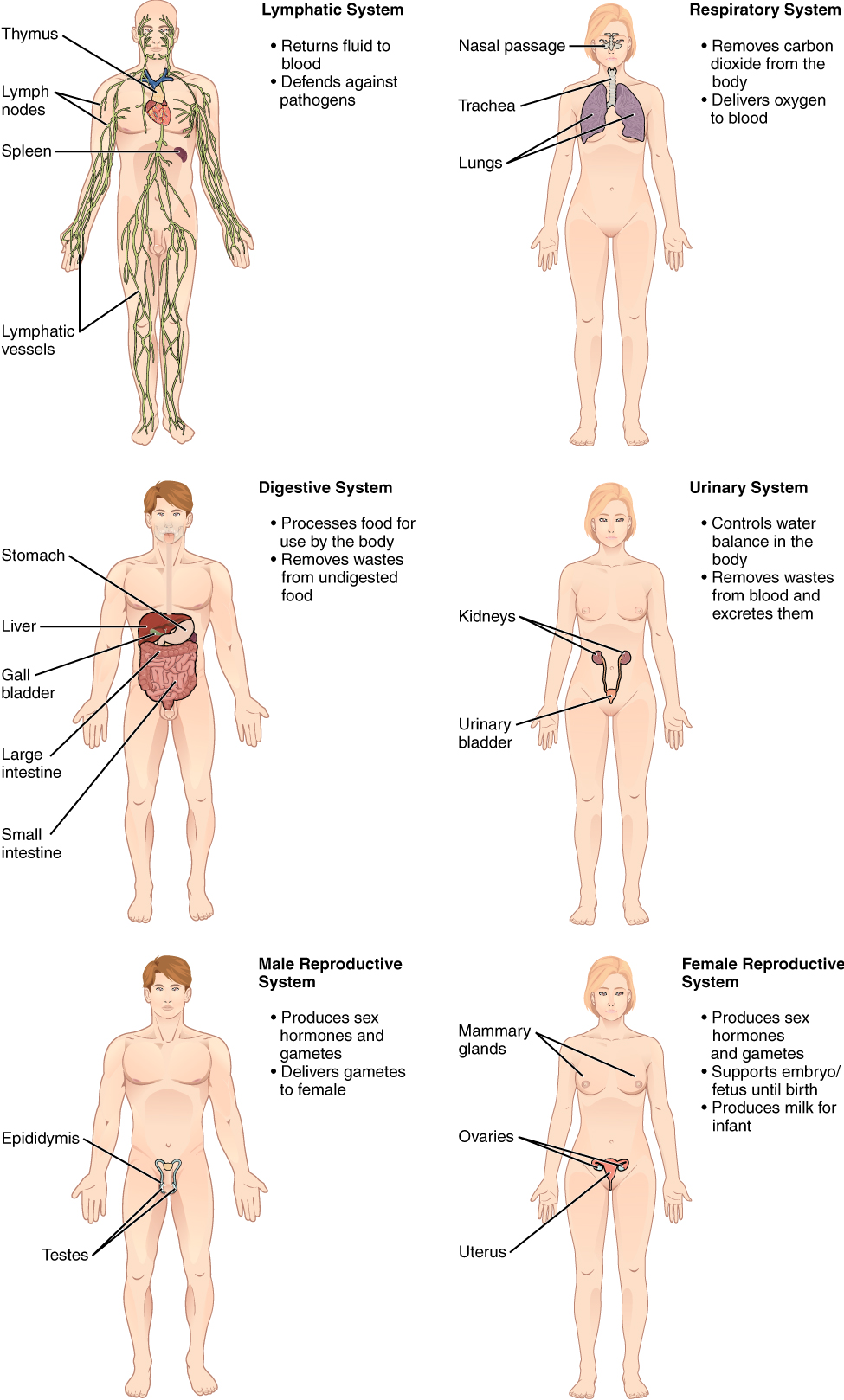
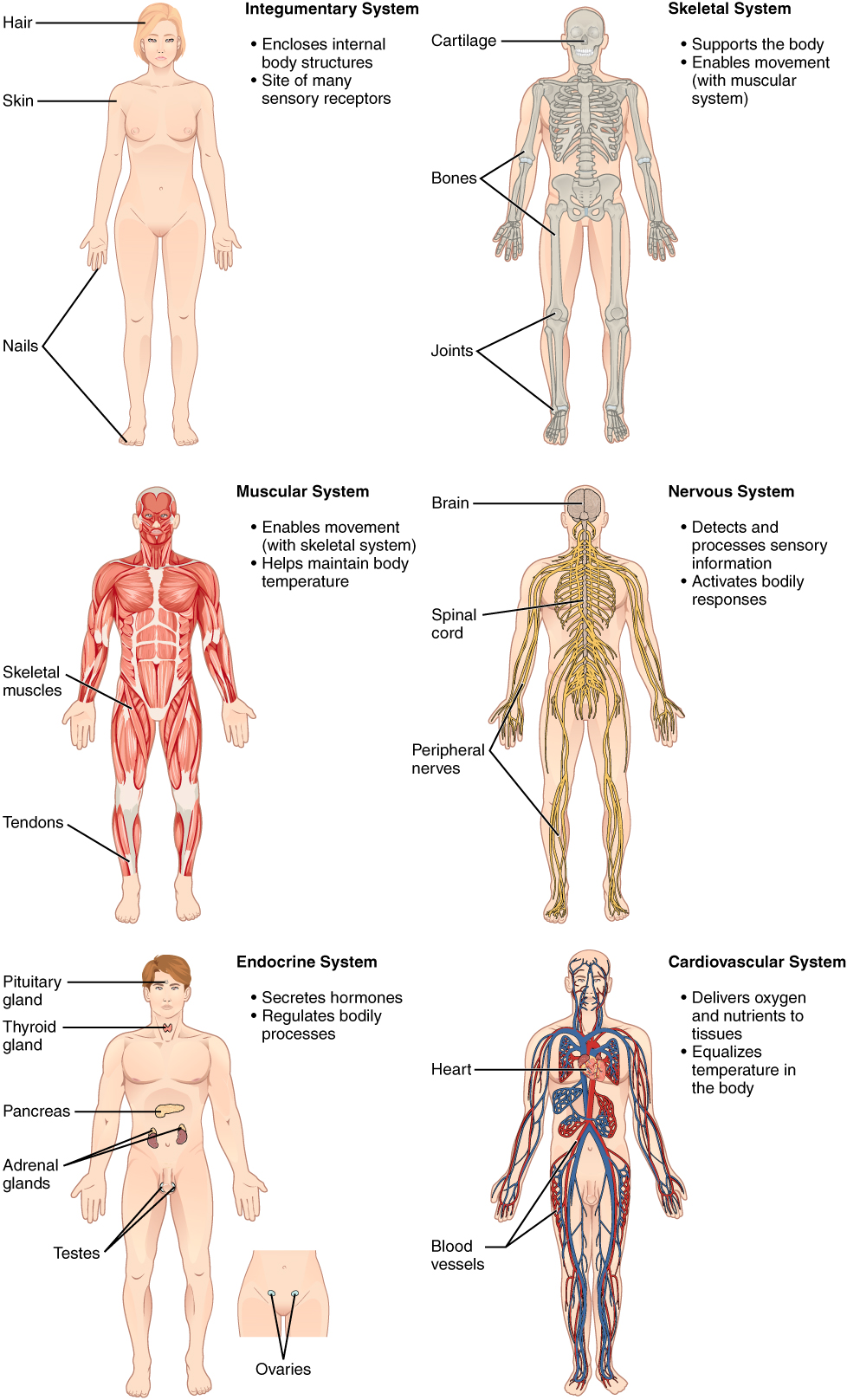
An organ is made up of a group of tissues that work together to perform a specific function. There are approximately 78 organs in the human body. A few examples of organs found in the human body, along with their functions, include:

* ***Kidneys*** – regulate water levels and remove waste products from the blood
* ***Heart*** – pumps blood throughout the body
* ***Stomach*** – digestion
* ***Skin*** – protection

**Human Organ Systems**

Organ systems are made up of a group of organs that work together to perform a specific function. Most of these organ systems overlap, and the health of one system can greatly impact the health of the other organ systems in the human body. The diagrams below show the organ systems found in the human body.

**Organ Systems of the Human Body**



<http://upload.wikimedia.org/wikipedia/commons/d/d8/Organ_Systems_I.jpg>

**Disease: Imbalance in the System**

**Diseases** are abnormal conditions that affect an organism. In terms of the organ systems, disease creates an imbalance in cells, tissues, or organs that can result in an inability of an organ system to function properly, or not at all. When this happens, it more often than not creates a domino effect that results in imbalances in multiple organ systems throughout the body. This is the reason that signs and symptoms of diseases are often found system-wide. Treating and correcting the imbalance in the original system affected will often correct the imbalances, and cure the symptoms, in the other organ systems.

For example, the Human Immunodeficiency Virus (HIV) is a virus that only infects white blood cells in the immune system. White blood cells are responsible for protecting and providing immunity to the human body from outside sources. Once HIV has destroyed a large number of white blood cells, creating an imbalance in the immune system, symptoms begin to appear in other organ systems that eventually lead to death. For example, these symptoms can appear in the following organ systems in cases of advanced HIV infection:

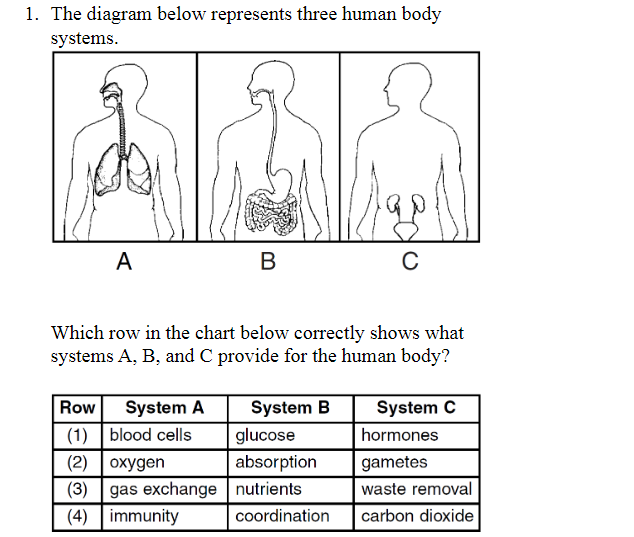
* **Digestive system** – painful swallowing, weight loss, fatigue, severe and persistent diarrhea, nausea, vomiting
* **Respiratory system** – persistent cough, shortness of breath, respiratory infections
* **Integumentary system** – skin rashes, flaky skin, persistent cold sores
* **Nervous system** – short-term memory loss, confusion, seizures, lack of coordination,

**Review Questions** *– answer questions on a separate sheet of paper*

1. Why do you think it is important for scientists to organize life into a hierarchy for study?
2. What is the difference between an atom, molecule, and macromolecule? Give an example of each.
3. How are cells, tissues, and organs related to one another? Give an example of each.
4. How are populations, communities, and ecosystems related to one another? Give an example of each.
5. Explain how a disturbance in a lower level of the life hierarchy organization, a cell for example, can impact the higher levels, a population for example.
6. Compare and contrast prokaryotes and eukaryotes. Give an example of each.
7. Why are there many different cell types in the human body if they all contain identical DNA?
8. Describe cell specialization. Why is it important that cells are able to specialize?
9. Compare and contrast the structure and function of a neuron and a red blood cell. How do their structures allow them to perform their functions?
10. What are the four types of tissues found in the human body? How are they classified?
11. Give an example of three organs that can be found in the human body and their functions.
12. What is an organ system? Choose one of the organ systems and list the organs that belong to that system, as well as the system’s function.
13. What are diseases? How can a disease create symptoms in multiple organ systems? Give an example.

**Log on to: *sfemminella.weebly.com*. Go to the notes section of the *Living Environment* page. Scroll Down to *Body Systems*. Click on *Introduction to Body systems.* Use the reading to answer the following questions:**

1. Why do you think it is important for scientists to organize life into a hierarchy for study?
2. What is the difference between an atom, molecule, and macromolecule? Give an example of each.
3. How are cells, tissues, and organs related to one another? Give an example of each.
4. Explain how a disturbance in a lower level of the life hierarchy organization, a cell for example, can impact the higher levels, a population for example.
5. Why are there many different cell types in the human body if they all contain identical DNA?
6. Describe cell specialization. Why is it important that cells are able to specialize?
7. Compare and contrast the structure and function of a neuron and a red blood cell. How do their structures allow them to perform their functions?
8. What is an organ system? Choose one of the organ systems and list the organs that belong to that system, as well as the system’s function.
9. What are diseases? How can a disease create symptoms in multiple organ systems? Give an example of one that does this.
10. Sketch one cell for each of the following types.



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| Neuron |  |
| Red Blood Cell |  |
| Osteocyte |  |
| Sperm |  |
| Skin |  |
| Muscle |  |