Name: _____Date:_____

Ms. Randall LE

<u>Unit 4 Human Systems and Homeostasis</u>

Unit Objectives:

- To describe the levels of organization in an organism
- To describe the function of each human system
- To relate tissues and organs systems to function
- To recognize the interdependence between tissues and organ systems in humans
- To describe system malfunctions and diseases
- To understand the mechanisms for self-regulation in human and plant systems
- To describe and exemplify a negative feedback loop
- To recognize and explain the following mechanisms for homeostasis:
    - Guard cells and stomata in a plant cell
    - glucose homeostasis
    - insulin/glucagon as a negative feedback loop
    - Thyroid gland as a negative feedback loop
    - sweating as temperature control system
    - stimulus and response feedback loop

Focus Questions for the Unit:

- How does the body maintain homeostasis?
- Why is it important to maintain personal health by eating a well-balanced diet and exercising?
- Why is reproduction essential to life?
- What is the function of mitosis and meiosis in human reproduction?

Define the following vocabulary:

White blood cells
Engulf
Vaccinations
Microbes
Virus
AIDS
Infectious agent
Cancer/cancer cells/carcinogens
Allergic reaction
Inheritance
Toxic
Nutrition
Feedback

Heart rate
Insulin
Pancreas
Guard cells
DNA
Gene
Recombination
Mutation
Embryo
Allele chromosome
Sexual reproduction
inherit

Lesson 1: Organization in Humans **Date:_____**

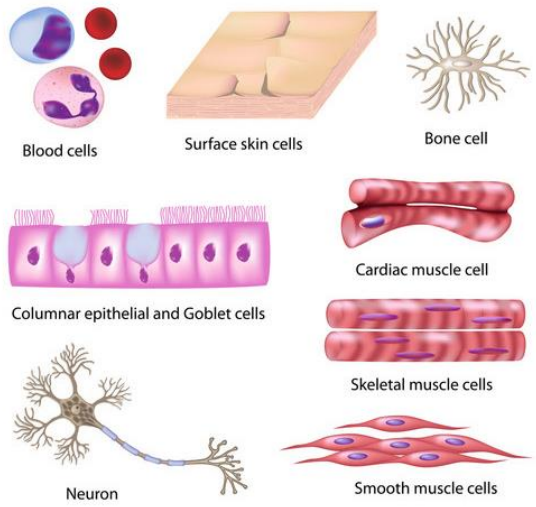
Objective: To describe the levels of organization in an organism

In unicellular (single-celled) organisms, the single cell performs all life functions. It functions independently with the help of cell organelles. However, multicellular (many celled) organisms have various levels of organization within them. Individual cells may perform specific functions and also work together for the good of the entire organism. The cells become dependent on one another.

Multicellular organisms have the following 5 levels of organization ranging from simplest to most complex:

LEVEL 1 - Cells

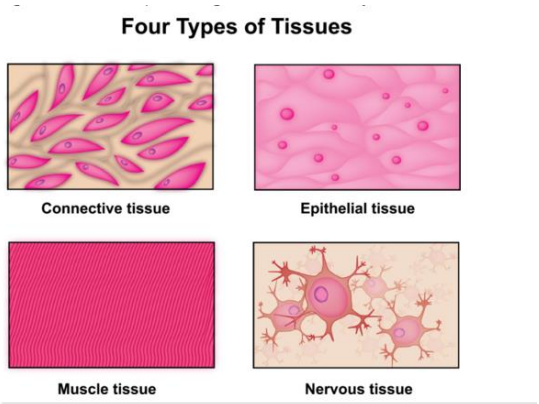
- The basic unit of structure and function in living things.
- May serve a specific function within the organism
- Examples- blood cells, nerve cells, bone cells, etc.



LEVEL 2 - Tissues

Made up of cells that are similar in structure and function and which work together to perform a specific activity. Humans have 4 basic tissues:

- Connective tissue connects different structures to form overall structure of the body
- Epithelial tissue covers body surfaces to protect organs; also secretes and absorbs substances
- Muscle tissue can contract to move bones
- Nervous tissue carries electric nerve signals

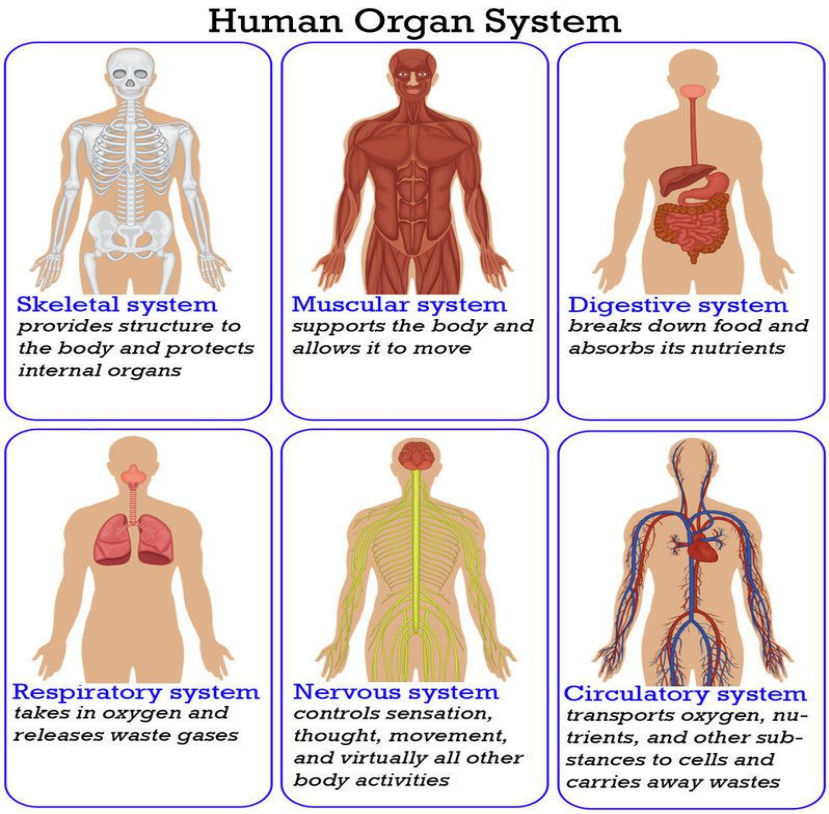


<u>LEVEL 3</u> - Organs

- Made up of tissues that work together to perform a specific activity
- Examples - heart, brain, skin, etc.

<u>LEVEL 4</u> - Organ Systems

- Groups of two or more tissues that work together to perform a specific function for the organism.
- Examples - circulatory system, nervous system, skeletal system, etc.
- The Human body has 11 organ systems - circulatory, digestive, endocrine, excretory (urinary), immune (lymphatic), integumentary, muscular, nervous, reproductive, respiratory, and skeletal.



LEVEL 5 - Organisms

- Entire living things that can carry out all basic life processes. Meaning they can take in materials, release energy from food, release wastes, grow, respond to the environment, and reproduce.
- Usually made up of organ systems, but an organism may be made up of only one cell such as bacteria or protist.
- Examples - bacteria, amoeba, mushroom, sunflower, human

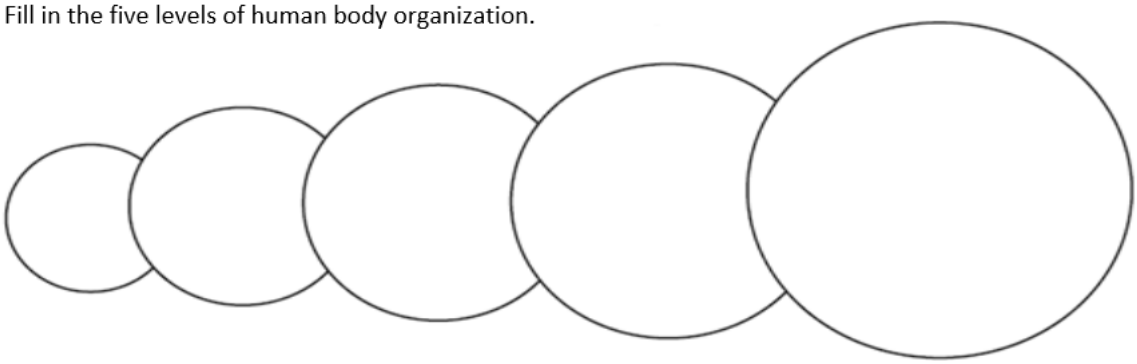
Summary

The levels of organization in the correct order then are:
cells --> tissues --> organs --> organ systems --> organisms

All systems of the body work together in order to maintain **homeostasis**. Hormones and the endocrine system play a large role in maintaining homeostasis. If homeostasis fails, the person can get sick and die.

Check your understanding:

1. Fill in the five levels of human body organization.



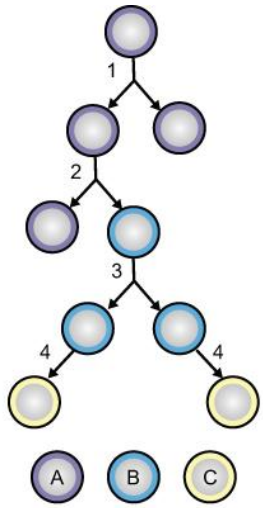
Practice: Read the following passage and answer the questions.

Stem Cells

An unspecialized cell that can divide many times and give rise to different, specialized cells is called a **stem cell**, as shown in Figure 1. Zygotes and embryonic cells are both types of stem cells. The stem cells found in embryos can divide indefinitely, can specialize into any cell type and are called embryonic stem cells. Embryonic stem cells are totipotent. Undifferentiated cells that are found within the body and that divide to replace dying cells and damaged tissues are called adult stem cells. Adult stem cells can divide indefinitely, and generate all the cell types of the organ from which they originate. They can potentially re-grow the entire organ from just a few cells. A third type of stem cell is found in blood from the umbilical cord of a new-born baby, and the placenta. These "cord blood stem cells" are considered to be adult stem cells because they cannot generate all body cell types, just different types of blood cells. Therefore, adult stem cells and cord blood stem cells are pluripotent.

Stem Cells in Medicine

Stem cells are of great interest to researchers because of their **ability to divide indefinitely**, and to differentiate into many cell types. Stem cells have many existing or potential therapeutic applications. Such therapies include treatments for cancer, blood disorders, brain or spinal cord injuries, and blindness.



A–Embryonic stem cells (purple)
B–adult stem cell (blue)
C–differentiated cell (yellow)
1–embryonic stem cell division to make more stem cells
2–totipotent embryonic stem cells can produce pluripotent adult stem cells
3–adult stem cells divide, and eventually differentiate into specialized cells. (4)

FIGURE 1 Division and differentiation of stem cells into specialized cells.

Embryonic stem cells, as shown in Figure 2, are taken from eggs that were fertilized in the laboratory and donated research. They may have the greatest potential because they are totipotent, and thus have the most potential medical applications. However, embryonic stem cells harvested from a donated embryo differ from a potential patient's tissue type. Therefore, just as in organ transplantation, there is a risk of a patient's body rejecting transplanted embryonic stem cells. Some individuals and groups have objections to the harvesting of embryonic stem cells, because harvesting the stem cells involves the destruction of the embryo. Some

researchers are looking into methods to extract embryonic stem cells without destroying the actual embryo. Other researchers have claimed success in harvesting embryonic stem cells from the embryonic fluid that surrounds a growing fetus. Adult stem cells, including cord blood stem cells, have already been used to treat diseases of the blood such as sickle-cell anemia and certain types of cancer. Unlike embryonic stem cells, the use of adult stem cells in research and therapy is not controversial because the production of adult stem cells does not require the destruction of an embryo. Adult stem cells can be isolated from a tissue sample, such as bone marrow, from a person. Scientists have recently discovered more sources of adult stem cells in the body. Adult stem cells have been found in body fat, the inside lining of the nose, and in the brain. Some researchers are investigating ways to revert adult stem cells back to a totipotent stage.

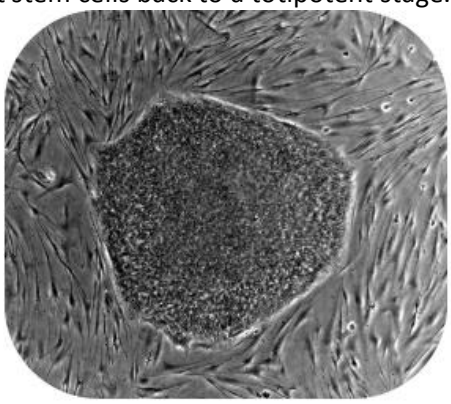


FIGURE 2
Human embryonic stem cell colony, which was grown in a laboratory on a feeder layer of mouse cells. Embryonic stem cells are totipotent.

<u>Questions</u>

1. What is the definition of a stem cell?

2. What can adult stem cells replace?

3. What is the main difference between embryonic and adult stem cells?

4. Name two ways in which researchers could harvest embryonic stem cells without destroying the actual embryo.

5. Name one source of adult stem cells in the human body.

6. A cell that is able to differentiate into all cell types is called
    a. pluripotent
    b. differentiated
    c. totipotent
    d. none of the above

7. Adult stem cells
    a. can divide indefinitely
    b. can generate all the cell types of the organ from which they originate
    c. can potentially re-grow the entire organ from just a few cells
    d. all of the above

8. A third type of stem cell is found in
    a. the placenta
    b. the liver
    c. the pancreas
    d. the heart

Lesson 2: The Human Digestive System **Date:_____**

Objective: To describe the function of the digestive system and to relate tissues and organs systems to function.

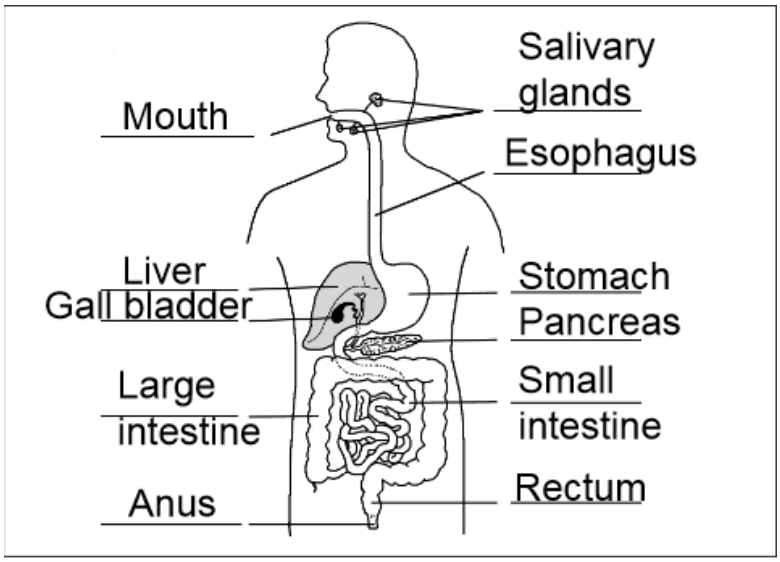
Digestive:

Function: to break down food into a usable form; large organic molecules into small organic molecules

Corresponding Life Process/Function: Nutrition

Corresponding Cell Organelle: vacuole and lysosome

Picture/Diagram of:



Important Organs:

In the digestive tube: mouth →esophagus→ stomach→ small intestine→ large intestine → rectum→ anus

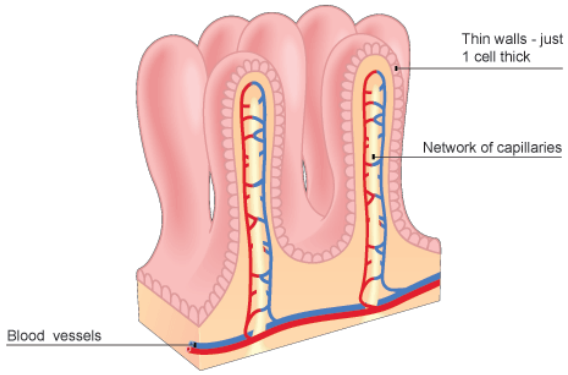
Part	Function
Mouth	Break down food into small pieces, saliva begins to chemically break down starch
Esophagus	Transports food from mouth into stomach
Stomach	Mixes strong acids with food to break it down
Small intestine	Long narrow tube mixes enzymes with food Small nutrient molecules diffuse into blood
Large intestine	Leftover water and minerals are absorbed into blood. Left over waste is formed into feces
Rectum	Stores and eliminates feces

Accessory organs (important, but not part of the tube): salivary glands, liver, gall bladder ,pancreas

A Closer Look: Small Intestine

- Completes chemical digestion
- Absorbs nutrients into blood

<u>Villi</u> - finger-like projections where absorption occurs



Following the completion of chemical digestion, there is a high concentration of nutrients (amino acids, sugars, fatty acids, etc…) in the small intestine. These nutrients are absorbed into the blood/lymph by diffusion, moving from high concentration to low concentration. The blood then transports these building blocks to our cell's, where they are used to build (synthesize) new organic compounds or to make energy (ATP) during cell respiration.

The digestive system works with the: Circulatory system

Describe relationship:

The nutrients in the small intestine are absorbed into the blood, which transports them to the body cells

The digestive system works with the: Respiratory system

Describe relationship:

Respiratory system provides oxygen and the digestive system supplies glucose. These are the reactants needed for respiration to occur (ATP production)

System Malfunctions

1. Diabetes Mellitus-the pancreas either doesn't produce enough insulin or any functional insulin for the absorption of glucose into cells

2. Liver cirrhosis-the liver become fibrous from cell death and disease.

3. Irritable bowel/Crohn's disease-an autoimmune inflammatory condition that affects absorption and nutrition.

4. Colon cancer-cancer cells can penetrate any part of the digestive tract.

5. Appendicitis -a swelling of the appendix .The appendix is a small, tube-like structure attached to the first part of the colon. It is in the lower right side of your child's belly. It has no known function in the body.

6. Ulcers- caused by H. Pylori bacterial infection that erodes the mucosal lining of the digestive tract.

Check your Understanding:

Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Pills of frozen poop fight killer disease. Treatment gives patients the gut bacteria of healthy people

by Janet Raloff
10:26am, October 22, 2014

These capsules contain frozen feces from a healthy individual. When swallowed, the microbes in them may conquer the *Clostridium difficile* bacteria that can cause serious — even lethal — disease.

Icy nuggets of human feces, delivered in pill form, can treat a potentially killer intestinal disease, a new study finds.

When doctors mention transplants, they usually mean swapping in a healthy organ for one that had been sick or injured. The new tissue would come from a healthy donor. But sometimes healthy people contribute another type of donation: Poop.

The idea may sound gross, but fecal transplants are based on good science. Medical teams harvest gut microbes excreted in the feces of a healthy person. Those microbes are then used to build up colonies of health-promoting bacteria inside a patient infected with *Clostridium difficile*. These sickening bacteria — commonly called *C. diff* — can cause gut-wrenching pain and diarrhea. Each year, these infections also kill 14,000 people in the United States alone.

Fecal transplants began in animals more than a century ago, notes Lawrence Brandt. He's a surgeon at the Albert Einstein College of Medicine in New York City. In those early cases, the procedure treated horses or other animals with severe diarrhea. Doctors made the first fecal transplant into a human in 1958, he says. Brandt has performed such implants since 1999. He described the value of the therapy for *C. diff* in an interview <u>published</u> in the March 2012 issue of *Gastroenterology & Hepatology.* (Gastroenterologists are doctors who treat diseases of the digestive tract.)

Such transplants have been very successful. They often quash a patient's disease within a day or two. To date, hundreds of people have been treated. But getting healthy microbes for treatments has at times proven challenging.

Doctors have used a range of techniques to transplant microbes into the gut of a sick patient. Some have inserted them up the rectum. Others have put them in pills that people swallowed. But live microbes can only

live a short time outside the body. So treatments had to occur fewer than 6 hours after "donations" had been collected. And within that same short window, potential donors had to be screened. Doctors had to make sure the microbes being donated would not risk making an already sick person even sicker.

Ilan Youngster is a physician at Massachusetts General Hospital in Boston. For the new study, his team extracted healthy gut bacteria from donated stool. Then they froze the microbes into capsules. This greatly prolongs the "shelf life" of the microbes. The researchers gave the capsules to 20 people with *C. diff* infections. In 14 patients, the infections cleared up after taking a two-day regimen, or 30 capsules. Four more people improved after a second round of capsules. The overall success rate for the treatment was 90 percent, the researchers reported October 11 in the *Journal of the American Medical Association*.

"By using frozen samples, you can screen donors ahead of time and establish a 'stool bank,'" says Younger, the study's lead author. You might think of these banks as similar to a Red Cross's blood bank. This Brown Cross, if you will, instead would bank fecal samples so that they would be "ready to use at a moment's notice," he told *Science News.*

Question: Describe the technology being used to help doctors treat C. diff patients in your own words. Explain the pros and cons of this treatment. Support your answer with evidence from the article.

Lesson 3: The Human Respiratory system **Date:_____**

Objective: To describe the function of the respiratory system and to relate tissues and organs systems to function.

Function: Trading oxygen and carbon dioxide between the external environment and the lungs

Corresponding Life Process/Function: gas exchange

The process of gas exchange should not be confused with cell respiration, the energy-releasing reactions that occur within the mitochondria of the cell.

Corresponding Cell Organelle: cell membrane

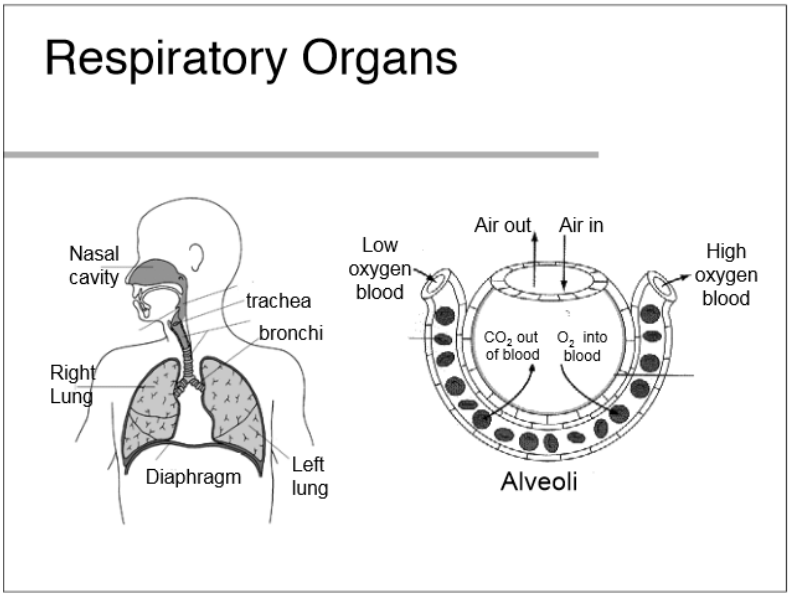
The Respiratory Surface

The respiratory surface is the place in the organism where gas exchange occurs. A respiratory surface must have the following characteristics:

- thin, one-cell
- moist
- large surface area
- contact with oxygen

Gas exchange takes place by diffusion- the movement of molecules from areas of high concentration to areas of low concentration. Increases in the surface area of the respiratory surface will increase the rate of gas exchange.

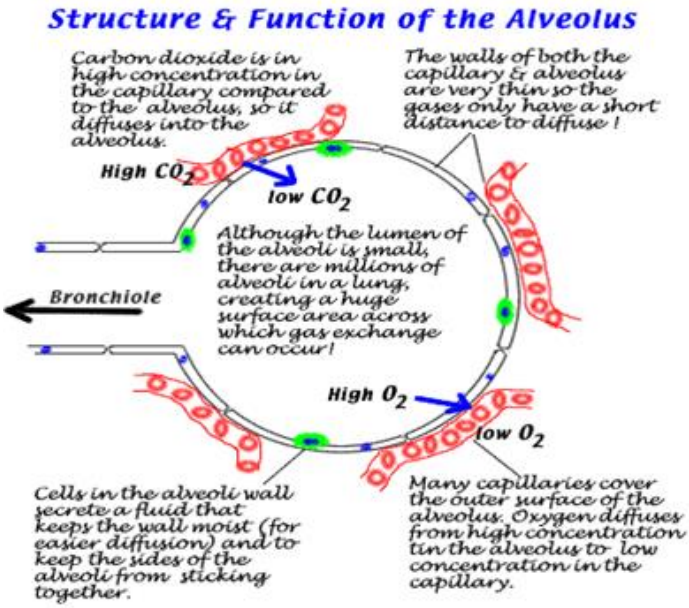
Picture/Diagram of:



Part	Function
Nasal cavity	Takes in, filters and warms air
Trachea	Windpipe which transport air into lungs
Bronchi	2 main branches, one leads to each lung
Lungs	Bronchi branch into smaller and smaller tubes eventually forming alveoli
Alveoli	Tiny air sacs where CO_2 and O_2 are exchanged Gases pass into and out of capillaries (circulatory sys.)
Diaphragm	Large muscle below lungs. Contracts causes inhale, relaxes causes exhale

The diagram below is a single alveolus (air sac) in the lung. There are millions of these alveoli in the lung.

- Why is this important? Increase the surface area for diffusion.
- What structures surround each alveolus?
    - *Capillaries*
- To what body system do these structures belong?
    - *Circulatory system*



There is a high concentration of oxygen in the alveoli and a low concentration of oxygen in the blood. Therefore, oxygen will leave the alveoli by the process of diffusion. At the same time, there is a high concentration of carbon dioxide in the blood and a low concentration of CO_2 in the alveoli. As a result, CO_2 will enter the alveoli by diffusion.

The respiratory system works with the: circulatory system

Description: transports the O_2 from the lungs to body cells and CO_2 from cells to lungs.

The respiratory system works with the: excretory system

Description: lungs act as an excretory organ and remove CO_2.

System Malfunctions

1. Lung cancer-caused by smoking and other carcinogens that affect the lungs
2. Emphysema- the inner walls of the air sacs weaken and eventually rupture — creating one larger air space instead of many small ones. This reduces the surface area of the lungs and, in turn, the amount of oxygen that reaches your bloodstream.
3. Asthma-allergic response that makes breathing difficult
4. Pneumonia-Bacterial or viral infection that can cause fluid buildup in the lungs
5. Bronchitis-inflammation of the bronchi due to bacterial or viral infection

Check your Understanding:

Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

A teen's invention helps log asthma symptoms

The new stethophone can record heartbeats and breathing — then ship the data to your doctor

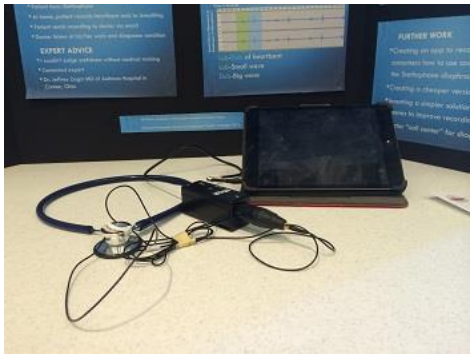
by <u>Bethany Brookshire</u>
2:56pm, October 27, 2014

Annika Urban shows off her stethophone, an invention that records heartbeat and breathing sounds to send to the doctor.

Washington— An asthma attack can be a terrifying experience. One minute you're fine, and the next you are fighting to breathe. Annika Urban, 13, found out firsthand that symptoms come and go very quickly. The teen decided to invent a device to record the sounds of asthma as they occur. She and other patients could then upload them to a computer and send them to their doctors.

The goal is to be able to alert doctors when a distant patient is having an attack. In some instances, this could decrease the time it takes to diagnose the disease and help patients get the proper medicine.

Annika showed off her invention at a competition in Washington, D.C., known as the <u>Broadcom MASTERS</u> (for Math, Applied Science, Technology and Engineering for Rising Stars). <u>Society for Science & the Public</u> runs the annual science competition, which is sponsored by Broadcom (a company that makes components to help you access the Internet wirelessly). The competition lets middle school students from around the United States share their science projects and inventions with each other and the public. (SSP also publishes <u>*Science News for Students*</u> and this blog).



The stethophone is a combined stethoscope and microphone. The sounds they pickup are run through an amplifier to increase the signal —then on to an iPad to record the sound.

Annika is a student and cross-country runner at Dorseyville Middle School in Pittsburgh, Pa. She was diagnosed with exercise-induced asthma two years ago. But it took her doctors a long time to confirm her disease because its symptoms often disappeared before the girl got to her doctor's office.

Asthma is a disease that causes the lungs' airways to become inflamed and swollen. Mucus can build up. Muscles around the airways tighten, limiting how much air can flow in and out of the lungs. During an asthma attack, people may cough, wheeze or feel that they can't get air out of their lungs. In the United States alone, more than 25 million people suffer from asthma.

But its symptoms can emerge and disappear quickly. As a result, many patients will no longer be wheezing by the time they see a doctor. This can make it hard for doctors to diagnose the disease.

Annika's new device might help speed those diagnoses. Her "stethophone" is a stethoscope — a device that detects heartbeats — paired with a microphone. Users can plug it into a smartphone or tablet computer. When someone has trouble breathing, the invention can store sounds of his or her breathing and heartbeat. Later, the patient can then send those recordings over the Internet to a doctor.

Designing the stethophone wasn't easy. Annika found the microphone built into smartphones and iPads would not work for this application. "One of the first steps I went through was creating the device with a simple microphone and an iPad," she says. "I was able to hear breath sounds but I was not able to hear a heartbeat."

The teen realized she needed a more powerful microphone. She borrowed a very high quality one from her father, Nathan Urban. He's a brain scientist at Carnegie Mellon University in Pittsburgh. His microphone easily picked up both the heartbeat and breathing sounds. But it was far too expensive for patients to buy for their personal use.

Annika knew she would need to boost the sound signal between the microphone and her iPad. The solution she came up with: a guitar amplifier. "I was able to hear heart and breath sounds extremely well and I sent these sounds to a doctor," she says. "He was amazed at the sound quality and said it sounded like a regular stethoscope."

The teen already has plans to improve her device. "I'd like to make an app to show the user how to record sounds, where to place the stethoscope and how to send it to the doctor," she says. Annika hopes her device one day will find use all over the world. From battlefields to homes, it might quickly send symptoms for analysis by a doctor far away.

<u>Question:</u> Explain the pros and cons of this invention. Support your answer with evidence from the article.

<u>Lesson 4</u>: The Human Excretory System **Date:_____**

<u>Objective:</u> To describe the function of the excretory system and to relate tissues and organs systems to function.

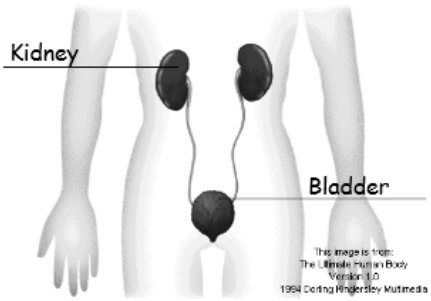
Function: Removal of cell (metabolic wastes) from the body
Life Process: Excretion
Corresponding Cell Organelle(s): vacuole, cell membrane

Types of Metabolic Wastes

METABOLIC WASTES	HOW PRODUCED
Water	**Respiration, dehydration synthesis**
Carbon dioxide	**respiration**
Salts	**metabolism**
Urea	**Protein metabolism**

Picture/Diagram of:

Part	Function
Kidneys	Collects waste from the blood and transforms it into urine
Bladder	Collects urine from kidneys and stores it until removal through urethra
Lungs	Excretes CO_2 from the blood
Skin	Excretes water and salts



Organs of Excretion

1) **Skin**

   Water, **salts** and **urea** exit the body when you SWEAT.

2) **Lungs**

   The lungs excrete carbon **dioxide** and water, which are both waste products of aerobic **respiration**.

3) **Liver - Functions of the Liver:**

   1) Production of Urea

   What is urea? What end products of digestion are broken down to make urea?

Urea is the waste product formed by the breakdown of excess amino acids in the liver.

4) The Urinary (excretory) System

The functional units of the kidneys are called **NEPHRONS**. There are millions of these microscopic structures in each kidney. The nephrons filter the blood, return useful substances to the blood and collect urine.

Organ	Function(s)
renal arteries	Blood carrying wastes enters the kidneys
kidneys	filter wastes out of blood to make urine; maintain water balance & blood pH
ureters	tubes that carry urine to the bladder
urinary bladder	Stores urine
urethra	tube where urine exits the body
renal veins	"clean" blood (no wastes) leaves the kidneys to re-circulate around the body

The excretory system works with the: Circulatory system

Describe relationship:

The blood carries wastes to the kidneys to be removed;

It returns the cleaned blood back to the body

The excretory system works with the: Respiratory system

Describe relationship:

The lungs excrete CO2 - one of the waste products of cell respiration

<u>System Malfunctions</u>

1. Urinary tract infection-bacterial infection of the bladder or kidneys
2. Renal calculi- A kidney stone is a hard, crystalline mineral material formed within the kidney or urinary tract.

<u>Check your Understanding:</u>

Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Urine may make Mars travel possible

A new recycling system turns pee into drinking water and energy

by Erika Engelhaupt
8:39am, April 18, 2014

Astronauts aboard the International Space Station toast people back home with water recycled from their urine. A new system not only would turn pee into drinking water but also produce energy.

NASA

Every day, you flush a liter or two of urine down the toilet. But if humans are going to get to Mars, they won't be able to afford throwing out this yellow water. Indeed, they are going to have to drink water from their own pee. Scientists have now built a recycling system that can turn astronauts' urine into both clean drinking water and energy.

That two-step process could be important in making long-distance space travel possible, report chemist Eduardo Nicolau of the University of Puerto Rico, in San Juan, and his colleagues. They described their new pee-recycler in the April 7 issue of *Sustainable Chemistry & Engineering.*

The International Space Station would be a likely first place to try out such a system. It already recycles pee using a complex process to filter out the water and purify it. "It makes yesterday's coffee into today's coffee," astronaut Don Pettit said when it was installed.

Before the space station, astronauts didn't harvest pee. The Russian Mir craft had a recycling system that accepted urine. It was known for breaking down, however. In the end, it didn't produce much drinkable water. NASA's space shuttles jettisoned urine into space. This created lovely "shooting stars" of pee that were visible from Earth. (Fortunately, the shuttles brought home the solid wastes, which otherwise could have made for a really disgusting type of space junk).

Astronauts report that the water made from recycled urine on the space station tastes great. But the system, installed in 2008, keeps breaking down. It also takes a lot of power to run. What's more, the system uses some filters and other materials that can't be recycled. These will add to a spacecraft's trash, notes Nicolau.

The system his team has come up with not only would remove water from pee, but also its urea. A nitrogen-rich chemical, urea is used as a fertilizer and as a raw ingredient in some fuel systems. Harvesting it from urine might reduce some of the weight and space that must be allotted for a spacecraft's fuel, Nicolau says. Indeed, some chemicals recycled from pee can be used to generate electricity, according to his team (which includes NASA scientists).

The new recycling system relies on chemistry to pull pure water out of urine. Through a process called forward osmosis, it uses a concentrated salt or sugar solution. This draws the water from the urine and across a membrane barrier. A tank, called a bioreactor, uses enzymes to convert the leftover urea into ammonia. That ammonia is used to drive a fuel cell, which uses chemicals to produce electricity.

No shortage of raw materials

People urinate about 50 percent more each day than they drink, notes Sherwin Gormly. That's crazy, you're thinking: How could you pee out more than you take in? Well, for one thing, your body turns some of your food into water. (When you burn carbohydrates, your body makes energy with a side order of carbon dioxide and water.)

Gormly knows about such issues. As an engineer at NASA's Ames Research Center in Mountain View, Calif., he helped design the system to recycle urine on the International Space Station. He now works for Desert Toad Water Technology Research in Carson City, Nev.

Surendra Pradhan of Finland's University of Kuopio shows off cabbages whose growth was boosted by fertilizing them with human urine.J. Holopainen/Univ. of Kuopio

Managing water — including pee — ends up being one of the biggest obstacles to supporting people on a trip to Mars or any other distant space destination. Without urine recycling, water for a trip to Mars could take up 80 to 90 percent of the mass on a spaceship, Gormly says. Launching something into space can cost up to $10,000 per pound. So shooting mega-tons of water into space quickly becomes crazy expensive.

Any recycling system that people will rely on for months or years has to be extremely efficient. The space station's system can reclaim 93 percent of the water on board. The new system that Nicolau's team has developed still needs tweaking. But even in its early stages, it too recovers more than 90 percent of the water going into it.

It's only generating a tiny trickle of electricity right now. In the lab, filtering one liter (or quart) of urine in eight hours produced about as much electricity as the static charge produced by rubbing a balloon on your hair.

“Still,” says Nicolau, “our system is a proof of concept.” Now it’s up to engineers to make it work even better. Eventually, he says, it might produce enough power to run itself.

Another limitation: The system requires small amounts of oxygen to make that electricity. And oxygen, of course, is something else you’re going to need to travel in space. “We are using some breathable oxygen from the cabin,” Nicolau says. So the system would require another process to make up that lost oxygen. This might require breaking down water (via electrolysis) to recover some of its oxygen, or using other chemical processes.

The new recycling process does produce drinkable water. At least in theory it does. Nicolau admits that his team has not yet sampled any. The reason: It has not yet been tested for bacteria and other germs. He promises a photo, though, once he and his team are able to gather around the bioreactor and toast each other with glasses of a beverage made from recycled urine.

Closer to home

We could even get energy-producing urine recyclers here on Earth. “You could deploy this in developing countries where water is scarce,” Nicolau says. It also might appeal to military troops sent to remote desert sites.

If a future in which you drink water made from urine doesn’t sound attractive, think of it this way: Your drinking water already comes partly from the entire planet’s pee; it’s just been recycled a lot more slowly.

Yet one more use for urine at home and in space: growing food. Several years, ago, Finnish scientists reported fertilizing veggies with human pee. Their cabbages grew bigger — and had fewer germs — than those treated with regular fertilizer.

Question: Explain the pros and cons of this invention. Support your answer with evidence from the article.

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<u>Lesson 5:</u> The Human Circulatory System **Date:_____**

<u>Objective:</u> To describe the function of the circulatory system and to relate tissues and organs systems to function.

Function: transports nutrients, gases, and wastes to all cells of the body

Corresponding Life Process/Function: transport

Why do most animals require a circulatory system?

Large organisms whose cells are not in contact with the external environment need a system to move materials.

Corresponding Cell Organelle(s): Endoplasmic Reticulum (ER

Humans have a CLOSED circulatory system consisting of three parts:

- **Arteries**
- **veins**
- **capillaries**

Like other relatively large, multicellular organisms, plants require a means of transporting materials. In plants, **xylem** tissue carries water from the roots to the stems and **phloem** tissue carries food (sucrose) from the leaves to the stems and roots.

The Blood Vessels

1. **Arteries**
   a. **Transport oxygenated blood**

      EXCEPTION : ***pulmonary arteries***

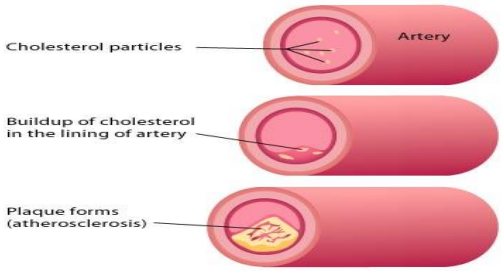
   b. transport **blood AWAY from heart**

   c. branch into smaller tubes called ***arterioles***

   d. A person's heart rate can be measured by taking their **pulse**.

      The pulse is created by the pressure of the blood against the artery walls as the heart pumps. The blood in the arteries is under relatively HIGH pressure. It can be detected where arteries lie close to the surface of the body → side of neck or wrist.

   e. The largest artery is the **aorta**.

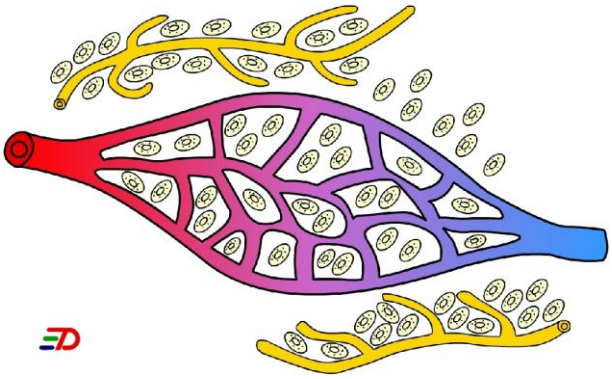


The picture to the left shows an artery and the buildup of cholesterol in the artery. This our buildup leads to many types of cardiovascular disease, including arteriosclerosis, high blood pressure, heart attack and stroke.

2. **Capillaries**
   a. One cell thick

   b. exchange of nutrients, gases, and wastes

   The capillaries are microscopic → therefore; they come into contact with **EVERY CELL** in the body. The exchange of materials between the blood and the body cells is usually accomplished using **DIFFUSION**.



Ex Examples:

- capillaries in the small intestine (villi) to absorb nutrients
- capillaries in the lungs (alveoli) to absorb oxygen; release CO_2
- capillaries in the kidneys filter wastes

3. **Veins**
   a. **carry deoxygenated blood**

      EXCEPTION: ***pulmonary veins***

   b. **carry blood to the heart**

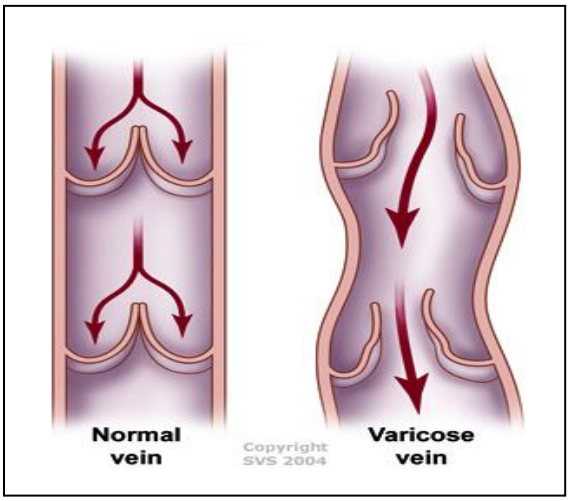
   c. branch into smaller tubes called ***venules***

   d. Blood in the veins is under relatively low pressure. Therefore, veins contain **valves** that prevent the blood from flowing backwards →They keep the blood moving in one direction!

   e. The largest veins are the vena **cava**.

The picture on the left shows a normal vein – note the valves that are preventing the blood from flowing backwards.

A varicose vein is pictured on the right. Your veins may stretch if you repeatedly sit or stand for a long time. This stretching can sometimes weaken the walls of your veins and damage your vein valves, especially in people who are susceptible to this problem.



The Heart

The heart is the **"pump**" in the circulatory system. It contains a special kind of muscle tissue called cardiac muscle, that has the ability to "beat" on its own.

The heart has four chambers:

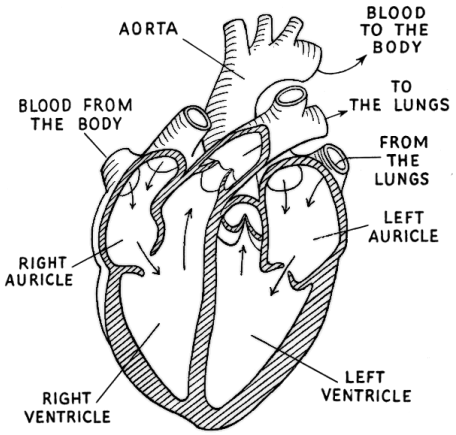
(a) There are two atria which are thin-walled receiving chambers at the top of the heart.

(b) There are two **ventricles** which are thick, muscular chambers that pump blood away from the heart back to body cells.

(c) There are **valves** between each atrium and ventricle, as well as between each ventricle and corresponding blood vessel.

(d) The **septum** is the wall that separates the two sides of the heart and prevents oxygenated blood from mixing with deoxygenated blood.

(e) The heart is an involuntary muscle → it is controlled by signals from the brain (medulla), as well as from the heart's pacemaker, or S-A node.



System Malfunctions

1. Myocardial infarction: a portion of the heart is starved of oxygen, and the muscle dies.
2. **Arteriosclerosis**, hardening of the arteries.
3. **Arrhythmia** is an abnormal heart rhythm usually caused by an electrical "short circuit" in the heart.
4. **Stroke:**

<u>Practice:</u> Read the following current event and then complete the summary

Teen finds the 'shape' of our beating hearts

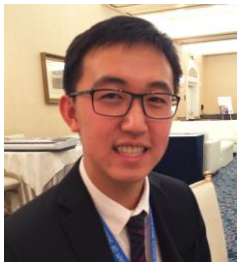
Kevin Lee used math to model how heart muscle moves with each beat

by Bethany Brookshire
6:00pm, March 11, 2014

WASHINGTON — Kevin Lee, 17, has always found the heart interesting. "It maintains a steady rhythm for millions of beats," he says. Then, suddenly, "it can fail without any explanation." But three years ago, the heart-obsessed senior at University High School in Irvine, Calif., was no longer content to sit on the sidelines. "I saw all these stories in the news about these athletes suddenly collapsing and dying," he recalls. "I thought, if I could find the reasons why that could happen, I could find ways to treat those conditions and ways to prevent them."

He hasn't succeeded. At least not yet. But Kevin has made some stunning progress, using math to show how the shape of the heart changes as it contracts, or beats. And he can now relate those changes to the electrical signals that tell the heart when it's time to beat.

Kevin presented his findings this week at the Intel Science Talent Search in Washington, D.C. Each year, Society for Science & the Public brings together 40 high school seniors to share their impressive research achievements with the public.



Intel Science Talent Search finalist Kevin Lee has a new mathematical approach to modeling how the heart beats.

The heart is made of strong, elastic and tough muscle. A bundle of cells inside the heart called the sinoatrial node sends out electrical signals directing the organ to contract. With each beat, the heart pumps blood in and out. Blood that is coming from the body circulates to the lungs where it takes up oxygen. Then it moves out and around to deliver that oxygen where it's needed. Throughout each contraction, the heart muscle radically changes its shape.

Current computer simulations of how the heart beats have been based on the pacing of the electrical signals from the sinoatrial node. But they don't include the changing shape of the heart muscle as it contracts. Kevin says those existing models rely on a string of polynomials. These are mathematical expressions (using only addition, subtraction and multiplication), and they must change at every time interval within a heartbeat. To understand heart motion, Kevin says, "you also have to account for the heart's elasticity, how it rebounds back…it just becomes a nightmare."

He decided to take a new approach. Kevin worked with *partial differential equations*. This alternative way allows him to mathematically express heartbeats and is specifically designed to include numbers that are constantly changing over time — like those numbers describing how a heart changes shape when it contracts. Instead of piling one type of mathematical expression atop another, partial differential equations allow the heart muscle and the electrical signals of the heartbeat to move together, Kevin explains.

The teen hopes that his model will help scientists better understand how the heart beats — and what happens when the muscle loses its regular rhythm. Those pacing problems, known as cardiac arrhythmias, can lead to severe health problems and to the sudden death of the athletes that Kevin heard about on the news. By better understanding how heart signals relate both to the timing of heartbeats and the shape of a contracting heart, Kevin believes medical companies might be able to make drugs and devices that more safely and reliably stabilize unhealthy hearts.

Question:

Explain how this model could benefit future medical research. Support your answer with evidence from the article.

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Lesson 6: The Human Immune System **Date:_____**

Objective: To describe the function of the immune system and to relate tissues and organs systems to function.

Infectious Disease

Definition : disease that can spread from person to person

Causes : viruses, bacteria, fungi, parasites

Examples : cold, flu, strep throat, malaria

Non-infectious Disease

Definition : disease that *cannot* spread from person to person

Causes : lifestyle, genetics

Examples : diabetes, hypertension, cancer

Pathogens

*What is a **pathogen**? **a microscopic organism that causes a disease (usually infectious**)*

Examples : viruses, bacteria, parasites, fungi

Your Body's Defenses :

Barriers

Chemical or physical barriers in the body that prevent the pathogen from entering
Examples : skin, mucus, cilia, gastric juice, tears

Inflammatory Response

The inflammatory response results in the redness, swelling and pain associated with an infection and involves **phagocytes** - white blood cells that kill pathogens by engulfing and digesting them.

Immune Response

Involves lymphocytes – white blood cells that recognize, destroy and remember each pathogen that enters the body.

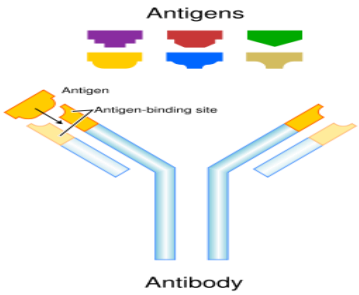
- **Immunity** - long-term protection against a future attack by a specific pathogen

Who to Attack?

antigens – unique proteins on the surface of a cell used to identify it as "self" or "not-self

"Self" Cells	"Not-Self" Cells
• **Contain antigens that the body recognizes** • NO IMMUNE RESPONSE!	• **pathogens or transplants** • **Contain antigens the body does NOT recognize** • IMMUNE RESPONSE LAUNCHED!

Antibodies



- **antibodies** - proteins made by *lymphocytes* made to attack SPECIFIC antigens
- antigen-antibody interactions are another example of ***specificity***.
- The **shape** of the antibody matches the **shape** of the antigen and attachment of specific antibodies to the antigens leads to the destruction of the pathogen

Memory Cells

- *special lymphocytes circulate in the blood that "remember" a specific antigen*
- If the same pathogen invades again, these cells will produce antibodies to protect you = **immunity**

Types of Immunity

Active Immunity	Passive Immunity
• **had the disease OR received a vaccination** • body must make antibodies against the pathogen using the immune response • **long-term**	• **received antibodies made by another organism** • Example : mom's breast milk • **short-term**

Active Immunity : Vaccination

- **vaccination** - injection of a *weakened* or *dead* virus or bacteria
- person does NOT get the symptoms (pathogen was weak/dead) ***BUT…*** **body produces antibodies to prevent a future attack by this pathogen**

Examples: polio, measles, flu, chicken pox

Immune Response

Vaccinations/AIDS/Organ Transplants

Vaccinations –vaccines are developed by using weakened ***pathogens*** to stimulate the immune system to react.

Steps for Making a Vaccination

a. Obtain the **pathogen (virus or bacteria**)_

b. Treat pathogen to **kill** or **weaken** it

c. Inject altered pathogen (**vaccine**) into organism

d. Body responds to **antigens** present by making **antibodies** and having **white blood cells** attack invader

e. Some white blood cells specific for this pathogen remain in the body for a long time to continue the protection from future attacks by the pathogen

Volunteer	Injected with Dead Chicken Pox Virus	Injected with Dead Mumps Virus	Injected with Distilled Water
A	X		
B		X	
C			X
D	X	X	

System Malfunctions:

AIDS (Acquired Immuno-Deficiency Syndrome) – develops when a virus, **HIV** , (Human Immunodeficiency virus) destroys the T cells (**white blood cells**) and the body is no longer able to protect itself from diseases that may attack it.

a. Most commonly contracted by **sharing needles** & unprotected **sex**

b. A person doesn't die from AIDS; a person dies from opportunistic **diseases** like cancers, pneumonia, etc.

Organ Transplant Rejection – when a person receives a new organ, precautions have to be taken to avoid the possibility of rejecting that organ. The immune system recognizes transplants as "foreign" and attacks them. To avoid "rejection" of their new organ, transplant patients receive injections of special drugs to reduce the effectiveness of their immune system. Their immune system now becomes weak and the patient may become ill from a pathogen that normally would not pose a threat.

Causes of Disease

Causes of Disease	Characteristics	Examples
1. Pathogens	Potentially disease-causing organisms in the air, water, and food	Bacteria, viruses, parasites, fungi
2. Inheritance	Defective genetic traits can be passed from parent to offspring	Sickle-cell anemia – hemoglobin is flawed and RBC's become twisted and cannot carry oxygen
3. Pollutants	Chemical agents present in the environment that may upset the body's normal functioning	Asbestos, PCB's
4. Organ Malfunction	Diseases may develop when one or more of the body's organs malfunctions	Kidney failure; diabetes from pancreas failure
5. Harmful Lifestyles	The way one lives can be an important factor in causing disease	Poor diet, lack of exercise leads to heart problems tobacco, alcohol, drugs, unsafe sexual experiences

Biological Research of Diseases

Category or Research	Methods Developed
Diagnosing Disease	Culturing (growing) bacteria from the infected person to determine what specific pathogen is responsible for the illness.
Preventing and Controlling Disease	Promoting improved sanitation measures, including frequent hand washing, safe garbage disposal, and sewage treatment. Sterilizing surgical instruments and treating wounds with antiseptics and other chemicals. Controlling populations of rats, flies, mosquitoes, and other disease carrying organisms with pesticides. Treating water, milk, & other foods to reduce pathogens. Vaccinating to promote the body's immune response to pathogens. Identifying the dangers of risky behaviors such as tobacco use.
Treating and Curing Disease	Developing antibiotics and other drugs to kill pathogens. Developing medical procedures, including surgical operations and laser techniques, to remove damaged or diseased tissue from body.

<u>Check your Understanding:</u>

Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Even penguins get the flu: It's not known, however, whether the virus makes these birds very sick

by Janet Raloff
9:00am, May 18, 2014

Flu infections have hit Adélie penguins in Antarctica, like those shown here. The virus responsible for the infections appears to have evolved into a form unique to the most southern continent.

Scientists have uncovered bird flu germs in Adélie penguins in Antarctica. The virus didn't infect many of those birds. But it is so unlike other flu viruses that biologists think it may have been evolving in isolation for decades. That has turned it into a distinctly Antarctic germ.

Bird flu viruses tend to be widely dispersed around the globe. And no wonder. Migratory birds can carry these viruses wherever they fly. Many of these long-distance travelers can migrate between two or more continents.

Sometimes a flu virus that infects birds will sicken them. Other times, birds pick up an infection but develop no symptoms. All infected birds do, however, shed the virus in their feces. Other members of close-knit bird colonies may step in those feces. Or the feces can get washed into water. So bird flu can spread widely and in many directions over long distances. That happens even when there aren't a lot of visibly sick birds. Along the way, other animals, including marine mammals, may also pick up the germs.

Recently, biologists reported finding flu antibodies in penguins. The presence of antibodies indicated that the birds had at one time been exposed to a virus. But such studies didn't show whether infections were ongoing in the penguins.

The new study was conducted by Aeron Hurt, a virus researcher at an international flu research center in North Melbourne, Australia, and his colleagues. They collected blood and throat germs from about 300 Adélie penguins — both adults and chicks — in Antarctica. The scientists sampled virus from the birds during January and February 2013. That was summer on the far southern continent.

A few penguins hosted “live” virus — a form that is infective. It belonged to a bird flu family known as H11N2. No infected penguin looked sick or underweight. Still, the presence of the virus showed some of the birds were harboring an active infection.

To better gauge where the germ might have come from, the scientists compared genes from it against the genes in other types of bird-flu viruses. The genes from flu in the few infected penguins were nearly identical. But those viruses had quite different genes from bird viruses circulating elsewhere in the world. That suggests the penguins’ virus was not a recent arrival. It was not, for instance, a germ picked up a continent away and dropped off last year by a migrating visitor, the scientists say.

In fact, they noted, the penguins’ virus was so different that it may have been evolving in Antarctica — in near isolation — for between 49 and 80 years. Hurt’s group reported its findings online May 6 in the journal *mBio*.

Antarctica, the authors posit, may be “the most extreme example” of a localized evolutionary sink for bird flu viruses. Such a sink would be a place where viruses arrive from elsewhere, now and again. Once established, those viruses could then evolve independently from flu germs elsewhere around the globe.

Describe the importance of the scientist’s findings. Support your answer with evidence from the article.

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Lesson 7: Human Locomotion **Date:_____**

Objective: To describe the function of the musculoskeletal system and to relate tissues and organs systems to function.

Function: Protection, support and movement
Life Process: none
Corresponding Cell Organelle(s): cytoskeleton

Human Locomotion involves the interaction of bones, cartilage, muscles, tendons and ligaments

1. Bones:

- make up the endoskeleton
- various shapes and sizes
- 206 bones in the human body

Functions:

- Protection of body structures
- Anchorage sites for muscle action
- Leverage for body movement
- Production of blood cells in bone marrow

2.Cartilage:

- Type of connective tissue
- Flexible, fibrous, and elastic

Functions:

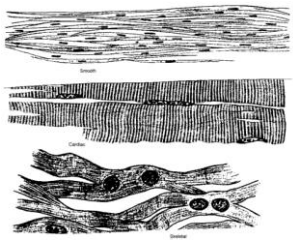
- Provides support
- Flexibility of joints
- Cushioning of joints
- Makes up most of an embryo's skeleton
- Found at the end of ribs, between vertebrae, end of bones and in the nose, ears, bronchi, trachea of adults

3. Muscles: 3 Major types

1. Visceral-(smooth, involuntary) Involuntary in action and smooth in appearance

2. Cardiac (heart)-involuntary in action and striated (striped) in appearance

3. Skeletal (striated, voluntary)-voluntary in action and striated in appearance



Skeletal muscles

Functions:

- Controlled by the central nervous system
- Move the bones in a coordinated manner
- Operate in pairs- extensors (extend limbs) and flexors(bend joints)
- Vigorous activity of these muscles can lead to oxygen deficiency – lactic acid build up due to anaerobic respiration in the cells

Tendons

- Composed of connective tissue
- Tough, inelastic, fibrous chords

Functions:

- Attach muscle to bones

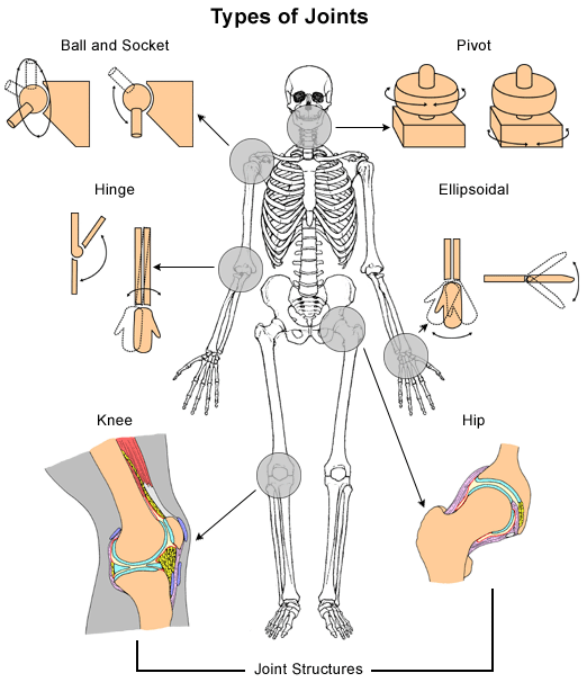
Ligaments

- Composed of tough elastic connective tissue
- Able to stretch slightly during joint movement

Functions:

- Connect ends of bones at moveable joints such as elbows, fingers, knee, and vertebral column

Joints-Place where 2 bones meet (examples include hinge, ball and socket, pivot, immovable)



System Malfunctions

1. **Arthritis-** an inflammation of the joints causing swelling and severe pain.
2. **Tendonitis-** an inflammation of the tendon usually at the bone attachment caused by physical stress and irritation.
3. **Sprain**-injury to the ligament
4. **Fracture-**breakage of bone
5. **Hernia-**hole in a muscle
6. **Gout**-buildup of uric acid crystals in a joint
7. **Cancer-**uncontrolled cell growth

Check your Understanding:

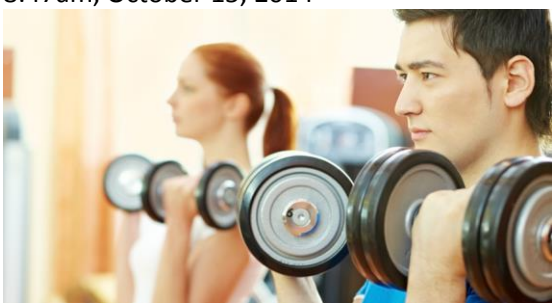
Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Exercise builds brawn — and brains

Lifting weights can boost memory, even in couch potatoes

by Esther Landhuis
8:47am, October 15, 2014



New research shows you can boost your memory by hitting the gym right after hitting the books.

Got an exam coming up? Head to the gym. It won't just tone muscle and keep you fit. It could also rev up your memory. Plenty of research has shown that moving the body — whether jogging, lifting weights or even playing fitness video games — helps the mind. However, many of those studies reported mental benefits only after participants exercised regularly for months or years. Now there's hope for couch potatoes: Just one 20-minute session of simple leg exercises can give the brain a lift, a new study finds.

Its lead scientist, Audrey Duarte, works in the Memory and Aging Laboratory at the Georgia Institute of Technology in Atlanta. As a neuroscientist, she's interested in why memory starts slipping as people age. And she suspected exercise might slow that decline. "We wanted to find simple things people can do to boost their memory, even just a little bit," she told *Science News for Students*.

Many earlier studies had asked volunteers to really move around. They assigned people to do various types of *aerobic* exercise, such as walking for an hour three times a week. Aerobic exercise makes the heart and lungs work hard. That helps to build muscle and improve blood flow. Duarte's team set the bar far lower. They assigned participants to do leg lifts — a type of *resistance* exercise. Such exercises rely on the contraction of muscles to build strength in particular tissues. Leg lifts have a second benefit: ease. "Anyone can do a 20-minute bout of moving their legs up and down," Duarte says.

Indeed, these leg lifts would be easy enough for grannies to do — even patients with dementia. However, for its initial study, Duarte's group worked with college students. Recruiting them for research tends to be easier. The researchers didn't want gym rats or athletes, though. They wanted to see if a single session of leg lifts might benefit even people who don't exercise regularly.

Before, during and after the leg exercises, the researchers measured heart rate and blood pressure in each of their 46 young recruits. They also took a small sample of saliva from each. From that they could measure an enzyme called amylase. This enzyme helps to digest starch. It also increases during times of short-term stress — such as keeping your hand submerged in cold water or getting filmed while giving an impromptu speech.

Research subjects in prior studies have faced those very stressors. The result? Increased stress hormones and higher amylase levels — but better memory. The leg lifts were performed using weights that targeted the *quadricep* muscles. The weight lifted was adjusted to match each person's maximal ability. Just 20 minutes of leg lifts produced amylase boosts similar to those produced during short-term stress, Duarte's team found. (Half the participants served as the *control* group. They moved their legs up and down on the same machine. Here, though, a researcher lifted each person's legs instead of relying on a recruit's muscles to do it.)

Before doing lifts, each recruit viewed a series of 90 pictures. Then they went home with the instruction to do no more exercise. Two days later, they returned to the lab for a test. A researcher showed each person 180 photos — half from the initial set — and then asked the subjects to indicate which ones looked familiar. The group that had done leg lifts scored about 10 percent higher than the control group. "What we found was on par with studies looking at how psychological stress can benefit memory in the short term," says Duarte. She thinks the magic happens during the "consolidation" phase. That takes place *after* learning. It's when memories are getting laid down in the brain.

Other scientists who study exercise and brain activities find the new results compelling. "Aerobic training has taken center stage as the type of exercise for improving brain health," says Teresa Liu-Ambrose. She's a cognitive scientist at the University of British Columbia in Vancouver, Canada. She notes, however, that "resistance training is emerging as an equally good option… and you can reap the benefits quite quickly."

Eelco van Dongen is a neuroscientist at Radboud University in Nijmegen, the Netherlands. He finds the new paper "very impressive." To his knowledge, it's the first time researchers have shown that a single round of resistance training can boost memory. The regimen's simplicity "will make it easier to apply in daily life or to use with people suffering memory problems," van Dongen says. He is currently running a similar study with young adults in the Netherlands. It will test if memory can improve with a single session of *interval training* on a stationary bike. That's a type of workout with alternating periods of high- and low-intensity exercise. His study has recruited people who already had been exercising regularly. In the future, Duarte's team plans to test if the leg regimen can improve brain power in older people. The group also would like to check if the benefits last longer than 48 hours — and if doing the exercises several times a week might yield a bigger boost.

Describe the importance of the scientist's findings. Support your answer with evidence from the article.

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Lesson 8: The Human Nervous System **Date: _____**

Objective: To describe the function of the human nervous system and to relate tissues and organs systems to function.

Function: control and coordination of all life activities

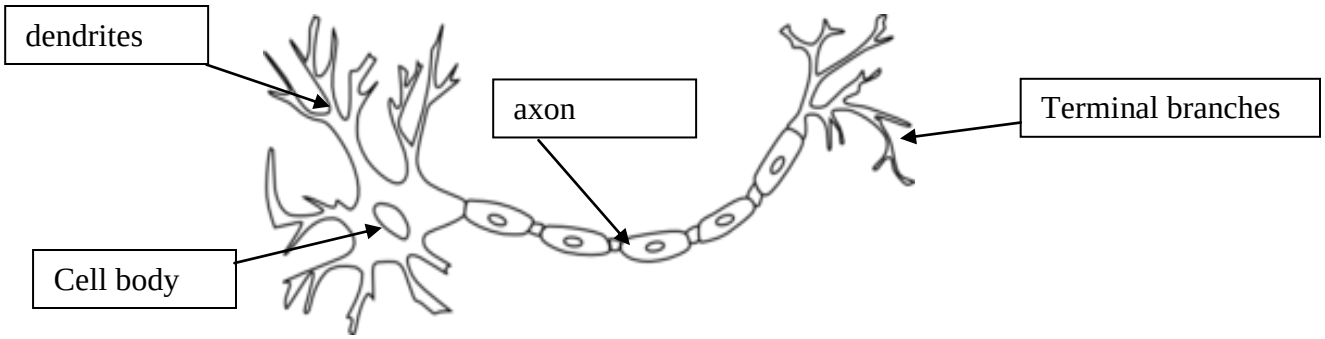
Life Process: regulation

Corresponding Cell Organelle: nucleus

Major Organs: Brain, cerebrum, cerebellum, medulla, spinal cord, nerves

Functional Unit: The Neuron (a.k.a. nerve cell)

Neurons are specialized animal cells that can generate an electrochemical signal called an **_impulse_**.



dendrites – detect stimuli and generate an impulse toward the cyton	**axon -** transmits the impulse away from the cyton and towards the terminal branches
cell body – (cyton) Contains the nucleus of the neuron	**terminal branches -** These branches secrete neurotransmitters; impulse will be transmitted to next neuron

The nervous system works with the circulatory system.

It tells the heart to speed up during physical activity and to slow down at rest.

The nervous system works with the muscular system.

It coordinates all the voluntary movements by your muscles and controls your balance.

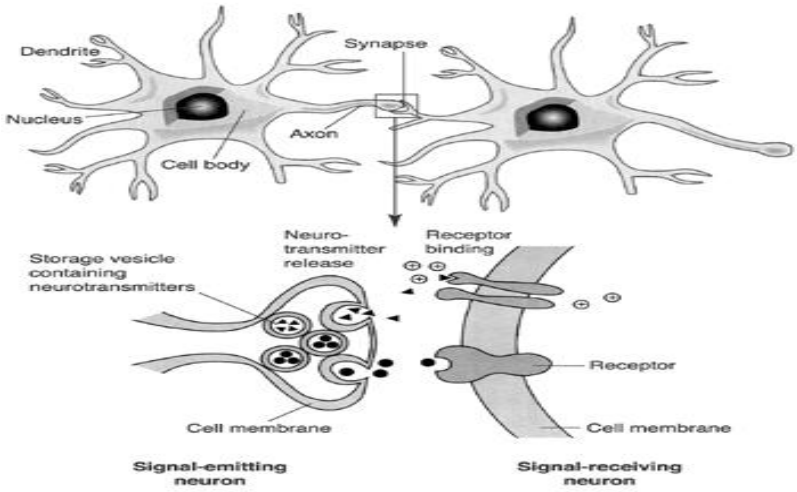
The nervous system works with the endocrine system.

These two systems work together to maintain homeostasis within the body

Nerve Cell Communication

Between 2 neurons (nerve cells) is a space, or gap, called the synapse.

How does an impulse (an electrochemical signal) travel from one neuron to the next?



The shape of the neurotransmitter must fit the shape of the cell receptor.

This is an example of specificity .The impulse crosses the synapse with the help of a protein called a neurotransmitter. Special structures called *vesicles* store these neurotransmitters in the terminal **branch** of a neuron. When the impulse reaches the terminal branches, these vesicles bind with the cell membrane and release the neurotransmitters into the synapse. They cross the gap and bind with receptors in the cell membrane of the *dendrites* of the neighboring nerve cell. The binding of the neurotransmitters creates the electrochemical signal impulse) in this neuron so that the message is transmitted to the next neuron in the pathway.

<u>System Malfunctions</u>

1. Alzheimer's disease: damages the brain and causes a steady loss of memory and of how well you can speak, think, and do your daily activities.2.

2. **Multiple sclerosis**, often called MS, is a disease that gradually destroys the protective covering of nerve cells in the brain and spinal cord. This can cause problems with muscle control and strength, vision, balance, feeling, and thinking.

3. Meningitis: is swelling of the lining around the brain and spinal cord. It can cause you to have a stiff neck, a fever, a headache, vomiting, trouble staying awake, and seizures. It is usually caused by a virus or bacteria.

<u>Check your Understanding:</u>

Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Owww! The science of pain

Scientists are homing in on how and why people experience this vital sensation

by Kirsten Weir
8:50am, June 25, 2014

Pain is unpleasant — but can save our lives. It informs us of where injuries are and, potentially, how serious they are. And pain reminds us to protect injured areas until they have time to heal.

Imagine a life without pain. No throbbing headaches. No stinging sunburns. No aching joints. If you think that sounds great, think again.

Some people can't feel pain. They're born that way. They also tend to die young — unlike, say, people who cannot see or hear, notes Luda Diatchenko. "Pain is much more important for survival," explains the pain researcher at McGill University in Montreal, Canada.

Pain protects us. When you touch a hot stove, you recoil in pain. That sensation helps you avoid getting a burn that could be dangerous — even deadly. The throbbing of a broken foot tells you to stay off it until it heals, so you don't do more damage. Without those signals, we'd all be in trouble. Big trouble.

Pain from an injury — such as a broken hand — serves an important purpose. That pain warns us to protect the injured tissue from further damage.

Some pain is straightforward. Burn your skin, pull a muscle or break a bone, and you feel discomfort. This short-term effect is called acute pain. Other pain can last months or years. Called chronic pain, its cause often remains a mystery. In fact, "sometimes the nervous system can get it wrong," says Steve Prescott. "You have pain that shouldn't be there," explains this pain researcher at the University of Toronto, Canada, and the local Hospital for Sick Children.

Scientists are still working out the different causes of pain, and the best treatment for each type. The biology of pain is complex. But the good news: Researchers are learning more about it every day.

Message sent

Pain is a kind of perception, similar to smelling, tasting and hearing. However, those senses tell you what's happening in the world around you. Pain tells you what's happening within the world of your own body.

When you suffer an injury, your nervous system is in charge of delivering the news. Imagine that you twist your ankle. Nerve cells in your ankle pick up the signal that something's wrong. A network of nerve cells relays this message to the spinal cord. From there, it shoots up to the brain. The brain then translates the message and registers the feeling: Ow! That's the simple explanation, at least. There are still a lot of questions about how those messages travel and how the brain turns them into a "feeling." Piece by piece, scientists are starting to understand how this complicated system works.

In recent years, researchers have found receptors for different kinds of pain. A receptor is a special protein on a cell. Its job is to pick up signals arriving at the outside of the cell. A receptor called TrpV1, for example, is found on nerve cells. TrpV1 detects signals about painful heat. It does that in a couple of ways. For starters, the receptor seems to react to heat itself. That's not totally surprising as heat also changes the shape of certain compounds in the body. (A compound is a substance formed from two or more chemical elements bound together in a fixed proportion.)

TrpV1 can detect those altered compounds. When you accidentally touch a hot stove, TrpV1 snaps into action. It takes the too-hot-to-handle message and sends it to the brain. Interestingly, that same receptor also detects the chemical compounds that make spicy chili peppers taste so uncomfortably hot.

TrpV1 is a receptor on cells that detects signals indicating painful heat. The same receptor also detects capsaicin, the spicy compound that gives chili peppers their heat.

Message received

The search for receptors has become a hot area for scientists too, says Prescott. However, he notes, research hasn't answered the important question of how those messages are converted to what you actually *feel* when you experience pain. Answering that question could help a lot of people. In the United States alone, more than 100 million Americans suffer from chronic pain, according to the Institute of Medicine. This U.S. health organization is part of the National Academy of Sciences.

In some cases, doctors know the cause of chronic pain. Inflammation is a common one. Inflammation is one way that the body responds to cellular injury. Beyond pain, it often triggers swelling, redness and heat. Arthritis, for example, is a disease that causes painful inflammation in the joints. The nerves themselves represent a second source of pain. Diabetes is a disease that can damage the nerves in the hands and feet. That damage leads to pain, tingling and numbness. Drugs used to treat cancer also can cause painful nerve damage.

Many other chronic pain disorders, however, have no easy explanation. Take migraines. These intense headaches aren't caused by inflammation or injury. They aren't linked to nerve damage, either. For a long time, experts thought of migraines and other episodes of chronic pain as symptoms of another problem, says Theodore Price. He is a pain researcher at the University of Texas at Dallas. More recently, pain researchers have changed their way of thinking. Now, Price says, many scientists believe that chronic pain occurs when the nervous system itself gets broken.

Pain memories

Brain cells are surprisingly flexible. When you make new memories or learn something new, your brain cells actually alter shape. “When you learn a math equation, the structure of your brain is literally changing,” Price says. It turns out that the same systems involved in learning and memory also are involved in sensing pain. In other words, pain changes nerve cells. Those changes happen both in the brain and in the spinal cord. And they may last even after the initial trigger for pain vanishes. Price calls this a kind of “pain memory.”

He and other scientists are trying to figure out whether they can reverse those changes. If they could wipe out the “pain memory” stamped onto the cells, maybe they could cure chronic pain. To do so, they’ve tested some drugs that interfere with molecules that transmit messages in the brain. (Molecules are the smallest units of chemical compounds that take part in chemical reactions.) The drugs are newly designed compounds that have not been tested yet in people. They did, though, seem to erase pain memory in mice and rats in Price’s experiments. But there remains a worry. Messing with brain cells could have unplanned side effects. “You don’t want to wipe out people’s memories or change who they are,” Price explains. Before he and his colleagues can test their new approach in people, a lot more work will be needed to make sure it’s safe.

In Toronto, Prescott is working to understand what might go wrong with the nervous system to unleash chronic pain. Part of his research involves figuring out how pain messages travel through the body.

Some scientists have suggested there are special networks for pain. Such a “circuit” of nerve cells would have only one job: transmit *ouch* signals. Other experts think pain just borrows the same circuits that relay messages about non-painful sensations. If that second theory is correct, the same network of cells that tells you a cat’s fur feels soft also might tell you that a scratch from its claws really hurts.

Prescott thinks the second theory is the right one. One clue that it’s right comes from an old illusion, called the thermal grill. Just as optical illusions fool the eye, sensory illusions can trick the body into feeling imaginary pain. The thermal grill is made up of metal bars set to different temperatures. The bars alternate: cool, warm, cool, warm. If you touch a single bar, it will feel either cool or warm. But place your hand over the whole grill at once, and it will feel painfully hot. In this way, Prescott says, “You can trick the nervous system into feeling pain.”

That’s a hint that the same network that picks up normal sensations, including warm and cool, also senses pain. Prescott thinks chronic pain might happen when the nervous system gets confused — just as it does in the thermal grill trick. “There may be parallels between the thermal grill and the way in which the nervous system gets broken to cause pain,” he explains. Then again, a confused nervous system may be only one explanation. “Pain is an extremely complex phenomenon,” says Diatchenko. “It can be broken in many different ways.”

Extra sensitive

Pain is complicated for lots of reasons. For one thing, there are many different types of pain — a muscle ache is very different from a pinch or a burn. Plus, some people are more sensitive to pain than others. Diatchenko at McGill University is trying to understand those differences. She is looking for genes that control pain sensitivity. A gene is a segment of DNA that codes, or holds instructions, for producing a protein. Offspring inherit genes from their parents. Genes influence how an organism looks and behaves.

Diatchenko has brought people into her laboratory and asked them to touch a warm surface. Then she turns up the heat, asking them to say when the heat becomes painful. The range is huge, she says. “Some people are really sensitive and some people are really not.” The sensitive people aren’t just wimpy or nervous. Areas of the brain involved in pain actually become active earlier in these people. That’s what brain scans using functional magnetic resonance imaging, or fMRI, show. (fMRI uses strong magnetic fields to create pictures of brain regions while they are active.) Some people, in other words, actually feel the pain sooner. They literally can’t take the heat.

Many different genes are involved in sensing pain. Scientists have identified some that seem to be especially important. One is a gene called COMT. Different forms of this gene occur naturally, Diatchenko observes. Some people have a form that is very active. They have a higher threshold for pain. In other people, the gene is less active. These people feel pain more readily. Interestingly, the gene isn’t just involved in pain. Differences in COMT also have been linked to differences in emotions, planning, memory and even personality.

There are good reasons why understanding a person’s sensitivity to pain is important, Diatchenko says. People who are more sensitive to acute pain are more likely to develop a chronic pain condition. Learning more about what makes their system for processing pain so touchy might help researchers find new ways to treat long-term pain. That is the ultimate goal for nearly every scientist who studies pain biology. As these experts fill in the blanks, they are hopeful that their research will help the millions of people who suffer from unexplained pain.

It might seem like there’s still a lot to learn. In part that is because the work has just begun. Only since the early 2000s have scientists started to understand pain at the level of cells and molecules, Price says. “We’re still in early days” of pain research, he notes. “The next 15 years? Who knows what it will bring.”

Describe the importance of the scientist’s findings. Support your answer with evidence from the article.

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Lesson 9: The Endocrine System **Date:_____**

Objective: To describe the function of the human endocrine system and to relate tissues and organs systems to function.

Function: to control and coordinate life processes using chemical messengers called hormones

Life Process: regulation

Corresponding Cell Organelle(s): nucleus

Differences between the Human Regulatory Systems:

	Nervous System	**Endocrine System**
Response Time	*Immediate response*	*Seconds to hours (depending on the hormone)*
Duration of Response	*Very short duration*	*Longer duration (sometimes permanent)*
Chemicals used	*Neurotransmitters*	*Hormones*
Signal Transmission Method	*Neurons*	*blood*

Parts of the Endocrine System

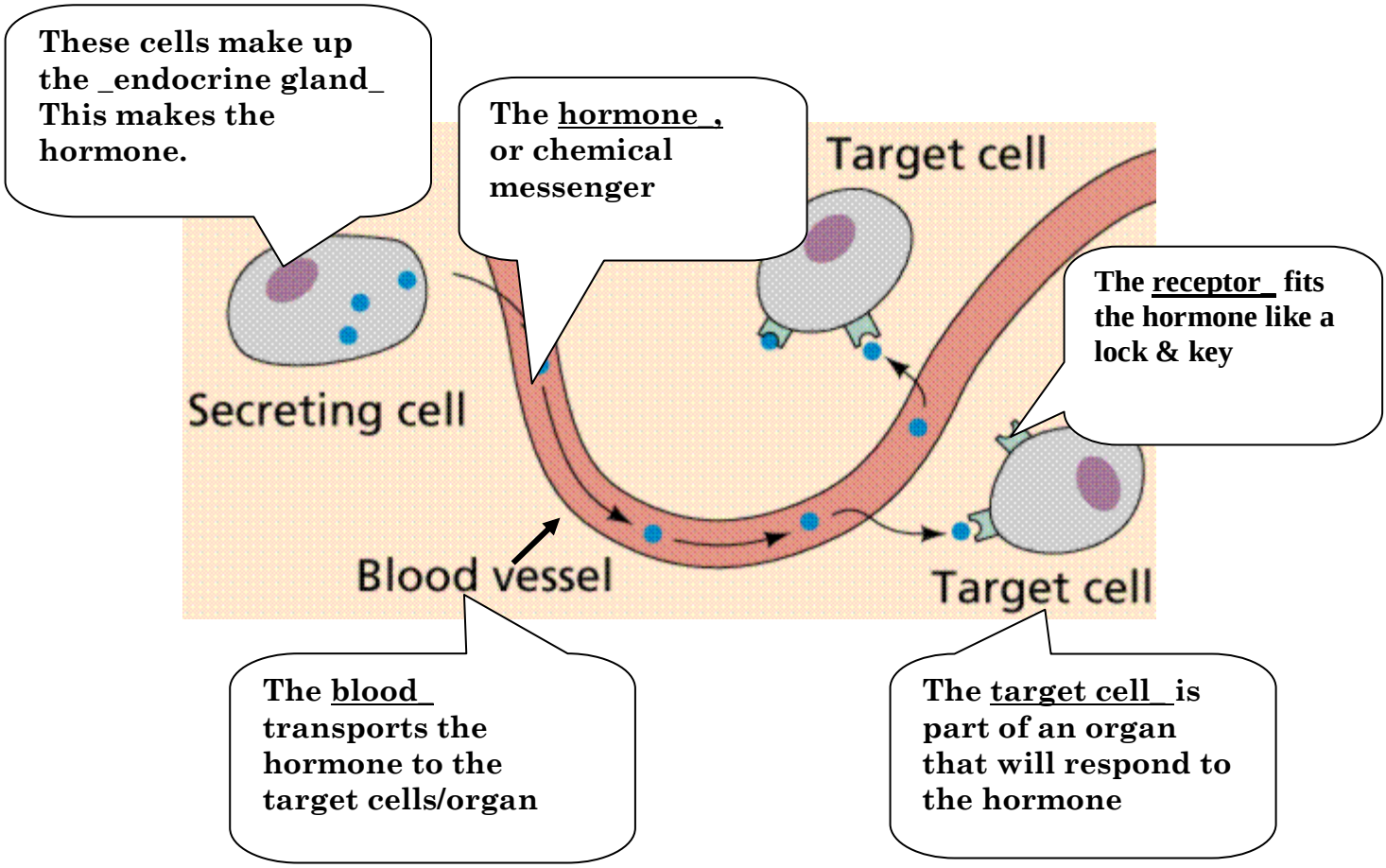
a. composed of a number of organs called **glands**

b. glands produce chemical messengers called **hormones**

c. most hormones are secreted into the **blood** (dissolved in the plasma)

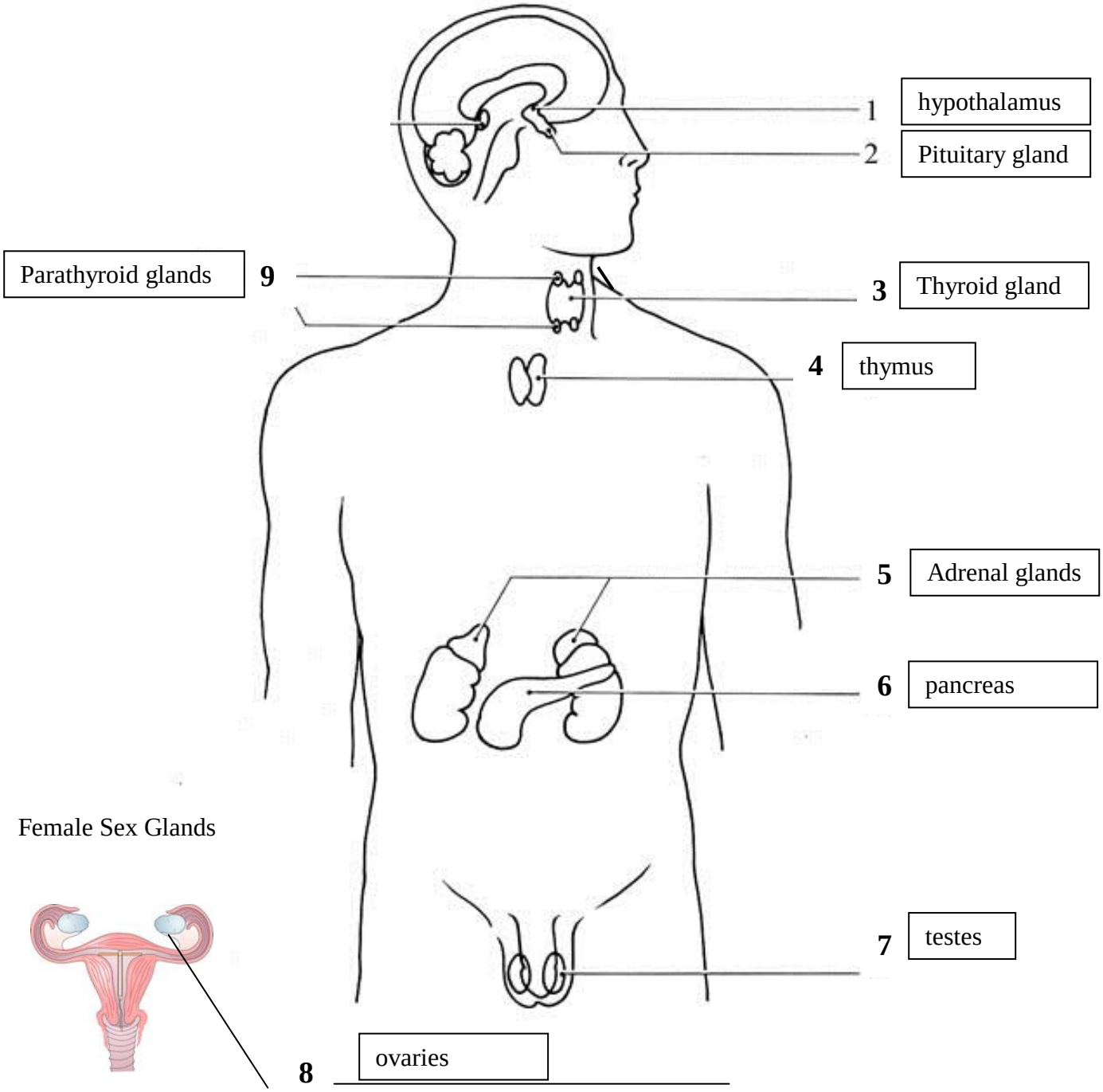
d. The responding cell/tissue/organ is called the **target** cell/tissue/organ.

How Hormones Work



Each type of hormone is recognized by ***specific*** target cells or organs.
In order to be affected by a particular hormone, the target cells must contain ***receptors*** that will "fit" the hormone – much like a lock & key.

Endocrine System Glands



Glands, Hormones & Their Functions

Gland	**Hormone(s)**	**Effect/Function(s)**
Hypothalamus	Oxytocin ADH	Uterine contraction; lactation Promotes water reabsorption in kidneys
Pituitary Gland (anterior)	TSH FSH Growth Hormone	Stimulates thyroid gland to produce thyroxin Stimulates activities of testes & ovaries Stimulates elongation of bones
Thyroid Gland	thyroxin	Controls body's metabolism
Adrenal Glands	Adrenaline	Increases heart rate and respiratory rate
Pancreas (Islets of Langerhans)	Insulin Glucagon	Lowers blood glucose Raises blood glucose
Ovaries	estrogen progesterone	Female secondary sex characteristics (puberty) Maintains uterus during pregnancy
Testes	testosterone	Male secondary sex characteristics (puberty)

<u>System malfunctions:</u>

1.**Hypothyroidism**- when your thyroid doesn't produce enough hormones
2.**Hyperthyroidism**- when your thyroid gland produces too much thyroid hormone. It's most commonly caused by Graves' disease.
3.**Diabetes Mellitus**-the pancreas either doesn't produce enough insulin or any functional insulin for the absorption of glucose into cells.

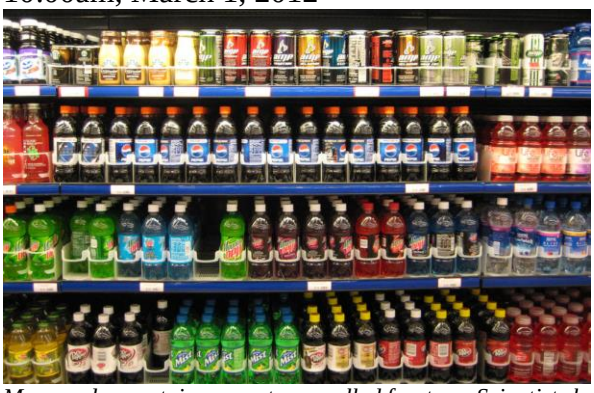
<u>Check your Understanding:</u>
Fill in the graphic organizer for this system in the back of your note packet.

<u>Practice:</u> Read the following current event and then complete the summary

Losing control over sugar

A common pollutant and sweetener mess with important hormones

by Stephen Ornes
10:00am, March 1, 2012



Many sodas contain a sweetener called fructose. Scientists have shown how fructose can cause the body to produce excess amounts of insulin, a hormone used to control sugar in the blood.
Marlith/Wikimedia Commons

Inside your body, sugar goes hand-in-hand with a substance called insulin. A type of hormone, insulin regulates the activity of cells and tissues. It calls the shots after you devour that delicious donut, helping organs pluck a type of sugar called glucose from the bloodstream. When insulin is missing or doesn't do its job, sugar accumulates in the blood instead of getting into and feeding cells. This throws the body's balance out of whack, causing a disease called diabetes.

An organ called the pancreas, near the beginning of the large intestine, produces insulin. The more glucose that tickles the pancreas, the more insulin it produces to process the sugar. But new studies show that other things can also cause the pancreas to release insulin. In one study, a sugar called fructose boosted insulin levels; in another, a common pollutant called bisphenol A (BPA) caused the same reaction.

Fructose gives fruit, honey and high-fructose corn syrup their sweetness. Nutritionists — backed by scientific studies — say we eat too much high-fructose corn syrup, found in foods from soft drinks to salad dressing. Scientists working on one of the new studies used human cells, mouse cells and live mice to study what happens when fructose meets the pancreas.

The team found that cells in the pancreas can "taste" the fructose, in a process similar to how the tongue tastes sugar. The study, like many other recent discoveries, shows that taste buds can occur — and taste chemicals — far from the tongue. Fructose alone didn't boost insulin levels. But in the study, when glucose and fructose appeared together, the pancreas produced more insulin than it did when it encountered glucose alone.

"The system seems to be elegantly made to keep a balance," Björn Tyrberg told *Science News*. Tyrberg, who led the new work, studies the biology of cells at Sanford-Burnham Medical Research Institute in Orlando, Fla.

The body may have a hard time keeping that balance in the presence of BPA, too. This chemical, commonly found in plastics and cash register receipts, can imitate a hormone called estrogen. One of estrogen's jobs is to keep track of insulin, telling the pancreas to produce more if it is needed.

In the second new study, scientists found that BPA, like estrogen, can trigger insulin production. But because BPA is a pollutant, it stimulates the pancreas to create insulin when it's not needed. The researchers also demonstrated that it doesn't take much BPA to get the pancreas to pump out extra insulin. BPA and fructose may be radically different compounds, but both can throw off the body's balance in similar ways.

Angel Nadal of Miguel Hernández University in Elche, Spain, led the BPA study. He told *Science News* that extra insulin in the blood may cause other tissues to start ignoring this important hormone. Called "insulin resistance," this condition can lead to the buildup of glucose in the blood indicative of type 2 diabetes. In experiments by Nadal and his colleagues, animals exposed to BPA ended up with insulin resistance more often than other animals did. Nadal thinks that BPA in the body may speed up the onset of type 2 diabetes in people with a family history of the disease.

Franck Mauvais-Jarvis of Northwestern University's Feinberg School of Medicine in Chicago told *Science News* that he doesn't think BPA alone can cause diabetes. Lots of different chemicals can throw off the body's balance. He says, "I suspect it's a cocktail of these nasties" that can make a person more likely to develop the disease.

Describe the importance of the scientist's findings. Support your answer with evidence from the article.

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<u>Lesson 10</u>: Maintaining Homeostasis: Feedback Mechanisms **Date:_____**

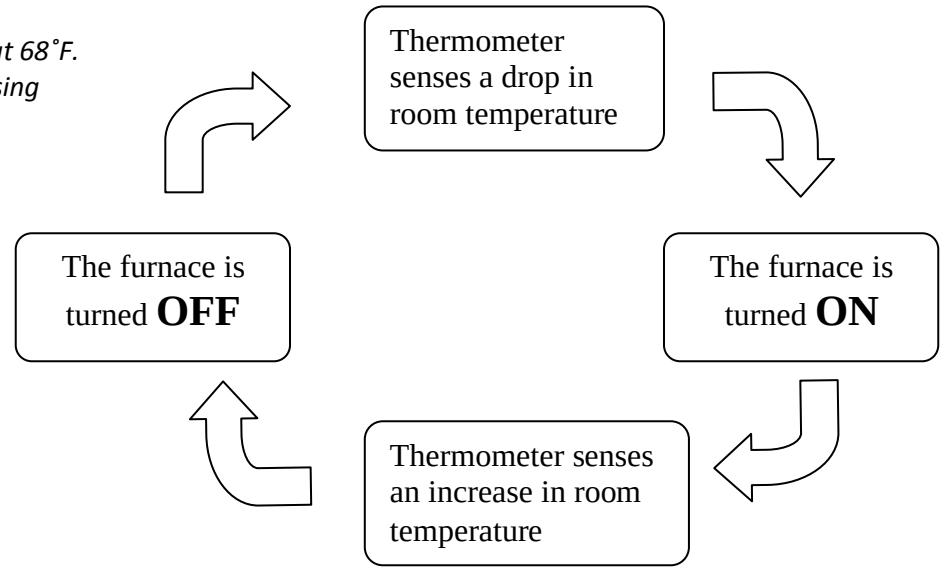
<u>Objective:</u> To describe mechanisms in which an organism can maintain homeostasis

What is DYNAMIC EQUILIBRIUM?
The body maintains dynamic equilibrium using **<u>feedback mechanisms</u>.**

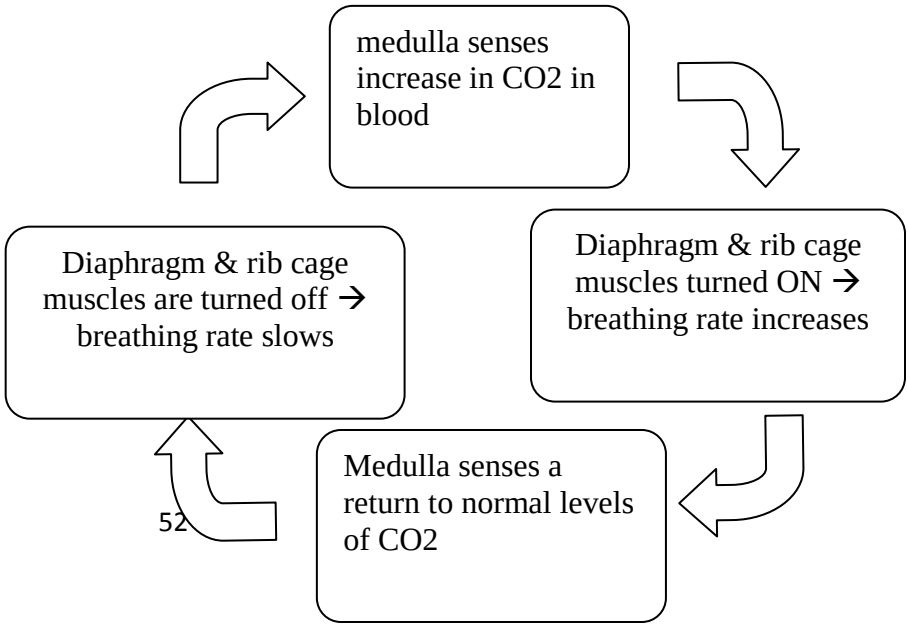
Definition: A signal that tends to turn on (stimulate) or turn off (inhibit) a process in the body to maintain homeostasis

There are two kinds of feedback: positive and negative. Negative feedback is more common in living things, as it helps the organism maintain homeostasis.

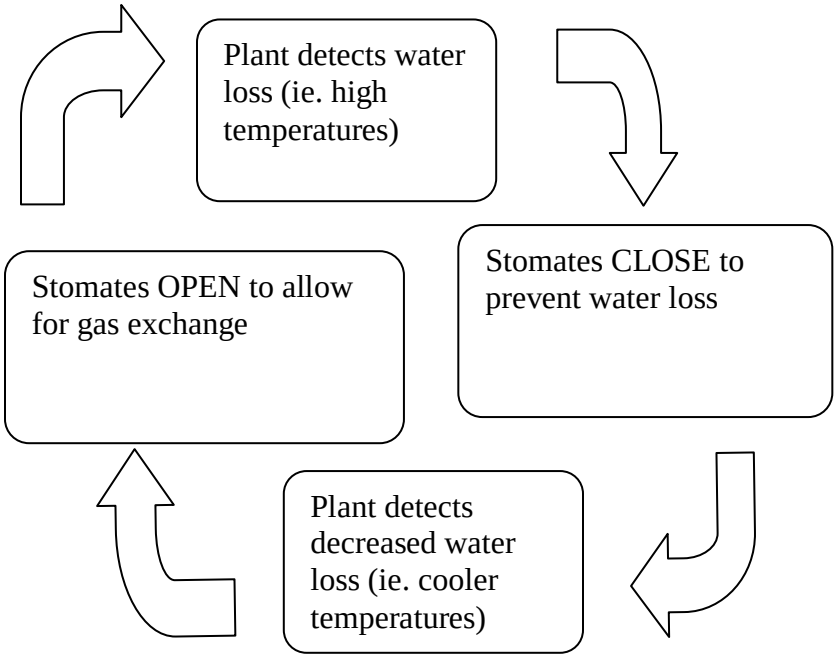
Negative Feedback Example #1 :
The thermostat in your house is "set" at 68˚F. How this temperature is maintained using negative feedback?



Negative Feedback Example #2 :
How is your breathing rate regulated by negative feedback during periods of high muscle activity?
(ie. when you exercise)



Negative Feedback Example #3 :
How is water loss and gas exchange regulated in plants?



What gas ENTERS the leaf during the day?

Carbon dioxide

What gas LEAVES the leaf during the day?

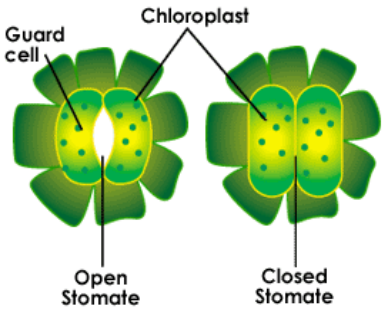
Oxygen

What biological processes are involved in the production and/or use of these gases?

Photosynthesis and respiration

What will the guard cells/stomates do on a hot and windy day? Why?

Close so that they don't lose too much water and dehydrate



Negative Feedback Example #4:

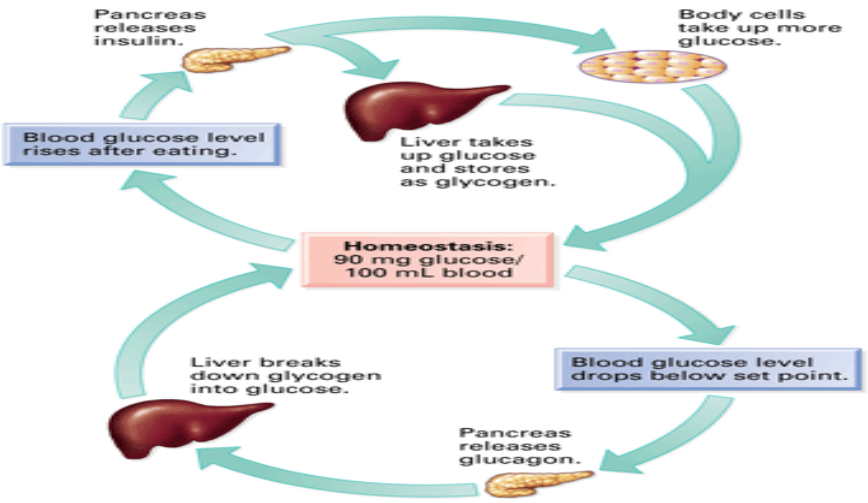
Regulation of blood glucose levels

You just finished eating lunch. **Glucose** is absorbed into the blood.

The **pancreas** releases **insulin** which travels to the liver in the blood. The liver **stores** the glucose as glycogen.

The glucose level in the blood returns to normal.

The **pancreas** stops producing **insulin**. No message needs to be sent to the liver.



<u>Check your understanding:</u>

In your own words, describe the feedback mechanism that is used when glucose levels in the blood drop too low. Be sure to include the gland, hormone and target organ involved.

Practice: Read the following current event and then complete the summary

How body temperature is affected by thyroid hormone
Written by Honor Whiteman

Researchers say they have discovered how thyroid hormone affects blood vessels to determine body temperature, potentially explaining why people who have disorders of the thyroid gland have higher sensitivity to environmental temperature.

An overactive thyroid (hyperthyroidism) can cause a person to feel too hot, while an underactive thyroid (hypothyroidism) can cause a person to feel too cold. The researchers from the Karolinska Institute in Sweden said that previous studies have attributed this to how thyroid hormone affects the metabolism within cells. The thyroid produces hormones that are able to influence how much the blood vessels dilate. In turn, this affects how much heat can escape the body.

For the study, published in the *Proceedings of the National Academy of Sciences*, the researchers studied mice with a mutated thyroid hormone receptor (receptor-mediated hypothyroidism). This particular mutation only affects one type of hormone receptor called TRalpha 1. According to the researchers, TRalpha 1 is only expressed in certain tissues, and the mutation makes the tissue unresponsive to thyroid hormone, particularly in the central nervous system, bone and all muscle types. Dr. Amy Warner, researcher at the Department of Cell and Molecular Biology at the Karolinska Institutet, told *Medical News Today*:

"This makes it easier to study certain aspects of thyroid dysfunction, while others remain normal. It's well known that thyroid hormone drives up basal metabolic rate, by affecting how quickly cells metabolize, and hypothyroidism should therefore show the opposite."

Mutated hormone receptor causes irregular temperature

Previous studies have shown that mice with this defect had an overactive metabolism, caused by the energy needed to generate heat from brown fat. "When our supposedly hypothyroid mice showed an increase in metabolism and were burning energy through activating their brown fat, we were confused by this paradox and wanted to find out why this occurred," Dr. Warner added.

The researchers took infrared images of the mice, which revealed that they were losing a significant amount of heat through their tails. This showed that the mutated thyroid hormone receptor meant the mice were unable to sufficiently regulate the constriction of their blood vessels.

Dr. Warner explained the findings to *Medical News Today*:"Mice with a non-functioning TRalpha 1 receptor cannot properly regulate their body temperature, and this is due to impaired control of their blood vessels, in areas where they are used for temperature regulation, such as the tail."

She continued: "Shown through infrared imaging, at room temperature, the tail blood vessels do not constrict properly, and too much heat is lost. The mice cannot defend their body temperature correctly, and therefore need to generate heat from their brown fat to keep warm. Activation of brown fat requires an increase in energy demands to maintain, hence why these mice have a higher metabolism, despite being hypothyroid."

When the researchers gave the mice a drug (midodrine) to artificially cause vascular constriction, they found that this reversed the heat loss from the tail, meaning the mice could maintain normal body temperature, and activation of the brown fat was "turned off." "Oxygen consumption and food intake were also normalized, meaning that the increased metabolism in these mice was due to the energy demands of the brown fat, not a consequence of the mutation itself," Dr. Warner added. "By looking at the function of isolated smooth muscle from tail artery, we know that (sympathetic) signal from the brain to the tail is intact in these mice, and the defect is within the smooth muscle itself."

Potential for improved thyroid disorder treatment

Dr. Warner said that until now, temperature sensitivity as a result of thyroid disorders has been attributed solely to the basal metabolic rate effects of too much or too little thyroid hormone. "However, this study shows that thyroid hormone's role in the vascular control of body temperature may be of particular importance," she added. **Dr. Warner noted that the findings of this study may open up the possibility to treat thyroid patients who find their temperature sensitivity to be significantly detrimental to their quality of life.** "Similarly, having a better understanding of all the conceivable consequences of thyroid hormone disorders is important for comprehensive patient care." Dr. Warner said that the team would like to carry out further research in order to determine exactly why the smooth muscle does not respond correctly in the mice to regulate their body temperature. She added: "We'd also like to see the use of infrared thermography extended to humans, to see if any heat dissipation differences can be seen between euthyroid and different thyroid conditions."

Describe the importance of the scientist's findings. Support your answer with evidence from the article.

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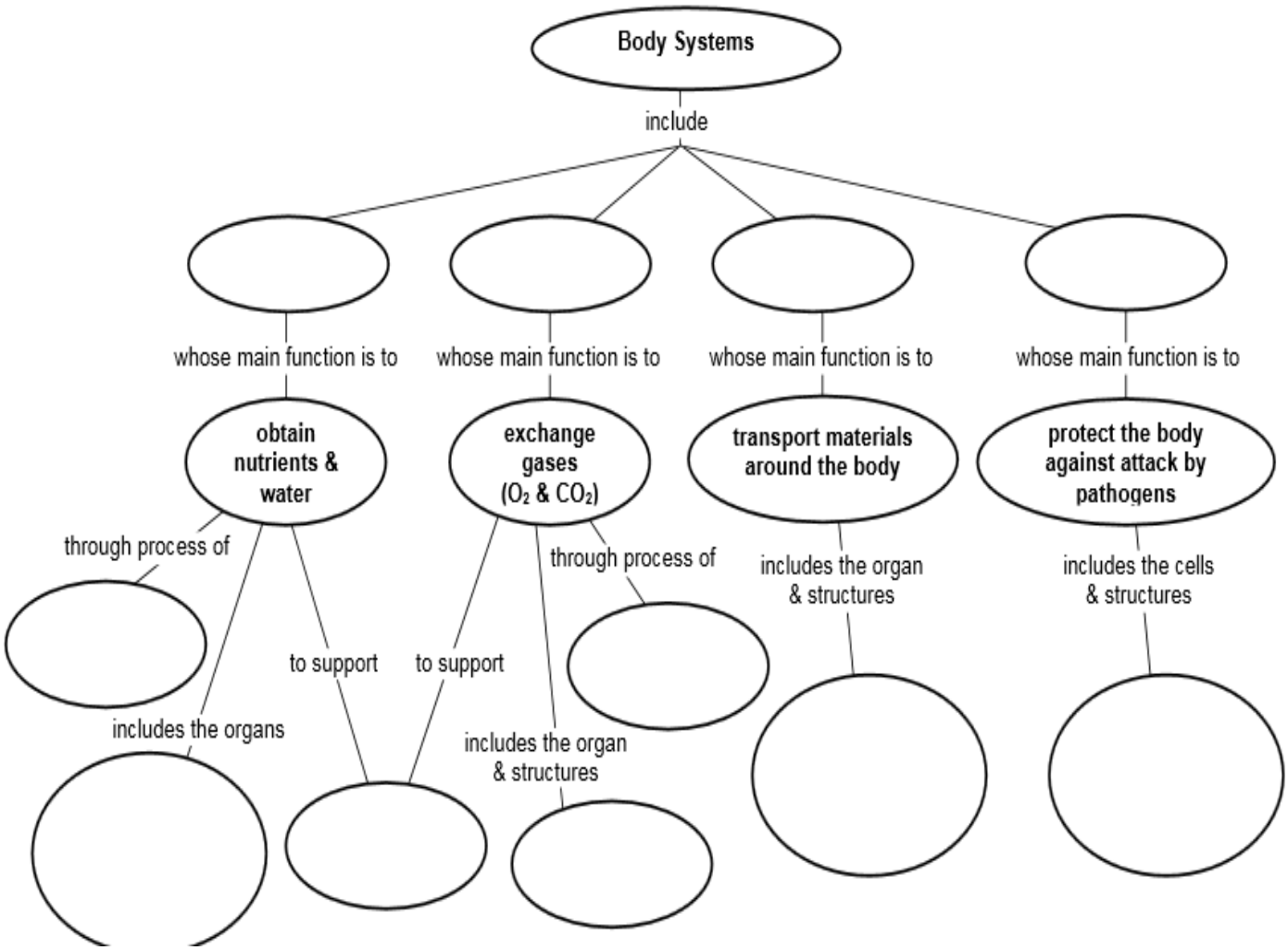
Summary chart: **SYSTEM**	**FUNCTION/HOMEOSTASIS**	**MAJOR ORGANS**	**DISEASES/DISORDERS**
Digestive			
Respiratory			
Excretory			
Circulatory			
Muscular/ Skeletal			
Nervous	.		

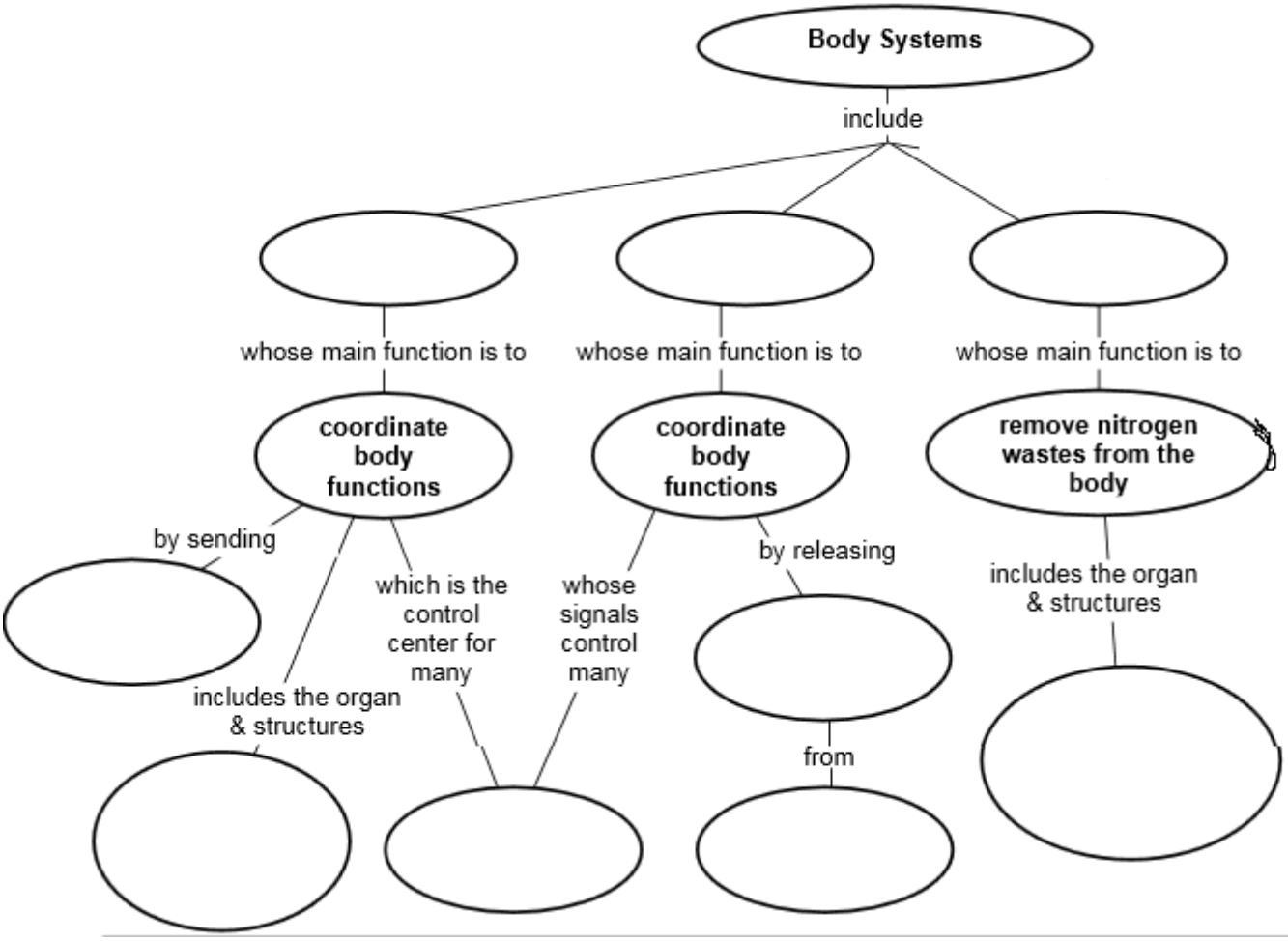
Endocrine			
Immune			

Concept map review:

Complete the concept map to help you review the concepts we learned in the digestive, respiratory, circulatory, and immune systems.



Complete the concept map to help you review the concepts we learned in the nervous, excretory, endocrine,
systems.



Key Concepts Synthesis

Directions: Use the following graphic organizer to identify the five most important concepts (in the form of single words or phrases) from your notes. Think about identifying the five most important concepts this way: If you had to explain your notes to someone who had not read them, what are the five most important concepts you would want them to understand? Complete the graphic organizer below.

Five Key Concepts (with page numbers)	Write the concept in your own words.	Explain why the concept is important and make connections to other concepts.
1.		
2.		
3.		
4.		
5.		