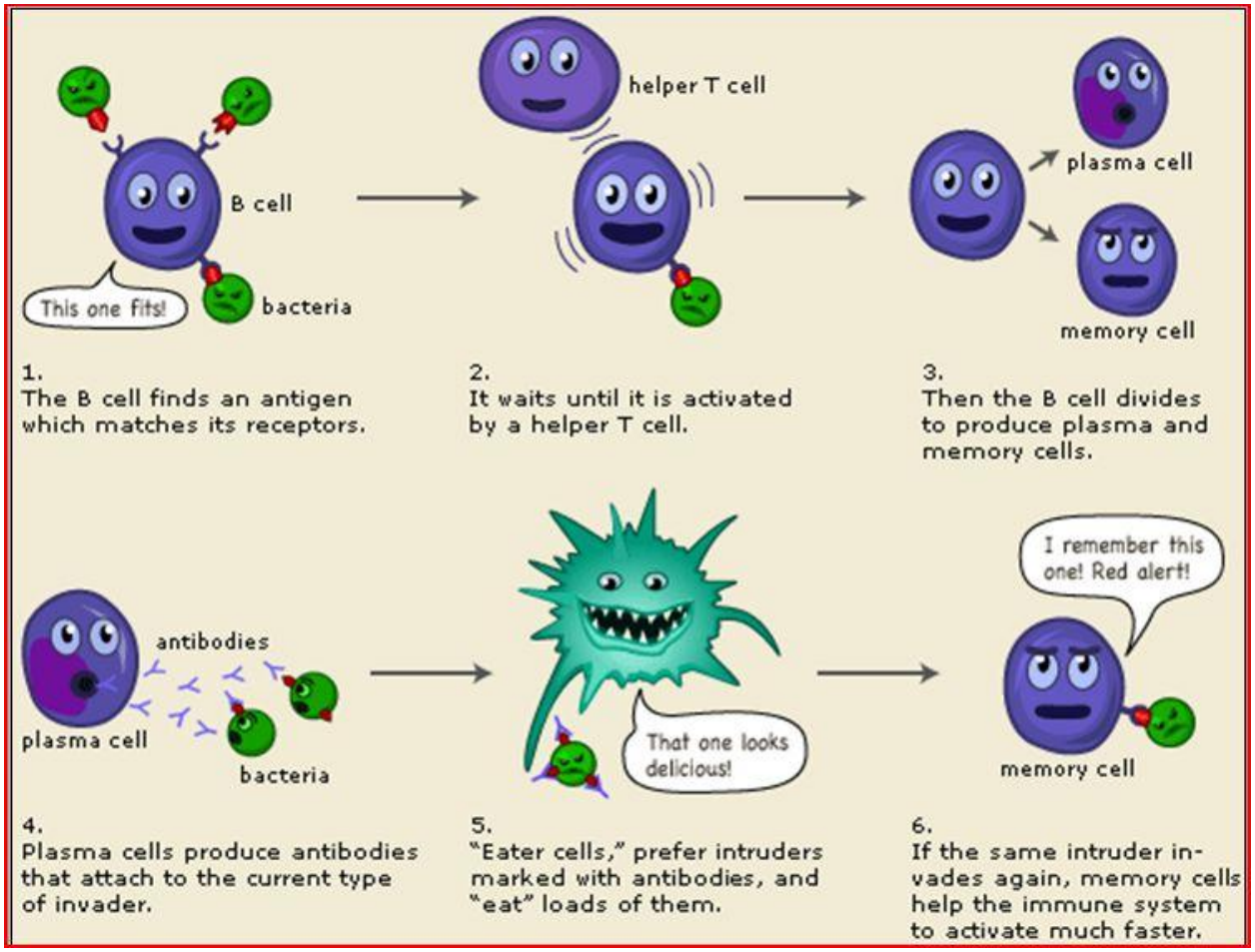
Protection and Control

Miss Yorke

Bio 30S



Learning checklist – Protection and Control

Learning increases when you have a goal to work towards. Use this checklist as guide to track how well you are grasping the material. In the center column, rate your understand of the topic from 1-5 with 1 being the lowest and 5 being the highest. Be sure to write down any questions you have about the topic in the last column so that you know what you have yet to learn.

Outcomes	Understanding	Questions?
Immune System Describe the body's defence mechanisms for protection from foreign agents Include: nonspecific and specific defences		
Describe the body's response to allergens, vaccines, viruses/bacteria		
Explain the role of the lymphatic system in protecting the human body Include: lymph nodes, lymph vessels, lymph ...		
Investigate issues related to the immune system and the protection of public health Examples: immunization, travel bans and advisories, epidemics		
Nervous System Describe the major organization of the nervous system. Include: central nervous system and peripheral nervous system (autonomic and somatic)		
Identify the functional regions of the brain on a diagram. Examples: general anatomy such as cerebrum, specific regions responsible for speech and other functions, left-brain/right-brain concept...		
Identify possible implications of concussions on brain function. Examples: multiple concussions		

in sport, second impact syndrome...		
Explain how a nerve impulse travels a particular pathway using chemical and electrical signals. Include: synapse		
Compare the general roles of nervous and hormonal controls recognizing that nervous and endocrine systems interact to maintain homeostasis. Include: communication, speed, duration, target pathway, action		
Wellness Describe how personal lifestyle can influence well-functioning protection and/or control systems Examples: impact of drugs, anabolic steroids, lack of sleep, inadequate diet...		
Investigate and describe conditions/disorders that affect protection and/or control in the human body		

* Remember each unit's connection to wellness and homeostasis.

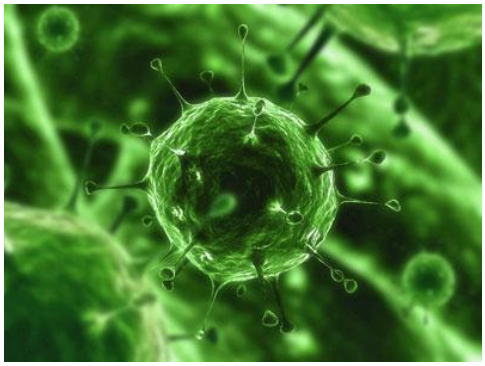
Movie – The Virus Hunters (CBC)

During the movie *The Virus Hunters,* pay attention to three viruses that are discussed and fill in the following chart:

Virus	**What does the virus do?**	**What is one interesting fact?**

Did you know the National Microbiology Center in Winnipeg had such an influence on the world?

Protection and Control Investigation Project



In groups of three, you will choose an issue or topic to investigate. This will be presented to the class in a creative and informative way. You may choose to present the information the following ways or find a new way to present. If another topic interests you more, have it approved by Miss Yorke. Be sure you have your method of presentation approved by Miss Yorke.

Your task:

- Deliver information you have collected in a relevant way.
- Be sure to include the Biology behind the issue
- The presentation must have a written component. (ie: poster, written script if you are doing a video)
- You must prepare a hand-out that will be photocopied to guide the class in your presentation. This MUST be completed 2 days before your presentation so that I can photocopy it in time.
- Use at least 3 CREDIBLE sources. Your other projects in Biology have been leading up to this major project. Be sure you have learned from all of my previous comments

Ideas for delivery (each project must have a written component, a presentation component, and a student handout)

i) Written component – PROPERLY CITED
   - Research paper
   - Poster – with properly cited information and diagrams
   - Script
   - Story book

ii) Presentation:
   - Lesson using PowerPoint or a poster
   - Skit
   - Video
   - Any combination of the above. Be sure you are choosing the method that BEST conveys your information.

iii) Student Handout

Topics:

- The Black Death
- Swine Flu
- Vaccines
- Antibiotics
- Fevers
- Allergies
- Immune Response
- Specific Defenses
- Disease spread/Epidemics
- West Nile Virus

Proposal date: _____

Presentation date: _____

Project Checklist

I) Written Component

i) Introduction – In a paragraph, introduce the topic or the issue you will be discussing. Be sure to introduce will be discussed on the body

ii) Body – Prepare and expand on three subjects relating to your topic. Be sure to discuss the Biology behind your topic. Include facts that you think are interesting

iii) Conclusion – Conclude your findings in a paragraph

iv) Citations – Properly cite your works in the body of your text as well as using the references at the end (use at least THREE CREDIBLE sources)

II) Presentation – Your group will be responsible for giving a 5 minute presentation. This presentation will be timed. If you need more time, please come see me BEFORE the day of your presentation. It is important that each group member presents the topics equally. The purpose of the presentation is to summarize your written component.

III) Student Handout – You will provide a one page handout that will help the class understand your information.

	Student	**Teacher**	**Mark**
Written - Introduction			/20
Written - Body			
Written – Conclusion			
Written - Citations			/3
Presentation			/15
Student Handout			/5

Checklist – check that each component is included

Total: /43

Protection and Control:

Create a concept map that outlines all the systems you think are involved in protecting the body.

Outbreak Videos:
No Running Water:
www.winnipegfreepress.com/no-running-water
Swine Flu video:
http://www.brainpop.com/health/diseasesinjuriesandconditions/swineflu/

Have you ever noticed during the "cold and flu season" that some people seem to be sick all the time while others seem to never get sick? Why is it that even though we are exposed to the same "germs" not all of us will get sick?

Our immune system is our body's natural defense against disease. It includes our lymphatic system and all the various types of white blood cells that recognize, engulf and destroy pathogenic (disease-causing) viruses, fungi, bacteria, and parasites--ideally before they have had a chance to make us sick.

In the same way, certain white blood cells of the immune system also protect us from cancer. When a cancer cell is produced in the body, these white blood cells will find it and destroy it, usually before it gets out of control and invades other parts of the body. So a strong immune system is also our best defense against cancer.

In this lesson, you will learn about the body's protective mechanisms. You will study how the immune system functions to protect us from disease and some of the problems associated with our own protective mechanisms.

Importance of the Immune System

Immunity is the body's capability to repel foreign substances and cells. To understand the power of the immune system, all that you have to do is look at what happens to anything once it dies. When something dies, its immune system (along with everything else) shuts down. In a matter of hours, the body is invaded by all sorts of bacteria, microbes, and parasites. None of these things are able to get in when your immune system is working, but the moment your immune system stops the door is wide open. Once you die, it only takes a few weeks for these organisms to completely dismantle your body and carry it away, until all that's left is a skeleton. Obviously your immune system is doing something amazing to keep all of that dismantling from happening when you are alive!

One of the best known examples of the importance of the immune system is the “Bubble Boy” or David Vetter. David was born on September 21, 1971. Even before he arrived, his parents and physicians were making extraordinary arrangements for his life. David had an older brother who died of Severe Combined Immune Deficiency (SCID) before David was born. SCID is a complete absence of an immune system. After the birth and death of one son with SCID, the Vetters opted to try a new approach to ensure David's well-being until an effective scientific option to reconstitute his immune system became available. They agreed to place David into a specially designed plastic-enclosed environment immediately after birth. The bubble was complete with filtered air and strict antiseptic precautions to ensure no germs could enter and infect David. The plastic incubator (later replaced by a plastic-enclosed "room") became popularly known as David's "bubble," and David was thus referred to as "the Bubble Boy." David's bubble was extremely effective, and it kept him healthy for twelve years. At the age of 12, David and his family were told that their wait was over: finally, medical science had developed a method by which they believed they could build David a new immune system. That experimental treatment was a bone marrow transplant from his older sister. Unfortunately, the transplant did not work as expected; unknown to physicians, the marrow David received carried a virus, Epstein-Barr Virus (EBV, better known as the virus which causes "mono," "mononucleosis," or "glandular fever"), and in the absence of cells to defend him against this virus, it grew out of control, causing a virulent form of lymphoma (cancer), impossible to cure. Knowing his time was limited, David was removed from the bubble, and for the last weeks of his life, he experienced the

warmth of human touch, and the loving embrace of the family who adored him and had sacrificed so much to give him the best possible opportunity at a full, healthy life.

David dramatically furthered the scientific understanding of this rare disease. Today, immune compromised patients are given bone marrow free of viruses, to prevent the formation of the lymphoma that David developed. His experience taught physicians that viruses could cause cancer. His blood and genes have been studied extensively, and cell lines established from his immune system have been used for scientific investigation into SCID for decades. In part because of the information garnered from the life of David Vetter, children born today with X-linked SCID who receive a transplant in the first three months of life (and before getting seriously ill) have a greater than 95% chance of developing enough immune function to allow them to live very full and healthy lives.

The Body's Natural Defenses

Your immune system works around the clock in thousands of different ways. However, it does its work largely unnoticed. We only notice it when something fails or reacts to our immune system.

Here are some examples:

- When you get a _____, all sorts of bacteria and viruses enter your body through the break in the skin. When you get a splinter you also have the sliver of wood as a foreign object inside your body. Your immune system responds and _____ while the skin heals itself and seals the puncture. In rare cases the immune system misses something and the cut gets _____. It gets inflamed and will often fill with pus. Inflammation and pus are both side-effects of the immune system doing its job.
- When a mosquito _____ you, you get a red, itchy bump. That too is a visible sign of your immune system at work.
- Each day you _____ thousands of microorganisms (bacteria and viruses) that are floating in the air. Your immune system deals with all of them without a problem. Occasionally a germ gets past the immune system and you catch a cold, get the flu or worse. A cold or flu is a visible sign that your immune system failed to stop the germ. The fact that you get over the cold or flu is a visible sign that your immune system was able to eliminate the invader after learning about it. If your immune system did nothing, you would never get over a cold or anything else.
- Each day you also _____ hundreds of germs, and again most of these die in the saliva or the acid of the stomach. Occasionally, however, one gets through and causes _____. There is normally

a very visible effect of this breach of the immune system: vomiting and diarrhea are two of the most common symptoms.

- There are also all kinds of human ailments that are caused by the immune system working in unexpected or incorrect ways that cause problems. For example, some people have _____. Allergies are really just the immune system _____ to certain stimuli that other people don't react to at all. Some people have diabetes, which is caused by the immune system inappropriately attacking cells in the pancreas and destroying them. Some people have rheumatoid arthritis, which is caused by the immune system acting inappropriately in the joints. In many different diseases, the cause is actually an immune system error!
- Finally, we sometimes see the immune system because it prevents us from doing things that would be otherwise beneficial. For example, _____ are much harder than they should be because the immune system often rejects the transplanted organ.

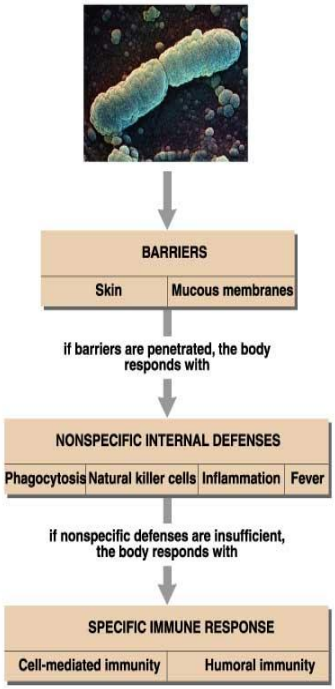
<u>Lines of Defense</u>

The body has lines of defense against microbial attack:

1) Nonspecific defenses:
   i) Physical and chemical barriers to invasion keep microbes out of the body; - 1st line of defense

   ii) nonspecific internal defenses combat invading microbes – 2nd line of defense

2) Specific defenses -- the immune system directs its assault against specific microbes – 3rd line of defense



1) <u>Non-specific Defenses</u>

i) Physical and Chemical Barriers

The **skin** is a passive barrier to infectious agents such as bacteria and viruses. The organisms living on the skin surface are unable to penetrate the layers of dead skin at the surface. Skin glands (oil and sweat) secrete chemicals that produce a pH of 3-5 and retard the growth of bacteria.

Many microorganisms are trapped by the **mucous** that lines the openings to the body such as the nasal passages, lungs, digestive system, urinary system and reproductive system. Without mucous, these openings would be easy portals of entry. Organisms are trapped by this mucous and ejected from the body by mechanisms such as a cough or a sneeze. **Cilia** that line our respiratory tract also act by sweeping away foreign particles that enter.

Tears and saliva secrete enzymes called **lysozymes** that breakdown bacterial cell walls. Organisms that enter through the mouth in our food or drink are usually killed by the **acids** in the stomach.

iii) **Nonspecific internal defenses**

a) Inflammatory Response - When microorganisms penetrate the skin or the epithelium lining the respiratory, digestive, or urinary tracts, it results in inflammation. This reaction is called the **inflammatory response**. Damaged cells release chemical signals such as **histamine** that increase capillary blood flow into the affected area (causing the areas to become heated and reddened). The heat makes the environment unfavorable for microbes and raises the mobility of white blood cells. It also increases the metabolic rate of nearby cells. Capillaries pass fluid into interstitial areas, causing the infected/injured area to swell. Platelets move out of the capillary to seal the wounded area.

b) Phagocytes - Pathogens (disease causing organisms) are attacked by **phagocytes**, a type of white blood cell that acts by ingesting invading microbes. The most common type of phagocyte is the **neutrophil**. Neutrophils circulate freely through blood vessels, and they can squeeze between cells in the walls of a capillary to reach the site of infection. They then engulf and destroy any pathogens they encounter. Another type of phagocyte is the **macrophage**, a type of monocyte. Macrophages consume and destroy any pathogens they encounter and rid the body of worn out cells and cellular debris. Some macrophages are stationed in the tissues of the body, awaiting pathogens, while others move through the tissues and seek out pathogens. Finally, macrophages clean up dead microbes, cells, and debris.

c) Fever - A serious infection may allow pathogen to spread throughout the body. The immune system now responds in two ways. It produces more WBCs and phagocytes release chemicals such as histamine that stimulate the actions of these WBCs by increasing body temperature.

Widespread heating of the tissue causes a **fever**, an increase in body temperature. Body temperatures above 37°C offer powerful protection against the spread of pathogens by slowing or stopping the growth of some microbes.

Physicians know that a fever and an increase in WBCs are two indications that the body is fighting infection. Fever is not a disease but a sign that the body is responding to an infection. In general, body temperature greater than 39°C is considered dangerous.

Function of Fever

When a child or parent becomes feverish with shivers, chills, and sweats, our first thought is to get the temperature down. Pharmacies sell billions of fever-reducing pills like aspirin and acetaminophen every year, and schools often insist that students stay home until their fever is gone.

But is this "fever phobia" backed up by science?

Increasingly, medical researchers are discovering that fever has endured in mammals and other creatures for good reasons, though the reasons why are not clear. Often, a fever in response to an infection is actually a reflection of the body's defenses going into high gear. Some parts of the immune system work better at a higher temperature, which strengthens resistance to infection and increases the odds of survival.

The new thinking is that mild fever can be a positive adaptation and shouldn't necessarily be treated. At other times, though, fever may spur the microbes' growth rate by raising the temperature of the host body. In this case, the attackers have evolved a way to chemically manipulate the host's immune system for their own advantage. And a high fever is a danger sign, especially in young children.

What is this mysterious phenomenon, fever? It's not simply a rise in body temperature. It is an upward shift in the body's "set point," or core temperature, which is regulated by the hypothalamus in the brain. In response to an infection, the body releases chemicals that cause a sensation of being cold. The hypothalamus then raises the set point by making the body burn fat, reduce blood flow to the skin, and shiver.

Most of the time, fever isn't dangerous in itself, but a patient will feel more comfortable at a lower temperature. In a dramatic demonstration of fever's benefits, researcher Matthew Kluger infected desert iguanas with bacteria.

Because these lizards are cold-blooded, they could only warm their bodies by seeking outside heat -- in this case, sunlamps. All except one of 13 iguanas sought the warmth to raise their temperatures, and those 12 survived; the other one died.

After that, Kluger injected 12 other iguanas with live bacteria, and als
drug. Five of them failed to develop a fever, and died as a result. The
became feverish despite the drug, survived.

Despite experiments like this, scientists haven't yet answered all thei
and ancient body symptom.

Questions:

9. Describe the first two lines of defenses in the body. What do you think happens if these first two lines fail?

10. Explain why the presence of pus and swelling at the site of an injury is a sign that the immune system is functioning.

11. How is a fever a sign that your body is fighting an infection?

12. What are neutrophils, macrophages, and phagocytes?

13. List and explain the ways the body defends itself using external and chemical barriers.

14. List and describe the nonspecific internal defenses.

15. Give what you know about "histamine," what do you think an "antihistamine" does? Can you think of any examples?

16. Knowing what you know now, make any changes that you would make to the original concept map you made.

17. Take the time to make study notes on the material we have learned so far in the unit. Writing study notes is a good skill to learn and will help you in future studies.

18. Using textbook page 620 and the information above, fill in the following chart and answer the following questions.

	Type of Defense	Function	Description of defense (include structures involved and examples
iii) External Barriers	v. mucous		
	vi.		
	vii. cilia		
	viii. chemicals (enzymes and acids)		
iv) Nonspecific Internal Defenses	iii. Phagocytic cells and natural killer cells		
	iv. Inflammatory response		
	iii.	Increases body temperature to slow or stop the growth of microbes	

Attachment 11.3

Concept Overview

Key word or concept.

Body's defense mechanisms

Write an explanation or definition in your own words. You will be paraphrasing.

Draw a figurative representation.

List facts (at least five).

Create your own questions about the concept.

Create an analogy.

Concept Overview Frame: Used by permission of Lynda Matchullis and Bette Mueller, Nellie McClung Collegiate, Pembina Valley S.D. No. 27, Manitoba.

2) Specific Defenses

The immune system also generates specific responses to specific invaders. A specific defense mechanism builds up resistance against a specific pathogen or antigen.

This system is more effective than the nonspecific methods as it has a memory component that improves response time when an invader of the same type (or species) is again encountered. Specific defenses are tailored to an individual threat. Two types of specific defenses are antibody-mediated and cell-mediated responses.

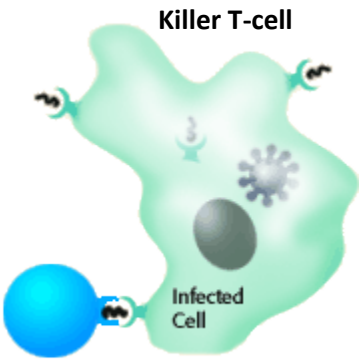
i) _____ results from the production of antibodies specific to a given antigen (antibody-generators, located on the surface of an invader). _____ bind to the antigens on invaders and kill or inactivate them in several ways. Most antibodies are themselves proteins or are a mix of protein and polysaccharides. _____ can be any molecule that causes antibody production.

Antibody-mediated immunity is provided by the B cells. Within a few days after an infection, an antigen causes the production of large amounts of the antibody capable of interacting with it.

ii) _____ requires direct physical contact with antigens. It is provided by T cells and does not involve the secretion of antibodies. T cells are involved in the attacking of certain bacteria, viruses, fungi and immunity to cancer cells.

There are four kinds of T cells:

1. _____- defends the body by destroying foreign, infected, and cancerous cells. A cell infected with a virus will display viral antigens on its plasma membrane. Killer T cells recognize the viral antigens and attach to that cell's plasma membrane. The T cells secrete proteins that punch holes in the infected cell's plasma membrane. The infected cell's cytoplasm leaks out, the cell dies, and is removed by phagocytes. Killer T cells may also bind to cells of _____.



2. _____ - regulate immune responses, enabling the other T cells and B cells to perform their functions by secreting messenger proteins or by direct contact with other cells. It is this cell that is destroyed by the HIV virus in patients with _____ _____. Destruction of helper T cells results in a depressed immune response allowing infection by a variety of microorganisms and the growth of certain kinds of tumors.

3. _____ - reduce the immune response of B cells and T cells to keep them in check.

4. _____ - remain in the body awaiting the reintroduction of the antigen

Under normal circumstances, the immune system responds to foreign organisms by the production of antibodies (B Cells) and the stimulation of specialized cells (T Cells) which destroy the organisms or neutralize their toxic products. In a normal healthy individual there is a balance of all the different cell types of the immune system providing an effective defense against all foreign invaders. When the immune response is not working properly (_____), the individual will become more susceptible to repeated infections.

When the immune system is out of balance, this function may be misdirected resulting in an immune response against the body's own cells producing a condition known as an _____. Examples of autoimmune disease are multiple _____ _____.

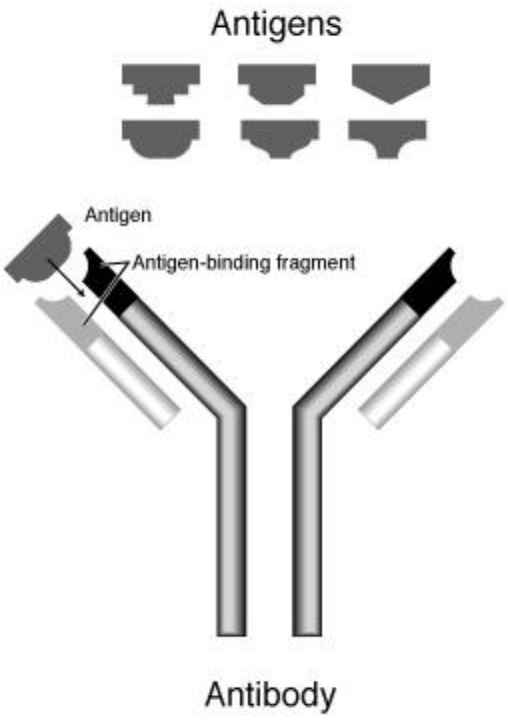
The function of the immune system most recently discovered is the system's ability to recognize and eliminate the abnormal (mutant) cells that frequently arise within the body. These mutant, or _____ may occur spontaneously, or they may be induced by certain viruses (oncogenic viruses) or chemicals (mutagens). An immune system that is functioning properly can recognize and dispose of such cancer cells by means of a process called immune surveillance. The malfunction of this process may result in cancer.

Complement System

The complement system, like antibodies, is a series of proteins. There are millions of different antibodies in your blood stream, each sensitive to a specific antigen. There are only a handful of proteins in the complement system, and they are floating freely in your blood. Complements are manufactured in the liver. The complement proteins are activated by and work with (_____) the antibodies, hence the name. They cause lysing (bursting) of cells and signal to phagocytes that a cell needs to be removed.

Antibodies:

Antibodies bind to specific antigens in a lock-and-key fashion, forming an antigen-antibody complex. Antibodies are a type of protein molecule known as **immunoglobulins**.



Antibodies are Y-shaped molecules composed of two identical long polypeptide (Heavy or H chains) and two identical short polypeptides (Light or L chains). Function of antibodies includes:
1. Recognition and binding to antigens
2. Inactivation of the antigen

Antibodies identify antigens as "self" or "non-self". An antibody fits precisely with an antigen. Therefore, an antibody that binds to one antigen cannot bind to another antigen. Antibodies make antigens clump together, making them inactive. Macrophages then engulf and destroy the clumped antigens. Your body does not automatically have antibodies against all pathogens that exist. When a pathogen invades the body, a macrophage brings the foreign antigen to the B Cells. In this way, the B Cells "learn" about the antigens on the pathogens surface and start to make appropriate antibodies. The B Cells then circulate through the body, releasing antibodies that bind to the new antigen. The production of antibodies from the first exposure to an antigen is known as the **primary immune response**.

A person who is resistant to a specific pathogen is said to have immunity to that pathogen. Once the body has been exposed to a disease, a large group of B cells and T cells remain capable of producing a **secondary immune response** if the pathogen re-appears in the body. This is called **naturally acquired immunity**. A secondary immune response is more powerful than a primary immune response, producing antibodies so quickly that the disease never gets a chance to develop. **Secondary immunity**, the resistance to certain diseases after having had them once, results from production of Memory B and T cells during the first exposure to the antigen. The secondary response is the basis for vaccination.

Vaccination

Vaccination is a term derived from the Latin vacca (cow, after the cowpox material used by Edward Jenner in the first vaccination). A vaccine stimulates the antibody production and formation of memory cells without causing of the disease. Vaccines are made from killed pathogens or weakened strains that cause antibody production but not the disease. Vaccines exist for all sorts of diseases, both viral and bacterial: measles, mumps, whooping cough, tuberculosis, smallpox, polio, typhoid, etc.

Recombinant DNA techniques can now be used to develop even safer vaccines. The immune system can develop long-term immunity to some diseases. Scientists can use this to develop vaccines, which produce induced immunity. **Active immunity** develops after an illness or vaccine. Vaccines are weakened (or killed) viruses or bacteria that prompt the development of antibodies. Application of biotechnology allows development of vaccines that are the protein (antigen) which in no way can cause the disease.

Passive immunity is the type of immunity when the individual is given antibodies to combat a specific disease. Passive immunity is short-lived, usually only lasting for few weeks. Examples of passive immunity include:

1. Milk from a mother's breast contains antibodies received by the baby. These antibodies will only last several weeks.
2. A Gamma Globin shot is purely an injection of antibodies to provide temporary immunity. You might receive a Gamma Globin shot if you travel outside of the country.

Allergies

An allergy is an abnormally high sensitivity reaction to an ordinarily harmless substance. The immune system of an allergic person reacts when an allergen (antigen that triggers the allergic reaction) is absorbed into their body, treating the substance as a harmful invader, causing the white blood cells to begin producing antibodies which attach themselves to mast cells found in connective tissues. When this occurs it causes the body to release histamine, which can cause allergy symptoms -- watery eyes, itching, sneezing or a runny nose.

The most common allergens include pollens, molds, insect stings, household dust mites, animal dander, foods, medications, and insect droppings. Some people are affected by only one allergen, while others can be allergic to many different substances at the same time. The only way to determine exactly what you may be having an allergic reaction to is to be tested.

An extreme, life-threatening allergic reaction usually to food, medications or insect bites is called an **anaphylactic reaction**. It can result in breathing problems, dizziness, hives, a sudden drop in blood pressure, an asthma attack, or unconsciousness. It can be fatal. It must be treated promptly. An emergency kit containing epinephrine (adrenaline) is usually used by patients prone to these attacks. It counters the fatal effects by working directly on the cardiovascular and respiratory systems. It also rapidly constricts blood vessels, relaxes muscles in the lungs to improve breathing, reverses swelling, and stimulates the heartbeat.

Questions:

1) Provide two visible examples of the immune system in action.

2) Describe three first-line defenses of the human body.

3) Explain the difference between specific and non-specific defences. Give an example of each.

4) Complete the table:

Cell Type	Function
	produce antibodies
killer T cells	
	regulate the immune response by enabling other T cells and B cells
Suppressor T cells	
	retain information about antigens

5) Differentiate between antibody-mediated and cell-mediated immunity?

6) What is a primary immune response? How does it differ from a secondary immune response?

7) How does the Complement System play a role in protecting our body from disease?

8) Briefly describe the cause of each of the following disorders of the immune system.

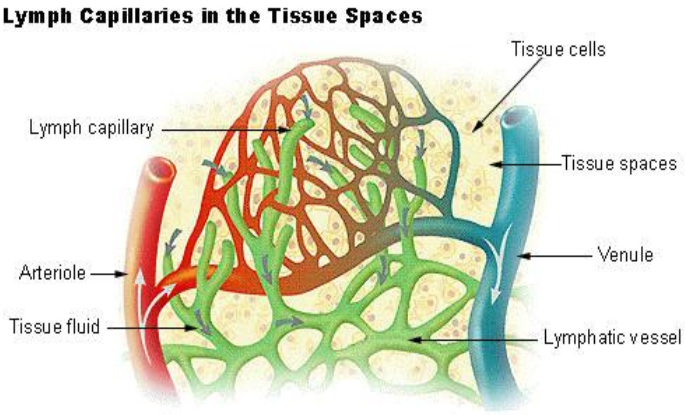
   a. Autoimmune Disease
   b. AIDS
   c. Allergies

9) Differentiate between passive and active immunity.

10) How do vaccinations provide protection against disease?

11) ** Add Specific Defenses to the chart you completed in the previous questions ***

The Lymphatic System



The lymphatic system can be thought of as a _____. The lymph vessels contain a clear, colorless fluid called _____, which is derived from a network of capillaries which collect this clear fluid as it filters through the capillaries of the blood. The lymphatic system provides our immune defenses, filters foreign substances and cell debris from the blood and destroys them; and produces a type of white blood cells known as _____, which circulate in the blood and lymph vessels.

The three functions of the lymphatic system are:

i. _____
ii. _____
iii. _____

Lymph passes from tiny capillaries to lymph vessels and flows through lymph nodes that are located along the course of these vessels. Cells of the lymph nodes _____, or ingest bacteria, old red blood cells, and toxic and cellular waste. Finally, the lymph flows into either the thoracic duct, a large vessel that runs parallel to the spinal column, or into the right lymphatic duct, both of which transport the lymph back into veins of the shoulder areas where is reenters the general circulation. All lymph vessels contain _____, like the veins, to prevent backflow.

In an infection, the lymph nodes occasionally become enlarged with lymph and white blood cells and become palpable (can be felt by an examiner). These can be felt most easily at the neck, in infections of the neck and head; in the armpit, in infections of the breast or arm; and in the groin, in infections of the pelvis or lower extremities.

The lymphatic system consists of:

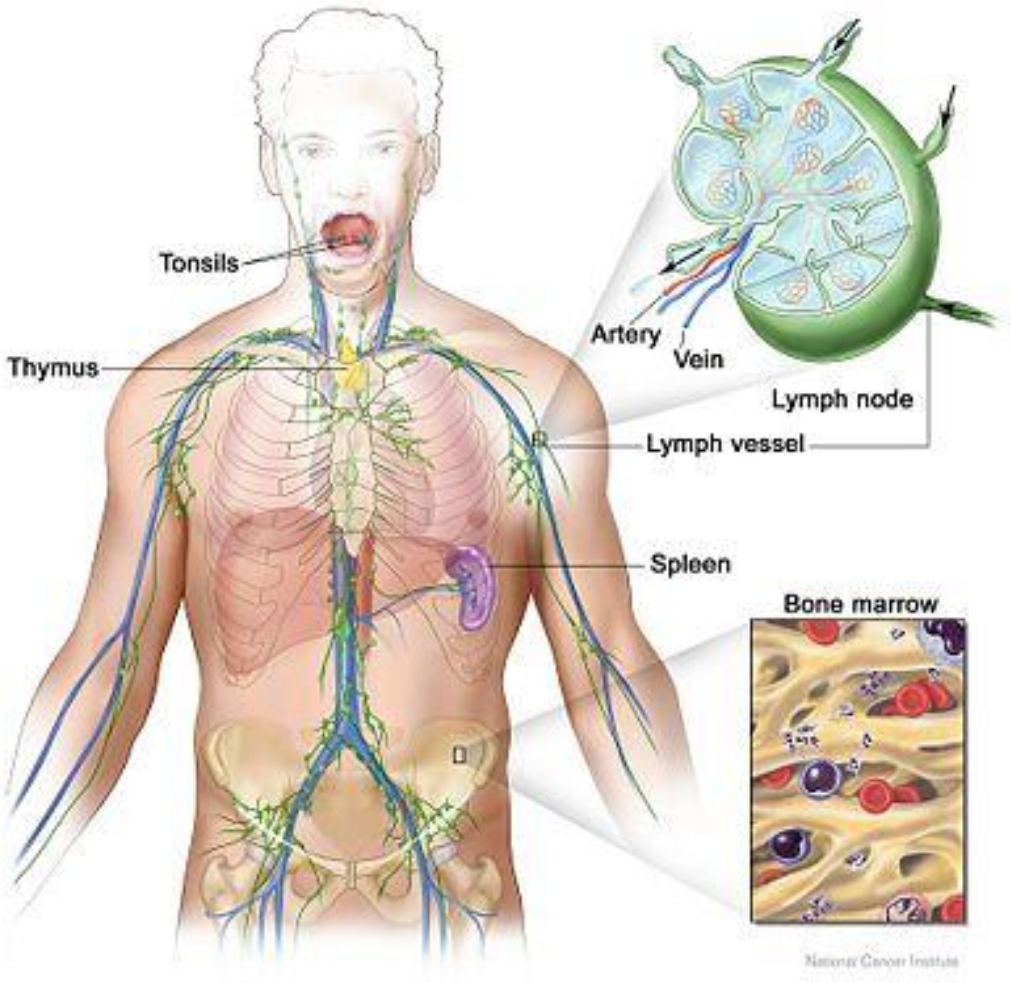
i) a network of _____ and larger vessels that empty into the circulatory system

ii) numerous small _____

iii) patches of lymphocyte-rich connective tissue (including the _____)

iv) _____

v) _____



The spleen, thymus, and bone marrow manufacture lymphocytes, which are the major cell type of the system. Lymphocytes arise from by mitosis of _____ in the bone marrow. Stem cells differentiate into the major players in the immune system (granulocytes, monocytes, and lymphocytes). Stem cells also differentiate into cells in the blood that are not involved in immune function, such as erythrocytes (red blood cells) and megakaryocytes (platelets). Stem cells continue to be produced and differentiate throughout your lifetime.

The _____ is considered the central organ that controls lymphocyte production and antibody

formation. The thymus is particularly active in infants and young children but decreases in size and importance in early adulthood.

The _____ is also involved in the destruction of old cells and other substances by phagocytosis and plays a role in immune responses. Just as the lymph nodes filter lymph, the spleen filters blood, exposing it to macrophages and lymphocytes that destroy foreign particles and aged red blood cells.

Lymphocytes can be classified as _____ (thymus-derived) or _____ (bone-marrow-derived).

Disorder – Elephantiases: results from blocked lymphatic vessels

When scarring of lymph vessels from infection by a parasitic worm prevents lymph from returning to the bloodstream, the affected area can become massively swollen. This is often a problem in the scrotum of

Questions:

1. What role does a lymphatic system play in defending your body against microorganisms?
2. What are the components of the lymphatic system?
3. What is Elephantisis?
4. Where are lymphocytes made?
5. What is the function of the spleen and the thymus?
6. What does the bone marrow make?
7. What does a swollen lymph node indicate?
8. Where does lymph come from?
9. Challenge: The lymph in the capillaries surrounding your digestive tract are high in fat globules?
10. What are the three functions of the lymphatic system?

Name _____

Date _____

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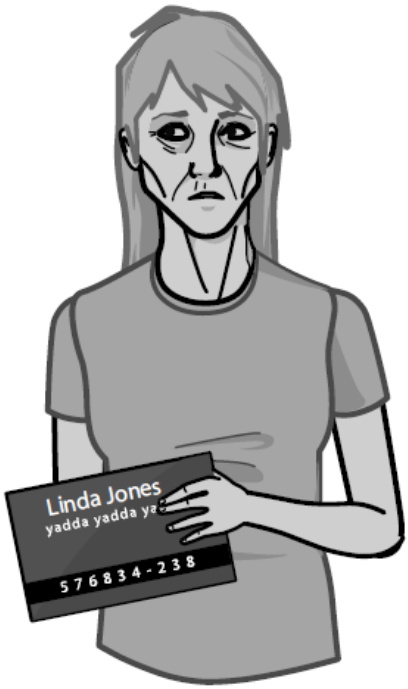
Addiction Vaccine

A company in Great Britain called Xenova has developed a vaccine that looks promising as a treatment for nicotine addiction. The vaccine works by triggering a person's immune system to make antibodies against nicotine. These antibodies recognize and bind to any nicotine that enters the bloodstream, blocking its entry into the brain. As a result, the reward pathway in the brain is not activated. This reduces "the hit" of the cigarette and therefore the cravings that follow. The vaccine is currently being tested in clinical trials to determine its effectiveness and safety.

Enter the near future: Following development of a successful nicotine vaccine, companies are producing vaccines for other drugs using basically the same principle; antibodies that bind to the drug (and other compounds similar to the drug) preventing entry into the brain's reward pathway.

Linda, who is 26 years old, has entered a treatment program for an addictive drug following arrest for crimes related to her addiction. This is not Linda's first arrest, nor her first time in a treatment program. Because of this, the judge hearing Linda's case sentences her to receive the vaccination that has been developed against her drug of choice. Once vaccinated, Linda will not feel any effects from the drug, nor will she feel any effect from compounds similar to the drug (such as prescription pain killers).

Should the judge be allowed to require that Linda have the vaccination?



Directions:

Answer the following questions in the appropriate boxes on the *Bioethics Organizer* (optional).

1. What are the facts involved in this scenario?
2. Who are the stakeholders involved? Who will be affected by decisions that are made?
3. What are some ethical questions raised by this situation?
4. What are the values that play a role in the decision?
5. List at least three possible solutions to this problem.
6. What is your best solution?

Name _____

Date _____

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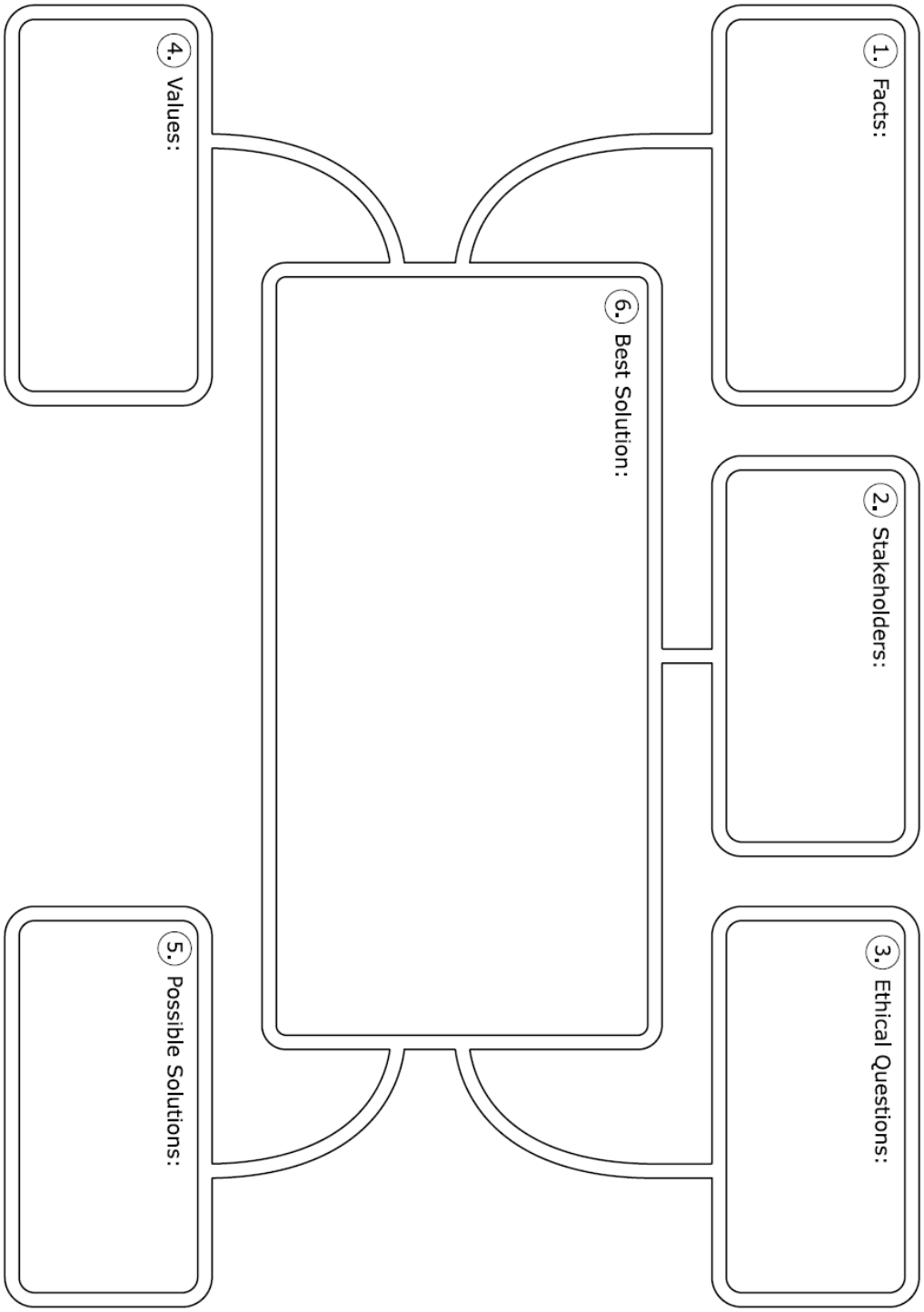
Bioethics Organizer



The Nervous System

As you read this, light from the computer screen bombards your eyes. Touch-sensitive receptors all over the skin of your body are stimulated by your clothes and the chair in which you are sitting. You breathe and shift positions in your chair. In addition to all these activities, your brain is using its reading skills to make sense of what is on the screen in front of you and storing memories of what you are reading. How is possible that your body can do so many different things at the same time?

Your **nervous system** coordinates and controls the essential functions in your body. It receives and relays information about activities within your body and monitors and _____. You can think of your nervous system as a _____ by with the various cells and parts of your body interact with the outside world. Without your nervous system you would be incapable of responding to changes inside and outside your body. In other words, you would be unable to maintain _____.

Basic Structure of the Nervous System

Central Nervous System – C.N.S

- _____
  _____
- _____
  _____
- only the brain deals with conscious thought

Peripheral Nervous System

The _____ form the peripheral nervous system.

1. Sensory Nervous System - sends information _____ or from external stimuli.
2. Motor Nervous System - carries information _____
   _____.
   - Somatic Nervous System - _____
     _____.
   - Autonomic Nervous System - _____
     _____.
     - Sympathetic - _____.
     - Parasympathetic - _____.

- ☐ Make a flow chart showing the nervous system containing the following words. Be sure to describe each word on the flow chart.
  - Nervous System
  - Central Nervous System
  - Peripheral Nervous System
  - Brain
  - Spinal Chord
  - Peripheral Nervous System
  - Motor Neurons
  - Sensory Neurons
  - Somatic Nervous System
  - Autonomic Nervous System
  - Sympathetic Division
  - Parasympathetic Division

Parts of the Brain

3 parts- _____

Human- 1.7 kg - 10 million neurons

- grows until about 20 years old

Reasoning and intellectual ability depends upon the _____

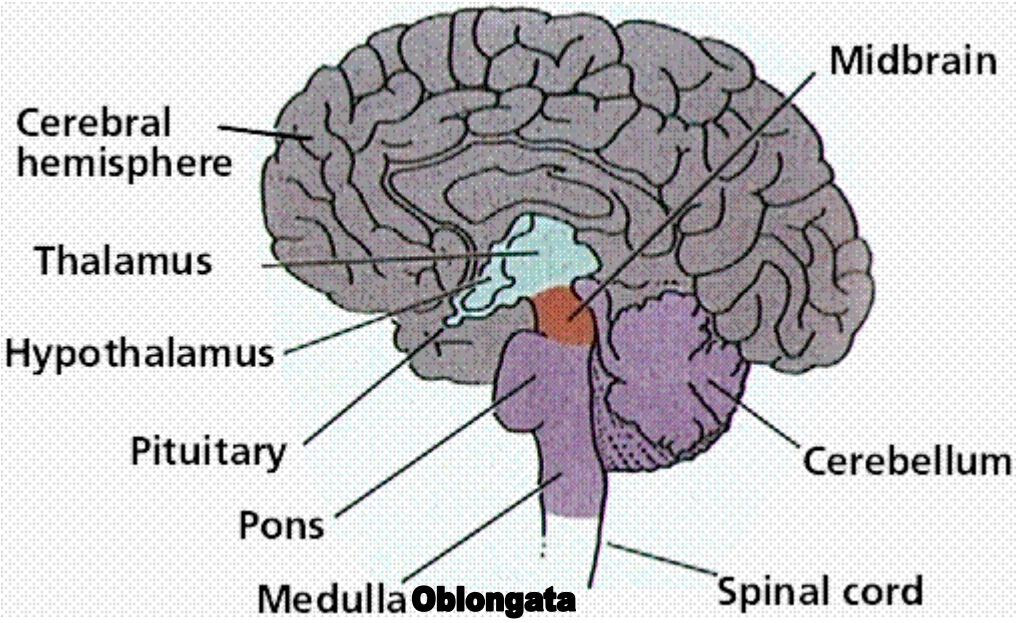
_____.

Pathways develop with use- the brain needs to be exercised to ensure fitness and development.

The differences in mental capacity between humans and other animals is due to the _____

_____ → the outer layer of the cerebrum. It is the folded and convoluted area responsible for complex thinking, reasoning and the various learning abilities of people.

- In preserved brains, it has a grey colour, so it is also known as "grey matter"



1. Hind Brain
   A. Medulla Oblongata
      - enlargement of the spinal cord at the base of the brain
      - control center for: a) _____
        b) _____
        c) _____
        d) _____

e) provides pathways for impulses moving from:
i) higher parts to motor nerves
ii) sensory receptor to the brain

B. Cerebellum
- above the medulla
- circular with curved grooves
- responsible for: a) _____
_____.
b) _____

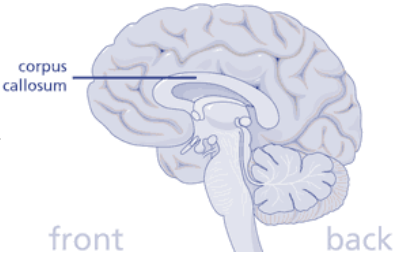
C. Pons (Medulla)
- sends signals from one side of the cerebellum to the other
- sends signals up and down side of the cerebrum to the medulla

2. <u>Mid Brain</u>
- minor importance
- _____
- _____

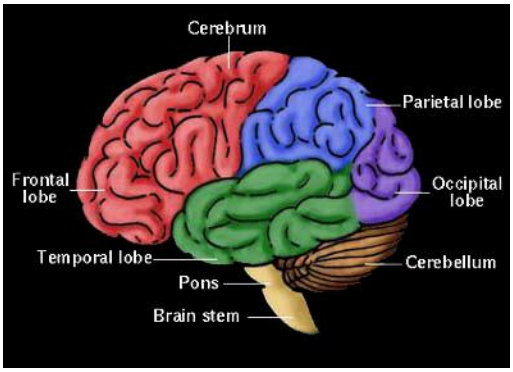
3. <u>Fore Brain</u>
A. Thalamus
- _____
- relays messages

B. Hypothalamus
- _____
- _____
- _____
- _____
- _____
- _____

C. Cerebrum
- Cerebral Cortex
  - 2 – mm thick
  - deep folds called fissures
  - shallow folds called sulcus



- Two hemispheres – _____
_____
→Left side – _____
_____
→Right side – _____
_____
___



- Four lobes
→Frontal – _____
- _____
→ Occipital - _____
→ Parietal - _____
→ Temporal - _____

<u>Spinal Cord</u>

- Found inside the vertebrae
- Thirty one pair of spinal nerves branch out to connect the peripheral system to the brain
- Dorsal Root – _____
- Ventral Root - _____

Parts of the Brain Questions:

1. Make a flow chart like the one you did previously containing the following words:

- Hindbrain
- Midbrain
- Forebrain
- Medulla Oblongata
- Cerebellum
- Pons (Medulla)
- Thalamus
- Hypothalamus
- Cerebrum
- Cerebral Cortex
- Left Hemisphere
- Right Hemisphere
- Frontal lobe
- Occipital lobe
- Parietal lobe
- Temporal lobe

2. List and describe the three main parts of the brain.

3. What do the pathways and routes in your brain determine?

4. Why do this think brain experts recommend keeping your brain "active" as you age (ie: crosswords, Sudoku, etc.).

5. What are the mental differences between humans and other animals due to?

6. Your chemoreceptors notice that there is not enough oxygen in your blood. They send a signal to your brain which tells your heart rate to increase. Which part of the brain are the chemoreceptors sent to (hint: you have to think about this one)

7. You are sleeping and your oxygen requirements are lower, so your breathing decreases. What part of your brain controls the contraction of your intercostals muscles and your diaphragm?

8. A brain-injured patient is having trouble balancing. Which part of the brain is likely damaged?

9. You walk into a dark room and your pupils dilate to let in more light. Which part of the brain is responsible for this reaction? Is this an example of the somatic nervous system or autonomic nervous system?

10. What is the hypothalamus responsible for?

11. What is the corpus callosum? Find out what FAS is and what the syndrome is caused from. Be specific which part of the brain it affects.

12. What do you think is your dominant side of the brain based on your primary skills? (ie: right or left side). Why or why not?

13. Reasoning and emotion probably come from which lobe of the cerebral cortex?

Prepare for Nervous System Quiz

Appendix 4: Bodychecking and concussions in ice hockey: Should our youth pay the price?

Anthony Marchie and Michael D. Cusimano

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Ice hockey, considered Canada's national sport, has more than 500 000 registered players,[1] many of whom aspire to play in the National Hockey League (NHL). With the drive to win at any cost permeating the game, it is not surprising that aggression is a commonly used tactic and has helped to turn hockey into a collision sport.[2] Nor is it surprising that youth often idolize and emulate the professional enforcers who protect their team's leading scorers.[3]

Bodychecking, thought by some a useful skill for winning games, is a major risk factor for injury.[2,4,5,6,7] With the rising incidence of traumatic brain injury in hockey,[8,9] too many Canadian youth are exposed to the lasting effects of such injuries, some of which are not fully realized until the brain completes its maturation.

Before the start of the 2002–2003 season, Hockey Canada (previously known as the Canadian Hockey Association), reversed its 20-year stance and decided to permit players as young as 9 years old to bodycheck in games.[10,11] Although the research[12] that was used to justify this policy was later deemed flawed by its author and others,[13] the policy stood. This ignited a debate that resounded throughout arenas, homes and league boardrooms across the country. Previously, only those aged 12–13 years and older could bodycheck, although some provinces such as British Columbia had a threshold of 14–15 years. Hockey Canada reversed its decision in May 2003 and decided to raise the starting age to 11; however, it continues to allow bodychecking starting at age 9 in an "experimental" fashion in 4 of some of the largest hockey associations in Canada.[14,15,16] The meaning of "experimental" does not appear in Hockey Canada news releases.

Those in favour of bodychecking claim that the game of hockey demands it; youth exposed to bodychecking at only a later age will be ill equipped to avoid injury. They believe that injuries result from improperly delivered or taken bodychecks and that poor technique should not deter leagues from permitting checking. They argue that the focus should be on educating coaches and teaching bodychecking skills at all levels of hockey.

Physicians are often called upon to assess youth with hockey-associated traumatic brain injury and to counsel players and their parents about subsequent return to play. Although recommendations about return to play are numerous,[17,18,19,20,21,22] none has been extensively validated.[18,23] A considerable number of youth who return to play on the goodwill of these

recommendations sustain repeated traumatic brain injuries.[18,24,25,26,27] None of the recommendations emphasizes the importance of counselling children and their families about the risks of returning to play or the option of not playing in a body-contact league. In our opinion, too much emphasis is placed on *when* to return to play and not enough on *whether* to return after an initial traumatic brain injury. To properly counsel players and inform the debate on allowing bodychecking in hockey, physicians must fully appreciate the medical risks associated with bodychecking in hockey.

What is the relation between bodychecking, injury and concussions?

Bodychecking, the most common cause of trauma in hockey,[2,28,29,30] accounts for 86% of all injuries among players 9–15 years old.[31] Players in contact leagues are 4 times as likely to be injured (among those 9–15 years old) and 12 times as likely to receive a fracture (among those 12–13 years old) as players in non-contact leagues.[2,32,33,34] Of reported injuries among players 9–15 years old, 45% are caused by legal bodychecks and 8% by illegal checks, without a significant difference in the injury profiles between the 2 types of checking.[35] Stricter enforcement of rules would not, therefore, have much impact on injury rates.

A comparison with football injuries helps highlight the issue of serious injury in hockey. Direct fatality and injury rates for football are half those for hockey: 1.8 per 100 000 football players in high school and 7.0 per 100 000 in college.[36] Nonfatal catastrophic spinal cord and brain injury rates are 2.6 per 100 000 hockey players and 0.7 per 100 000 football players among high school athletes.[37]

Among the serious injuries caused by bodychecking, concussions are of particular concern because of the risk of permanent sequelae. In studies involving youth and adults, concussions have ranged from a brief period of neural dysfunction to loss of consciousness and amnesia.[38,39,40,41] There may be headache, cognitive, memory and executive-function disturbances, visual abnormalities, motor and sensory changes,[38,39,40,41,42] and seizures.[43] Permanent electrophysiological changes in brain function have been observed in injured junior hockey players 16–20 years old who had recovered and returned to play.[44] Some reported concussions are shown to be contusions on CT scanning.

Repeated mild brain injuries in youth and adults occurring over months or years can result in cumulative deficits.[24,25,26] High school athletes with a history of 3 concussions are 9 times more likely than those with no history of concussion to have changes in their mental status.[25] These patients have "long-lasting alterations in neurological motor functions," [27] and some have had to relearn how to stand.[45]

The younger developing brain is at an even higher risk of injury. Repeated concussions may lead to permanent learning disabilities and other neurological and psychiatric problems.[46,47,48,49] Pre-adolescent youth with a traumatic brain injury may never fully develop the social and cognitive skills

characteristic of adults and may be more violent than those without such an injury.[50,51]

Each season, 10%–12% of minor league hockey players 9–17 years old who are injured report a head injury,[45] most commonly a concussion.[38,39,52] Concussions are most often caused by bodychecking[38,39,40,53] and rarely by being struck with a puck.[38] A review of the literature published between 1966 and 1997 revealed that youth aged 5–17 years had about 2.8 concussions per 1000 player-hours of ice hockey; the number per 1000 player-hours was about the same among high school players, as high as 4.2 among university hockey players and 6.6 among elite amateurs.[38] Among Canadian amateur hockey players over 18 years old, the rate is 4.6–6.0 concussions per 1000 player-hours.[39] When 14 years was the age at which bodychecking was first allowed in British Columbia, 15 years was the average age at which players had their first concussion.[39] Undoubtedly, this threshold age will decline as the new rules about bodychecking are implemented across the country.

Reports of injuries involving youth and adult hockey players show that, despite advances in equipment design, the number of concussions is increasing.[8,9,29,52] Based on these findings and Hill's criteria for causal association,[54] the link between bodychecking and injury and concussion is convincing. It makes sense, given our knowledge of the disease process. The link is analogous to the association between smoking and lung cancer.[54] Findings from meta-analyses[28,38] and prospective[29,39,40] and retrospective[39,40,52] studies support the association between bodychecking and concussion. In addition, the incidence rates of concussion and other hocky-related injuries increase with increasing age, when more bodychecking is expected, and with higher levels of play, which suggests a dose–response effect. Learning to bodycheck when young does not reduce a player's rate of injury as he or she ages, and it prolongs the risk exposure.[38,40,55,56]

Return to play?

Even minor concussions are serious injuries[42,57] because they can lead to second-impact syndrome or cumulative effects in the event of another concussion. Second-impact syndrome is often the main reason for delaying a sports player's return to play after a concussion. The syndrome is caused when players who remain symptomatic sustain a second blow to the head. Even if this second blow is minor, the brain may swell rapidly, resulting in extensive further injury, or uncal herniation and death, probably because of the loss of autoregulation of the cerebral vasculature.[58,59,60]

There are expert guidelines[17,19,22,24,25,26,61] on *when* players can return to play, without specific reference to age, but no mention of *if* players should return to play. Our experience indicates that players who have had a second concussion, or their parents, often wished they had been given the option of whether to return to play at all. Physicians should counsel patients and their families about the risks and benefits of continued play[62] and should explain the importance of being realistic about ambitions for a future in hockey — only 1 of every 4000 minor league hockey players will ever play in the NHL,[63]

and only 1.3 of every 1000 will earn an athletic scholarship to an American university.[64] Because symptoms often worsen with exercise and because the length of time the brain is vulnerable after a concussion is unknown,[65,66,67] prudence dictates erring on the side of caution when deciding on when or whether athletes should return to play.

Should bodychecking be allowed in youth hockey?

Many proponents of bodychecking argue that it is an important skill that allows players to take control of the puck, creates scoring opportunities and helps with defensive positioning and coverage, making it valuable to overall team play.[18] Teams often have a checking line of 3 players who play against an opposing team's top scoring line to minimize their scoring opportunities and tire them out. As is evident in any playoff series, this checking is often used as physical and mental intimidation to gain control of the game.[31,68]

However, the relation between aggressive play and winning is much weaker than the proponents of bodychecking believe. In a study of 1462 recorded penalties in all 18 Stanley Cup final series from 1980 to 1997, teams playing with less violence were more likely to win.[69] Compared with more violent teams, they had on average over 7 more shots on goal per game and 53 more shots on goal over a 7-game series. Losing teams engaged in more violence early in the game, which suggests that their motivation was not frustration of defeat but, rather, the mistaken belief that violence contributes to winning.[69]

Although the contribution of bodychecking to a team's success is questionable, it is such an integral part of the game at the professional level that it is unlikely to be eliminated soon. However, players should not be introduced to bodychecking until they can make a mature, informed choice regarding the issue. Enforced league policies that disallow bodychecking are still the best hope for reducing young players' injuries.[70]

The risks of bodychecking make it clear that checking is not necessary for play at the Canadian minor league hockey level[55] — a position supported by the Canadian Academy of Sport Medicine.[4] The American Academy of Pediatrics recommends limiting bodychecking among players 15 years of age and less.[2] Variations in body size and strength[34] occur in all age groups, but they are most pronounced from 13 to 15 years; differences of 53 kg in body mass and 55 cm in height between the smallest and largest players have been reported in this age group.[31] Since most physical growth is not complete before a person is 17 or 18 years old, bodychecking and hitting should be banned until at least that age. Leagues with players old enough to give consent should obtain informed consent from players before they join the body-contact league. The standard waiver that players are asked to sign to release leagues of all responsibility in the event of injury does not reach the standard of consent expected in activities with more than minimal potential harm. Also, it is unclear how informed consent will be obtained from the 9-year-old players in the 4 hockey associations who will be participating in Hockey Canada's "experiment" [15] and whether the process conforms to Tri-Council Policy.[71]

Awareness of injury prevention is fortunately being raised through programs such as the recently implemented Fair Play in minor hockey leagues.[72] Such programs have been shown to reduce injury rates.[32] Another strategy for maximizing player safety is education.[73,74,75] Hockey Canada has recognized this need and has launched 2 programs to help coaches improve their skills: the Competency Based Educational Program and the Coaches Mentorship Program.[55]

Although coaches have a responsibility to teach safety techniques and coaches and parents should act as role models for good sportsmanship, these actions rarely happen consistently.[69] Recently, 22 of 34 minor league coaches refused to participate in a video about concussion prevention because they thought that watching the video would make their players less aggressive and successful as a team.[45,73] In one community, players 14–15 years old were less likely than younger players to believe that sportsmanship was "real important."[31,70] Moreover, 26% of players 12–15 years old who understood that bodychecking from behind could cause serious injury or death reported that they would be willing to do so if they were angry or wanted "to get even." [31]

In addition, parents may be encouraging their children to win at all costs in the hope of their pursuing scholarships and professional contracts.[76] In one study, 32% of injured players said that they would continue to bodycheck to ensure a win; an additional 6% said they would do so in order to injure another player.[77] Since aggression may be a learned behaviour rewarded in sport,[78] youth and the public in general must be educated about its dangers and social unacceptability. Ideally, as role models for youth,[79] professional players and media personnel should emphasize nonviolence.

Moreover, although the use of protective equipment may prevent some injuries, it may foster the attitude that it can prevent all injuries, it may lead to more lenient enforcement of the rules and, paradoxically, it may increase the number of serious injuries.[74,75,80,81,82,83]

Education and the elimination of bodychecking remain the most effective strategies for preventing concussions and other hockey-related injuries. Eliminating bodychecking could refocus the game on fun and skill — on skating, shooting, passing and team play. Physicians must play their roles as socially responsible citizens: the future of our youth and the game depend on it.

Footnotes

This article has been peer reviewed.

Contributors: Both authors contributed substantially to the writing of the manuscript and approved the final version.

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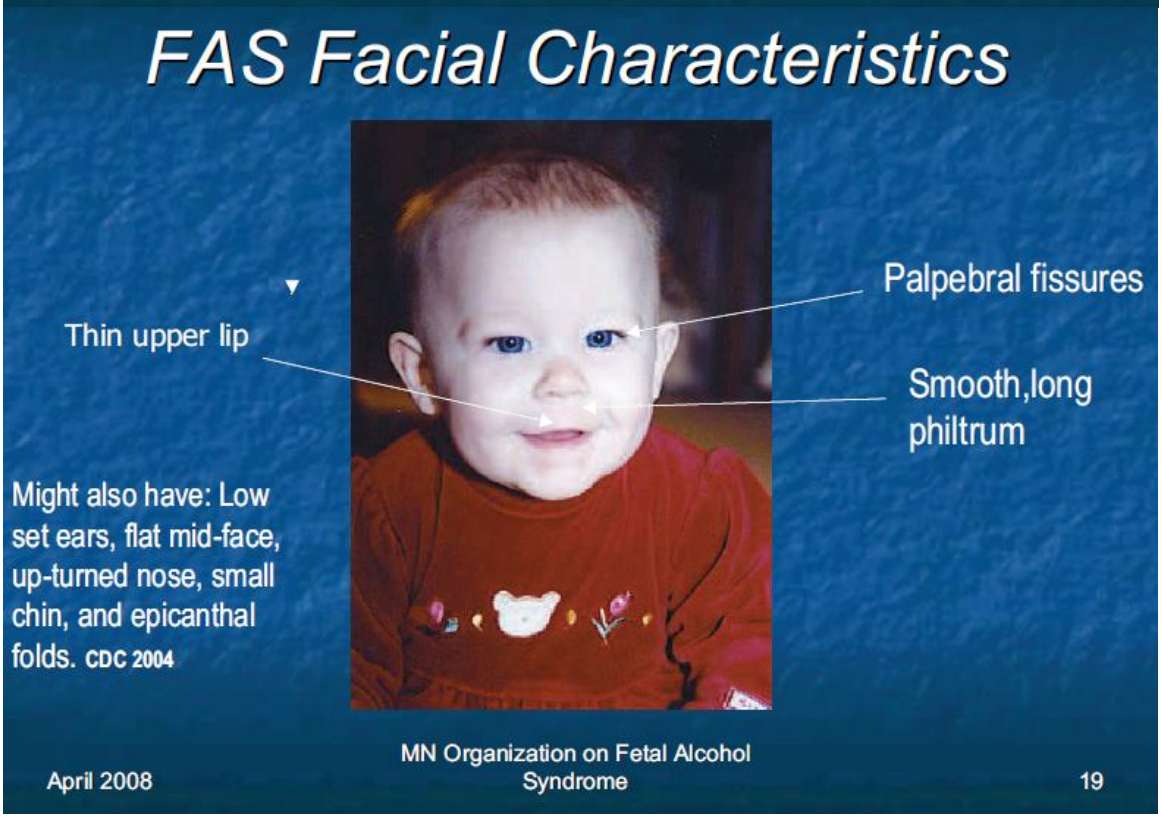
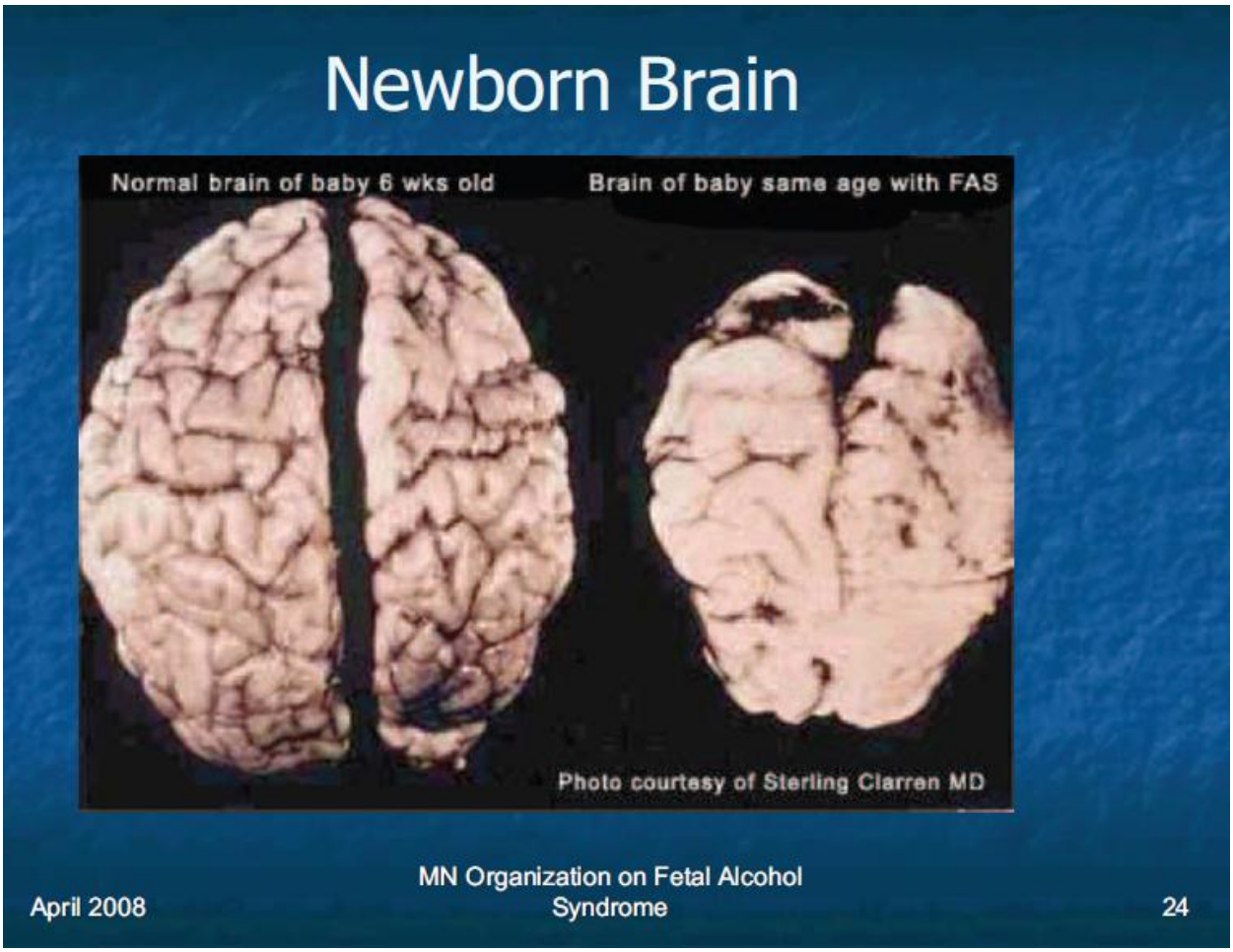
Competing interests: None declared.

Fetal Alcohol Sydrome – how alcohol damages the brain




Newborn Brain
Normal brain of baby 6 wks old
Brain of baby same age with FAS
Photo courtesy of Sterling Clarren MD
April 2008
MN Organization on Fetal Alcohol Syndrome
24

Stimulus and Response

One of the basic life functions of all living things is the ability to respond to a stimulus. There are many stimuli to which an organism must respond: a change in air temperature, a change in carbon dioxide level in the blood, contact with a hot or sharp object, the itch at the end of your nose, the hardness of your chair, the cramp in your leg, a feeling of hunger, and many more that have not been mentioned.

There are three main types of structures related to stimuli and responses. The three structures are receptors, neurons, and effectors.

A **receptor** is a kind of sensor that picks up information about an organisms internal or external environment. Receptors may be neurons themselves, or they may be organs that are specialized for detecting stimuli. A receptor picks up a certain kind of stimulus. For example, the eye is a receptor that is sensitive to light, but not to odour.

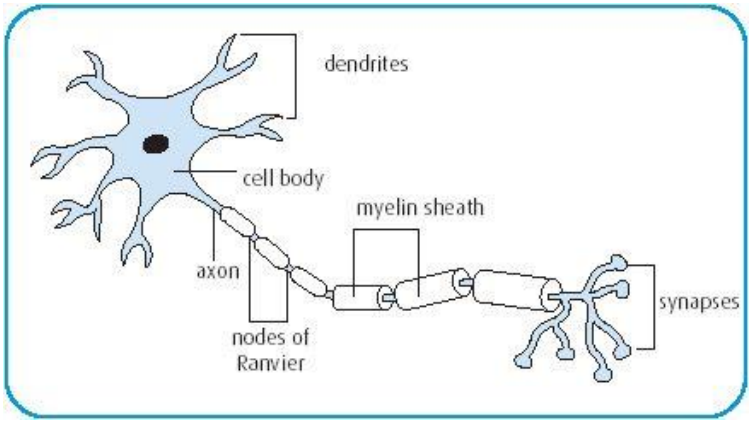
A **neuron** is a specialized cell that transmits electrochemical messages, or nerve impulses, from the receptors to the effectors.

An **effector** is a structure that responds when it is stimulated by nerve impulses. The principal effectors are muscles and glands. Muscles respond by contracting; glands respond by secreting.

Neuron Structure

Some neurons, such as those in the brain, are a fraction of a centimeter in length. Others, such as those that run through the legs, are as long as a meter, going from the toes to the spinal cord.

A neuron has several distinct parts, as shown below. The cell body of the neuron contains the nucleus and most of the cytoplasm known as **soma.** Soma flows into the extensions. The shape of the cell body varies. Some are round, while others resemble a diamond or are irregular in shape.



Nerve fibers extend from the cell body. These fibers contain one long fiber, the **axon,** and one or more short fibers, the **dendrites.** A neuron can have as many as 10000 dendrites. While the dendrites are shorter than the axon, they branch extensively because their function is to pick up impulses, either from receptors or other neurons in the vicinity, and conduct them toward the cell body. The axon carries the impulses away from the cell body, passing it on to other neurons or cells.

The axons of many neurons are covered with a white, fatty protein known as **myelin sheath.** The main function of this sheath is to insulate the axon, preventing the loss of chemical ions that are present in the nerve fiber. Since these ions are necessary for the transmission of impulses along a nerve cell, the presence of a myelin sheath increases the speed of transmission. In myelinated axons, gaps that are not covered with the myelin sheath are called **nodes of Ranvier**. Nerve impulses jump from node to node, resulting in transmission up to 20 times faster than in non-myelinated axons. Note: Neurons are incapable of division, and those that die are not replaced.

Types of Neurons

Biologists classify neurons according to their function. There are sensory neurons, associative neurons, and motor neurons.

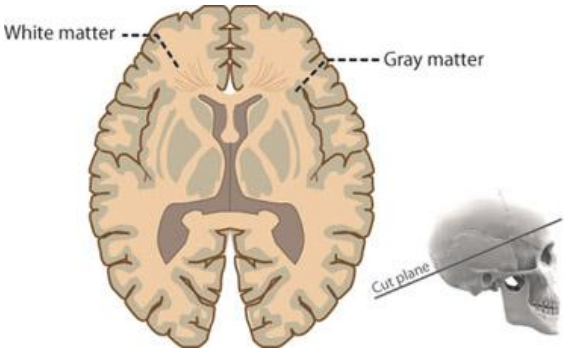
Sensory neurons transmit impulses from receptors to the brain or spinal cord. These pick up the stimuli of sight, smell, sound, taste, and touch. Sensory neurons are important in carrying messages about a person's internal or external environment.

Associative neurons, (also called interneurons or association neurons) found only in the brain, ganglia, or spinal cord, are responsible for coordinating nervous activity (they "decide" what to do) and relaying the messages from the sensory neurons to the proper motor neurons to effect an appropriate action by the effectors (muscles and glands).

Motor neurons receive messages from the associative neurons in the brain and spinal cord and activate the muscles and glands (the effectors).

Nerves

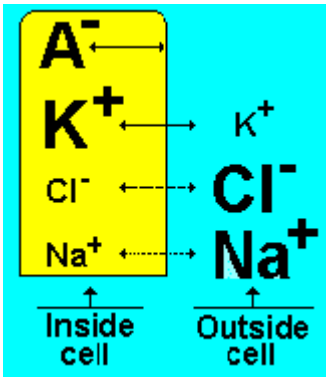
A **nerve** is a bundle of nerve fibers (axons) bound together by a sheet of connective tissue. The cell bodies of those neurons are gathered together into groups. A group of cell bodies that is located outside the brain or spinal cord makes up a ganglion. A group of cell bodies that is inside the brain or the spinal cord is referred to as a nerve center. Within the brain and spinal cord, the myelinated fibers form areas referred to as white matter. The cell bodies of the neurons and unmyelinated fibers make up the gray matter of the brain and spinal cord.



The white matter is the tissue through which messages pass between different areas of gray matter within the nervous system. Using a computer network as an analogy, the gray matter can be thought of as the actual computers themselves, whereas the white matter represents the network cables connecting the computers together.

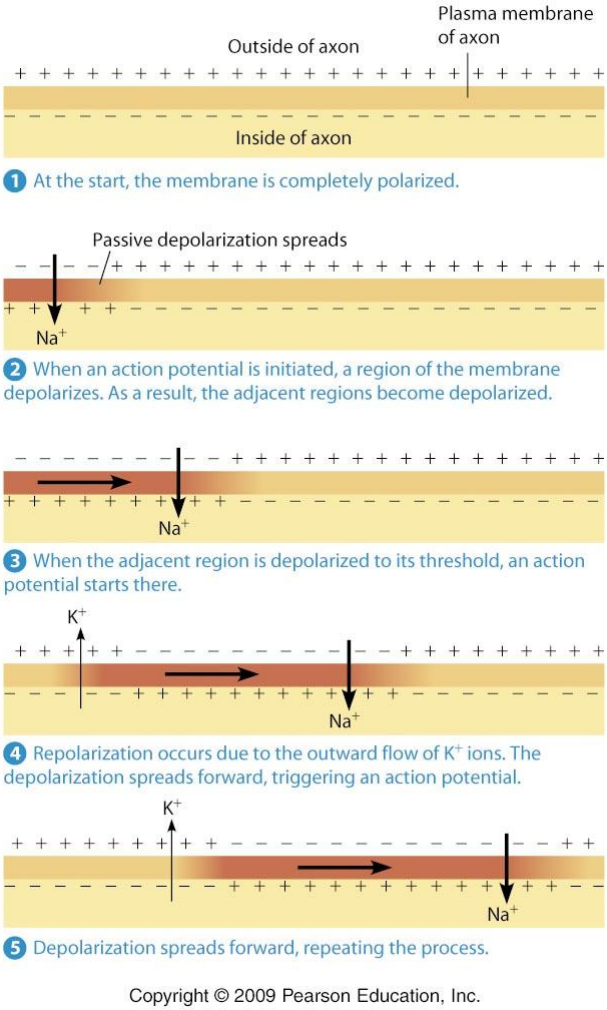
Nerve Impulse- The resting neuron

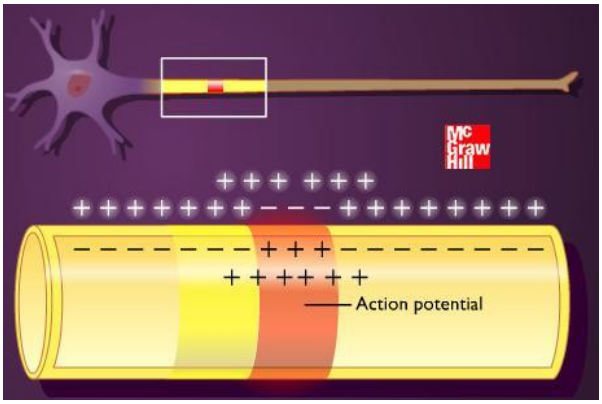
The transmission of an impulse along a neuron is an electrochemical process and not a pure electric current, as was once thought. The transmission of an impulse from one neuron to another is a chemical process.



In a neuron at rest (one that is not transmitting an impulse), there is an unequal distribution of positive and negative ions inside and outside the membrane. This membrane that surrounds the nerve fiber is selectively permeable. That is, some molecules can pass through but others cannot. This membrane can control the passage of certain ions (electrically charged atoms) across it, letting them into or out of the cell. Chloride ions, for example, have an extra electron and are negatively charged, whereas sodium and potassium ions lack electrons and are therefore positively charged.

When a nerve cell is at rest (has not been stimulated), it is said to be **polarized.** The membrane is very much more permeable to potassium ions than to sodium ions, and potassium ions (more concentrated inside the cell) move outward more quickly than the sodium ions (more concentrated outside the cell) move inward. In addition, a **sodium-potassium pump** moves, by active transport, three sodium ions to the outside for every two potassium ions it moves into the nerve cell. Therefore, the membrane has a net positive charge on its outer surface and a net negative charge on its inner surface.





Nerve Impulse- The moving impulse

A stimulus applied to a neuron starts a nervous impulse. The nature of the stimulus varies with the particular neuron. Light stimulates the light-sensitive neurons in the retina of the eye; sound stimulates the sound-sensitive neurons in the ears.

Whatever the stimulus, it initiates a **nerve impulse** by increasing the permeability of the membrane to sodium ions and they flow into the nerve. The result is a reversal of the charge on the membrane (depolarization) at the point where the impulse is passing; **the interior of the cell becoming positively charged and the outside negatively charged.

The polarization reversal (reversal of charges inside and outside the membrane) of a small segment of a neuron causes the polarization of the adjacent area to become reversed as well.

When this happens, the part that was stimulated first becomes repolarized and returns to its original condition. This depolarization and repolarization of the membrane produce an action potential.

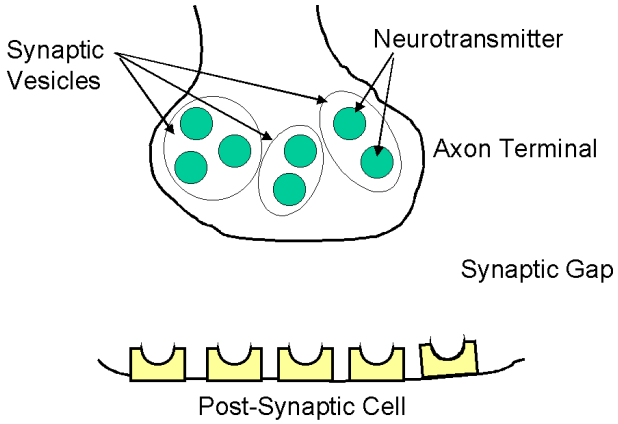
The reversal of the outside and inside charges on a small portion of a neuron lasts for about 0.001 second.

The Nerve Threshold

A nerve impulse is self-propagating. Once started, it moves along without outside help. All of the impulses passing along a nerve fiber are of the same strength. If a stimulus is strong, more impulses are sent, but not larger ones. If the stimulus is too weak, no impulse is sent at all. A dendrite needs a certain amount of stimulation before an impulse is initiated. This minimum amount of stimulation is called a neurons threshold. If the stimulus is equal to or greater than the **threshold,** the neuron will respond by sending an impulse. This is known as the all-or-none **response.**

The Synapse

Because one neuron does not touch another, there is no contact between them, and the electrochemical impulse cannot pass directly from one nerve cell to another. The microscopic space that exists between the axon of one neuron and the dendrite of another is called a **synapse.**



An axon ends in many small fibers. The endings of axons (synaptic knobs) have cytoplasmic vesicles called synaptic **vesicles** inside them. These tiny sacs are filled with compounds called neurotransmitters. Neurotransmitters include the following compounds: acetylcholine, noradrenalin, dopamine and serotonin.

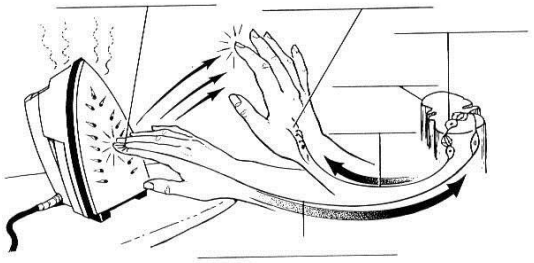
Transmission from Neuron to Neuron

When an impulse reaches the end of an axon, it stimulates the synaptic vesicles to release their transmitter substance into the synapse. The substance, acetylcholine, for example, diffuses across the synapse to the dendrite of the adjacent neuron. The acetylcholine combines with the receptor molecules in the cell membrane of the dendrite or cell body of the next neuron, increasing the permeability of the membrane at that point on the second neuron to sodium ions, and reversing the polarization of the membrane. The electrochemical impulse starts on its way along that neuron. Transmission of acetylcholine from a motor neuron axon to a muscle cell (across a neuromuscular junction) stimulates the muscle cell to contract.

The Reflex Act

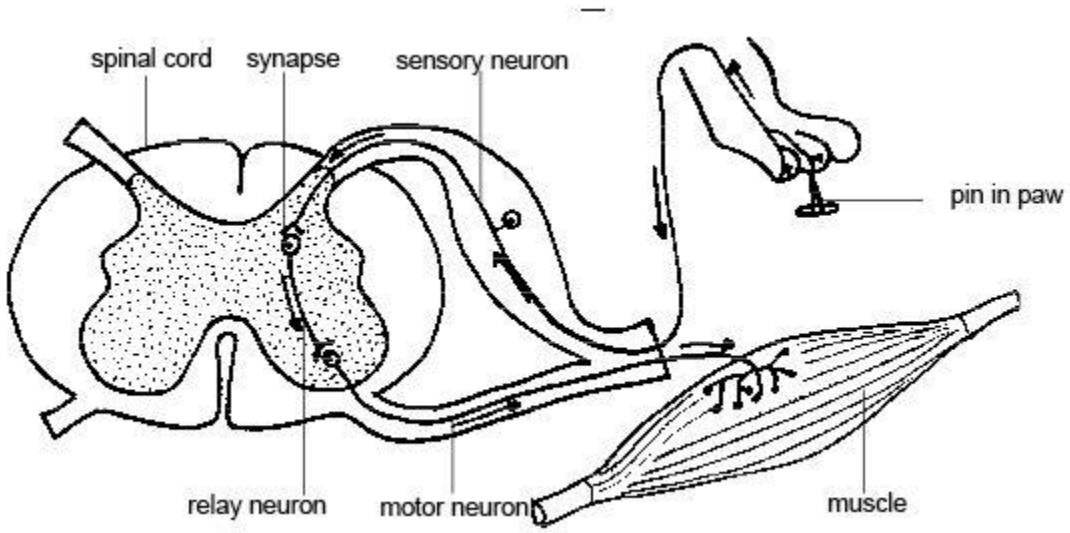
When an effector responds to an impulse, the response is called a **reflex act.** A reflex act is an automatic or involuntary action, which is always the same when a particular stimulus is involved. The closing of the pupil of the eye in response to bright light or the rapid withdrawal of the hand after touching something hot, are both examples of the reflex act.

The Reflex Arc



EXAMPLE: A **reflex arc** is initiated by stepping upon a sharp stone. Impulses (started by receptors in the toe) travel along sensory neurons to the spinal cord, where associative neurons are stimulated. The impulses are "switched" to other neurons; among them motor neurons that stimulate leg muscles to contract and move the foot away from the rock.

Impulses going from the injured toe to the spinal cord result in reflex movement, but also travel up nerve pathways to the brain. Associative neurons in the brain are activated. Impulses may pass from the brain to many parts of the body, leading to voluntary movement.



The reflex arc consists of five parts, which usually involve three neurons. The reflex arc requires:

- **Receptor.** The receptor recognizes some change in the environment, whether heat, light, sound, or some other factor. The receptor is stimulated to initiate a nervous impulse
- **Sensory neuron.** The sensory neuron conducts the impulse from the receptor to the spinal cord.
- **Associative neuron.** The associative neuron directs the impulse from the sensory neuron to the motor neuron. It allows the impulse to be routed into a number of possible pathways.
- **Motor neuron.** The motor neuron carries the impulse to the appropriate organ (usually a muscle) to produce the response.
- **Effectors.** The effector is the muscle or organ that will contract or otherwise respond appropriately to the stimulus.

The **spinal cord** connects the brain with other parts of the body, and functions as a two-way conducting pathway, carrying impulses from sensory neurons up to the brain and conducting impulses from the brain for motor neurons to relay to the muscles and glands of the body. A second major function is to act as a center for reflex activity.

Another Example...

When a doctor wants to check your reflexes, he sometimes strikes the tendon just below the knee cap with his little rubber hammer. He watches to see if your lower leg moves forward immediately. If it does, all is well. This forward movement of the lower leg is a **reflex act** and happens involuntarily. The rubber hammer strikes the tendon, pulling it down, and stretches the muscles in the upper thigh. The stretch receptors, being embedded in the thigh muscles, pick up the stimuli. Let us follow the path of an impulse generated by only one receptor through the **reflex arc** to one **effector.**

1. Receptor: The hammer has exceeded the receptor's out
2. Sensory Neuron: An impulse is initiated and propagated along a sensory neuron to the spinal cord.
3. Associative Neuron: One associative neuron takes the impulse to the brain; a second, takes the impulse directly to **a motor neuron's** dendrites.
4. Motor Neuron: The motor neuron is stimulated and relays the signal to the thigh muscle.
5. Effector: The thigh muscle contracts. Because of this quick responding reflex act, your leg responds to the tap of the hammer even before you are aware of the pain.

Stimulus and Response Questions:

1. Describe the main functions of the nervous system.

2. Differentiate between the terms stimulus, receptor, impulse, and effector.

3. Describe the structure of a neuron and the functions the following parts: soma, axon, dendrites, myelin sheath, and nodes of Ranvier.

4. Differentiate among sensory, motor, and associative neurons.

5. What is a nerve?

6. a) What changes occur in the neuron during the resting potential b) during the action potential?

7. What is the function of the sodium-potassium pump?

8. How does the all-or-none principal relate to the transmission of a nerve impulse?

9. What is a neurotransmitter?

10. a) What is the reflex act? b) Provide some examples of reflex acts in your body.
    c) How does the reflex act help protect you from harm?

11. Describe the reflex arc that would be involved if you touched a hot stove.

Do Reflex Arc Lab

Intro to the Endocrine System

Time Magazine - Monday, Nov. 29, 2010

Strike a Pose

By John Cloud

Powerful people use their bodies to convey authority. There's the hawklike leaning-forward pose, made famous in a 1957 photograph of Lyndon Johnson looming over his tiny colleague Senator Theodore Green — or, more recently, by Sue Sylvester in almost every episode of Glee. There's also a subtle, more relaxed way to convey power, which is to occupy as much space as possible — feet on the desk, fingers interlaced behind the head, elbows expansive. You can find images of several Presidents so comporting themselves in the Oval Office as their advisers smile nervously.

Recently, a team of researchers at Columbia and Harvard wondered not whether power can manifest itself in posture — that seems clear — but whether certain postures could make people feel more commanding. More powerful people — i.e., those who make more money and have higher-status jobs — reliably show higher levels of testosterone (no matter their gender) and lower levels of the stress hormone cortisol than people lower on the totem pole. The researchers reasoned that if you put low-power people in high-power postures, their hormones might respond accordingly.

To see if the researchers were right, I went to a Columbia lab, sat down in my typical slouch and spat into a little tube. Have you ever tried to spit on demand? It's harder than you think. Columbia assistant professor Dana Carney gave me a piece of gum to help. Then Carney put me in the hawk and feet-on-the-desk power postures, and 15 minutes later, I spat into another tube.

Carney sent both spit samples to a lab at Penn State. When the results came back a couple of weeks later, it turned out my testosterone had doubled in the short amount of time I spent in the power positions.

My response wasn't unusual. In the most recent issue of Psychological Science, Carney and her colleagues Andy Yap at Columbia and Amy Cuddy at Harvard published a paper evaluating the responses of 42 people who underwent a test similar to the one I took. They found that cortisol and testosterone levels significantly changed for most people after they had been placed in high-power postures. Conversely, testosterone levels fell significantly in participants who were placed in low-power positions — those who had to either sit with shoulders slumped or stand with ankles crossed and arms hugging the torso.

All of the participants were subsequently given $2 and told they could keep the money or possibly double it in a gambling exercise. Nearly all the people who had been placed in high-power poses opted to double down. They were more likely to risk losing the money than the low-power people and to report feeling powerful.

The paper builds on earlier research showing that if you hold a pencil in your teeth — which forces your facial muscles to approximate a smile — you will report feeling happier. Carney and her colleagues have a useful phrase for how posturing the body can change the mind: it's called the effects of embodiment. And their findings support the notion that you really can fake it till you make it.

The Endocrine System

The endocrine system is a collection of special ***glands**** in the body that produce chemicals called ***hormones****. Hormone means to "excite". You have over 50 hormones busily orchestrating and regulating such things as: when you feel hungry or full; how you sleep; your body temperature; how you break down and utilize the food you eat; whether you are fat or thin; when you start puberty and how long it takes; how you handle stress; how much adrenaline you have in an emergency situation...even how and when you grow.

Glands

Exocrine glands secrete substances out through a duct. The exocrine glands include the salivary glands, sweat glands and glands within the gastrointestinal tract. The exocrine glands are the glands of external secretion.

Endocrine glands secrete a substance (a hormone) directly into capillaries in endocrine tissue. The endocrine glands are "glands of internal secretion."

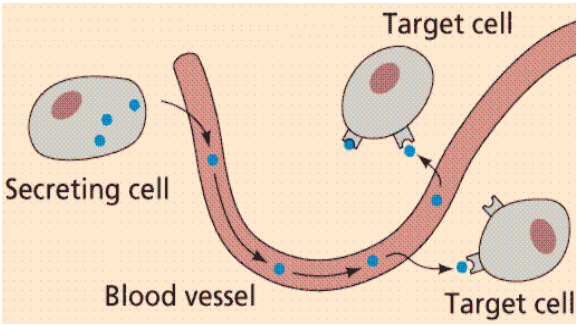
A few glands have the ability to carry on both exocrine and endocrine functions. These glands are **heterocrine glands** or mixed glands. The pancreas, testes and ovaries are heterocrine glands.

Hormones

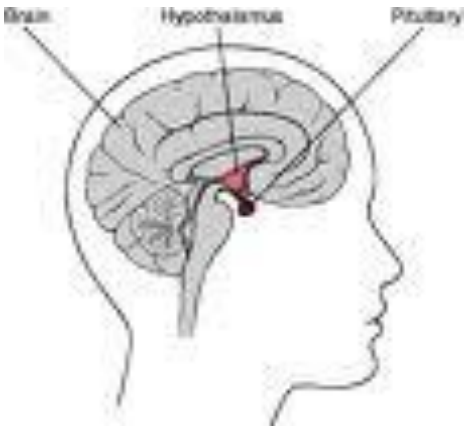
A **hormone** is a chemical substance produced in one part of the body and transported in the blood to another part of the body where it exerts its effect. For this reason, hormones are described as chemical messengers.

Mechanisms of Hormone Action

Hormones are carried by the bloodstream to their destination or **target cells**. When a particular hormone reaches its target cells, special receptors on the cell's surface combine with the hormone and may carry it into the cell. The hormone then activates certain responses. For example, it may make the cell membrane more or less permeable to glucose or it may control the rate at which enzymes carry out reactions. Receptors on target cell membranes bind only to one type of hormone.



Endocrine Glands - The endocrine system and the nervous system are so closely associated that they are collectively called the neuroendocrine system. Neural control centers in the brain control endocrine glands. The main neural control center in the brain is the **hypothalamus**. Suspended from the hypothalamus by a thin stalk is the **pituitary gland**. The hypothalamus sends messages to the pituitary gland. The pituitary gland then releases hormones that regulate body functions.



<u>Pituitary Gland</u>

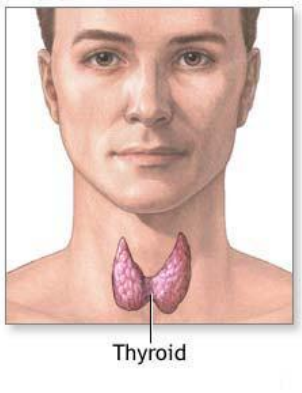
The pituitary gland is found on a small stalk at the base of the brain. It controls the action of all other endocrine glands and is therefore often referred to as the "**master gland**". It is composed of two separate halves: the posterior lobe which is derived from brain tissue and the anterior lobe which is derived from epithelial tissue of the roof of the mouth.

The **posterior lobe** of the pituitary gland secretes two hormones **oxytocin** and **antidiuretic hormone** (ADH).

- **Oxytocin** causes contractions of the smooth muscle in the uterus during childbirth. In males, it is needed to stimulate muscles of the sperm duct to propel the sperm out of the body.
- **Antidiuretic hormone** (ADH) controls the elimination of water from the kidneys.

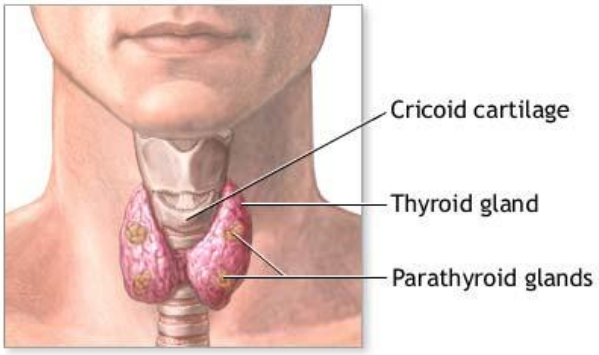
There are at least seven hormones produced in and secreted by the **anterior lobe** of the pituitary gland. Most of these are important in regulating the secretion of other endocrine glands.

1. ***Thyroid Gland***



The thyroid gland is the largest endocrine gland. Appearing almost like two glands, it has two dark red lobes connected by a narrow band of tissue. The thyroid gland has a rich supply of blood vessels, and for its weight, about 30 g, it has the highest rate of blood flow of any organ in the body. About 3 or 4 cm high and 2.5 cm across, it is located in the neck at the junction of the larynx and the trachea.

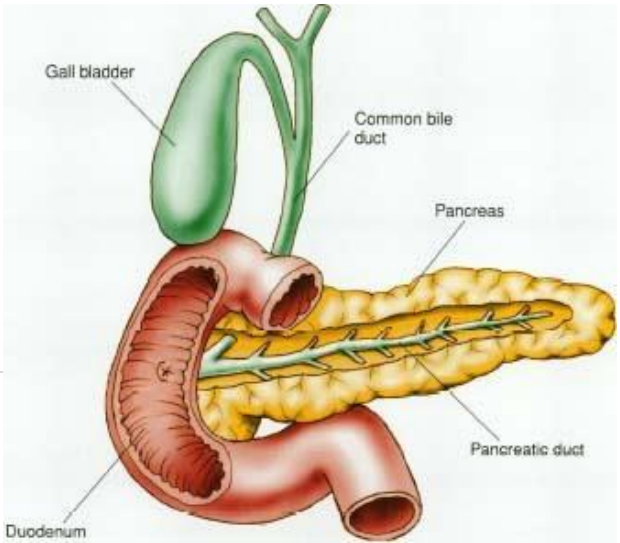
- Produces two hormones:
  - **Thyroxin** regulates the rate of metabolism in the body. It is activated by the hypothalamus.
    - A goiter is the enlargement of the thyroid gland, usually caused by a deficiency in iodine in the diet.
    - Too much thyroxin causes a condition called hyperthyroidism.
      Symptoms: increased metabolic rate, increased appetite but loss in weight, increased thyroid size, rise in respiratory rate, profuse sweating, increase in heart rate and blood pressure, increased blood sugar, irritability, and protruding eyeballs.
    - A deficiency of thyroxin is a condition known as **hypothyroidism** and is characterized by a reduction in metabolic rate. Accompanying this is an increase in weight, decrease in pulse rate, and general sluggishness.
  - **Calcitonin** acts by preventing the release of calcium from the bones. This lowers the blood calcium level.



3. ***Parathyroid Gland***

Attached to the posterior (back) surface of the two lobes of the thyroid gland are small, oval, reddish tan masses of tissue called the parathyroid glands. There are usually four, two in each lobe of the thyroid gland.

- **Parathormone (parathyroid hormone)** raises calcium levels in the blood. It causes calcium to be released by the bones, prevents calcium excretion by the kidneys, and increases the amount of calcium absorbed by the intestine.



4. ***Pancreas***

The exocrine function of the pancreas was studied in the digestion unit. Digestive secretions are delivered to the

duodenum through the pancreatic duct. Since the pancreas is a heterocrine gland, it also functions an endocrine gland.

- **Insulin**- Lowers blood sugar level.
- **Glucagon**- Raises the concentration of glucose in the blood.

5. Gonads: Ovaries and Testes

The gonads are heterocrine glands. Their exocrine function is the production of sex cells, which are carried by ducts. The ovaries produce egg cells and the testes produce sperm.

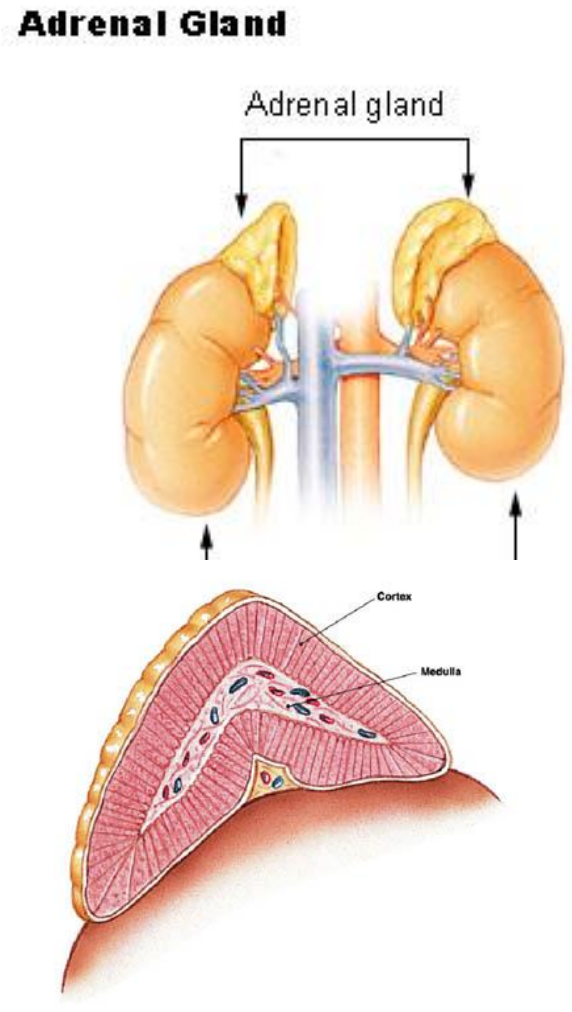
Testes

- **Testosterone** - The production of this hormone is stimulated by **Interstitial Cell Stimulating Hormone** (ICSH) from the pituitary gland. The effects of this hormone become noticeable on boys of 12 to 15 years of age. Testosterone is responsible for the development of male secondary sex characteristics and for the proper function of the reproductive organs.

Ovaries- produce two hormones.

- **Estrogen**- Responsible for the development of the female secondary sex characteristics at puberty and helps to maintain them during adult life.
- **Progesterone**- Prepares the uterus to receive the fertilized egg cell.

6. Adrenal Glands



The adrenal glands lie like small caps on top of the kidneys. Each adrenal gland has two parts: the outer part of the gland is called the **adrenal cortex**; the inner part is called the **adrenal medulla**.

Adrenal cortex - produces several hormones, all of which are steroids. They fall into three groups: **glucocorticoids**, **mineralocorticoids**, and **sex hormones**.

- **Cortisone** metabolism of carbohydrates and proteins,
- **Aldosterone** salt and water balance

… are some of the hormones they produce.

Adrenal medulla - produces only two hormones:

- **Adrenalin** (and **noradrenalin).** Adrenalin is more potent in its action than noradrenalin and 80% of the total secretion of the adrenal medulla is adrenalin.

QUESTIONS:

1. Why are hormones referred to as chemical messengers?
2. Since hormones bathe many or even all of the cells of the body, why do only specific target cells respond to the hormones?
3. Describe how the hormones of the pancreas act together in a negative feedback mechanism to regulate the concentration of glucose in the blood.
4. Why is the pituitary gland sometimes called the "master gland"?
5. Match the following glands to the hormone(s) produced.

1. parathyroid _____
2. ovary _____
3. pituitary _____
4. pancreas _____
5. testes _____
6. adrenal _____
7. thyroid _____

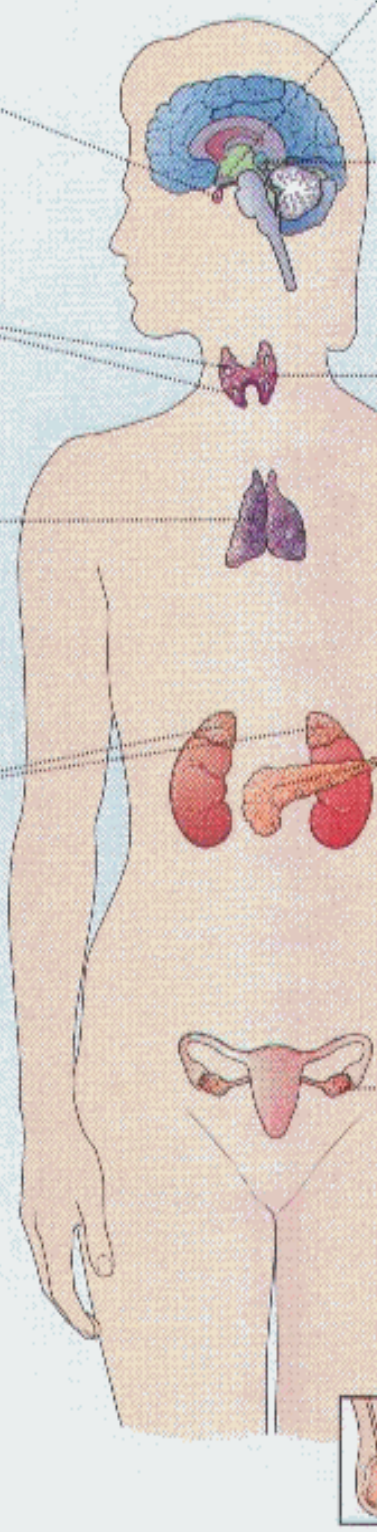
a. insulin
b. adrenalin
c. calcitonin
d. estrogen
e. testosterone
f. parathormone
g. glucagon
h. aldosterone
i. antidiuretic hormone (ADH)
j. thyroxin
k. progesterone
l. oxytocin
m. cortisone

6. **FILL IN THE FOLLOWING CHART**

COMPARING TWO SYSTEMS		
	NERVOUS	**ENDOCRINE**
COMMUNICATION		
RESPONSE SPEED		
DURATION		
TARGET PATHWAY		
ACTION		

Human Endocrine System

Endocrine glands produce hormones that control many body functions.



Hypothalamus
The hypothalamus makes hormones that control the pituitary gland. It also makes the hormones ADH and oxytocin, which are stored in the pituitary gland.

Pituitary gland
Responding to signals from the hypothalamus, the pituitary gland releases hormones some of which control other endocrine glands.

Pineal gland
The pineal gland secretes melatonin, which controls body functions in response to daylight and seasonal changes.

Parathyroid gland
These four patches of tissue on the thyroid gland release the parathyroid hormone, which regulates the blood calcium level.

Thyroid gland
The hormone thyroxine, which speeds up metabolism and helps manage growth and development, is secreted by the thyroid gland.

Thymus
Thymosin, which stimulates the development of T cells for the immune system, is secreted by the thymus.

Pancreas
The pancreas has patches of tissue called the islets of Langerhans, which have cells that make the hormones insulin and glucagon. Insulin and glucagon control the blood sugar level.

Adrenal glands
The adrenal glands make epinephrine and norepinephrine, two hormones which cause the "fight or flight" response. They also secrete aldosterone, which affects the body's osmotic balance, and cortisol, which promotes glucose synthesis.

Ovaries
The hormones estrogen and progesterone are made in the ovaries. They maintain the female reproductive system and secondary sex characteristics. Progesterone maintains the uterus during pregnancy.

Testes
The testes make testosterone, a hormone that maintains the male reproductive system and secondary sex characteristics.