

Chapter 19

Immune System - Part I (Lymphatic System)



Day One:

Today, your child should complete their reading and practice problems for the week.

Below are the supplies for this week's lab:

- 1 plastic shopping bag
- 1 pair of scissors
- 15 cm of string, large rubber band, or tape
- 4 pieces of wrapped candy, peanuts, raisins, or other item

National Science Education Standards covered this week:

12FSPSP1.2 The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.

Definitions

adaptive (specific) immunity	one of two different types of immunity; identifies each invading pathogen (such as bacteria or viruses), unhealthy body cells (such as cancer cells), and other foreign particles
B cells	created by the red bone marrow and are one of the primary agents within our adaptive immune system
immune response	all actions involved with the identification and removal of foreign invaders by the immune system
immune system	the body's defense mechanism; a general term used to describe the collective anatomy/physiology of several systems within the body to remove foreign invaders
immunity	the ability of the body to resist infection and disease
innate (nonspecific) immunity	all defensive actions our bodies undergo to prevent the spread of infection or disease, <u>regardless of the damaging agent</u>
interstitial fluid	excess fluid which "pools" in areas where capillaries exchange nutrients and wastes
lymph	recycled plasma from the blood
lymph nodes	inch-long (2.5 cm) oval-shaped organs connected to the lymphatic vessels and are filled with protective lymphocytes ;act as traps for pathogens
lymph nodules	specialized lymphatic tissues which are found between the epithelial and connective tissue layers of the digestive, respiratory, and urinary system
lymphatic vessels	thin-walled vessels surrounding vascular tissues which carries "pooled" interstitial fluid back into the cardiovascular system

lymphocytes	a specific type of white blood cells (leukocytes) whose function is to eliminate all potentially damaging substances from our body
NK cells	part of the innate immune system; indiscriminately attacks every foreign invader considered to be a threat
right and left subclavian veins	directs lymphatic fluid from the right lymphatic duct and the thoracic duct towards the heart
right lymphatic duct	smaller of two ducts which carries lymph from the right side of the head, right upper limb, shoulder and lung, and the right side of the heart
spleen	largest lymphoid organ located in the upper left portion of the abdomen; removes old red blood cells and recycles iron for use by the bone marrow
T cells	make up over three quarters of all lymphocytes; mature within the thymus of the lymphatic system after being created by the red bone marrow; primary agent of cellular defense within the adaptive immune system
thoracic duct	larger of two ducts which carries lymph from the left side of the head, neck, chest, the left upper limb, and the entire body below the ribs
tonsils	specialized tissues within the lymphatic system responsible for the storage of large numbers of lymphocytes; found in the oral cavity

Sample questions to ask your child after completing the weekly reading.

What are the differences between the two different types of immunity mentioned this week?

Our innate immunity does not identify the specific threat that is invading the body. It simply attacks all foreign invaders. Our adaptive immunity, on the other hand, involves defenders who identify specific invading pathogens (such as bacteria or viruses), unhealthy body cells (such as cancer cells), and other foreign particles before they begin their attack.

How does the cardiovascular system rely upon the lymphatic system?

The lymphatic system regulates the volume of blood by returning excess fluids found in interstitial spaces back into the blood stream and towards the heart.

What three types of lymphocytes exist within the body and which of these are part of our innate immunity?

Three types of lymphocytes include T cells, B cells, and NK (natural killer) cells with the latter being part of our innate immunity.

What are the main differences between lymphatic tissues and lymphatic organs?

When compared to the three lymphatic organs, lymphatic tissues such as the lymph nodules and tonsils tend to be smaller, not protected by a layer of connective tissue, and are not attached to any vessels of the lymphatic system.

Day Two:

Your child should check their work on the practice worksheets today with the answer key on the next page.

In addition, your child should read the lab activity and start collecting all of the necessary materials!

Answer Key for Practice Problems

Vocabulary Review

- | | |
|------------------------------------|----------------------------------|
| 1) lymphocytes | 11) adaptive (specific) immunity |
| 2) immune response | 12) NK cells |
| 3) innate (nonspecific) immunity | 13) lymph |
| 4) B cells | 14) right lymphatic duct |
| 5) right and left subclavian veins | 15) lymph nodules |
| 6) interstitial fluid | 16) tonsils |
| 7) lymph nodes | 17) immunity |
| 8) thoracic duct | 18) immune system |
| 9) spleen | 19) lymphatic vessels |
| 10) T cells | |

Multiple Choice

- | | |
|------|------|
| 1) D | 4) D |
| 2) B | 5) B |
| 3) E | 6) A |

Application Questions

Normally T cells are programmed to attack specific pathogens within the thymus before migrating to other lymphatic tissues. Without the thymus, this processing is prevented; and, since T cells make up three quarters of all lymphocytes within the lymphatic tissues, a decreased number of lymphocytes would be expected. The loss of T cells results in an increased susceptibility to infection.

Day Three: Lab Activity

Your child should have already read through this lab and has been reviewing all of this week's vocabulary words.

Collect your supplies for the lab:

- 1 plastic shopping bag
- 1 pair of scissors
- 15 cm of string, large rubber band, or tape
- 4 pieces of wrapped candy, peanuts, raisins, or other item

Simulating the most frightening form of defense imaginable or...

You want me to fit that in there?!?!

A model of phagocytosis among white blood cells will be explored during this challenge.

Materials:

1 plastic shopping bag

1 pair of scissors

15 cm of string, large rubber band, or tape

4 pieces of wrapped candy, peanuts, raisins, or other item

Procedure:

With the materials in hand, the students are challenged to get the candy into their bag according to the following rules:

- The candy must enter through a solid part of the bag.
- The inside of the bag may not be directly open to the external environment (which means you cannot simply drop the candy into the bag.)
- The candies entering the bag must remain clustered together.
- You may work with your hands in the bag to act as the inside of a cell.
- All materials must be used

Explanation:

Back in Chapter 15, you learned that white blood cells are known as phagocytic cells due to their ability to consume foreign pathogens within the blood. Within the lymph nodes are specific types of phagocytes called **macrophages** which are very efficient at engulfing and destroying pathogens that find their way into the lymphatic system.

The main problem that one has to consider is how a cell such as a macrophage can ingest such large objects without the use of a mouth or other cavity to ingest such materials. Imagine having to ingest a beachball - how could it be done?

Macrophages utilize the process of **phagocytosis** in which the foreign object is engulfed entirely by the cellular membrane of the macrophage itself. This object is brought into the macrophage surrounded by a pinched-off area of its own cellular membrane. The macrophage's membrane is never opened up to the outside environment. If this were to occur, it would likely perish.

This activity is very similar to the actions of a macrophage within the lymph nodes of our bodies. The pictures below will help you solve the puzzle...



**HOW CAN IT
BE DONE?**



A view from inside of the bag...

Chapter 20

Immune System - Part II (Immune Response)



DOES AN
ANATOMIST
WALK WITH A
LYMPH?

Day One:

Today, your child should complete their reading and practice problems for the week.

Below are the supplies for this week's lab:

- 1.75 cups (~91 grams) powdered whole milk
- 4 cups (946mL) warm water (between 43-51 °C or 110-125 °F)
- 1/3 cup (80 grams) of plain yogurt with active and live cultures
- Five (5) one-cup containers with lids
- Mixing bowl and whisk
- Small cooler or insulated lunch container
- Fresh fruit
- Spoons

National Science Education Standards covered this week:

12BPS3.1 Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.

Definitions

active immunity	type of immunity which develops after the body produces its own antibodies in response to the presence of a foreign antigen
artificially acquired active immunity	type of active immunity which stimulates the body to produce antibodies under safe conditions
artificially acquired passive immunity	type of passive immunity in which antibodies are transferred into another individual through artificial means (i.e. as through a tetanus or rabies shot)
clones	any one of the many identical copies of specific lymphocytes
complement	a group of proteins which help to "mark" pathogens by attaching themselves to the foreign invader
fever	a condition in which the body temperature is increased above 37.2°C (99°F)
histamines	chemical which helps to trigger inflammation and increases blood flow towards the infected area
immunological surveillance	defense mechanism utilized by the natural killer (NK) cells to identify surface antigens on foreign cells before destroying the invader
inflammation	symptoms such as swelling, redness, excessive warmth, and pain in an area that contains damaged tissues
interferons	proteins released by lymphocytes and/or cells which are infected with viruses; tags the infected cells for attack by the immune system or instructs healthy cells to prepare for the impending spread of infection
macrophage	a type of white blood cell which sweeps through the blood and consumes pathogens and cellular fragments
memory cells	clones which remain inactive and flow throughout the body after an infection; can be quickly activated to generate a faster immune response during future infections

naturally acquired active immunity	type of active immunity which develops from birth and continues throughout a person's lifetime
naturally acquired passive immunity	type of passive immunity in which antibodies are transferred into another individual without any artificial means (i.e. via breast milk)
passive immunity	a type of immunity which is produced by transferring antibodies from another source
physical barriers	initial barrier within the body's innate immunity; external structures such as hair and fingernails keep dangerous organisms and materials from entering the body
vaccine	a solution of dead or inactive pathogens containing their unique antigens; common source for a person's artificially acquired active immunity

Sample questions to ask your child after completing the weekly reading.

What are the defensive tools of the innate immune system?

Physical barriers, Phagocytic cells, Immunological surveillance, Interferons, Complement, Inflammation, and Fever

Which of the defensive tools mentioned above utilizes the NK cells predominately?

NK cells are used in large part of the immunological surveillance system of the immune system

How do antibodies identify specific pathogens within the body?

Although the general structure of antibodies is the same, a small area at their tip contains unique chemical "keys" which can only bind with specific antigens (locks) on the surface of pathogens.

Why is it unlikely that we can become ill from the same pathogen in two different times of our life?

The presence of memory T and B cells (clones) in addition to a wealth of antibodies patrolling the blood and lymphatic systems after an infection quickly and efficiently destroy invaders that reappear in different times of our lives.

Day Two:

Your child should check their work on the practice worksheets today with the answer key on the next page.

In addition, your child should read the lab activity and start collecting all of the necessary materials!

Answer Key for Practice Problems

Vocabulary Review

- 1) fever
- 2) complement
- 3) vaccine
- 4) passive immunity
- 5) macrophage
- 6) clones
- 7) histamines
- 8) memory cells
- 9) immunological surveillance
- 10) physical barriers
- 11) interferons
- 12) inflammation
- 13) naturally acquired active immunity
- 14) artificially acquired active immunity
- 15) active immunity
- 16) artificially acquired passive immunity
- 17) naturally acquired passive immunity

Multiple Choice and True/False

- 1) D
- 2) D
- 3) E
- 4) B
- 5) F
- 6) T

Application Questions

Without a blood supply, antibodies and T cells do not have easy access to the cornea. Therefore no immune response occurs to reject the transplanted foreign cornea.

Day Three: Lab Activity

Your child should have already read through this lab and has been reviewing all of this week's vocabulary words.

Collect your supplies for the lab:

- 1.75 cups (~91 grams) powdered whole milk
- 4 cups (946mL) warm water (between 43-51 °C or 110-125 °F)
- 1/3 cup (80 grams) of plain yogurt with active and live cultures
- Five (5) one-cup containers with lids
- Mixing bowl and whisk
- Small cooler or insulated lunch container
- Fresh fruit
- Spoons

Homemade Yogurt *or...*

Yogurt loves going to the opera. They are very cultured individuals.

The generation of yogurt from a stock solution will be demonstrated.

Materials:

1.75 cups (~91 grams) powdered whole milk
4 cups (946mL) warm water (between 43-51 °C or 110-125 °F)
1/3 cup (80 grams) of plain yogurt with active and live cultures
Five (5) one-cup containers with lids
Mixing bowl and whisk
Small cooler or insulated lunch container
Fresh fruit
Spoons

Procedure:

- 1) Whisk together the powdered milk and warm water in a large mixing bowl until the milk is dissolved.
- 2) Add the yogurt and quickly whisk the mixture until most of the clumps are dissolved. Do not allow the mixture to cool.
- 3) Seal the mixture into the cups and place them into the insulated cooler for 6-8 hours. Do not move the cooler during this time!
- 4) Remove the containers and refrigerate overnight. Add fresh fruit and enjoy your chilled homemade yogurt.

Explanation:

Not all bacteria trigger an immune response within the intestines. The human body maintains a mutualistic relationship with the trillions of bacteria within its intestines. Gut flora (bacteria within the intestines) thrive in this environment

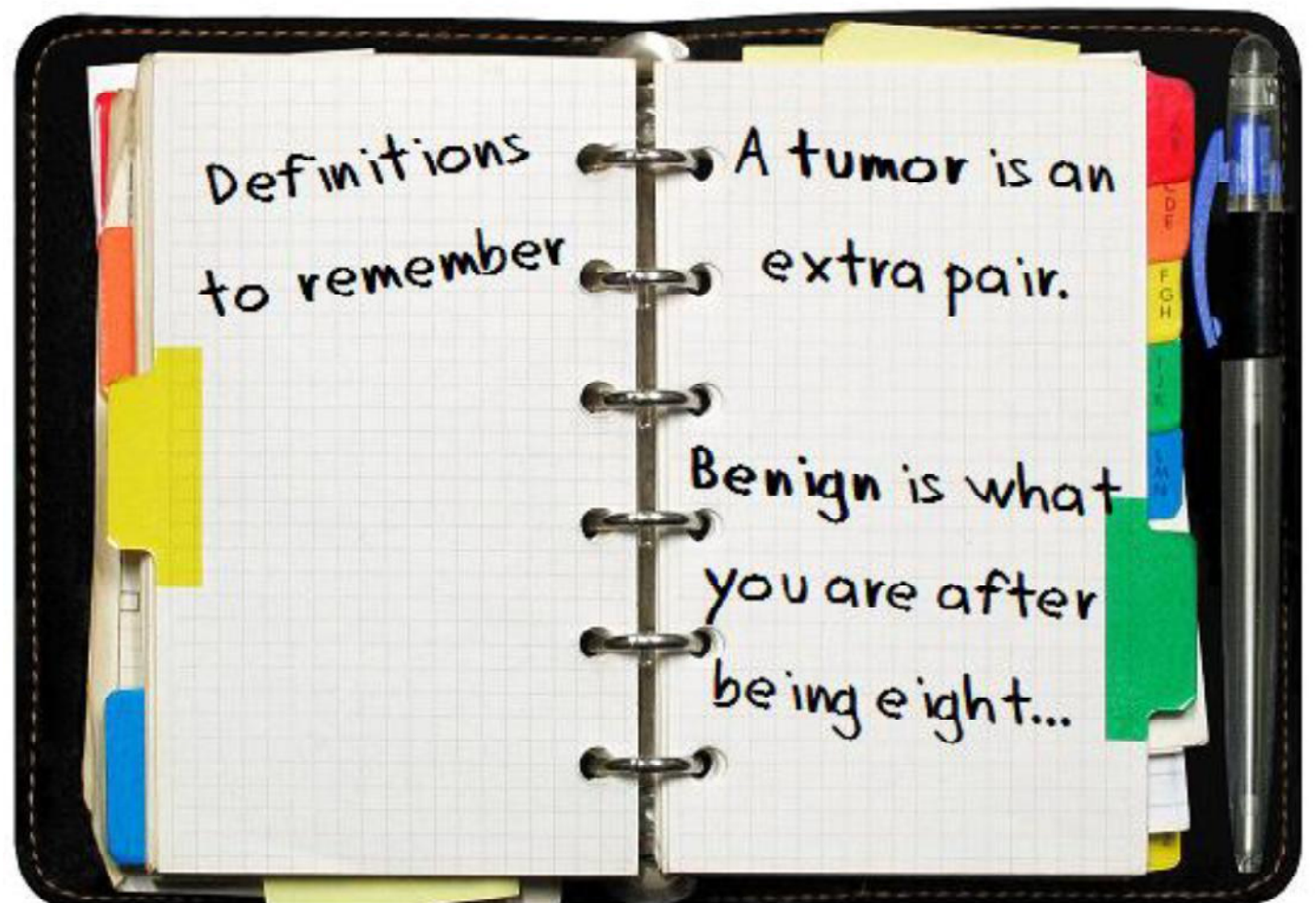
which is rich in water, warmth, and food. The reason why our body does not identify these organisms as potential threats and mobilize an immune response is unknown to researchers.

Although we can live without gut flora, they commonly assist our immune system a great deal. These "good" bacteria reduce the amount of harmful bacteria in the intestines by competing with them for nutrients, they break down large sugar compounds into smaller, more easily digestible simple sugars, and they can prevent against diarrhea which may occur after taking a series of antibiotics. Antibiotics typically kill not only bacteria which cause infection, but also the beneficial strains of bacteria as well. Foods such as yogurt are an excellent source of "good" bacteria such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. These are likely the "active and live cultures" that could be found within your homemade yogurt.

As the yogurt rests or "incubates" for 6-8 hours, live bacteria from the plain yogurt will begin to feed upon a sugar known as lactose within the milk and release lactic acid as a waste product. This acid causes the proteins within the milk powder to clump together, providing yogurt with a more firm consistency and a mildly sour taste. Due to the chemical changes taking place as the bacteria grow, any movement of the cooler may separate the coagulated protein from the water within the milk and form a bilayer which can ruin the generation of yogurt. This is why it is important not to disturb the containers during the incubation period.

Chapter 21

Fluid Transportation: What can go wrong?



Definitions
to remember

A tumor is an
extra pair.

Benign is what
you are after
being eight...

Day One:

Today, your child should complete their reading and practice problems for the week.

Below are the supplies for this week's lab:

4 packages (4oz/113g) plain gelatin
Four cups (946mL) cold water
Eight teaspoons (33.6g) sugar
Four beef bouillon cubes
*Ten foil muffin cups
*Muffin pans
Ten sealable sandwich bags
Sauce pan and stove

Aluminum foil
Measuring spoons
Permanent marker

*If muffin cups/tins are not available, you can use disposable plastic cups

National Science Education Standards covered this week:

12FSPSP1.2 The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease producing organism. Many diseases can be prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.

Definitions

ACE	complex molecule produced by the lungs which is responsible for narrowing the diameter of arterioles, allowing blood to flow faster
allergens	normally harmless substances encountered every day which may induce an allergic response
allergy	a reaction caused by the immune system against normally harmless substances encountered daily
aneurysm	rupture of the aorta of the heart or the large arteries within the brain
angina	extreme chest pain
arteriosclerosis	deposits of hardened calcium within the arteries
atherosclerosis	clogging of arteries by cholesterol deposits
benign tumors	cancerous cells which do not invade neighboring tissues or cells
cancer	the uncontrollable growth of individual cells within the body
cholesterol	type of fat; excess amounts within the blood can cause deposits to form within arteries which may lead to atherosclerosis
clotting factors	proteins which assist in the formation of fibrin from fibrinogen
coronary artery	one of two arteries which supply the heart with blood
heart attack	restriction of blood flow through either of the coronary arteries; immediate damage to the heart muscle begins without a supply of blood and oxygen
hemophilia	a genetic disorder in which the the formation of fibrin is slowed down considerably due to a decreased volume of clotting factors within the blood
hypertension	high blood pressure
lymphomas	malignant cancerous cells which spread to other areas of the body via the lymphatic system or blood stream

malignant tumor	a tumor that has invaded and caused trouble for nearby organs/tissues of the body
sickle cell anemia	inherited genetic disorder causing red blood cells to abnormally fold themselves into shapes resembling stiff crescent-shaped rods
tonsillectomy	procedure involving the removal of the tonsils due to infection
tumor	a mass of cancerous cells

Sample questions to ask your child after completing the weekly reading.

What happens to the heart rate when the body is experiencing a haemorrhage?

The body responds to a hemorrhage by increasing the heart rate in order to raise the decreasing blood pressure.

Narrowing the arterioles will induce what type of response with the blood pressure?

The narrowing of the arterioles will cause an increase in blood pressure.

What are the similarities and differences between atherosclerosis and arteriosclerosis?

Both of these conditions result in the clogging of an artery. Arteriosclerosis is caused by deposits of hardened calcium while atherosclerosis is caused by cholesterol (plaque).

What causes a cold and why is there no vaccine for this illness?

The cold can be caused by many different types of viruses. With so many different pathogens causing this disease, our immune system is incapable of building up a defense until well after the virus has entered the body and has begun to spread. And, because of the nature of viruses, most medications are ineffective at preventing their spread throughout the body.

Day Two:

Your child should check their work on the practice worksheets today with the answer key on the next page.

In addition, your child should read the lab activity and start collecting all of the necessary materials!

Answer Key for Practice Problems

Vocabulary Review

- | | |
|---------------------|------------------------|
| 1) cancer | 11) hemophilia |
| 2) aneurysm | 12) heart attack |
| 3) hypertension | 13) arteriosclerosis |
| 4) allergy | 14) angina |
| 5) atherosclerosis | 15) allergens |
| 6) clotting factors | 16) sickle cell anemia |
| 7) ACE | 17) lymphomas |
| 8) coronary artery | 18) tonsillectomy |
| 9) cholesterol | 19) tumor |
| 10) benign tumors | 20) malignant tumor |

True/False (with corrections):

- 1) **TRUE** - Benign cancers do not spread or invade neighboring tissues.
- 2) **FALSE** - An aneurysm in the brain will likely cause a stroke within a person.
- 3) **FALSE** - The severity of hemophilia depends upon the volume of clotting factor in the blood.
- 4) **TRUE** - The clogging of arteries by hardened calcium deposits is known as arteriosclerosis.
- 5) **TRUE** - Angina is one possible symptom for a person about to suffer a heart attack.
- 6) **FALSE** - Colds and flus are caused by viral infections.

7) **TRUE** - The body responds to a hemorrhage by increasing the heart rate in response to a lowered blood pressure.

Application Question

As the spleen enlarges, so does its ability to filter and store additional red blood cells. This results to fewer red blood cells in circulation, which is defined as anemia. Lowered levels of red blood cells decrease the body's ability to deliver oxygen to the tissues. This slows down the tissue's ability to produce energy (ATP) and results in the patient's feelings of exhaustion and lack of energy. In addition, without a normal amount of red blood cells circulating through the skin, the patient will have a paler complexion.

Day Three: Lab Activity

Your child should have already read through this lab and has been reviewing all of this week's vocabulary words.

Collect your supplies for the lab:

4 packages (4oz/113g) plain gelatin
Four cups (946mL) cold water
Eight teaspoons (33.6g) sugar
Four beef bouillon cubes
*Ten foil muffin cups
*Muffin pans
Ten sealable sandwich bags

Sauce pan and stove
Aluminum foil
Measuring spoons
Permanent marker

*If muffin cups are not available, you can use disposable plastic cups

Stowaways on our Phalanges or...

Somebody pass me the hand sanitizer...

Homemade nutrient media will be created to test for the presence of pathogens on the hand.

Materials:

4 packages (4oz/113g) plain gelatin

Four cups (946mL) cold water

Eight teaspoons (33.6g) sugar

Four beef bouillon cubes

*Ten foil muffin cups

*Muffin pans

Ten sealable sandwich bags

Sauce pan and stove

Aluminum foil

Measuring spoons

Permanent marker

*If muffin cups are not available, you can use disposable plastic cups

Procedure:

Part One:

- 1) Wash your hands very well before starting this activity!
- 2) Place the muffin cups in the muffin pans without touching the inside of any of the papers.
- 3) Mix together the gelatin, cold water, sugar, bouillon in a sauce pan and stir while slowly bringing the mixture to a boil.
- 4) Remove the pan from the heat and cover loosely with aluminum foil for 15 minutes.
- 5) Fill each muffin cups half full with the mixture and cover loosely with aluminum foil until the gelatin becomes firm. Be certain not to touch the inside of the tins.
- 6) Seal each of the cooled cups in a baggie and keep them in the refrigerator until you begin your lab. You will want to use this media within three days.

Part Two:

- 1) Label four of the baggies as "Water #1-4" and the remaining four as "Soap #1-4."
- 2) Without washing your hands, touch the surface of Water #1 with your fingers.
- 3) Wash your hands with water only. Shake off the excess water and touch the surface of Water #2 with your same fingers.
- 4) Do not dry your fingers with anything!
- 5) Wash your hands with water only once again. Shake off the excess water and touch the surface of Water #3 with your same fingers.
- 6) Wash with water one final time and again touch the surface of Water #4.
- 7) Immediately use your same fingers to touch the surface of Soap #1.
- 8) Wash your hands with soap and water. Again, do not dry your fingers with anything! Shake off the excess water and touch the surface of Soap #2 with your same fingers.
- 9) Wash your hands with soap and water once again. Shake off the excess water and touch the surface of Soap #3 with your same fingers.
- 10) Wash with soap and water one final time and again touch the surface of Soap #4.
- 11) Seal each of the cups within their baggies and carefully turn them upside down. Allow them to remain undisturbed for 48 hours at room temperature in a warm area. The top of a refrigerator or attic are good locations. The cups are inverted because you do not want any condensation to collect on the surface of the media.
- 12) Turn the cups over and observe the various growths of bacteria and fungi that have developed on the surface of the media.

Make certain to keep the baggies closed! You do not want to open the bags and breathe the air within the baggies!

- 13) Be sure to wash your hands after handling the bags, and throw them away when you are done.

Explanation:

Although the culture media you created in this activity will not grow visible "colonies" of the viruses which cause the common cold or flu, it is hopeful you will gain a stronger appreciation for the importance of handwashing in your daily health.

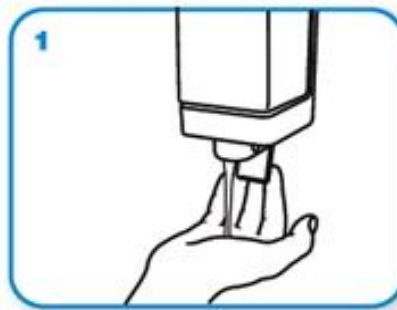
If you are interested in continuing this project, I would recommend using Q-Tips fresh out of their container to swab areas around your home. Don't forget doorknobs, keyboards, faucets, and handrails.

It is likely that the majority of the colonies you observed in your culture media were some form of fungus. Any fuzzy-looking, irregularly-shaped, dark-colored growths are likely colonies of fungi. Bacterial colonies tend to be small and circular in appearance. They may also appear in a variety of colors; or, they can be clear as well.

The following graphic from the World Health Organization (http://www.who.int/gpsc/clean_hands_protection/en/) demonstrates the proper handwashing technique to use to prevent the spread of microbes on your hands:



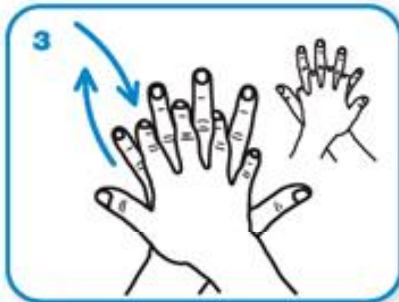
Wet hands with water



apply enough soap to cover all hand surfaces.



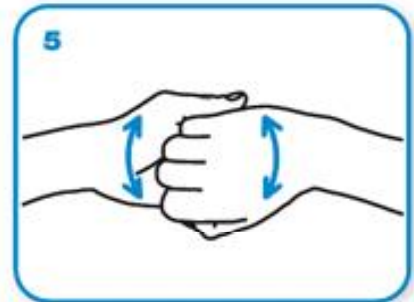
Rub hands palm to palm



right palm over left dorsum with interlaced fingers and vice versa



palm to palm with fingers interlaced



backs of fingers to opposing palms with fingers interlocked



rotational rubbing of left thumb clasped in right palm and vice versa



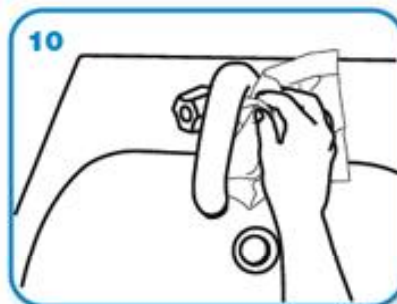
rotational rubbing, backwards and forwards with clasped fingers of right hand in left palm and vice versa.



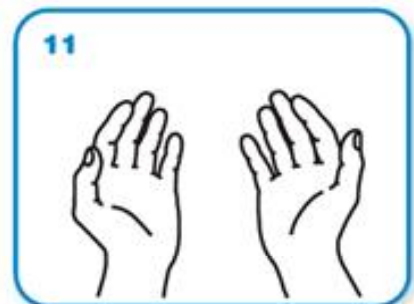
Rinse hands with water



dry thoroughly with a single use towel



use towel to turn off faucet

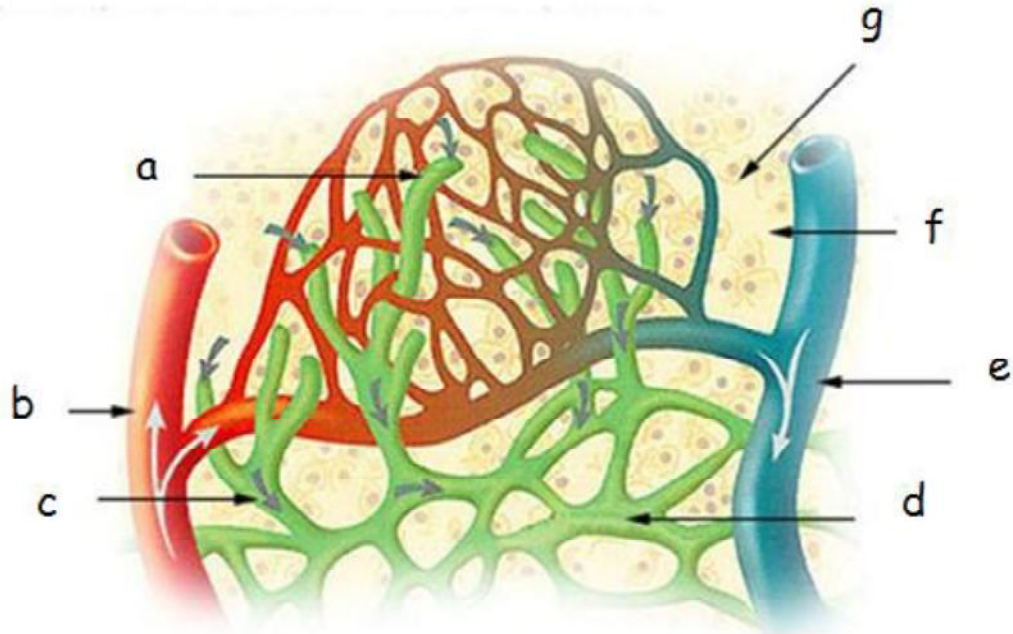


...and your hands are safe.

- 3) Endurance-trained athletes such as marathon runners often have a decreased heart rate compared to that of a nonathlete when both are resting. Explain why an endurance-trained athlete's heart rate decreases rather than increases.

4) Correctly identify the following structures within the following image. Use the words from the word bank below:

Lymph capillaries among interstitial space



WORD BANK: arteriole, lymphatic vessel, interstitial space, lymph capillary, path of lymph, tissue cells, venule

- a)
- b)
- c)
- d)
- e)
- f)
- g)

Unit Quiz Answer Key

- 1) That there is no immediate effect indicates there is a reservoir of T cells in the lymphatic tissue. As the reservoir is depleted through time, the number of lymphocytes decreases and the animal is more susceptible to infections. The ability to produce antibodies decreases because of the loss of helper T cells that are normally programmed to attack specific pathogens within the thymus before migrating to other lymphatic tissues.

- 2) Histamine can produce inflammation in response to an infection and help to create an environment that is unfavorable to pathogens; however, it cannot effectively remove the pathogen from the body. Therefore, antihistamine would not be able to reduce the effects of an infection. It would be more likely reduce the inflammation and other symptoms caused by the body's reaction to an allergen by reducing the symptoms of itchy eyes, sneezing, and mucus production.

- 3) Regular exercise increases the heart's ability to pump blood more efficiently throughout the body. Endurance-trained athletes have decreased heart rates because their hearts pump more blood with every beat. Therefore, an endurance-trained athlete doesn't have to work as hard when at rest to deliver the necessary volume of blood throughout the body.

- 4) Word match from picture:
 - a) lymph capillary
 - b) arteriole
 - c) path of lymph
 - d) lymphatic vessel
 - e) venule
 - f) interstitial space
 - g) tissue cells