STO-121

Keeping a Balance: Homeostasis and Negative Feedback

Part 1: Homeostasis and Negative Feedback

Organisms are continually exposed to changes in their external and internal environments. To be healthy, organisms must maintain **homeostasis**, a "dynamic equilibrium" or "steady state," which keeps their internal environment balanced within normal limits. Failure to maintain homeostasis may result in disease or death.

To maintain homeostasis, organisms use **negative feedback mechanisms** that detect changes from the **set point**, (the normal state) and trigger appropriate responses that return their body systems to the set point.

1. Use the information in the box above to write definitions for the following words:

   - Homeostasis

     _____

     _____

   - Negative feedback mechanism

     _____

     _____

   - Set point

     _____

     _____

2. Why are feedback mechanisms important?

   _____

   _____

3. The process of homeostasis is like driving a car at the speed limit (55 miles per hour).

   - What is the set point for driving a car?

     _____

   - If you detect that the speed of the car is above the set point, what response should you make?

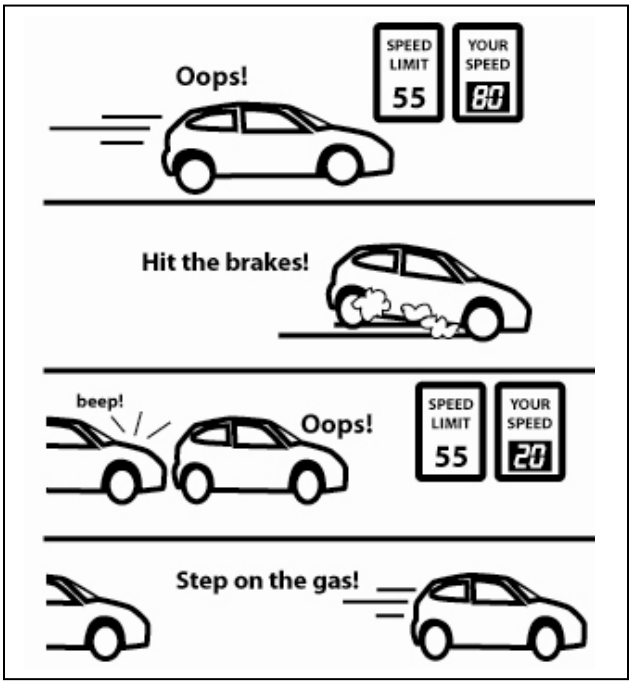
     _____

     _____

   - If you detect the speed of the car is below the set point, what response should you make?

     _____

     _____



4. Cut along the dotted lines on the blue *Regulating the Speed of a Car* cards in your lab kit.

5. Arrange the cards in the boxes on the *Negative Feedback Graphic Organizer* sheet to illustrate how negative feedback mechanisms can be used to drive within the speed limit.

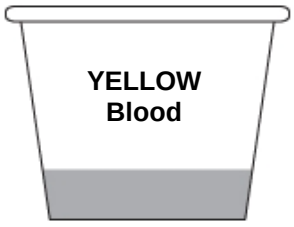
6. Record the arrangement of the cards in the table below:

Number on Graphic Organizer	1	2	3	4	5	6
Letter on Card						

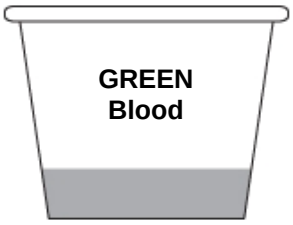
Part 2: Regulating Sugar Concentration in Cupples - a simulation

Cupples are adorable little creatures that spend their lives doing two things, eating and exercising. When Cupples eat, the concentration of sugar in their blood increases. When Cupples exercise, they use food for energy, and the concentration of sugar in their blood decreases.

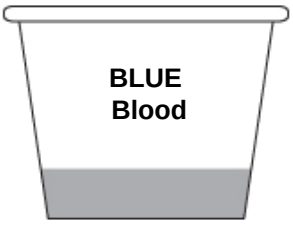
To maintain homeostasis, Cupples need to keep the concentration of sugar in their blood at a normal level. If they have the normal concentration of sugar in their blood, they will be green.



Unhealthy Cupple with **high** concentration of sugar in its blood.



Healthy Cupple with **normal** concentration of sugar in its blood.



Unhealthy Cupple with **low** concentration of sugar in its blood.

1. What color is Cupple blood when the concentration of sugar in its blood is at the set point (within the normal range of sugar concentration)?

   _____

2. What color is Cupple blood when the concentration of sugar in its blood is too low?

   _____

3. What color is Cupple blood when the concentration of sugar in its blood is too high?

   _____

4. How does eating affect the concentration of sugar in the blood of a Cupple?

   _____

   _____

5. How does exercising affect the concentration of sugar in the blood of a Cupple?

   _____

   _____

6. Pour the tube of green "Cupple Blood" into the little cup. This cup represents a healthy Cupple who has the normal concentration of sugar in its blood.

7. The Cupple is hungry. Feed the Cupple by using the labeled dropper to add 5 drops of "Sugar" to the cup. Gently swirl the contents of the cup to mix the "Sugar" with the Cupple blood.

   - What color change occurs when the Cupple eats?

     _____

   - What does this color change tell you about the concentration of sugar in the Cupple's blood?

     _____

   - What response (action) could the Cupple make to restore its blood sugar level to the set point (normal range)?

     _____

   - How would this action restore the Cupple's homeostasis?

     _____

     _____

8. Now the Cupple exercises. Simulate the effect of this exercise by adding 10 drops of "Exercise" to the cup. Gently swirl the contents of the cup to mix the "Exercise" with the Cupple blood.

   - What color change occurs when the Cupple exercises? _____

   - What does this color change tell you about the concentration of sugar in the Cupple's blood?

     _____

   - What response (action) could the Cupple make to restore its blood sugar level to the set point (normal range)?

     _____

   - How would this action restore the Cupple's homeostasis?

     _____

     _____

9. Whoops! As you can see, the Cupple exercised too much! To maintain homeostasis, the Cupple needs to eat the proper amount of sugar.

10. Count the number of drops of "Sugar" that you need to add to the cup to restore the proper sugar balance. Be sure to gently swirl the contents of the cup to mix the "Sugar" with the Cupple blood after each drop.

    - How many drops of "Sugar" were needed to restore homeostasis? _____

    - How did you know when you gave the Cupple enough "Sugar" to restore its homeostasis?

      _____

    - What would happen if you gave the Cupple too much "Sugar"?

      _____

11. To maintain homeostasis, Cupple use negative feedback mechanisms to detect changes from the set point (normal state), and trigger appropriate responses that return their systems to set point.

    - What color represents the set point (normal state) in this simulation?

      _____

    - What feedback response was needed to maintain homeostasis when the sugar concentration in Cupple blood went above the set point?

      _____

    - What feedback response was needed to maintain homeostasis when the sugar concentration in the blood went below the set point?

      _____

12. Cut along the dotted lines on the green *Regulating the Concentration of Sugar in Cupple Blood* cards in your lab kit.

13. Arrange the cards in the boxes on the *Negative Feedback Graphic Organizer* sheet to illustrate how negative feedback mechanisms can be used to keep the sugar concentration in a Cupple's blood within a normal range.

14. Record the arrangement of the cards in the table below:

Number on Graphic Organizer	1	2	3	4	5	6
Letter on Card						

Part 3: Negative Feedback and Body Temperature

Humans use negative feedback mechanisms to maintain homeostasis for many of their body systems. In this part of the lab, you will read about a human negative feedback mechanism that regulates body temperature. You will use the information to arrange cards on the *Negative Feedback Graphic Organizer* sheet.

Body Temperature Homeostasis

Body temperature is normally maintained at about 37°C (98.6°F). If your body temperature increases, receptors in the hypothalamus region of the brain detect the change and send signals to sweat glands causing perspiration (sweating). The hypothalamus signals also cause blood vessels in the skin to dilate (open) to increase blood flow to the body surface. These responses decrease body temperature.

If your body temperature decreases, receptors in the hypothalamus detect the change and send signals to muscles causing shivering which produces heat. The hypothalamus signals also cause blood vessels in the skin to constrict (close) to decrease blood flow to the body surface. These responses increase body temperature.

Too Hot	Too Cold
Blood Vessel Dilation: Blood vessels in skin enlarge to increase blood going to the skin and increase heat loss.	**Blood Vessel Constriction:** Blood vessels in the skin get smaller to reduce blood going to the skin and decrease heat loss.
Perspire: Sweat glands secrete sweat which removes heat when water evaporates.	**Shiver:** Rapid contraction and relaxation of skeletal muscles. Heat is produced by respiration. **"Goosebumps":** Hairs on skin stand up to insulate the body and trap heat.
Body Stretches Out: Increases the exposed body surface to release heat.	**Body Curls up:** Decreases the exposed body surface area to reduce heat loss.

1. Cut along the dotted lines on the pink *Regulating Body Temperature* sheet in your lab kit.

2. Arrange the cards in the boxes on the *Negative Feedback Graphic Organizer* sheet to illustrate how negative feedback mechanisms keep body temperature constant. Record the arrangement of the cards in the Data Table below:

Number on Graphic Organizer	1	2	3	4	5	6
Letter on Card						

3. What is the set point for body temperature? _____

4. If this negative feedback mechanism detects an increase in body temperature (above the set point), what response should be triggered to maintain homeostasis?

_____

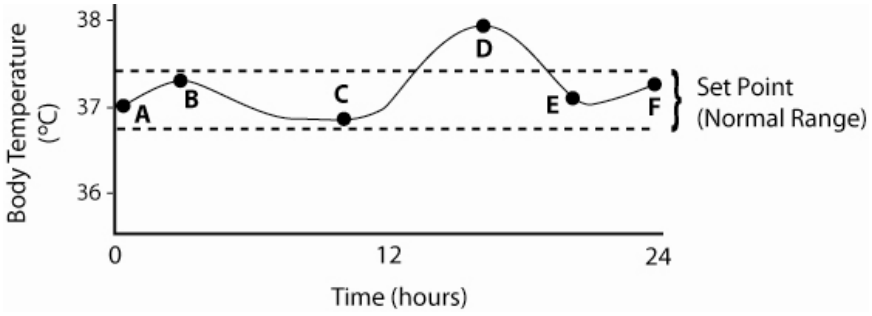
_____

5. If this negative feedback mechanism detects a decrease in body temperature (below the set point), what response should be triggered to maintain homeostasis?

_____

_____

The graph below shows evidence of disease in the human body. Base your answer to questions 6 and 7 on the information in the graph.



6. A disruption in homeostasis is indicated by temperature change between points
    1. A and B
    2. B and C
    3. C and D
    4. E and F

7. The action of a feedback mechanism is indicated by temperature change between points
    1. A and B
    2. B and C
    3. C and D
    4. D and E

Part 4: Negative Feedback and Blood Glucose

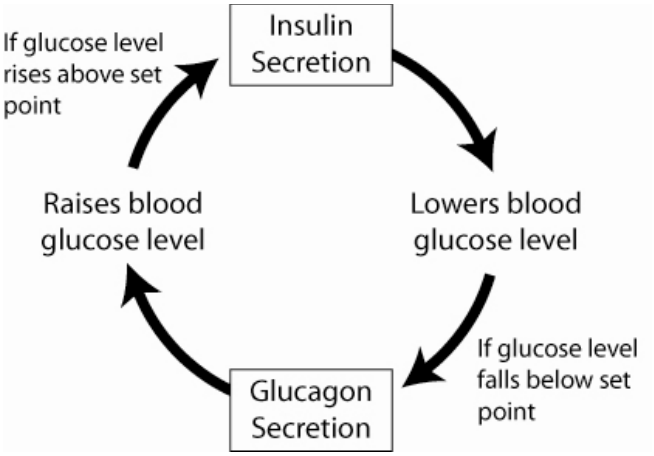
Humans use negative feedback mechanisms to maintain homeostasis for many of their body systems. In this part of the lab, you will read about a human negative feedback mechanism that regulates glucose (sugar) concentration in the blood. You will use this information to answer questions about how this feedback mechanism maintains homeostasis.

Blood Glucose Homeostasis

The concentration of glucose in the blood affects every cell in the body. Therefore, its concentration is strictly controlled within the range 80-100 mg of glucose per 100 ml of blood. Very low levels of blood glucose or very high levels of blood glucose are both serious conditions and can lead to death.

Blood glucose concentration is controlled by the pancreas. The pancreas has glucose receptor cells, which monitor the concentration of glucose in the blood, and it also has endocrine cells which secrete the hormones **insulin** and **glucagon**. These two hormones have opposite effects on blood glucose

Glucagon stimulates the release of stored glucose from the liver which increases blood glucose levels. Insulin stimulates the uptake of glucose by cells which decreases blood glucose levels.



After a meal, glucose is absorbed from the digestive tract and glucose concentration in blood increases. This increase is detected by the pancreas, which responds by secreting insulin. Insulin causes glucose to be taken up by the body cells. This reduces blood glucose, which causes the pancreas to stop secreting insulin.

If the glucose level decreases too much, the pancreas detects this change and responds by secreting the hormone glucagon. Glucagon causes the release of stored glucose from the liver. This increases blood glucose, which causes the pancreas to stop producing glucagon.

1. What is the set point (normal level) for blood glucose? _____

2. What organ detects above or below normal blood glucose concentrations? _____

3. If blood glucose levels are too high, what hormone will this organ secrete? _____

4. If blood glucose levels are too low, what hormone will this organ secrete? _____

5. How does insulin cause the blood glucose level to decrease?

   _____

   _____

6. How does glucagon cause the blood glucose level to increase?

   _____

   _____

7. People who have Type 1 Diabetes do not make enough insulin. What effect would this have on their blood glucose level?

   _____

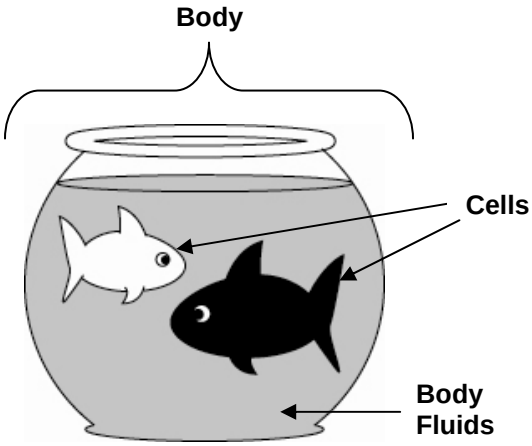
   _____

8. If their blood glucose level is too high, what two actions could people with diabetes take to maintain homeostasis?

   _____

   _____

Part 5: A Fishbowl Analogy for Homeostasis



Maintaining homeostasis in the body is similar to keeping conditions in a fishbowl balanced.

- The contents of a fishbowl represent a multicellular body. Fish represent the cells of a multicellular body.
- For fish to survive, the internal environment (fluids) in the fishbowl must be maintained to provide the proper temperature and the proper levels of nutrients, oxygen, carbon dioxide, and waste.
- Devices such as heaters/coolers, automatic feeders, air bubblers and filters can be used to maintain the proper internal environment.

Use the words from these lists of human body parts and functions to complete the Fishbowl Analogy Table below:

Human Body:
- Body fluid
- Digestive tract
- Kidneys
- Lungs
- Muscles
- Skin

Functions:
- Barrier
- Internal environment
- Maintain constant temperature
- Maintain food level
- Excrete nitrogen wastes
- Maintain oxygen
- Homeostasis

Fishbowl Analogy Table:

Fishbowl	Human Body	Functions
Fish	**Cells**	**Need to stay alive**
Glass bowl		
Water		
Air pump		
Filter		
Heater		
Feeder		
Everything working together		

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