

Negative Feedback, Homeostasis, and Positive Feedback – Examples and Concepts¹

Changes in Breathing

First, you will investigate how your breathing changes as you re-breathe the air in a plastic garbage bag.

1a. How do you think your breathing will change as you re-breathe the air in the bag for several minutes?

1b. Explain your reasoning.



Procedure

- A.** If you have asthma or some other breathing difficulty, check with your teacher about whether or not you should breathe into a bag. Each person whose health permits should complete steps B and C while other group members observe.
- B.** To prepare to breathe into your 8-gallon plastic garbage bag, open the bag completely and swish it through the air until the bag is nearly full of air. Then, gather the top of the bag in both hands. Open a small hole in the center just big enough to surround your nose and mouth. Hold this opening tightly over your nose and mouth.
- C.** Breathe into your bag for 4 minutes (or as long as you can). Breathe as normally as you can.
- D.** Notice any changes in breathing rate (number of breaths per minute) and volume of each breath (the amount of air taken in with each breath).

If you are observing another member of your group, watch how a crease in the bag changes as the person breathes in and out. This will help you to notice any changes in breathing rate and/or volume of each breath. Record your observations in question 2.

Results and Analysis

2a. Describe how your breathing changed as you re-breathed the air in the bag for several minutes. Include any changes in breathing rate and/or volume of each breath.

2b. Describe how breathing changed for each of the other subjects in your group.

Subject Name	Changes in Breathing Rate and/or Volume of Each Breath

3a. Summarize the overall pattern of changes in breathing rate and volume of each breath.

3b. What do you think caused these changes in breathing?

¹ By Drs. Ingrid Waldron, Lori Spindler and Jennifer Doherty, Dept Biology, Univ Pennsylvania, © 2023. Teachers are encouraged to copy this Student Handout for classroom use. This Student Handout and Teacher Preparation Notes with background information, instructional suggestions, and information to guide optional student investigations are available at https://serendipstudio.org/sci_edu/waldron/#breath.

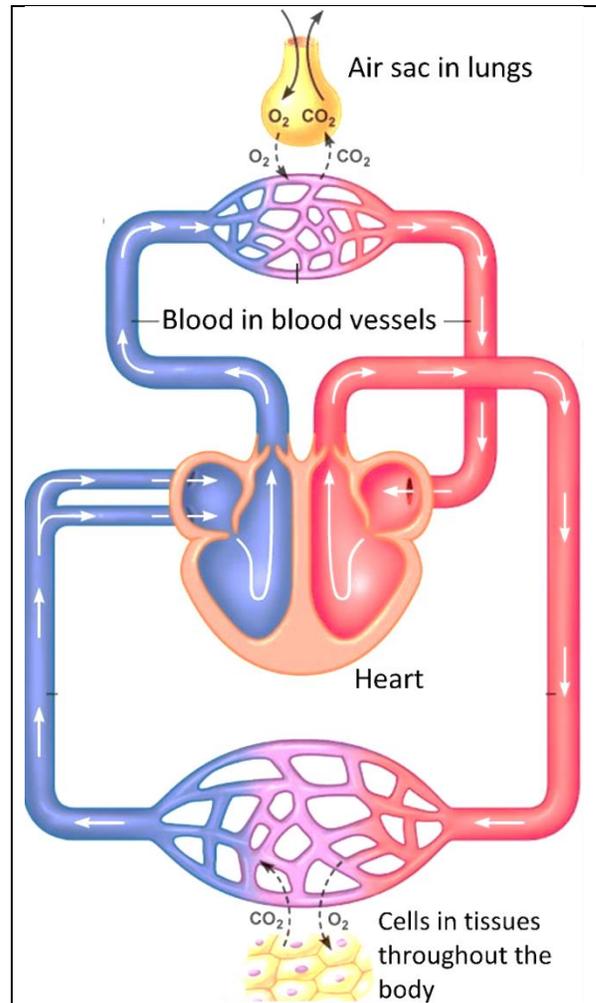
Questions 4-8 will help you understand the reasons for the changes in breathing you have observed.

4. The statements below describe how O_2 moves from the air in your lungs to the cells in your body. Write the letter of each statement next to the part of the figure which the statement describes.

- a. In your lungs there are millions of tiny air sacs, each surrounded by many tiny blood vessels. O_2 diffuses from the air in the air sacs to the blood in the surrounding tiny blood vessels.
- b. Your blood carries O_2 from your lungs to your heart.
- c. Your heart pumps your O_2 -carrying blood throughout your body.
- d. Your O_2 -carrying blood flows through tiny blood vessels near every cell in your body.
- e. O_2 diffuses from your blood into your cells.

5a. Draw a long arrow that shows how the CO_2 produced by your body's cells gets to the air sacs in your lungs.

5b. How is the CO_2 in the air sacs in your lungs removed from your body?



6a. Compared to the air you breathe in, the air you breathe out has _____ CO_2 .
(less / more)

6b. Compared to the air you breathe in, the air you breathe out has _____ O_2 .
(less / more)

7. As you re-breathed the air in the bag over and over again:

- what happened to the level of CO_2 in the air in the bag? decreased ___ increased ___
- what happened to the level of O_2 in the air in the bag? decreased ___ increased ___

8a. If there were no change in your breathing rate or the volume of each breath while you re-breathed the air in the bag over and over again:

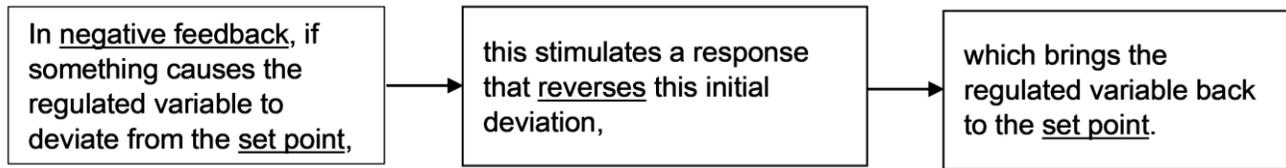
- what would happen to the levels of CO_2 in your blood? decrease ___ increase ___
- what would happen to the levels of O_2 in your blood? decrease ___ increase ___

8b. How could you bring more O_2 into your lungs?

8c. As your group members re-breathed the air in the bag, did the changes in breathing help to prevent decreases in blood levels of O_2 ? Explain.

8d. Did the changes in breathing help to prevent excessive accumulation of CO_2 ?

When you were re-breathing the air in the bag, your breathing changed to maintain high enough blood levels of O₂ and prevent excessive accumulation of CO₂. This is an example of **negative feedback**, which is defined in this flowchart.



9. Complete this flowchart to describe how negative feedback keeps blood levels of O₂ and CO₂ in an optimum range – not too high and not too low.



10a. Why is it useful to have negative feedback regulation of blood levels of O₂?

10b. Why is it useful to have negative feedback regulation of blood levels of CO₂?

11. When you are running, how does your breathing change?

Questions 12-13 will help you to understand why your breathing changes when you are running.

12a. Mark the glucose molecule in the chart with an asterisk (*).

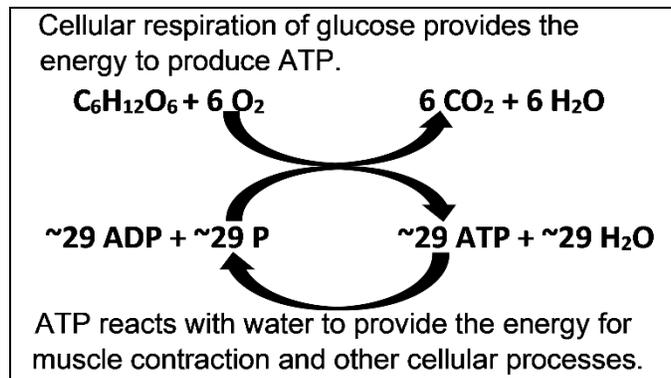
12b. Circle the molecule in the chart that you need to breathe in.

12c. Draw a rectangle around the molecule that you need to breathe out.

12d. Draw a line around the process that produces ATP.

13a. Why do you use more ATP when you are running?

13b. Why do you need to breathe faster and deeper when you are running?



Negative Feedback Regulation of Body Temperature

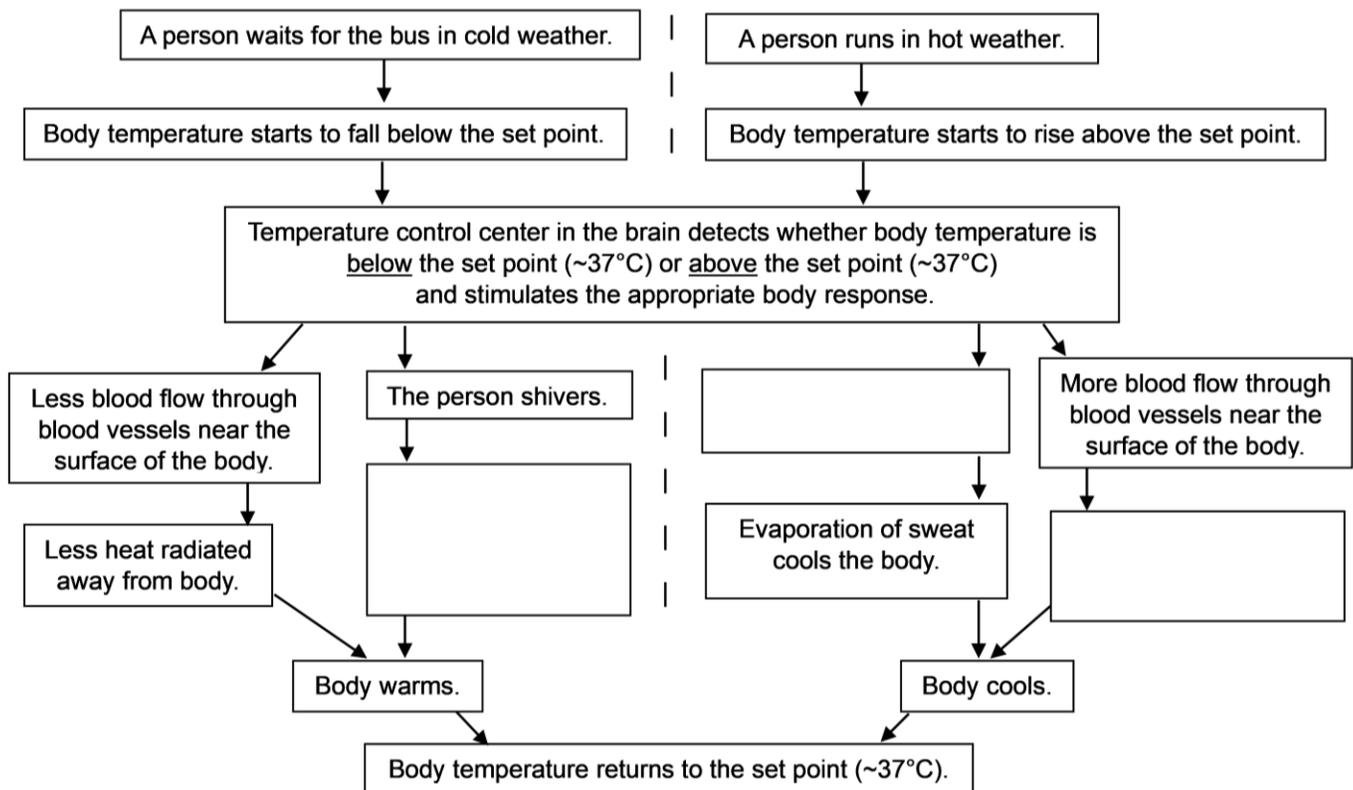
Negative feedback also maintains body temperature within an optimum range, even when the external environment gets colder or hotter.

14a. What could go wrong if your body temperature got too low?

14b. What could go wrong if your body temperature got too high?

Part of your brain functions as a temperature control center. Usually, the set point for body temperature regulation is approximately 37°C ($\sim 37^{\circ}\text{C} = \sim 98.6^{\circ}\text{F}$). If your body temperature starts to fall below $\sim 37^{\circ}\text{C}$ or increase above $\sim 37^{\circ}\text{C}$, then the temperature control center triggers responses that bring your body temperature back to the set point ($\sim 37^{\circ}\text{C}$).

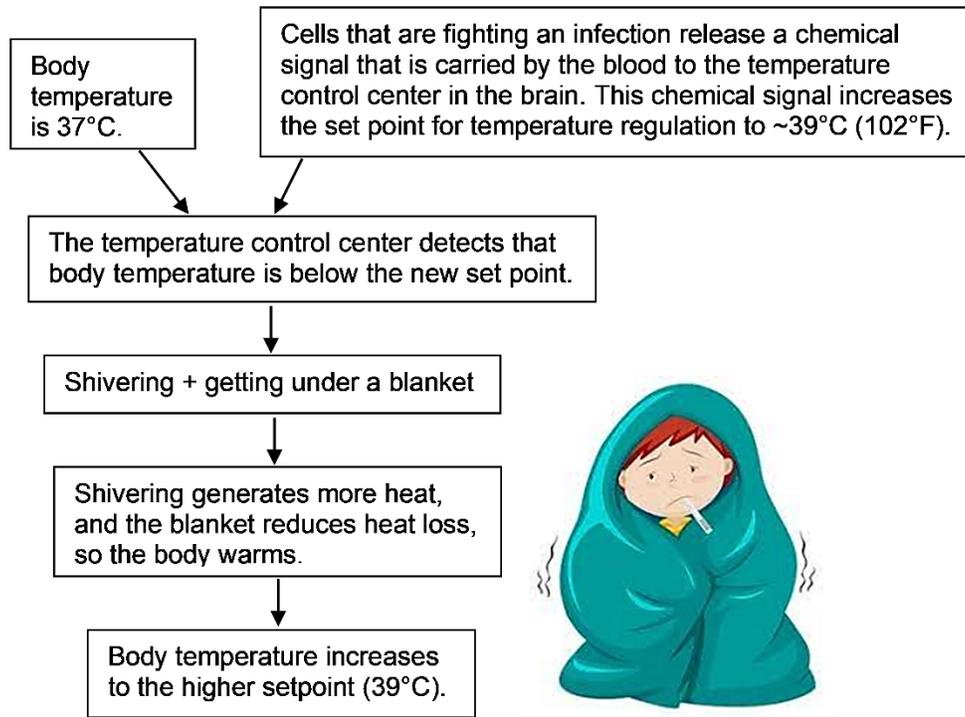
15. Complete this flowchart to show how a person's temperature control center keeps body temperature close to 37°C .



Thus far, you have seen that your body maintains a relatively constant body temperature and your body maintains relatively constant levels of CO_2 and O_2 in your blood. Your body also keeps other internal conditions in an optimum range. This maintenance of relatively constant internal conditions is called **homeostasis**.

16. Explain how negative feedback contributes to homeostasis.

Homeostasis and negative feedback do *not* mean that body temperature is always constant. For example, when you have an infection, your body temperature may increase and you may develop a fever. The fever helps your immune system fight the infection. This flowchart shows how a person who has an infection develops a fever.



17. Notice that the person described in this flowchart is shivering, even though his body temperature is at the normal set point (37°C). Explain why he is shivering.

Diabetes – A Failure of Negative Feedback Regulation of Blood Glucose Levels

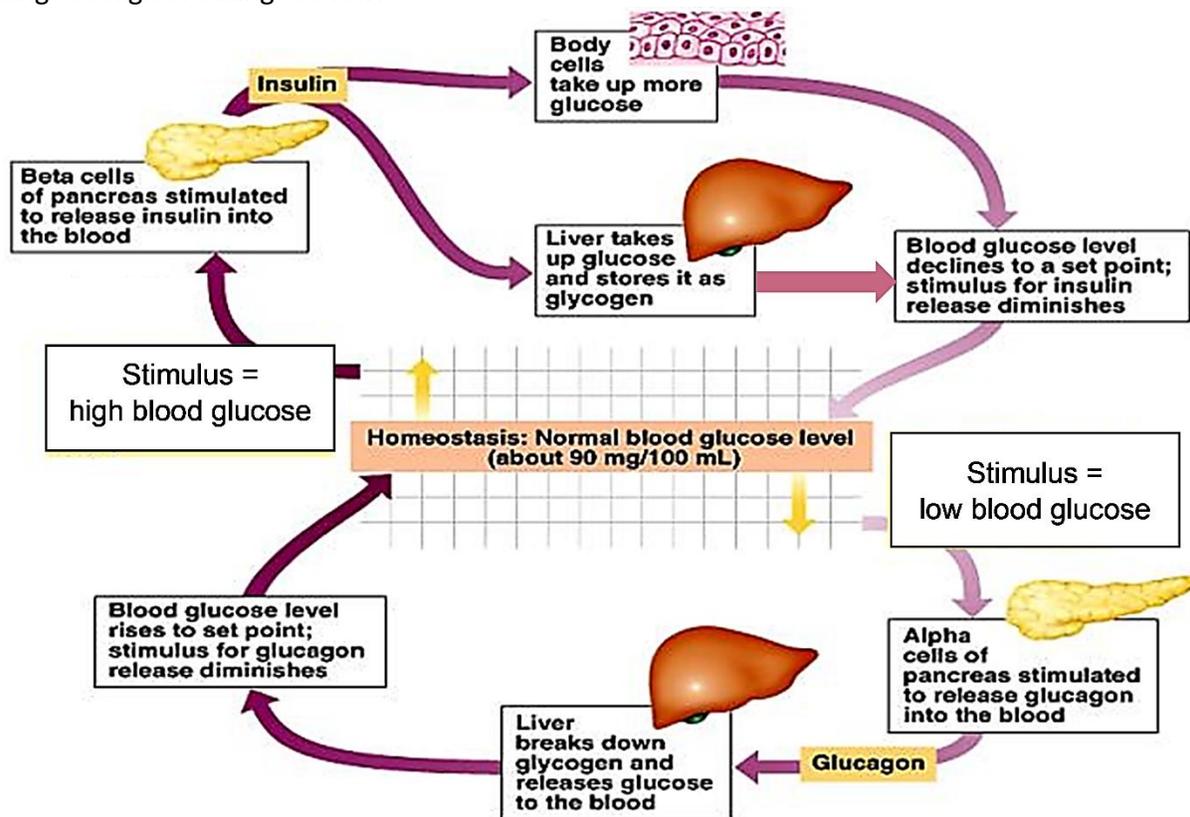
When negative feedback doesn't work correctly, this can result in illness. For example, defects in negative feedback regulation of blood glucose levels can result in diabetes. In a person with diabetes, too much glucose in the blood injures blood vessels and nerves, which can cause heart disease, kidney disease, stroke, and/or blindness.

18. What problems could result if a person's blood glucose levels get too low, so the person's cells do not get enough glucose?

19a. After a meal, would you expect blood glucose levels to decrease ___ or increase ___?

19b. Explain your reasoning.

This figure shows normal negative feedback regulation that prevents blood glucose levels from rising too high or falling too low.



20a. When blood glucose levels are high, excess glucose is stored in glycogen, which is a polymer of glucose. Write polymer next to glycogen in the figure.

20b. Insulin and glucagon are hormones, which are chemical messengers that travel in the blood. Write hormone next to insulin and glucagon in the figure.

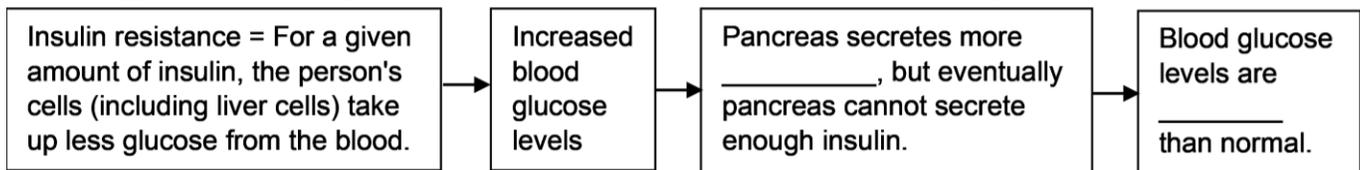
21a. After a person eats a meal, glucose is absorbed from the gut into the blood. Describe the physiological responses that prevent an excessive rise in blood glucose levels after a meal.

21b. When a person has not eaten for a long time, what physiological responses help to prevent blood glucose levels from falling too low?

22a. In a person with type 1 diabetes, the pancreas can't secrete insulin. Which effect would the lack of insulin have? higher than normal blood glucose levels ___ lower than normal ___

22b. Explain your reasoning.

23. Type 2 diabetes begins with insulin resistance (defined in this flowchart). Fill in the blanks.



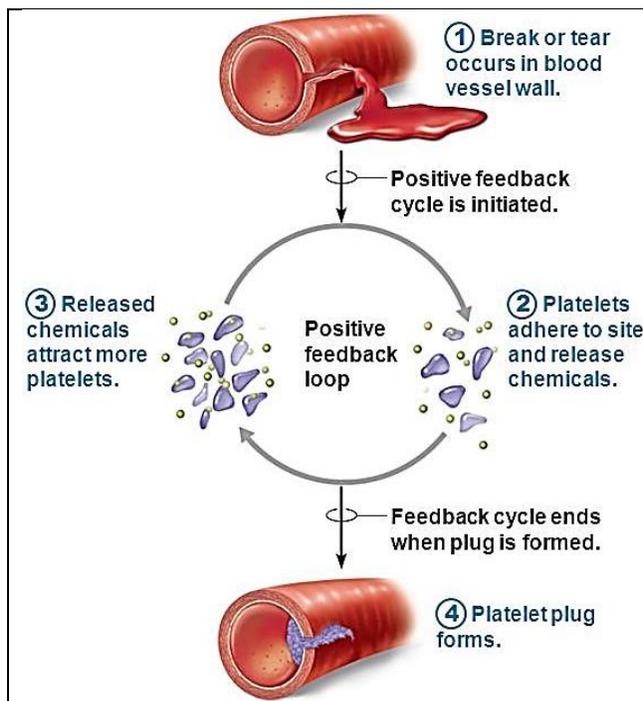
Positive feedback produces rapid change.

In **positive feedback**, an initial change stimulates more change in the same direction. Thus, positive feedback amplifies an initial change. The result is rapid change.

For example, this figure shows how positive feedback contributes to the rapid formation of a platelet plug when a blood vessel has been injured.

- Blood contains platelets, which stick to injured blood vessel tissue.
- When platelets stick to injured tissue, they begin to secrete chemical signals that attract more platelets.
- Many platelets accumulate quickly and plug the hole in the injured blood vessel.

24. Explain how positive feedback helps to prevent excessive blood loss after a blood vessel has been injured.



25. In many ways, positive feedback is the opposite of negative feedback. To illustrate this, fill in each blank in the table below. (Hint: See above and page 3.)

Positive Feedback	Negative Feedback
An initial change stimulates more change in the _____ direction.	An initial change away from the set point stimulates a response that _____ the initial change.
Positive feedback results in _____.	Negative feedback keeps a regulated variable (e.g., body temperature) _____.

26a. If you are cold, shivering can increase your body temperature. Is shivering part of positive feedback ___ or negative feedback ___?

26b. Explain your reasoning.

27. Explain why positive feedback and negative feedback are appropriate names for these two different types of feedback.