Lesson Summary: Human sensory systems are highly adaptable. This activity demonstrates the process of sensory adaptation. Students investigate how the perception of temperature changes under three separate conditions. They also relate the process of sensory adaptation to homeostasis.

Grade Level 9-12

Lesson Length
1 class period

Alignment with Minnesota Science Standards

- Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review. Benchmark codes: 9.1.1.1.1 & 9.1.1.1.4
- Scientific inquiry uses multiple interrelated processes to investigate and explain the natural world. Benchmark codes: 9.1.1.2.1, 9.1.1.2.2, & 9.1.1.2.3
- Natural and designed systems are made up of components that act within a system and interact with other systems. Benchmark codes: 9.1.3.1.3
- Science, technology, engineering and mathematics rely on each other to enhance knowledge and understanding. Benchmark codes: 9.1.3.4.2, 9.1.3.4.3, & 9.1.3.4.4
- Organisms use the interaction of cellular processes as well as tissues and organ systems to maintain homeostasis. Benchmark codes: 9.4.1.1.1 & 9.4.1.1.2
- Cells and cell structures have specific functions that allow an organism to grow, survive, and reproduce. Benchmark codes: 9.4.1.2.2, 9.4.1.2.4, & 9.4.1.2.5

Objectives—Students will be able to

- Describe important pathways in the peripheral nervous system for thermal sensation
- Describe the neural process of sensory adaptation
- Collect and interpret data

Assessment Options

- Explain how the sensations of the external environment can change over time
- Provide an example of how information travels from the skin in the peripheral nervous system to the central nervous system

Teacher's Notes

See the document titled **How to Build the This Is Cool Experiential Station** on the BrainU website at http://www.brainu.org/files/es_thiscool_howto.pdf for more instructions.

Materials

- 1 cup/container marked **HOT** and filled with hot water
- 1 cup/container marked **ROOM TEMPERATURE** and filled with room-temperature water
- 1 cup/container marked **COLD** and filled with cold water

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Procedures

Engage - Part I: Experiment

1. Place one finger in the middle [**ROOM TEMPERATURE**] container and leave in the water for 15 seconds.
2. Place the finger from the middle container into the container with cooler [**COLD**] water. How does that finger feel? Warmer or colder?
3. Move the finger from cooler water into the middle container; wait 30 seconds. How does that finger feel? Does it change over the course of 30 seconds? Does it feel warmer or colder than it did originally?
4. Move the finger from the middle container into the warmer [**HOT**] water. How does that finger feel? Warmer or colder?

Engage - Part I expanded: Optional Procedures

Work in teams of two and have one team member document the observations of the other team member running the trial.

Try the experiment moving in different orders between the cups. Try hot to room temperature to cold, or even cold to hot or hot to cold. Document changes in differences in how the temperature feels for each experimental variation.

Use written observations to construct lab worksheets or write a lab report.

Explore - Questions

1. If you walked into a 72° F room from outdoors when the temperature outside was 90° F, how would it feel? Why?
2. If you walked into a 72° F room from outdoors when the temperature outside was -20° F (below zero), how would it feel? Why?
3. What does this tell you about the nerves that are responsible for detecting heat or cold?
4. Can you think of a way to activate these nerves without using extreme temperatures? (Hint, think about things that you can eat.)

Engage - Part 2: Your Own Test

You have a friend that can build any device you want. Brainstorm with your group and briefly describe a device that could test this phenomenon more accurately. Make a list of things you need to consider before testing. Try to be as complete as possible. How does your device relate to brain function?

Want more information? See the graphic which shows sensory pathways from the skin to the brain

at http://www.rci.rutgers.edu/~uzwiak/AnatPhys/ChemicalSomaticSenses_files/image026.jpg

Use the following keywords to search for more information on this subject. Include one of these terms when you describe the experiment:

- primary sensory cortex
- cortical homunculus
- thermoreceptor
- brain topographic map

Background Material

Visit the glossary on the BrainU website at http://brainu.org/glossary-neuroscience-terms for definitions of terms used in this and other lessons.

Question 1. How is temperature sensed in the skin though thermoreceptors?

Human skin is full of different receptors that sense heat, cold, pressure, pain, etc. See http://faculty.washington.edu/chudler/receptor.html for some information on skin receptors.

Within the dermis of the skin, free nerve endings that are responsible for the sensation of non-painful warmth or cold are called thermoreceptors. Thermoreceptors have ion channels that change the voltage across the nerves in relation to temperature. Nerves fire action potentials in response to either warmth or cold which gives two types of thermometers: those that detect warmth and those that detect cold.

Warmth receptors respond to warming which results in an increase in the rate of action potential generation in the corresponding sensory nerve. Nerve fibers with warmth receptors begin firing at ~30°C, show maximum firing rate at ~ 40°C, and stop firing at ~ 45°C. Cold fibers show a maximum firing rate at ~ 32°C and cease firing at 38°C. Cold receptors start firing again at 45°C and have a second peak at 48°C. This is called *paradoxical heat* and explains why hot tap water can “feel” cold.

Warmth and cold receptors show differences in their resonance to temperature. In nerves with warmth receptors, the firing rate signals how warm the skin is. In contrast, in nerves with cold receptors, the pattern of action potentials changes with how fast temperature changes across the skin.

Question 2. How does thermosensation keep us alive?

The main function of thermosensation is to help our bodies to maintain homeostatic balance.

Homeostasis literally means “same state” and it refers to the process of keeping the internal body environment in a steady state when the external environment is changed.

One of the most important examples of homeostasis is the regulation of body temperature which is controlled by the specific areas in the hypothalamus that receive information from thermoreceptors in the skin and in some of the major blood vessels.

If the outside air is too cold, the body will act to keep heat in. Such actions include reducing blood flow to the skin surface, getting goose bumps, shivering, and prompting behaviors such as putting on a coat. Conversely, if the outside air is warm, the body will work to release heat by dilating blood vessels near the skin, sweating, and slowing down physical movement.