American Museum of Natural History

Educator's Guide

Are these rows straight or tilted?

OUR SENSES

AN IMMERSIVE EXPERIENCE

amnh.org/our-senses-educators

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ESSENTIAL QUESTIONS

What are senses?

Senses are biological systems that we use to gain information about the world around us and our own physical condition. Every sight, sound, scent, and taste is detected by specialized **sense organs** that send signals through the **nervous system** to the **brain**. The brain decodes these signals and converts them into conscious **perceptions**.

Many people think we only have five senses, but in fact we have many more. The five best-known senses enable us to gather information about our surroundings:

- **Vision:** We see when cells at the back of our eyes detect light waves reflected from objects. These cells react to brightness, shadow, and the wavelength—or color—of the light. Then they transmit signals to the brain, which interprets the information and forms an image.
- **Hearing:** Sound waves travel through the air and are transformed into vibrations in our ears. These vibrations trigger nerve cells in the inner ear to send signals to the brain. Human ears evolved to detect only certain frequencies, so there are many sounds we cannot hear.
- **Touch:** Touch is not just one sense. Our skin contains specialized nerve endings that detect different sensations, including temperature, pressure, and texture. The brain puts together information from all of these sensations to create a unified perception of touch.
- **Smell & Taste:** The human nose has about 400 kinds of receptors that detect different scent molecules. Many aromas do not come from a single molecule, but instead from a complex combination of molecules. When we eat, odor molecules drift from the throat to the back of the nose. There, they stimulate the same receptors that send signals to the brain to help us smell, but we experience the sensation as flavor.

In addition to these senses that detect features of our environment, we also have senses that monitor the body. They send messages to the brain about balance, hunger, thirst, body temperature, breathing, and more. For example:

- **Balance:** Like hearing, balance is detected in the inner ear. A small organ called the vestibular system detects where we are in three-dimensional space, and transmits signals to the brain about the orientation of the body.

How does the human brain use sensory information to understand the world?

All of our senses are continuously gathering information and sending it to the brain. It is up to the brain to interpret and integrate that information by:

- **Selecting:** We can't possibly pay attention to all the sensory information we encounter. The brain must determine what is most important. Humans tend to notice faces and movement, because focusing on those helped our ancestors survive. Memories and expectations also influence what grabs our attention.
- **Correcting:** When sensory information is incomplete, or inconclusive, the brain figures out the most likely interpretation. It fills in gaps in information, corrects errors, adjusts for lighting, and resolves conflicts.

What we perceive also depends on our cultural and personal experiences. For example, the scent of a particular perfume might trigger memories and associations in one person that are very different from what that scent triggers in someone else.

How do senses differ among different animals, and why?

The sensory organs and brain structures of various animals differ significantly. Each species has evolved in response to its environment to sense different information. Therefore, individual species can detect only a portion of what's out there. For example, humans can see only certain wavelengths—the slice of the electromagnetic spectrum known as **visible light**. Some animals can see more wavelengths, others fewer.

In addition, many species can sense information in the environment that humans cannot detect at all. All animals create small electric fields. Some creatures, like sharks, can sense these faint electric fields, which helps them locate prey. There are also species, such as migrating birds, that can sense Earth's magnetic field, allowing them to navigate over long distances.

Many *Heliconius* butterflies evolved to look like another species. That's why the three butterflies in the top image appear to be identical. But the *Heliconius* butterflies have ultraviolet marks. That is how they recognize their own kind when it is time to mate. These marks are revealed in the bottom image.

How do humans study and extend the ability to sense and perceive?

Through technology, such as microscopes and telescopes, humans can obtain information that we cannot detect with our biological senses alone. In addition, we use technology to enhance and interpret what we perceive. Powerful computers allow us to process and visualize large quantities of data, expanding our ability to see the patterns and forces that shape our world.

MAP OF THE EXHIBITION

Our Senses: An Immersive Experience explores the relationship between our senses and perception, and reveals how the brain actively constructs our perception of reality.

The exhibition contains two main types of rooms:

EXPERIENCE ROOMS

Immersive sensory simulations in each room demonstrate a fundamental aspect of a specific sense. Each room includes a "How Does It Work?" section that explains the biology behind that sense.

EXPLORATION ROOMS

In these rooms, activity stations demonstrate the role of the brain in processing sensory information to construct our perception of the world.

1. Introduction
- 1a. Art Installation

2. Seeing
- 2a. Vision experience
- 2b. "How Does It Work?" interactive

3. Detecting
- 3a. Vision section
- 3b. Sounds section
- 3c. Electromagnetic fields section

4. Hearing
- 4a. Hearing sounds
- 4b. "How Does It Work?" interactive

5. Selecting
- 5a. Brain comparison interactive
- 5b. Attention-focusing stations

6. Balance
- 6a. Wavy room
- 6b. "How Does It Work?" interactive

7. Correcting
- 7a. Perception stations
- 7b. Cultural objects

8. Touch
- 8a. Touch stations and "How It Works" models

9. Smelling
- 9a. Scent interactives
- 9b. "How Does It Work?" interactive

10. Live Presentation

11. Extending Our Senses
- 11a. Wall graphics
- 11b. Table interactive

TEACHING IN THE EXHIBITION

1. Introduction

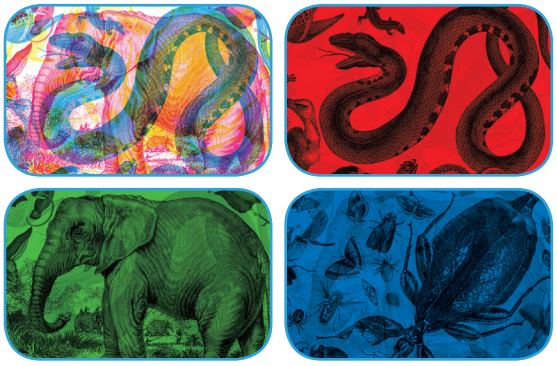
1a. Art Installation: As students enter the gallery, they will see a structure that initially looks like a jumble of disconnected objects. But as students proceed, the objects appear to cohere into a single image.

This structure illustrates the central message of the exhibition: our sense organs detect fragments of information in the world and the brain pieces them together to create a unified, coherent perception.

2. Seeing — EXPERIENCE ROOM

When light interacts with objects and enters our eyes, we see our surroundings.

2a. Vision experience: When we look at an object, what we see depends on how the surface of the object interacts with light. Some images shown here absorb red light. Others absorb blue or green. As the light changes, students will see only the images that absorb that color. Students can shine a flashlight on the wall to see all the images at once. This works because the white light from the flashlight is a mixture of all colors. The white walls reflect it all, while the images reflect certain colors in the mix.



Clockwise from top-left: the same picture seen under white light, red light, blue light, and green light

2b. "How Does it Work?" interactive: Our eyes detect color using light-sensing cells called cones. Students can explore how cone cells respond to different colors.

3. Detecting — EXPERIENCE ROOM

There's no one "right" way to see the world. In this room are several examples of sensory differences among species.

3a. Vision section: Humans can only see a small slice of the electromagnetic spectrum. Through interactives that investigate how snakes, bees, and butterflies see, students can explore wavelengths too long or short to trigger a response in the human eye.

3b. Sounds section: Just as species differ in how they see the world, they also differ in how they experience sound. Each species detects a different range of sound frequencies. Here, students can turn a dial to slow down or speed up otherwise inaudible sounds and bring them into human hearing range.

3c. Electromagnetic fields section: Some creatures sense phenomena that humans cannot detect at all, such as the faint electric fields that all animals produce. Students can use a simulated platypus bill to detect hidden prey by sensing their electric fields.

4. Hearing — EXPERIENCE ROOM

Sound waves are transformed into vibrations in our ears. Triggered by these vibrations, nerve cells in the inner ear send signals to the brain. However, what we perceive depends in part on what we focus on.

4a. Hearing sounds: We can *hear* many sounds at once, but we can only *listen* to one or two sounds at a time. As students move through different sound environments, they will be prompted to focus their attention on specific sounds, such as one person's voice or a particular musical instrument.

4b. "How Does it Work?" interactive: Students can press buttons to produce several tones and observe how these tones activate hair cells in different parts of the inner ear.

5. Selecting — EXPLORATION ROOM

Our senses are always detecting and reporting information to the brain, but we can only consciously perceive a small subset of that information. Many factors determine what the brain focuses on.

5a. Brain comparison interactive: Different species' brains prioritize different senses. Students can manipulate 3-D animations of a dolphin brain, a coyote brain, and a human brain to see the neural pathways in each species' brain that are devoted to processing a particular sense.

5b. Attention-focusing stations: At these stations, students can explore factors that determine what types of sensory information the human brain prioritizes.

- **Cheshire cat illusion:** This interactive reveals that when we are faced with competing images, the brain prioritizes certain types of visual information, including movement and faces.
- **Eye-movement tracking graphics:** These graphics show how people's eyes move over an image. The marks reveal which elements of a painting people tend to focus on.
- **Inattention blindness video:** This challenge illustrates how the brain tends to focus on one thing at a time, tuning out other information.
- **Priming:** An image that can be seen in two ways shows that what we perceive depends not just on what is visible, but also on prior sensory experiences.

6. Balance — EXPERIENCE ROOM

Organs in the inner ear govern balance, orientation, and movement. However, our ability to balance also involves integrating other senses, including sight.

6a. Wavy room: The walls and floors of this room are painted with black-and-white waves to make it appear distorted. Students are challenged to keep their sense of balance as they experience how the brain deals with conflicting information: the floor may not look flat, but it feels flat.

Note: If you or your students feel physically uncomfortable in this room, please use the bypass to the left of the entrance.

6b. "How Does it Work?" interactive: Students can tilt model heads that demonstrate how the vestibular, or balance, system works.

7. Correcting — EXPLORATION ROOM

What we perceive is generated by the brain. The brain receives information from the outside world and actively creates what we experience.

7a. Perception stations: At these stations, students can explore the behind-the-scenes work that the brain does to form a coherent perception.

- **Inverted masks:** This activity demonstrates how the brain overrules our senses based on what it already knows and expects to see.
- **Wall of gray squares:** This interactive shows how the brain compensates for lighting, ignoring shadows to help us perceive the actual color of an object.
- **Language word blocks matching game:** This game illustrates how recognition and memory contribute to perception: students can find word pairs faster in a language they know.

It is easy to recognize a word match in a language we know. But foreign letters are just shapes, so we have to look at every part of each letter.

- **Prism glasses:** This experiment demonstrates how the brain can resolve conflicting data, as long as there is a consistent pattern to work with.

7b. Cultural objects: Our cultural background impacts how we perceive the world. Here students can examine objects from the Museum's East Asian collection to explore the relationship between culture and perception.

8. Touch — EXPERIENCE ROOM

Our skin contains specialized nerve endings for detecting different sensations. What feels like just one sense of touch is the result of the brain knitting together many different sensations to create a unified perception.

8a. Touch stations and "How Does it Work?" models: Through a variety of touch activities that engage different nerve endings in the skin, students can explore several sensations that contribute to their sense of touch.

9. Smelling — EXPERIENCE ROOM

Often, what we experience as a single scent is made up of many different chemical components. We sense these components individually, and then integrate them in the brain.

9a. Scent interactives: The scent of chocolate is a mix of many fragrant molecules. In this room, students can smell several single-molecule scents and guess which ones are found in chocolate.

9b. "How Does it Work?" interactive: Each type of scent molecule connects with specific receptor cells located at the back of the nose. Here, students can match "molecule" shapes with their corresponding "receptor" shapes. When a specific combination of receptors is triggered, it is revealed as the code for a familiar scent.

10. Live Presentation

In this 16-minute presentation that runs every half hour, a series of activities and simulations reveals how senses help animals locate resources and avoid danger, and explores some distinctive features of human perception.

11. Extending Our Senses

Humans use technology not only to expand what we can detect. We also use technology to enhance what we can perceive, through artificial intelligence that helps us recognize patterns amid a sea of data.

11a. Wall graphics: By examining images derived from tools such as X-rays and ultrasound, students can explore how we use technology to access information imperceptible to our biological senses.

11b. Table interactive: In a hands-on activity that explores the power of artificial intelligence, students can arrange plastic cups to make a picture, and then see if a computer can accurately identify what they made.

The image at left, created using three space telescopes, shows a galaxy located about 12 million light years away from Earth. The image at right, generated by a scanning electron microscope, is an up-close look at a spider producing blue silk for its web.

Come Prepared Checklist

- ☐ Plan your visit. For information about reservations, transportation, and lunchrooms, visit **amnh.org/plan-your-visit/school-or-camp-group-visit**.
- ☐ Read the **Essential Questions** to see how themes in the exhibition connect to your curriculum.
- ☐ Review the **Teaching in the Exhibition** section for an advance look at what your class will encounter.
- ☐ Download activities and student worksheets at **amnh.org/our-senses-educators.** They are designed for use before, during, and after your visit.
- ☐ Decide how your class will explore the exhibition:
  - You and your chaperones can facilitate the visit using the **Teaching in the Exhibition** section.
  - Students can use the **worksheets** and/or the **map** to explore the exhibition on their own or in small groups.

Correlation to Standards

A Framework for K-12 Science Education

Scientific and Engineering Practices
• 1. Asking Questions • 6. Constructing Explanations
• 8. Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts
• 1. Patterns • 2. Cause and Effect: Mechanism and Explanation
• 6. Structure and Function

Disciplinary Core Ideas
• PS4.B: Electromagnetic Radiation • LS1.A: Structure and Function
• LS1.D: Information Processing

Glossary

brain: our most complex organ, it connects us with the outside world, makes thinking possible, and allows us to survive. The hub of our nervous system, the brain weighs about 1.4 kg (3 lbs) and contains around 100 billion neurons and other cells that support their function.

infrasonic: sound waves with a frequency below the lower limit of human hearing

nervous system: a branching network of neurons that sends, receives, and processes electrical and chemical signals throughout the body to and from the brain. Organs and muscles rely upon these signals to function.

neurons: key building blocks of the nervous system responsible for processing and transmitting electrical and chemical information. These cells have long, slender extensions that can connect to other neurons or muscle and gland cells.

perception: the conscious experience of sensory information

sense organs: our bodies' specialized detectors that take in information from our environment and then send nerve signals to the brain

ultrasonic: sound waves with a frequency above the upper limit of human hearing

visible light: the range of wavelengths in the electromagnetic spectrum that humans can see

CREDITS

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Photo Credits

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