

# SYSTEM ALERT!

Tomorrow is almost here.

## SENSES LET THE WORLD IN

The way water looks when it ripples. The coldness of ice cream. The sharpness of a car horn. All day long, your senses are teaching you about the world you live in. They teach you about yourself too: your senses are crucial for monitoring your own body.

You collect sense information using sense receptors. Your nervous system carries these messages from your receptors to your spinal cord and to your brain. Your brain uses the information to show you a multisensory view of the world around you. Be thankful – you owe the world to your senses.

### HOW MANY SENSES DO HUMANS HAVE?

More than 2,000 years ago, Aristotle wrote that humans had five senses: sight, sound, touch, smell, and taste. Just try to squeeze that number by a biologist today.

These days, scientists list six, 12, even 20 or more senses! Why no agreement? Because there are many different ways to count them. Do we just count the obvious sense organs like Aristotle did? It's not that simple. Your ears let you hear, but they also provide you with a sense of balance. There are many complications like this.

So, let's simplify. What are the broad types of things that senses measure? There are, roughly speaking, four of those.



### TEMPERATURE



A hot pepper's heat does not come from its temperature. The heat it makes in your mouth comes from a molecule in the pepper called capsaicin. The shape of the capsaicin causes it to bind with temperature receptors on your tongue, sending a "false positive" signal of high heat to your brain. ⚠️

Your **temperature sense** monitors the outside and inside of your body. It helps you avoid burning yourself. It helps your body maintain a healthy temperature and lets you know when you have a fever. The scientific name for this sense is thermoreception.

How does it work? Certain proteins in you change shape when the temperature changes. This shape change sends a message that ultimately helps you decide to put on a coat or leave it at home.

By the way, not every area on the human body is equally sensitive to temperature. The cheeks and lips are about 100 times more sensitive than the feet! ⚠️

An old tale has it that a frog won't jump out of boiling water if the water is heated very gradually. FALSE. Though 19th-century scientists believed this one, today's scientists say this is not true. ⚠️



# LIGHT

If you're reading these words, thank your opsins! All human and animal **sight** depends on proteins called opsins. When light touches an opsin in your eye, the opsin protein changes its shape. This change sends a signal to your brain. In the human eye, there are rod opsins and cone opsins, used for seeing in low light and bright light, respectively. Only your cones distinguish the color of the light they detect.

A large percentage of the human brain is dedicated to processing the visual data that comes in through the eyes. The brain searches for familiar patterns. One pattern might represent your basketball. Another might represent your hairbrush. ⚠️



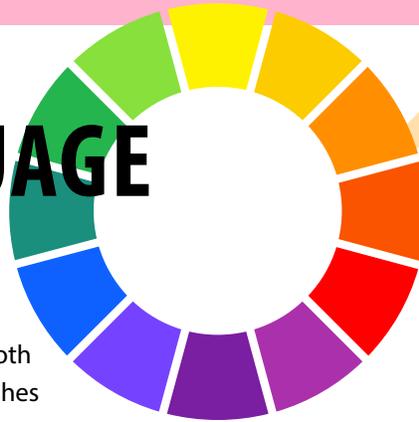
You enter a crowded hall and quickly spot your friend. Your brain and eyes work together to let you see. But they also work together to let you *not see*. There are always many irrelevant details that could distract from your focus. These are kept from your attention.

However, this can backfire. In one experiment, viewers watched six people pass around a basketball. Can you believe that *more than half* of the viewers didn't notice when a person in a gorilla costume walked right through the middle of the game? ⚠️



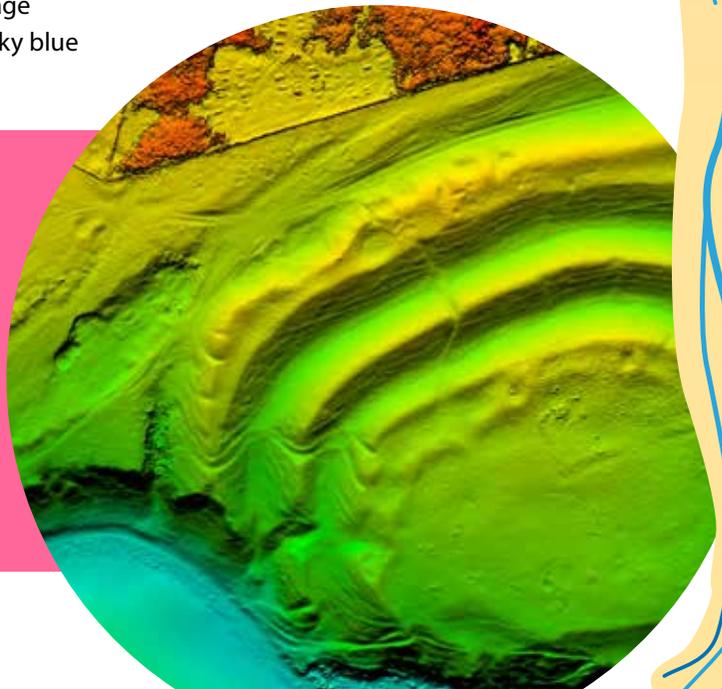
## THE COLOR/LANGUAGE CONNECTION

Languages used by different cultures recognize different numbers of colors. Some languages just have one word for both blue and green, for example. At least one language distinguishes only three colors – black, white, and red. The English language recognizes 11 colors but Russian recognizes 12. In Russian, sky blue is distinguished from other blues. ⚠️



## LiDAR

What echolocation is to bats (see page 4), Light Detection and Ranging (LiDAR) technology is to robots. LiDAR bounces laser light off objects in the environment. The time it takes for the light to bounce back tells how far away an object is. LiDAR is an important source of information for autonomous vehicles, enabling them to construct 3-D models of their environment in real time. ⚠️



# MOVEMENT



Several important senses rely on detecting movement.

On stage before you, a man is singing. Pressure waves spread through the air, traveling from his mouth to your ears. The waves vibrate your ear drums. This causes fine hairs in your inner ear to move. The movements of these hairs send electrical signals along your auditory nerves, allowing you to **hear**. (Of course, it will not really be *listening* until the signal is in your brain and you choose to focus on it.)

Your ears relate to your **sense of balance** too. When you move your head, this causes small pockets of fluid in your ear to slosh, bending tiny hairs. The way those hairs are bent by the fluid gives your brain information about the movement, which helps you stay balanced while you are riding your bike or standing in line.

**Proprioception** is the sense that tells you where your limbs and other body parts are located in relation to one another. (Close your eyes and test if you can feel the position your body is in.) This sense helps you coordinate your body movements. ⚠️



Elephants can hear clouds gathering. Cloud movements make sound waves outside the range of human hearing. The frequency of the waves is very low, in a range called infrasound. An elephant's ears are ideal for picking up infrasound. ⚠️

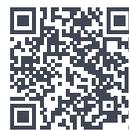
Some amputees get only limited use from artificial arms. Without a connection to their body's proprioception system, the person wearing the arm must rely on sight alone to guide it. This can be challenging. However, new technology called HAPTIX (Hand Proprioception and Touch Interfaces) hopes to use nerve implants to let prosthetics communicate with the biological body. ⚠️

After getting off a boat, you might still feel the boat's swaying motion for an hour or so. But for those suffering from mal de débarquement syndrome, that sensation can stick around for years! ⚠️

## CODE CUBE™

Code Cube™ is a cool piece of wearable, programmable technology from Pitsco. It is also a good example of the similarity between machine sensors and human senses. Code Cube has a built-in LED screen, the ability to make sounds, and – crucially – an accelerometer. An accelerometer is a device that measures a change in speed. Your own body is able to feel changes in speed when you are driving with someone who suddenly hits the brake or the gas pedal.

The signal from the accelerometer travels to the Code Cube's processor. The processor responds by following its programming. So, at the shake of a wrist, the LED screen can display a picture. Or a sound effect can play. This is up to the imagination of the programmer – you. Code Cube is designed to be programmable even by beginners, thanks to block-based programming. ⚠️



# CHEMICALS



**Smell** and **taste** are both part of the chemosensory system – senses based in chemical detection. High up inside your nose, receptors called olfactory cells detect molecules by their chemical composition. If you sniff a slice of cherry pie, you are drawing molecules from the pie into your nose and putting them in contact with your olfactory cells. Different olfactory cells react to different chemicals in the nose.



Scientists regard the sense of smell and taste as overlapping, in the sense that taste begins with smell. However, your tongue also has 10,000 dedicated taste receptors (called buds) on your tongue. But there are only five types of receptors: salty, sweet, bitter, sour, and umami. ⚠️



Every year, kids ages 5-15 gather in New York City for one reason: to show off their stinky shoes. In the annual Odor-Eaters Rotten Sneaker Contest, competitors try to impress (or revolt) judges with the putridness of their footwear. The most foul-smelling shoe wins. ⚠️



Fido is a handheld device used by law enforcement agents for detecting explosives while in the field. Fido relies on a chemical-recognition system engineered at MIT. In seconds, a sample of material can be scanned. Even traces of explosive too small to be seen with the eye can be discovered. ⚠️

# ANIMAL SENSES

Many animals have senses that are vastly superior to our own. A dog's brain is about 40 times more dedicated to figuring out smells than ours. And if you think you can compete with a flamingo's sense of balance, try standing on one leg for four hours.

But some animals have senses we can't relate to at all. Sharks use **electroreception** to detect electrical fields, which helps them hunt. In their facial pores is a kind of jelly. This jelly reacts to the electrical fields of their prey.

Roundworms orient themselves using **magnetoreception** – a sensitivity to the Earth's magnetic field.

And bats and dolphins use a sense called **echolocation**. They emit noises that echo off nearby objects. These echoes help them navigate. But maybe we shouldn't include this one because – get this – some blind humans have taught themselves this skill to perceive their surroundings. They make clicking noises and listen for the sound's reflection. ⚠️



Volume 8, No. 3

**SYSTEM ALERT!**  
Tomorrow is almost here.

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**SYSTEM Alert!** is published by Pitsco, Inc. Information and articles are geared to middle-level students.

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Student name: \_\_\_\_\_ Class/Hour: \_\_\_\_\_

## ***SySTEM Alert!* Quiz (Volume 8, Number 3)**

1. LiDAR bounces \_\_\_\_\_ off surrounding objects to construct 3-D models of the environment.
  - A. sound waves
  - B. chemicals
  - C. electricity
  - D. laser light
2. What are two types of light-sensitive opsins that can be found in the human eye?
  - A. rod opsins and cone opsins
  - B. field opsins and point opsins
  - C. light opsins and dark opsins
  - D. left opsins and right opsins
3. A(n) \_\_\_\_\_ is a device that measures a change in speed.
  - A. accelerometer
  - B. odometer
  - C. thermometer
  - D. hygrometer
4. By Aristotle's count, how many senses does a human have?
  - A. four
  - B. five
  - C. six
  - D. seven
5. In the Russian language, which color is seen not as blue but as its own color?
  - A. blueberry blue
  - B. swimming pool blue
  - C. sky blue
  - D. midnight blue



6. Bats, dolphins, and even some humans can detect objects by bouncing sound off the objects and listening for reflections. This sense is called \_\_\_\_\_.
  - A. electroreception
  - B. magnetoreception
  - C. chemoreception
  - D. echolocation
  
7. What molecule in hot peppers binds with temperature receptors on the tongue?
  - A. capsaicin
  - B. casein
  - C. sucrose
  - D. chloride
  
8. Where are olfactory cells located?
  - A. spread across the tongue
  - B. high up inside the nose
  - C. along the spinal column
  - D. in the inner ear
  
9. The lips are more sensitive to temperature changes than the feet. By how much?
  - A. 3 times
  - B. 10 times
  - C. 100 times
  - D. 10,000 times
  
10. What is the name for sound waves in the very low frequency range?
  - A. supersonic
  - B. ultrasound
  - C. tardasound
  - D. infrasound

**Bonus:** Choose one of your senses and imagine losing it. Write about how your life would be different without that sense. What would you miss? How would you adapt?