Olfaction

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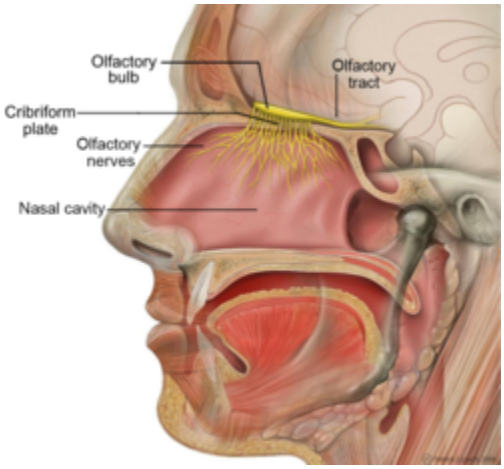
Objectives

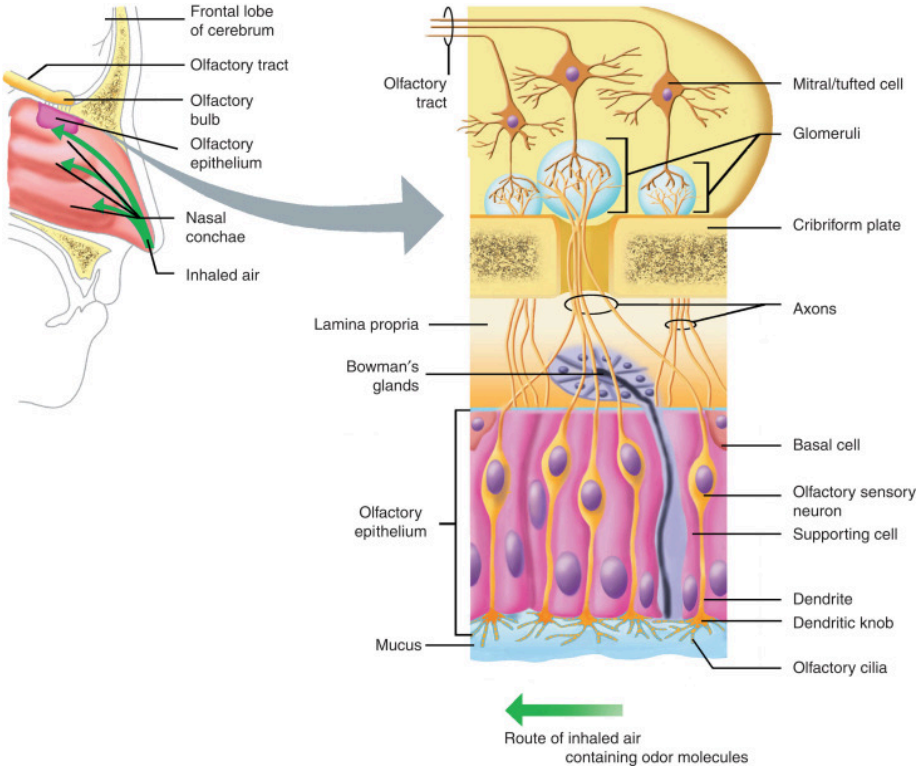
1. Learn how the human olfactory system makes sense of chemicals encountered in our environment.
2. Demonstrate different factors that might affect our sense of smell.

Background Information

In a world perfumed by the scents of sweet flowers, freshly baked bread, and even gasoline, humans are capable of discriminating at least one trillion different odors. The human olfactory system is designed to sense volatile chemicals encountered in the environment, giving us our ability to smell. The sense of smell is often referred to as a chemosense, because this system gives the brain information about the chemical composition of objects. However, no two people experience a scent in the same way due to differences in genetic sensitivities.



The peripheral olfactory system consists of the nostrils, nasal cavity, and olfactory epithelium. The olfactory epithelium resides at the top of our nasal cavity and contains the cell bodies of olfactory neurons. When we breathe, small molecules called odorants enter the nasal cavity and bind to receptors on the olfactory neurons. The olfactory neurons send their axons up through the cribriform plate into the olfactory bulb, where they synapse onto sites called glomeruli. Interestingly, each glomerulus receives inputs only



from olfactory neurons that have the same odorant receptor. This means that one odorant receptor is directly linked to one specific glomerulus, allowing for highly specific odor detection. Olfactory neurons synapse onto dendrites mitral and tufted cells in the glomeruli, where they send their axons to the primary olfactory cortex in the brain.

The olfactory cortex sends smell information to numerous areas in the brain, including the amygdala, thalamus, hippocampus, hypothalamus, and brainstem. Together, these brain regions can help us combine smells with memory, regulate motor behavior brought on by odors, amplify emotions, and integrate smells with other sensory systems.

There are two primary ways that odorants reach the nasal cavity. The first (and most obvious) is called orthonasal olfaction, where breathing air through the nose brings odorants in through the nostrils. The second, less appreciated route is through retronasal olfaction, where odor molecules travel through the back of the throat up to the nasal cavity. When we eat, retronasal olfaction provides much of the multisensory experience we know as “flavor” by combining taste information from the tongue and somatosensory information from the mouth. An easy way to demonstrate the importance of retronasal olfaction is to simply pinch your nose the next time you eat and see how the flavor is affected.

A primary goal of sensory systems in general is to combine the brain signals generated by “low level” stimulus features into a single, meaningful perceptual object. For example, the image of a cup consists of lines, contours, shading, colors, etc. Our visual system can recognize and describe these low level features, but we are ultimately able to recognize the object as a cup. Our olfactory system operates similarly. For example, the smell of chocolate arises from a combination of over 500 distinct odorants, yet we easily recognize this complex mixture as chocolate. Unlike the visual system, our olfactory system cannot detect these low level features of individual odorants. In fact, humans are only capable of picking out 3-4 attributes of smell, no matter how complex it is.

Below, we have provided a variety of activities you can implement in the classroom to teach students about smell.

Activity 1: Expose your nose

Materials

Item	Quantity	Notes
Small plastic cups	At least 12	- 90 count of 1 ounce plastic cups on Amazon for $8 - Ideally they should be colorful to help prevent visual identification of spices
Ground spices	Small bottles of each spice	- Cumin, garlic powder, clove, oregano, cinnamon, ginger, dill weed, chili powder, and rosemary

Before you begin

1. Pour each spice into individual cups labeled 1-9.
2. Prepare spice mixtures.

a. For cup 10, mix chili powder and garlic powder
b. For cup 11, mix garlic powder, cumin, and ginger
c. For cup 12, mix cloves, cinnamon, rosemary, and oregano

In the Class

1. Starting with cup #1, have students smell and pass the cups in an assembly-line fashion.
2. Students should try to identify the spices by smell and record their guesses.
3. Afterward, reveal the spices and spice mixtures and have students score their performance.
4. Possible discussion questions after the exercise
    a. Were some spices easier to identify than others? Why?
        i. Answer: some spices are more volatile and give off more molecules into the air. They are perceived to be a stronger smell
    b. Why was it difficult to identify the individual components of the spice mixtures? What does this suggest about the sense of smell?
        i. Answer: the olfactory system processes odors as complex patterns rather than isolating individual components. The sense of smell is highly integrative, meaning it is better at recognizing holistic scents rather than individual elements.

Activity 2: Smell vs. Taste

Materials

Item	Quantity	Notes
Jelly beans	Lots of jelly beans with at least 4 different flavors	- 20-flavor jelly bean box (4.5 oz) can be bought on Jelly Belly website for $5.49 https://www.jellybelly.com/20-assorted-jelly-bean-flavors-4-5-oz-flip-top-box/p/98627
Bowl	1	- To mix the jelly beans in

In the Class

1. Mix jelly beans of different flavors/colors in a bowl.
2. Instruct students to pinch their nose shut, close their eyes, and choose one jelly bean from the bowl at random.
3. With the eyes still closed and nose still pinched, have the student bite half of the jelly bean. Let the student attempt to guess the flavor
    a. It should be more difficult without retronasal olfaction!
4. After they've guessed, let the students open their eyes and nose. Have them eat the second half of the jelly bean and guess again.

Activity 3: Smell sensitivities

Materials

Item	Quantity	Notes
Small plastic cups	At least 4	- 400 count of disposable, clear plastic cups on Amazon for $14
Water		- Used to dilute
Perfume	1 bottle	- Any perfume of choice

Before you begin

1. Pour equal amounts of water into each cup. Then, spritz different amounts of perfume into each cup as follows:
    a. Cup A: one spritz
    b. Cup B: two spritz
    c. Cup C: three spritz
    d. Cup D: four spritz
2. Label the cups as A-D and keep note of how many spritzes are in each up
3. Mix up the order of the cups

In the Class

1. Place the cups out at random and pass them around in assembly style.
2. Have students rank the samples from strongest (most pungent) to weakest (least pungent)
3. Compare the results between different classmates to demonstrate how people smell differently! The scent you smell could be different from how your friend perceives it.
4. Possible discussion questions:
    a. Which sample had the strongest smell?
    b. Was it easy to distinguish the smells or did they seem similar? Why?
    c. Why do you think people perceive smells differently?

Activity 4: Temperature and smell

Temperature impacts how we smell! Warmer environments cause odorants to disperse more readily into the air, resulting in stronger and more noticeable smells.

Materials

Item	Quantity	Notes
Cookies	At least 1 package	- Chips Ahoy cookies can be bought at Jewel Osco or Target for ~$4
Microwave		- Used to heat up the cookies

Microwave-safe container	2	

Before you begin

1. Microwave one cookie and place it in one bowl. Put an unmicrowaved cookie in an identical bowl.
    a. Cover both bowls with foil and poke holes in them. This will prevent students from identifying cookies visually.

In the classroom

1. Ask students which cookie smells better. Keep track of which cookie "wins"
2. Possible discussion questions:
    a. Was it easy to identify which odor was warm and which odor was room temperature? Why?
    b. Can you think of any other examples of when temperature influenced your smell? (i.e. cold vs. warm pizza)

Activity 5: Synthetic odor processing

Materials

Item	**Quantity**	**Notes**
Sliced apples	At least 1 apple	- Can be bought at any grocery store. Ideally select one that is more fragrant
Small bag of jolly ranchers	1 bag	- Can buy the whole bag to share with the class, but only use the green apple flavored ones for the experiment
Small plastic cups	At least 4	- 400 count of disposable, clear plastic cups on Amazon for $14

Before you begin

1. Place apple slices in one cup and green apple jolly ranchers in the other cup
2. Cover both cups with tin foil and poke holes to prevent visual identification

In the classroom

1. Ask students to smell both cups and have them identify which cup contains the natural odor and which contains the artificial odor
2. Possible discussion questions:
    a. Was it easy to identify which odor was natural and which odor was artificial?
    b. How do you think the natural and artificial odors compare on a chemical level?

Image Credits (in order of appearance):

1. https://en.wikipedia.org/wiki/Olfactory_system
2. https://www.sciencedirect.com/science/article/abs/pii/B9780123851574000725