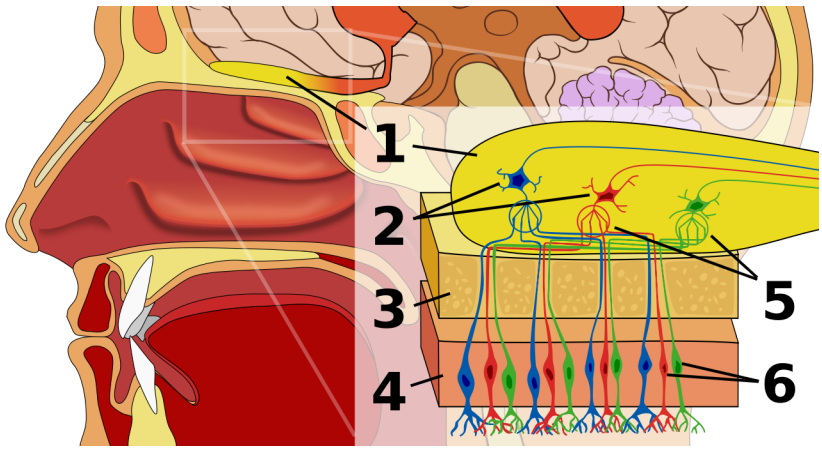
OBJECTIVES

- Students will identify odors from a panel of single and combinations of spices
- Students will differentiate between natural and artificial odors
- Students will experience flavor with and without the aid of smell

KEY CONCEPTS

1. Smell is a form of chemoreception, and is more multidimensional and sensitive than vision or hearing
2. Combinations of odors are perceived together and can be hard to dissociate (synthetic percept)
3. Artificial odors are usually a subset of the natural/real odors
4. Smell and taste are very intimately related

BACKGROUND INFORMATION



Olfaction is the sense of smell, mediated by a specialized sensory cells in the nasal epithelium (4, see right). Odorant molecules, which are usually volatile small molecules, bind to receptors on olfactory sensory neurons (6). When these neurons are activated, they transmit signals to mitral cells (2) in structures called glomeruli (5). There is a large degree of convergence from the OSNs to mitral cells, which gather and relay information from the olfactory bulb (1) to various parts of the brain. Patterns of activation of these brain regions, which include the piriform cortex (i.e. olfactory cortex), the amygdala, and the entorhinal cortex, produce olfactory percepts.

Each OSN expresses only one type of olfactory receptor (OR) in its dendrites; however, ORs may bind to a range of odorant molecules with varying affinities based on their chemical structures. ORs are all G-protein coupled receptors; odorant binding activates the G-protein, which indirectly leads to action potential initiation in the OSN. ORs are encoded by individual OR genes, which are thought to comprise one of the largest gene

families in the human genome (approximately 400 functional genes plus 600 pseudogene candidates = 3% of the entire genome).

Olfaction, as a form of chemoreception, is far more multidimensional than the other main senses. For example, vision is determined by a finite number of properties of light, including luminance, wavelength, etc, that are perceived from the real world in a spatial manner. In contrast, the possible chemical structures that may activate ORs are nearly unlimited, and there is no real way to distinguish where smells come from. As a result, unlike vision, audition, and somatosensation, it is essentially impossible to map olfaction.

GETTING READY

Materials

- 9 ground spices
    - chile powder, garlic powder, cloves, cinnamon, star anise, basil, pepper, cocoa powder, ginger
- 3 mixtures of 2/3/4 spices
    - 2 spices: chile powder + garlic powder
    - 3 spices: cloves + cinnamon + star anise
    - 4 spices: garlic powder + basil + ginger + pepper
- Plastic cups
- Pairs of real and artificial foods, e.g. apples and apple candy, mint and mint candy
- Hot food/cold food, e.g. microwaved and RT cookies
- Jolly Ranchers
- Tissues

Mentor Preparation

- Prepare all spices
- Divide supplies for each section and put in separate boxes

Classroom Preparation

- Warm up cookies
- Prepare real foods (apples, mint, etc)

IN THE CLASSROOM

Warm-up Activity (2 minutes):

Students will all close their eyes and try to imagine the best meal they have ever had. While their eyes are still closed, they will share what was so memorable about the meal (smell-wise).

(Optional) Students will watch a clip from the movie “Ratatouille” where the food critic tastes ratatouille and is immediately brought back to his childhood.

Lesson Introduction/Description (5 minutes)

Review previous lessons on other sensory systems in a table on the main whiteboard

Sense	Information
Vision	Light
Hearing	Air vibrations
Touch	Skin vibrations
Smell	??

- “Why do we have the sense of smell?”
- “Are smell and taste connected?”

Hands-on Group Activities (20 minutes each):

Station 1: Odor Identification Test and Synthetic Olfaction

9 numbered (not labeled) cups will each contain a single, commonly used spice. To prevent visual identification, the cups will be covered; alternatively, mentors can hand cups of spices to students who have their eyes closed. Students will attempt to identify spices by smell and write down their guesses in a list (Spice 1 = __, Spice 2 = ___…). Based on their guesses for the individual spices, students will next attempt to identify which spices make up a series of spice mixtures. Afterward, the spices and mixtures will be revealed and students can score their performance.

- *Were some spices easier to identify than others? Why?*
- *For spices that were difficult to distinguish, why was it difficult?*
- *What was difficult about identifying the components of the spice mixtures? What does that suggest about the sense of smell?*

Other talking points: impact of volatility, chemical groups, smell as a multidimensional sense

Station 2, Part A**: Odorants as Volatile Molecules**

2 packages of Chips Ahoy cookies, 1 warmed and 1 at room temperature, will be placed on the table. Students will identify which package smells "better." This is strictly to illustrate the point that odorants are molecules that must reach the nasal epithelium, which can be modulated by temperature to increase or decrease their volatility.

Station 2, Part B**: Natural vs. Artificial Odors**

Cups will contain either real food (e.g. apples) or artificial food (e.g. apple candy). To prevent visual identification, the cups will be covered; alternatively, mentors can hand cups to students who have their eyes closed. Students will attempt to identify which cup contains the natural odor and which contains the artificial odor.

- *Was it easy to identify which odor was natural and which odor was artificial? What is it about the artificial odor that tells you it is artificial?*
- *How do you think the artificial odor compares to the natural odor on a chemical level?*

Other talking points: how food/perfume/etc companies create artificial odors, connection to fundamental frequencies and harmonics

Station 2, Part C**: Smell-Taste Interaction**

Students will close their eyes and be given a random flavor of Jolly Rancher. Students will place the candy in their mouths and try to identify which flavor they have (they can open their eyes again). After identifying the flavor, they will repeat the procedure, pinching their noses prior to putting the candy in their mouths. Students will have significant problems identifying the flavor when the sense of smell is blunted.

- *Is it harder to identify the flavor when your nose is plugged? When has this happened to you before?* E.g. when you have a cold
- *Why do you think it is more difficult? What does this suggest about the relationship between smell and taste?*

Debrief (5 minutes): Time permitting

Schedule (expected time):

8:40-8:50 **Warm-up Activity/Lesson Introduction**

8:50-9:10 **First Station**

9:10-9:30 **Second Station**

NOTES/CONCERNS/ISSUES

- It is important to warn students not to breathe too deeply during the Smell ID test. They might accidentally inhale a bunch of ginger!