

# Neuroscience for Kids

<http://faculty.washington.edu/chudler/neurok.html>

## TEACHER GUIDE

# Our Chemical Senses: Olfaction

**EXPERIMENTS:** olfactory fatigue, things that interfere with smell, smell and memory, and odor matching.

*Featuring a “Class Experiment” and “Try Your Own Experiment”*

## WHAT STUDENTS WILL DO

- PREDICT and then DETERMINE olfactory fatigue time in minutes, for at least two odor materials
- COLLECT all class data for olfactory fatigue times
- CALCULATE the average and range of times for each substance
- LIST factors that affect olfactory fatigue
- DRAW a simple diagram of the neural “circuitry” from the nose to the brain
- DISCUSS the functions of the sense of smell
- LEARN HOW to design experiments about the sense of smell that include asking specific questions, defining control conditions, and changing one variable at a time; for example:
  - TEST people’s abilities to identify odors in mixtures
  - FIND OUT if gender influences how we detect odors
  - FIND OUT whether subjects can match odors in unmarked containers

### SUGGESTED TIMES

\*45 minutes for introducing and discussing the activities

\*45 minutes for the “Class Experiment”

\*45 minutes for Explore Time and “Try Your Own Experiment.”

# SETTING UP THE LAB

## Supplies

### For the Class Experiment

- **odorants:** at least two strong but harmless materials in containers. (*check for allergies*)
  - ✓ oil of peppermint
  - ✓ oil of cloves
  - ✓ almond extract
  - ✓ very ripe banana
- **containers** for odorant materials, such as 35mm film canisters with holes in the lids—these are good because items cannot be seen; or small, disposable plastic restaurant containers with lids, such as those for small amounts of salad dressing, etc. If transparent containers are used, cover the sides and tops with opaque tape, or use a blindfold for subjects. **Number the containers and keep a code sheet.**

You will need enough containers for each student group to have two odorants (or a number you decide) at the same time.

- **timers** or stop watches
- **paper** for recording results

### For “Try Your Own Experiment”

- **odorants** in addition to those above (*check for allergies*)
  - ✓ cinnamon
  - ✓ garlic, fresh crushed or powder
  - ✓ ginger, fresh sliced or powder
  - ✓ onion
  - ✓ vanilla extract
  - ✓ chocolate or hot cocoa
  - ✓ rosemary
  - ✓ perfume
  - ✓ mouthwash
  - ✓ lemon peel
  - ✓ orange peel
  - ✓ Pinesol or other cleaning agent
  - ✓ coffee, ground rather than brewed
  - ✓ others materials from the ethnic or cultural backgrounds of the students
- **timers** or stop watches

- **water** for dilutions
- **containers** for odorant materials, such as 35mm film canisters with holes in the lids—these are good because items cannot be seen; or small, disposable plastic restaurant containers with lids, such as those for small amounts of salad dressing, etc. If transparent containers are used, cover the sides and tops with opaque tape, or use a blindfold for subjects. **Number the containers and keep a code sheet.**

### **Other Preparations**

- For the Class Experiment, students can **write results** on a sheet of paper. For “Try Your Own Experiment,” help students **create data sheets and graphs as needed.**
- **Construct a chart** on the board where all data can be entered for class discussion.
- **Decide the size of the student groups;** for example, groups of four could have two subjects and two data recorder/timekeepers. For “Try Your Own Experiment,” students should switch roles so more people can be subjects, if they want.
- **Decide the number of odorants to test** (two or more). Olfactory fatigue times will be several minutes (probably 4 or more) for each material.
- **Make sure that people are comfortable in their roles.**
- **Encourage groups to choose a girl and a boy as co-subjects** in at least some tests, because gender differences do exist in odor detecting abilities.
- **Modify activities for exceptional students:** check for allergies and for students who have had a bad experience with a particular smell, so that no one becomes ill.

## **INTRODUCTORY ACTIVITIES**

### **Give students initial information**

Introduce the olfactory system with reading, lecture, and discussion before doing the lab work. In addition to covering the anatomy and physiology of the system, discuss concepts such as olfactory fatigue, smells and memories, things that affect our sense of smell, and other topics you think might come up in the “Try Your Own Experiment” section.

### **Introduce lab activities with a demonstration**

Before students enter the classroom or lab on experiment day, **set out a shallow dish** of suntan oil containing coconut oil, or a freshly brewed cup of strong coffee, or some other

odorant that will be noticed by anyone walking into the room. You may need to restrict air flow in the room for this time so that the smell remains strong. Make no mention of the odor as students enter the room. After students have been in the room for four or five minutes and you have begun class, ask them if they notice the odor as much as they did when they first entered the room. Ask if the odor reminded them of any past experiences. This will lead into the Class Experiment on olfactory fatigue (and into other experiments later).

**Use Explore Time to engage students** (*This section is reproduced from the Teacher Resource.*)

To encourage student participation in planning and conducting experiments, first provide Explore Time or Brainstorming Time. Because of their curiosity, students usually "play" with lab materials first even in a more traditional lab, so taking advantage of this natural behavior is usually successful.

For some experiments, such as the olfactory lab, brainstorming is probably best. In these labs, if students investigate the materials before starting the experiments, they will probably identify (or hear others identify) and memorize many of them. Further, in activities to stimulate memories associated with odors, the "surprise" element of a sudden whiff of material is important in generating an interesting experience. Instead of letting students explore, the teacher can simply indicate the lab bench, saying that the containers of odor materials will be available for experiments. When students see that opaque, numbered containers of materials are available, they can begin to generate questions for investigations, and the teacher can offer more ideas.

# CLASS EXPERIMENT

## *What's that smell?*

*The sections below match those in the Student Guide. The comments guide teachers in preparing and teaching the labs.*

### LAB QUESTION

After the Introductory activity, help students to write the following Lab Question or one that matches it closely:

**How long does it take for our sense of smell to “get used to” or fatigue to an odor so that we no longer notice it, even though it is still there?**

### PLANS AND PREDICTIONS

Encourage students to add their own knowledge and experiences in order to make predictions after you have provided background information.

Ask students to predict the time for olfactory fatigue in minutes. Ask other questions to encourage thinking about how the sense of smell works; for example, will the time be the same for all smells?

### PROCEDURE

#### 1. Introduce safety precautions:

##### General:

Follow all standard lab safety guidelines for preparing and teaching the activity; e.g., take precautions to avoid germ spread; wash hands; dispose of chemicals properly; use equipment properly.

##### Specific:

- Check for allergies or sensitivities to odorants.
- Do not use oil of wintergreen; it is highly toxic if ingested.

- Make sure students do not eat or drink any materials.
  - Teach students the proper way to fan or waft odors to the nose, making sure they do not hold containers directly under their noses. **See Teacher Demonstration below.**
  - Keep flammable solutions, such as perfumes, away from open flames.
  - Wear safety goggles.
2. **Explain** the steps in the class experiment. These are listed in the Student Guide. Each pair or group will test fatigue time for at least two odorants. Determine the number of students in a group and the number of odorants they will have time to test.
  3. **Demonstrate** the safe way to smell odorants:

Sit at a bench or table with an **open container** of odorant (one of the four listed for the Class Experiment) on the bench, about 15 to 20 inches away. Make sure the container is stable, e.g., that it is short and wide, or, if it is something narrow, such as a test tube, put it in a rack. Use your hand to fan or waft the scent gently from the container toward your nose. Maintain consistent fanning for the several minutes it will take for the odor to fatigue. Breathe normally—**do not breathe deeply or hyperventilate**. Use an opaque container and make sure subjects cannot see into the top.

Demonstrate also the way to smell material in a **closed container with holes** in the lid. Holding the container about 15 inches from your nose, waft air from the top of the container toward your nose. If the smell is pleasant or not strong, bring the container closer and sniff gently. Instruct students never to smell deeply until they have an idea of what kind of material is present.

4. **Give** students appropriate containers of odorants.

## DATA AND OBSERVATIONS

- Make sure students cannot see the materials they are smelling, unless the material is a colorless liquid or is otherwise obscure.
- Check to see that students are fanning the odorants carefully and consistently, and are **not hyperventilating**. Inconsistent fanning will result in occasionally bringing large doses of odorant to the nose and difficulty in getting fatigue.
- If fatigue times are very long, students may be sitting too close to the material. Also, they may need to report when the smell is very weak rather than gone altogether.
- Have the data recorders from each group list their results in the prepared chart on the board.

- Students should note the range and calculate the average fatigue time for each material. They can also make observations about the variability of times.

## **ANALYSIS: THINK ABOUT IT!**

**The following questions can encourage thinking about the activity; add your own questions. (See also the specific questions in the Analysis section of the Student Guide.)**

- How do your results compare with those of other groups?
- Can you explain the differences you see among the observations? (Differences in individual physiology; different wafting techniques; interfering smells, noises, etc., may have distracted the subject)
- Do you have any direct evidence from your experiment to show that olfactory receptors exist? (There is no direct evidence; this would require microscopic investigation to identify possible receptors, and recording from nerves with tiny electrodes to show nerve impulses resulting from odor presence and changes.)
- Discuss what the results mean in terms of the concepts learned in the Background lecture and discussion on the olfactory system.
- Students should be able to draw a simple circuit showing the path of odor signals from nasal epithelium to the olfactory bulb, then to the olfactory cortex, and on to either the limbic system or the frontal cortex. The grade level and depth of the lecture and discussion will determine the detail expected.

## **CONCLUSIONS**

Students should:

- State how the Lab Question was answered in their experiments.
- List three things (or a number you choose) they think are important about today's experiment. Focus students by asking such questions as: How is our sense of smell important to us? What do our brains do with sensory (particularly smell) information? Can you experiment on some questions on your own? Do scientists know everything there is to know about the sense of smell?
- List ways to improve this experiment.

# TRY YOUR OWN EXPERIMENT

## LAB QUESTION

After Students have completed the Class Experiment, brainstorm with them for ideas such as masking or altering the sense of smell or testing it in different ways. Questions can help them formulate plans: Can some people smell things when others can't? What kinds of things make it hard to identify smells? Do smells sometimes make you happy or sad?

As mentioned in the Teacher Resource, it is probably not a good idea to let students explore the new materials before they formulate ideas for their experiments, because they would begin to identify the materials quickly.

**See that each group defines a Lab question, as they did in the Class Experiment.**

## PLANS AND PREDICTIONS

### SUGGESTIONS FOR EXPERIMENTS

*(Add your own ideas to this list. The Student Guide contains some of these suggestions, but not in detail.)*

1. Interfere with the ability to identify odors by **mixing two materials together**. (More than two will make it quite difficult.) Try two materials that are quite different, then mix two that are somewhat similar or are frequently associated, to see in which cases the individual components are easier to identify. After students try to identify mixed materials, ask if it is easier to identify the same things when they are kept separate, as a further experiment.

Different:

cinnamon and garlic  
banana and onion  
peppermint and coffee

More similar:

cinnamon and ginger  
orange peel and lemon peel  
vanilla and almond extracts



2. Check **gender differences** by giving the same five or more odorants to a girl and a boy for identification. In order to avoid giving hints to other subjects, have subjects write rather than say their answers.
3. Investigate the **effect of concentration** on olfactory fatigue. Set up four dilutions of a liquid odorant and test the fatigue time—be sure to begin with the least concentrated (why?). You may need to experiment ahead of time to find the appropriate dilutions of some odorants. For vanilla, try 0.1%, 1.0%, 5%, and 10%. Students doing this experiment can graph their results with vanilla concentration on the x-axis and times on the y-axis.
4. Present three or four common odorants to the group and ask each student to write briefly the memory this smell brings up. Suggested odorants: cinnamon, hot cocoa, coffee, garlic. **Take into account the ethnic backgrounds** of your students and try to include smells that mean something to different cultures.
5. Try a **matching game** with sets of containers that contain the same odorants. For example, put five materials into five containers, then make an identical set of five. Label the ten containers from 1 to 10, writing the code on a separate piece of paper (e.g., 1 and 7: banana; 2 and 4: peppermint) Mix them up and give them to two or more subjects, asking each to match identical odors and write down their answers.
6. For a **variation on the matching game**, make a set of ten containers where only eight are matched and the last two are different from each other. This can illustrate how our **expectations might interfere** with what our senses are telling us, an interesting topic for further discussion.

## HOW TO DESIGN A GOOD EXPERIMENT

*(This section is also in the Student Guide)*

In designing experiments to answer questions like these, keep in mind what a successful investigator must do:

- Ask a **very specific question**: not, for example, “Can I interfere with the sense of smell?” but rather, “If I mix odor materials together, will a person be able to identify the components?” It’s good to have the general question in mind, but ask a narrow question for each experiment.
- Be sure you understand the **control condition** for your experiment, and then **change only one thing, or variable**, in the experiment.
  - ✓ For example, if you tested for differences between boys and girls, you can **define the control condition** as testing a girl. The **variable** is gender, and you would change it to a boy for your next experiment.

- ✓ Some new experiments are themselves just control experiments. For example, if you did a matching game for your experiment, with five pairs of odor materials, that could be your control experiment. If you have time, you could add a variable in the next experiment by using four matching pairs of odor materials and an additional two that don't match. The unmatched pair would be the variable in the new experiment.
- ✓ Researchers try to change only one variable in a new experiment after they do a control experiment. Sometimes this is difficult, but at least they must be aware of other variables and think about what effects they might have.
- Use the Worksheet to write down your new lab question, your predictions, and the steps in your procedure. Follow the general plan of the Class Experiment.

## **PROCEDURE**

- Follow all standard lab safety guidelines for preparing and teaching the activity; e.g., take precautions to avoid germ spread; wash hands; dispose of chemicals properly; use equipment properly.
- If time is limited, restrict the number of materials you put out for experimenting.
- Before students begin their experiments, have each group write a simple plan that includes a question, a prediction, a list of steps they will take to answer the question, and data sheets and graphs (if needed).
- The list of steps in the experiments should include comments on the control system and on the variable being tested.
- Approve each group's experiment before they begin.
- Remind students to keep good records.
- Students should clean up the lab when they finish.

## **DATA AND OBSERVATIONS**

- If students are doing more olfactory fatigue experiments (for example, with a concentration series, they may need to use open containers for fanning odors toward themselves. If a material has a very strong smell, a container with holes in the lid may work better— to reduce the amount of odorant.

- For odor identification, mixing, and matching experiments, closed containers with holes in lids are probably best. Make sure students do not put their noses right up to containers when they first smell them.
- Make supplies available to students. Check to see if anyone is allergic to the odorants.
- Suggest that students create any data sheets and graphs they need.

## ANALYSIS: THINK ABOUT IT!

The following questions can encourage thinking about the activity; add your own ideas. (See also the specific questions in the Analysis section of the Student Guide.)

- Have each group present its findings in a quick oral presentation (two to three minutes).
- What was the control experiment or condition for your experiment? What did you change or add as your variable?
- Did you make sure to change only one variable? Were there variables you could not control?
- If you did a type of “interference” experiment, where do you think the inference was happening, in the nose or in the brain? (It may be both, or it may be just one. Encourage thinking, and point out that finding the answer would take more detailed experiments, such as recording the electrical signals from the receptor cells to see, for example, if one cell is responding to two molecules. Let students know that it is OK to say, “it **seems** the interference is in the brain,” but that is not **evidence**.)

## CONCLUSIONS

(See also the questions in the Student Guide.)

Ask students how certain they are of their conclusions. Would they need more evidence to make their conclusions more secure?

Each group should write a final conclusion, making sure it addresses their Lab Question.

## **MORE *SENSE OF SMELL* ACTIVITIES**

Do other animals smell odors the way we do? Are there animals that are much more sensitive to smells than we are? How do aquatic animals, such as fish, smell things? What about whales? Can insects smell anything? Do some library or World Wide Web research and report to your class.

Find out about abnormalities or diseases of the human olfactory system, using your library or the Web. Here are some words to get you started:

Anosmia  
Hyperosmia  
Hyposmia

### **Here are some Web sites to get you started:**

<http://www.monell.org/sensation.htm>  
<http://www.monell.org/neuroscience.htm>  
[http://www.nih.gov/nidcd/textonly/health/pubs\\_st/smltaste.htm](http://www.nih.gov/nidcd/textonly/health/pubs_st/smltaste.htm)  
<http://www.hhmi.org/senses> and <http://www.hhmi.org/senses/d/d110.htm>  
<http://faculty.washington.edu/chudler/nosek.html> (Neuroscience for Kids)  
<http://faculty.washington.edu/chudler/chsmell.html> (Neuroscience for Kids)  
<http://www.oslo.sintef.no/gemini/1998-01E/30.html> (Insect Olfaction)  
<http://www.sfn.org/briefings/smell.html> (Society for Neuroscience)  
<http://www.leffingwell.com/olfaction.htm> (Leffingwell and Associates, a commercial site of the flavor and fragrance industry, with good basic science information)

What role do smells play in advertising? Have you ever gone into a store and immediately noticed a pleasant smell? Do you think this encourages people to buy things? Some stores naturally have smells associated with them, such as bakeries or cosmetics stores. But others are now providing constant smells that may or may not belong to any of their products.

Have you seen perfume samples in magazines? The odor is embedded in a folded piece of paper, and when you pull it open the fragrance is released. Do you think this is a more effective way of advertising than showing pictures of the perfume container or of people wearing it? Why?