SOCIETY FOR THE TEACHING OF PSYCHOLOGY

Build-Your-Own Sensation & Perception Lab Kits

A Compilation of Inexpensive, Accessible Activities

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Contents

Evidence-Based Teaching Strategies in this Resource

The activities described in this resource are examples of active learning course components, where students are “doing things and thinking about what they are doing” (Bonwell & Eison, 1991, p. 5). Active learning course components are critical for student success (for reviews see, Ramirez, 2020; Sandrone & Schneider, 2020) and are a fundamental tool for instructors to use to increase student engagement with psychology (according to the American Psychological Association Principles for Quality Undergraduate Education in Psychology (2011)). For example, active learning has been shown to narrow the achievement gaps for underrepresented students in science, technology, engineering and math (STEM) fields (Theobald et al., 2020), and can, more broadly, lead to better learning outcomes and improve students critical-thinking skills (Kontra et al., 2015). Importantly, active learning is successful across all modalities of instruction (i.e., online, blended/hyflex, or in-person), as research has demonstrated that even in traditionally asynchronous Massive Open Online Courses (MOOCs), take-home, hands-on laboratory kits can improve student exam scores and self-efficacy (Deboer et al., 2019). Lastly, this resource follows the guidelines under the Undergraduate Neuroscience Education: Blueprints for the 21st Century (Wiertelak & Ramirez, 2008), as these laboratory-style activities allow students to gain deeper involvement in neuroscience content (i.e., the neuroscience of sensation and perception).

References

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Overview

With changes in course modalities (between online, hyflex/blended and in-person instruction) due to the pandemic, low-cost, hands-on activities that are easy to implement and distribute to students are particularly needed in psychology courses. This project aimed to compile, modify and/or design Sensation and Perception activities that have accessible, inexpensive materials for the use in either take-home laboratory kits or as active learning assignments in-person.

In this resource you will find a list of activities (gathered from multiple sources; see the General Resource List on the next page) broken down by sense (e.g., vision, hearing, touch, etc.). For each activity there is:

- A sample materials list and budget (set for a traditional class size of ~30 students, although many of the materials can be bought in bulk)
- An activity and set-up guide for instructors
- An activity instructions/procedure for students, including "Student Questions/Discussion Prompts"
    - This also includes variations on the activities and activity extensions (where applicable)
- Reference links for all activities (where applicable)
- Additional background and informational links (where applicable)
- Current connection links (where applicable)
    - These include recent (from ~2015-2021) research and news articles with topics that relate to the current activities

Important Notes on Pricing/Links:

- All pricing and links were found through Amazon (as it is widely accessible); however, prices/suppliers can and do change frequently (which may mean that links become broken or inaccessible over time)
- Please use this as a reference list/guide for example products/estimate costs
    - *It is also recommended that you check your local grocery, dollar, thrift or craft stores for better prices and to support establishments in your area!*
- Similarly, you can buy Sensation and Perception Kits through retailers like Carolina®, however, these can be expensive (for both instructors and students) and are limited to the experiments that are in each kit

It is my hope that by having many options for Sensation and Perception activities in one place, instructors will be able to better and more easily choose which activities will work best for their class and budgets!

Take-Home versus In-Class Activities

For these activities, materials and supplies were chosen that are easy to handle and give to students (for example, individually wrapped food items). If you decide to distribute materials to students as take-home activities (or if your class is completely online), the majority of the supplies can fit within a typical gallon-sized Ziploc® bag. This makes it easy to give (or ship) to students, if that is your preference. For example, in the fall of 2020, I was able to fit several of the touch, smell and taste activities (divided into smaller plastic bags for each demonstration) into one-gallon sized bag before my campus pivoted to remote instruction. These were handed to students before they went home (and, further, a location on campus was set up where they could come pick them up with social distancing measures in place).

Many of the materials are also things that: 1) are relatively common (so it is possible that students would have them already in their homes), 2) are relatively inexpensive (although, I would not assume all students have the means to purchase their own supplies and it would be best to check in with students before asking them to purchase anything) and 3) can be reused (or used multiple times) in different activities. Therefore, this gives instructors and students maximum flexibility in choosing which activities could work for their class and institution.

General Resource List

- Links for background information, online demonstrations, and additional experiments:
  - Society for the Teaching of Psychology (APA Div 2)
    - Instructor Resources
    - Teaching of Psychology Idea Exchange (ToPIX; may require login)
  - Neuroscience for Kids
    - Sensory Background Information
    - Sensory Experiments
  - Interactive Sensation Laboratory Exercises (ISLE) – complementary set of activities, experiments and illustrations to go along with Schwartz & Krantz (2015) "Sensation & Perception" textbook
  - Learn.Genetics
    - Sensory Background Information (includes interactive apps for Apple Products)
    - Teach.Genetics – instructions for different sensory experiments
  - Scientific American – Science Buddies "Bring Science Home" Experiment List
  - Exploratorium – Science Snacks Experiment List
  - Society for Neuroscience – Brain Awareness Campaign (includes educator resources)
  - The Brain from Top to Bottom
  - MIT – Full Steam Ahead
    - Making Music and Sounds Program
  - Ben Balas, PhD – Hands-On Vision Science Course

- Links for up-to-date sensation and perception research and news:
  - Neuroscience News
  - BioPsychology NewsLink
  - American Association for the Advancement of Science – EurekAlert!
  - Society for Neuroscience – BrainFacts.org

Vision Activities

Activity: Distortion Goggles

Question: How do neurons adapt to changing visual cues?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Press-On Fresnel Prisms (30 Diopter)	Western Ophthalmics Cooperation® – 3M® Press-On Prisms ▪ Prisms are sold individually (you will need two prisms per goggle) **Note: 3M® and Bernell® also sell press-on prisms, however, you will need to register with a school/educator account*	$44 (for 2 prisms)
Goggles	Amazon – HANCHS brand safety goggles ▪ This package contains 5 goggles **Note: there are many brands of safety goggles available – any will work as long as the lenses are relatively flat (rather than having curved lenses)*	$20
Scissors	Amazon – Amazon Basics Multipurpose Scissors (3 pack) **Note: you can use any scissors to cut the press-on prisms to fit your goggles*	Free - $10
Throwing Item & Target	Throwing item – you can use any ball or bean bag for students to throw at a target ▪ Option 1 ($15): Amazon – Franklin Sports Bean Bags (8 in total) ▪ Option 2 ($17): Amazon – KEVENZ brand Standard Pressure Training Tennis Balls (contains 12 tennis balls); *these can be used for other activities* Target - you can use any small clean/empty basket or a cardboard box for this activity or you can make a target on the floor using masking tape!	Free - $20

Activity Guide & Set-up:

- As both the goggles and press-on Fresnel prisms are more expensive, this activity might work better as a group or in-class activity (rather than in individual take-home lab kits)
    - Depending on how many sets of goggles you would like to make, you may want to assemble them before using them with your students

- *****Important safety notes:***
    - *Please be mindful of any public health/social distancing policies on your campus and sanitize the equipment properly if sharing goggles*
    - *As students will be wearing goggles that alter their vision, please be sure that the area surrounding students is clear and that students know how to use the equipment properly!*
        - *Some students may feel uncomfortable wearing the goggles and, therefore, these activities should be voluntary*

Estimated Time: 30 minutes (after assembling the goggles); plan for each student to take 5-10 minutes for their turn

Activity Procedure:

1. Assembling the Goggles

a. Inspect the edges of the Fresnel prisms to see which way the ridges go
    i. Make sure that you orient your prisms the same way on each of your goggle lenses
b. Before removing the adhesive back of the prisms, lay one on each of your goggle lenses (double checking that the ridges of both of the prisms are going in the same direction)
c. Using scissors, cut the prism so that it covers the entire goggle lens (getting rid of any excess prism)
d. Make sure the lenses of the goggles are clean and dry
e. Remove the adhesive back of the prisms and stick them to the goggle lenses (do this slowly to prevent air bubbles)

2. Testing the Goggles
    a. Place a basket/box (or make a 30 cm square on the floor using masking tape, if you have no basket) at one end of the room (this will be the "target")
    b. Before putting the goggles on, stand ~3 m away from the target and practice throwing the ball (or other soft item) into the target to see how good your aim is without the goggles (repeat this ~3-5 times)
        i. For safety reasons, it may be best to throw the ball underhand
    c. Next, put on the goggles and try throwing the ball into the basket again (keep throwing until you get the ball in ~3 times)
        i. Important notes:
            1. Make sure that you can see the basket/target with the goggles on
            2. Make sure that you do not look through the sides of the goggles when you are throwing the ball (keep looking through the prisms)
            3. Be mindful to not fall or bump into anything while wearing the goggles/immediately after removing them (you may want a partner who is watching for safety)
3. Lastly, remove the goggles and try throwing again!
    a. Pay attention to how close you get to the basket and keep throwing until you make it into the basket ~3 times

Activity Variations:

- You may be able to buy prism/distortion goggles online; however, there seems to be variation as to what is being distorted (e.g., some goggles use prisms, while others are "inversion" goggles that use mirrors)
    a. Please check the quality of the goggles before purchasing!

Student Questions/Discussion Prompts:

- How did the accuracy of your throw change when you put the goggles on? How many tries did it take you to get the ball in the target 3 times?
- What did you notice about the accuracy of your throws when you took the goggles off? Were you surprised at all? How many tries did it take you and why do you think it took you that many tries?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Exploratorium Science Snack – Distortion Goggles
    - Li, A. (2008). Experiencing visuo-motor plasticity by prism adaptation in a classroom setting. *Journal of Undergraduate Neuroscience Education*, *7*(1), A13.
    - University of Minnesota (2016) article - Neural Plasticity: The Prism Goggle Experiment

Activity: Blind Spot

Question: How is the back of your eye (i.e., the fundus) organized?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Index cards (or paper)	Option 1: Amazon – Oxford brain Ruled Index Cards ▪ This is a 300 pack of index cards Option 2: Any sort of printer paper would work for this task	Free - $2
Pens (or markers/ sharpies)	Amazon – BIC® brand ball point pen ▪ This package contains 60 pens (*these can be used for other activities)* **Note: you can use any writing instrument for this task*	$6
**Notes: You might be able to find index cards or pens cheaper at your local dollar/grocery store or through your institution.*		

Activity Guide & Set-up:

- This activity can be done independently
- Distribute the index cards (or paper) and a writing instrument to your students (either in-person or via take-home lab kits)
    - If using computer paper, cut the paper into strips of ~5 cm x 20 cm segments before giving to students

- *****Important safety note:***
    - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*

Estimated Time: 10 minutes (including making the blind spot card)

Activity Procedure:

1. Using a writing instrument, make a letter "X" on the left side of the index card or paper (~2.5 cm from the edge; see figure below)
2. On the right side of the index card or paper, make a letter "Y" (~2.5 cm from the edge; see figure below)
3. Hold the card at eye level about an arm's length away (making sure that the "Y" is still on the right)
4. Close your right eye and look directly at the "Y" with your left eye
    a. Notice that you should also be able to see the "X"
5. Focus on the "Y", but be aware of the "X" as you slowly bring the card toward your face
    a. The "X" will disappear, and then reappear, as you bring the card toward your face
    b. Try moving the card closer and farther to pinpoint exactly where the "X" disappears
6. Now close your left eye and look directly at the 'X" with your right eye
    a. This time the "Y" will disappear and reappear as you bring the card slowly toward your face

Figure: Example blind spot card set-up

Task Variations:

- There are several versions of this blind spot activity using different symbols (instead of the "X" and "Y")
  - See Neuroscience for Kids: Sight (Vision) for more examples
  - ***Note:*** *you also can find printable versions of the blind spot tester online instead of making your own with an index card!*
- Using a ruler (and a partner to help) you can also calculate the size of your blind spot (see links below)
  - Neuroscience for Kids – Measuring Your Blind Spot
  - Exploratorium Science Snack – Blind Spot
- With more materials (including flashlights) you can also have students view their retina (see links below)
  - Exploratorium Science Snack – Seeing Your Retina
  - Ben Balas, PhD: Hands-on Vision Science – The Retina

Student Questions/Discussion Prompts:

- Why do we have a blind spot? How does your blind spot relate to where different structures are located in the back of your eye?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
  - Neuroscience for Kids – Sight (Vision)
  - Exploratorium Science Snack – Blind Spot

Activity: Lens Demonstration

Question: How does the lens bend light towards the back of your eye?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Magnifying Glasses	Amazon – OBTANIM brand Mini Plastic Handheld Magnifying Glasses ▪ This is a pack of 20 magnifying glasses	$10
Paper	Any sort of printer paper would work for this task	Free - low cost

Activity Guide & Set-up:

- This activity can be done independently or in partners/groups
- You will need to be in a room with the overhead lights turned on and/or near a well-lit window
- Distribute the paper and magnifying glasses to students (either in-class or via take-home lab kits)

Estimated Time: 10-15 minutes

Activity Procedure:

1. Activity #1
    a. In a room with the overhead lights turned on, place the paper on a flat surface (like a table/desk or floor)
    b. Hold the magnifying glass a few inches above the paper and adjust it up/down or tilt it to focus
        i. You should be able to form a focused, miniature image of the overhead lights on the paper

2. Activity #2
    a. In a room with a well-lit window, hold the paper upright or against a wall, out of direct sunlight
    b. Hold the magnifying glass a few inches in front of the paper and adjust it forward/back or tilt it to focus
        i. You should be able to form a focused, miniature image of the window scene on the paper

Task Variations:

- If you do not have a window, you could also do this with a computer screen (and form a miniature image of your computer screen on the paper)

Student Questions/Discussion Prompts:

- What did you notice about the orientation of the image? How does the magnifying glass relate to lens in your eye?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Teach.Genetics - Lens Demonstration

Activity: Light/Dark Adaptation

Question: How does our eye adapt to changing lighting conditions?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Blindfolds	Amazon – EUICAE brand Eye Mask Sleep Mask Blindfold Eye Cover ▪ This package contains 30 blindfolds (*these can be used for other activities)*	$10
Colored Paper	Amazon – Tru-Ray brand Construction Paper (10 colors, 50 sheets)	$5
**Note: You may be able to get cheaper supplies at a dollar/grocery store. If you are planning on doing this in-person, normal flashlights would also work!*		

Activity Guide & Set-up:

- This activity can be done independently or in partners/groups
- You will need access to a dark (but not pitch-black) room for this activity
- Cut up a minimum of five different color pieces of construction paper into ~5 cm squares
    - Every student (or group of students) should get at least five differently colored construction paper squares
- Distribute supplies to students (either in-person or via take-home lab kits)

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus and sanitize the equipment appropriately if sharing blindfolds*

Estimated Time: 20 minutes

Activity Procedure:

1. Take your blindfold and put it over ONE of your eyes (plan to keep it on for at least 10 minutes)
2. In a normally lit room, gather your pieces of construction paper and arrange them in a rainbow row (or by lightest to darkest)
    a. Notice how easy it was to do that task
3. Shuffle your construction paper
4. After about 10 minutes, either turn off the lights or move to darkened room with your construction paper
    a. Before you take your blindfold off, try re-arranging your construction paper again
        i. Did you make any errors in your color categorization this time?
5. Next, take off your blindfold and, using the eye that has been dark adapted, see if you can discern the colors of your construction paper

Student Questions/Discussion Prompts:

- How does your eye adjust to changing light levels? What parts of your eye are involved in this process?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Neuroscience for Kids – Dark Adaptation and Seeing in the Dark
    - Exploratorium Science Snack – Pupil Size

Activity: Vision Disorders

Question: What are some disorders of the eye and how do they affect vision?

Materials List & Sample Budget:

Materials	Example Items/Links
Vision Simulators (optional)	Several online retailers sell "Vision Simulator" Glasses or Cards (they range in price) ▪ Option 1 ($26): Nasco Education "Vison Challenges Simulation Glasses" Set ○ There are 6 glasses in this set ▪ Option 2 ($1 each, but minimum order of $25): Ohio Optometric Association "Adult Vision Simulator Cards" ○ Each card simulates 4 eye disorders

Activity Guide & Set-up:

- As the vision simulators are more expensive, this activity might work better as a group or in-class activity (although there are also online options – see the Activity Procedure below)

- ****Important Safety Notes:***
  - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*
  - *Please be mindful of any public health/social distancing policies on your campus and sanitize the equipment appropriately if sharing simulators*

Estimated Time: 10-20 minutes

Activity Procedure:

1. In-Class Vision Simulators
   a. Distribute the simulators and look through them
      i. Notice how your vision changes depending on the simulator used

2. Online Vision Simulators
   a. There are many online vision simulators available:
      i. Sight Simulator for Cataracts, Glaucoma, and Retinopathy
      ii. Vision Loss Simulator for Glaucoma, Cataracts, Diabetic Retinopathy, Macular Degeneration, Glare and Presbyopia *(warning: has sound – you can mute!)*
      iii. Eye Disorder Simulations: photos of various eye disorders

Student Questions/Discussion Prompts:

- How was vision affected in each of the simulations?
- What parts of the eye are affected by each of these disorders/diseases?

Additional Resources & Current Connections:

- Current Connections – making a bionic eye for use in medical trials
  - Neuroscience News (2021) article – Bionic Eye Study Paves the Way Toward Human Trials

Activity: Peripheral Vision

Question: What is the difference in acuity between our peripheral and central vision?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Deck of Cards	Amazon – Bicycle brand Standard Playing Cards ▪ This package contains 12 decks of playing cards **Note: you can use any items that have color, numbers or letters on them (e.g., make your own cards with paper and markers or use other printed materials)*	$23
Protractor (optional)	Amazon – EBOOT brand Math Protractors ▪ This package contains 50 plastic protractors	$18
Tape (optional)	Amazon – Amazon Basics Brand Masking Tape ▪ This package has 3 rolls of masking tape *(these can be used for other activities)*	$8
Pens /Pencils (optional)	Amazon – BIC brand ball point pen ▪ This package contains 60 pens *(these can be used for other activities)* **Note: you can use any writing instrument for this task*	$6
String (optional)	Amazon - Shintop Natural Jute Twine ▪ This roll has ~100 m of twine *(this can be used for other activities)*	$6

Activity Guide & Set-up:

- This activity can be done independently or in partners/groups
- Distribute ~3-4 playing cards to each student (either in-person or via take-home lab kits)
    - If you are using the other materials, distribute them to students
        - Make sure to cut the string into ~1 m sections before you distribute

- *****Important Safety Notes:***
    - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups*

Estimated Time: 20-30 minutes (depending on the version you choose); plan for a student to take ~5-10 minutes to do the task

Activity Procedure:

1. Version #1: Playing Cards Only
    a. Position the playing cards face-down near you so they are easy to grab (try not to peak at what they are!)
        i. You may want to shuffle them before using or work with a partner during this task if it is easier!

b. Sit at a table with your eyes focused in front of you at a point directly ahead at eye level
    i. Try not to move your eyes AT ALL while doing this task (just continue to stare directly at the point in front of you)
c. Grab a playing card with your right hand (or have a partner give you one) and extend your right arm all the way out to your side
    i. Make sure that the card is positioned so that the numbers on the card are facing you (BUT don't look at it – continue looking at the point straight ahead!)
d. With your right arm extended, slowly rotate your arm in an arc so that you are moving in front of you (see figure for example)
e. Pay attention to your peripheral vision and notice when you are first able to "see":
    i. The motion of the card in your peripheral vision
    ii. The color of the card
    iii. The suit of card you have
    iv. The number on your card
f. Repeat the procedure using your left hand and a new card!

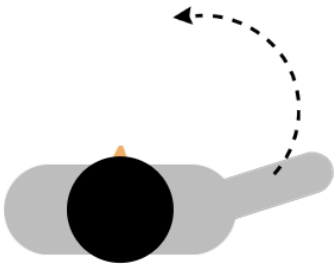


Figure: Example set-up as shown in Version #1: part d

2. <u>Version #2: Record the Differences in Acuity</u>
    a. If you would like a more laboratory-based experience, use the protractor, string and tape to measure the angles at which you notice the above features of the playing cards in your periphery
    b. To make a large-scale protractor on a desk in front of you:
        i. Sit so that you are centered on the desk
        ii. Place the protractor in front of you so that it is touching the center of your stomach/chest
        iii. Take a piece of tape and write "0 degrees" on it and place it an arm's length away directly in front of you on the table (in line with the protractor's 90-degree mark)
        iv. Using your outstretched arm, a piece of string, and your standard-sized protractor as a guide, create a large-scale tabletop protractor by marking the angles every 10 degrees with small pieces of tape
            1. On either side of the 0-degree mark, label your tape in 10-degree increments up to 90 degrees, which should be directly to the left and right of you (see figure for example)
            2. The numbers should be about an arm's length away from you on the desk

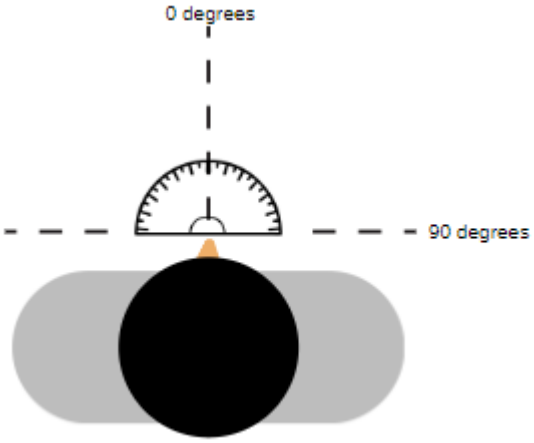


Figure: Example set-up as shown in Version #2: part b

    c. Repeat the steps in Version #1, but this time have your partner record the angles at which you notice:
        i. The motion of the card in your peripheral vision
        ii. The color of the card
        iii. The suit of card you have
        iv. The number on your card

Task Variations:

- Instead of making a large-scale protractor, you can buy a 'Field of Vision Disk" online (note: they are a bit pricey and can range between $30-$50)
- You can also make your own Vision Disk out of cardboard (see link below)
    - Scientific American – Put Your Peripheral Vision to the Test

Student Questions/Discussion Prompts:

- When could you sense the motion, color, and/or writing on the cards? How does this relate to where your rods and cones are positioned in your retina?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Exploratorium Science Snack – Peripheral Vision
- **Current Connections**
    - XKCD Comic – Visual Field
        - This comic illustrates (many) different properties of the visual field

Activity: Visual Acuity *(Snellen Eye Chart Demonstration)*

Question: How good is your visual acuity?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Snellen Eye Chart	The American Academy of Ophthalmology has printable versions of the Snellen Eye Chart for adults ▪ *Note: when you print this eye chart, the biggest letter at the top of the chart should be ~2.5 cm tall*	Free - low cost
Tape	Amazon – Amazon Basics Brand Masking Tape ▪ This package has 3 rolls of masking tape *(these can be used for other activities)*	$8
String (optional)	Amazon - Shintop Natural Jute Twine ▪ This roll has ~100 m of twine *(this can be used for other activities)* *Note: You need a way of measuring 3 m from the eye chart for this activity. For take-home demonstrations, it might be easier to measure out 3 m of string for students. In class, you could just use a measuring tape instead of string.*	$6
Pen & Paper (optional)	Students may want to write down their results (they can use any pen/paper for this)	Free - low cost
Chair (optional)	You can use any chair for this task (or you can have students stand)	Free
**Notes: You could have students print the eye chart and/or find tape from their rooms/homes/offices. There may also be lower cost options for these items at your local dollar/grocery store.*		

Activity Guide & Set-up:

- This activity works best with a partner/groups but can be done independently
- If you are using the string, cut it into 3 m sections
- Distribute the Snellen Eye Chart, tape and string to students (either in person or via take-home lab kits)

- *****Important Safety Notes:***
  - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups*

Estimated Time: 10-15 minutes; plan for each student to take ~5 minutes for their turn

Activity Procedure:

1. Tape the Snellen Eye Chart to an empty wall at eye level
2. Using either the string or measuring tape, measure 3 m from the wall with the Snellen Eye Chart
   a. Place a piece of tape at the 3 m point OR put a chair here (if choosing to sit)
   b. Stand (or sit) at this mark
3. Cover one eye
   a. If you use eyeglasses for distance vision, the glasses should be worn during the test at first (you can always try removing the glasses later on)

4. Have a partner point to the topmost first line in the Eye Chart and you should read those letters out loud (to the best of your ability)
    a. Continue reading the letters out loud until you either reach the bottom row or until the letters are too difficult for you to see
5. Have your partner note (or write down the number) of the smallest line seen correctly (i.e., the line with more than half of the letters correctly identified)
6. Repeat the test with your other eye covered and record the results (if you wear glasses, you can also try removing them and repeating the process)
7. Switch students!

Student Questions/Discussion Prompts:

- How do doctors and scientists measure visual acuity?
- What does it mean when someone says they have 20/10 vision (is this good or bad vision?)

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - The American Academy of Ophthalmology – Home Vision Test for Children and Adults
- Additional background information can be found at:
    - The American Academy of Ophthalmology – All about the eye chart!
- Online vision tests/simulators:
    - An online vision test (not for diagnostic purposes) can be found at:
        - Essilor – Test Your Vision Online
    - An online vision simulator:
        - My Eye Dr. – Vision Simulator

Activity: Lateral Inhibition & the Visual Pathway

Question: How do the receptors/cells in our retina influence each other?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Paper	White printer paper works best for this activity	Free - low cost
Tape	Amazon – 3M brand Tape Sheets ▪ This package contains 50 tape sheets in total *(these can also be used for other activities)* **Note: if doing this as an in-class activity, you can use any clear tape*	$7
Scissors	Amazon – Westcott brand Scissors for Kids ▪ The package contains 6 scissors *(these can be used in other activities)*	$5
**Notes: Instead of purchasing paper, tape or scissors for students, you could have students find them from their rooms/homes/offices. There may also be lower cost options for these items at your local dollar/grocery store.*		

Activity Guide & Set-up:

- This activity can be done independently or with partners/groups
- Distribute two sheets of printer paper, two tape sheets and scissors to students (either in-person or via take-home lab kits)
    - **Note**: You could also pre-cut sheets of paper for students into 6 x 28 cm strips if you don't want to distribute scissors to students
        - In this case, each student would then receive a full sheet of paper, the 6 x 28 cm strip of paper and two tape packets

Estimated Time: 10-15 minutes

Activity Procedure:

1. Take the full sheet of paper and roll it lengthwise into a tube that is about 1.5 cm diameter (the tube length should be 28 cm)
    a. Tape it to keep it from unrolling
2. If you did not precut the second sheet of paper, please cut it lengthwise into a strip that's about 6 x 28 cm
    a. Roll this strip lengthwise into a tube that is also about 1.5 cm in diameter and tape it as well (the tube length should also be ~28 cm)
3. With both eyes open, look through the first tube you made (the one from a full sheet of paper) at a bare wall or white screen (or another piece of paper if you do not have a wall/screen available)
    a. Notice that the spot of light you see through it is brighter than the wall of the tube (the wall of the tube should look dark; see figure for example)
4. Next, look through the tube you made with the smaller strip of paper (the wall of this tube should be thinner than the previous tube)
    a. Notice that the spot of light you see through the tube should appear darker than the wall of the tube (see figure for example)

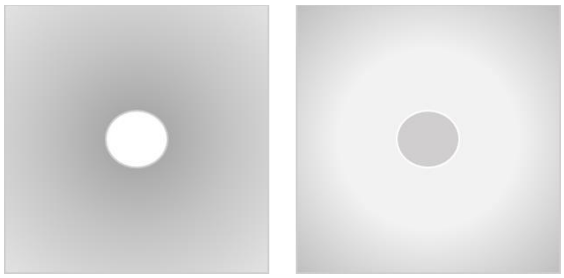


Figure: Left) Example of the bright spot seen by looking through the tube made of the full sheet of paper. Right) Example of the darker spot see by looking through the tube made out of the smaller strip of paper.

Student Questions/Discussion Prompts:

- Why does the center spot of light look brighter when you use the tube made out the full sheet of paper (as compared to when you look through the tube made with the smaller strip of paper)?
- What cells in the retina are responsible for this lateral inhibition?

Additional Resources & Current Connections:

- Other activities that showcase lateral inhibition
  - Exploratorium Science Snack – Lateral Inhibition
  - Hermann Grid Illusion explanation
  - Mach Bands
    - Interactive Sensation Learning Exercises (ISLE) – Mach Bands
- Resources for the visual pathway
  - Build-Your-Own Receptive Field
    - Skogsberg, K. (2021). Some assembly required: Building a hands-on model of a single receptive field in the retina. *Advances in Physiology Education, 45*(2), 307–309. https://doi.org/10.1152/advan.00156.2020
  - Vsauce: Mind Field (Season 3: Episode 3) – The Stilwell Brain
    - This is a ~26-minute video where they recreate the visual pathway from retina to brain using participants to represents different neurons from retina to IT cortex
  - The Gallant Lab
    - Retinotopy Demonstration
    - Berkeley News (2011) article (with links to YouTube videos and interviews) - Scientists use brain imaging to reveal the movies in our mind
  - XKCD Comic – Visual Field
    - This comic illustrates (many) different properties of the visual field

Activity: Binocular Disparity

Question: How does the brain process the two different images coming from your two eyes?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Paper	White printer paper works best for this activity	Free - low cost
Tape	Amazon – 3M brand Tape Sheets ▪ This package contains 50 individual tape sheets in total **Note: if doing this as an in-class activity, you can use any clear tape*	$7
Pens /Pencils (optional)	Amazon – BIC brand ball point pen ▪ This package contains 60 pens *(these can be used for other activities)* **Note: you can use any writing instrument for this task*	Free - $6

Activity Guide & Set-up:

- This activity can be done independently or with partners/groups
- Distribute one sheet of printer paper, and two pieces of tape (or two tape sheets) to students (either in-person or via take-home lab kits)

Estimated Time: ~10 minutes; plan for each student to take ~5 minutes for their turn

Activity Procedure:

1. Take a full sheet of paper and roll it lengthwise into a tube that is about 1.5 cm in diameter (the tube length should be ~28 cm)
    a. Tape it to keep it from unrolling
    b. Mark (or put a line on) the halfway (mid) point of the tube on the outside with a pen/pencil
2. Hold the tube in your left hand and hold it to your left eye (keeping both eyes open)
    a. You should be able to see the inside of the tube and what is around the tube
3. While still holding the tube with your left hand, hold up your right hand (so that your palm is facing you) and place it against the right side of the tube about halfway down the barrel of the tube, where you made the mark (your pinky should be touching the tube; see figure)
4. If you continue looking straight ahead with both your eyes, you should notice that your hand appears to have a hole in it!
5. You can try switching your eyes and hands!

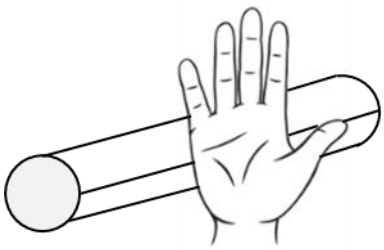


Figure: Example set-up as shown in step 3

Task Variations:

- If you want a free demonstration of binocular disparity you can have students use their hands/fingers
    - Close your left eye and hold up your left index finger at an arm's length
        - While looking at your left index finger with your right eye, cover an item in the distance with your left index finger (e.g., something on a wall, a person far away, etc.)

    - Now close your right eye and open your left eye
        - The item you were covering with your left index finger should have moved slightly so it is now visible (see figure for example!)
    - This demonstrates that your eyes see two different images of the world
- There are also more complicated versions of this task using two pieces of paper:
    - Exploratorium Science Snack – Overlapping Spots
    - Exploratorium Science Snack – Circles or Ovals

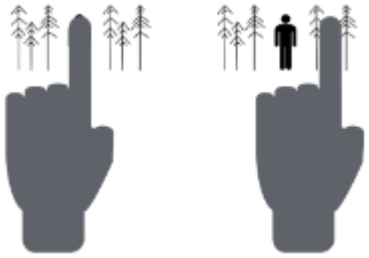


Figure: Left) image seen by right eye. Right) image seen by left eye.

Student Questions/Discussion Prompts:

- Why did you see two (slightly) different images of the world when you switched eyes? How do you think this helps you perceive and navigate through your surroundings?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Exploratorium Science Snack – Hole in Your Hand

Activity: Depth Perception

Question: How do we perceive depth and see the world in 3D?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Activity 1: Dominant Eye Demo		
Hands	For this activity you just need your hands and something to look at!	Free
Activity 2: Depth Perception Demo with Pens		
Pens/ Pencils	Amazon – BIC brand ball point pen ▪ This package contains 60 pens *(these can be used for other activities)* **Note: you can use any writing instrument(s) for this demonstration*	$6
Activity 3: Drop It/Catch It - Depth Perception		
Small Cups	Amazon – Comfy brand 3 oz small paper bathroom cups ▪ There are 300 small (3 oz) bathroom cups in this package (*these can be used for other activities)* **Note: any small cup(s) will work for this demonstration*	$13
Paperclips	Amazon – DANRONG brand Assorted Paper Clips (Small, Medium and Large) ▪ This set contains 650 paperclips of different sizes *(these can be used for other activities)* **Note: you can use any small objects for this activity as long as they can fit in the cups (e.g., coins)*	$7
Tennis Balls (optional)	Amazon – KEVENZ brand Standard Pressure Training Tennis Balls ▪ This set contains 12 tennis balls (*these can be used for other demonstrations)* **Note: you can use any small balls for this activity (e.g., foam/plastic balls.)*	$17
Additional Materials (Optional)		
View-Master®/ Finder	Amazon – Basic Fun brand Classic View Master with Reels ▪ This contains 1 View Master and two reels	$20
**Notes: Students may have these supplies in their rooms/homes/offices. There may also be lower cost options for these items at your local dollar/grocery store.*		

Activity Guide & Set-up:

- These activities can be done independently or in partners/groups
- Distribute the supplies to students (either in-person or via take-home lab kits)
    - Students should receive two pens/pencils (or one pen with a cap), a small cup, a few paperclips (or small objects) and/or a tennis ball (if you are using them)

- ****Important Safety Notes:***
  - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*

Estimated Time: 10-30 minutes (depending on the activity)

Activity Procedure:

1. Activity #1: Dominant Eye
   a. Extend your arms out in front of you and make a triangle with your thumbs and index fingers
   b. With your arms still extended, look through the opening of the triangle you made with your fingers with both eyes and center the opening on a distant object (like a clock or door knob)
   c. Now close your left eye
      i. If the object stays centered in the triangle, your right eye (the one that's open) is your dominant eye (if the object is no longer framed by your fingers, your left eye is your dominant eye)

2. Activity #2: Depth Perception with Pens
   a. Hold two pens (or pencils), one in each hand
   b. Extend both arms fully, with the pens oriented horizontally, and try to touch the tips of the pens together with your eyes open
      i. Notice how easy or hard that was to do
   c. Now close one eye and try to touch the tips of the pens together again
      i. Notice if it is more or less challenging than having both eyes open
   d. Task Variations:
      i. Instead of using two pens, you can use a pen (or marker) with a cap and have students try to put the cap on the pen with their arms extended and compare how easy or hard it is with two eyes open versus one eye open
      ii. Using a metal washer (or another solid circular objects) you can also have students try to thread a pen/pencil through the washer opening with two eyes open (versus one eye open)
         1. Exploratorium Science Snack – Thread the Needle

3. Activity #3: Drop it/Catch it! – Depth Perception Demo
   a. Drop it! Activity
      i. Place a small cup about 60 cm in front of you (about arm's length) on a desk/table
      ii. Grab a one of your paper clips and hold it ~45 cm above the cup
      iii. With both eyes open try to drop the paperclip in the cup
      iv. Repeat again with a second paperclip but close one eye
   b. Catch it! Activity
      i. Have students pair up and stand ~3 m apart from one another
      ii. Give one person a tennis ball
      iii. Try throwing and catching the tennis ball with one hand with both eyes open and then with one eye closed
         1. ****Safety Note**: please be mindful of your surroundings when doing this task as tennis balls can go rogue

4. View-Master Demonstration
   a. Students really enjoy looking through view-masters/finders and they are a great way to generate discussion on stereoscopes

Student Questions/Discussion Prompts:

- Were these tasks harder with both eyes or with one eye? Why?
- What are the components of depth that we perceive?
- How do our eyes adjust to objects at different distances?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
  - Neuroscience for Kids – Depth Perception
- **Additional Activities**
  - With additional supplies, students can make their own 3D glasses and images
    - NASA Solar Terrestrial Relations Observatory (Stereo) – Playing in 3D
    - Ben Balas, PhD: Hands-on Vision Demos – DIY anaglyphs
- **Online option:**
  - You can ask students to show/upload/bring in a picture that shows depth and have them analyze the picture for different monocular depth cues (e.g., relative size, relative height texture gradient, linear perspective, aerial perspective)

Activity: Color Mixing

Question: What is the difference between color addition and color subtraction?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Small Cups	Amazon – Comfy brand 3 oz small paper bathroom cups ▪ There are 300 small (3 oz) bathroom cups in this package *(these can be used in other activities)*	$13
Food Coloring	Amazon – Spice Supreme brand Assorted Food Colors ▪ This package contains 4 food colors (red, blue, green, yellow)	$4
Water	You will need water for this activity	Free
Pipettes/ Eye Droppers	Amazon – Moveland brain 3ml Disposable Plastic Pipettes ▪ This package contains 200 pipettes **Note: eye droppers would also work for this demonstration*	$12
Flashlight	Amazon – Boao bran Mini-Flashlight Keychains ▪ This package contains 48 keychain flashlights **Note: if doing this as an in-class activity, you can use any type of flashlight (you need a minimum of two, but three is best)*	$18
Acetate/ Cellophane Filters	Amazon – Fiesta Wraps store Colored Cellophane Sheets ▪ This package includes 10 different colors and 120 sheets of cellophane	$10
Tape	Amazon – 3M brand Tape Sheets ▪ This package contains 50 tape sheets in total *(these can be used in other demonstrations)* **Note: if this is an in-class activity, you can use any clear tape*	$7

Activity Guide & Set-up:

- As this activity requires water/food coloring, it would be best as an in-class demonstration with groups/partners or as a whole class demonstration (this would also minimize the amount of supplies needed to be purchased– see below for set-up)

- Each group of students should have:
  - Four small cups
    - Three should be filled halfway with water, one should be empty
    - Place ~1-2 drops of red food coloring in the first cup of water, ~1-2 drops of blue food coloring in your second cup of water and ~1-2 drops of yellow food coloring in the third cup of water
  - 3 pipettes/eye droppers
  - 3 flashlights
  - Red, blue and green acetate/cellophane filter sheets
    - It might be easiest to cut these sheets to fit the diameter of your flashlight
    - Tape one filter to each of your flashlights
    - *****Safety note**: make sure that the flashlights do not get too hot/stay on for extended periods of time, as that could melt the cellophane/acetate*

- ***Additional Safety Notes:**
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*

Estimated Time: 20-30 minutes

Activity Procedure:

1. Color Subtraction
    a. Add ~10 drops of yellow water into the empty cup
    b. Next, add ~10 drops of blue water into the same cup
        i. Notice what color the water in the cup turned
    c. Lastly, add ~10 drops of red water into the same cup
        i. Notice what color the water in the cup turned

2. Color Addition *(you may want to dim the room lights for this demonstration)*
    a. Shine the green flashlight on a white empty wall or desk
    b. Next have second student shine the blue light on the same spot on the wall (the green flashlight should still be on)
        i. Notice what color is now projected on the wall
    c. Lastly, shine the red flashlight on the same spot on the wall
        i. Notice what color is now projected on the wall

Task Variations:

- Using the color acetate/cellophane filters, and photos on your phone/computer (or printed out), you can demonstrate how light is transmitted and absorbed and how that changes our color perception
    - Exploratorium Snack Science – Color Table
- With transparent acetate and a color printer, you can demonstrate how the photoreceptors in our eyes process color
    - Exploratorium Science Snack – The Three Little Pigments
- Instead of flashlight, you could use colored LED lightbulbs
    - Exploratorium Science Snack – Poking Fun at Color Mixing
- Using your cell phone and a microscope (and/or computer), you can also demonstrate how technology companies take advantage of our visual system by investigating the pixels on our screens
    - Exploratorium Science Snack – Pixels, Pictures and Phones
    - Note: Current phones (like an iPhone 13 Pro) have cameras with at least 10x optical power, which means that you do not need a microscope to see the pixels on your computer screen (just zoom in on a computer screen with your phone's camera to see the pixels!)

Student Questions/Discussion Prompts:

- Were there differences in the colors that were made when you added pigments (food coloring) together versus when you added multiple colored lights together?
- What is the difference between color addition and subtraction?
- How many distinct color receptors do we have in our eyes? What are their most sensitive wavelengths and how does this contribute to distinguishing colors?

Additional Resources & Current Connections:

- Interactive Sensation Learning Experiments (ISLE): Color Perception

Activity: Color Perception *(Color Deficiency Demonstration)*

Question: Are there differences in how people perceive colors?

Materials List & Sample Budget:

Materials	Example Items/Links
Color Vision Tests (optional)	Several online retailers sell variations of color deficiency tests (they range in price) ▪ Example: Ishihara's Tests for Color Deficiency (~$40)

Activity Guide & Set-up:

- As purchasing color vision tests for each student can be expensive, these tests would best be used as an in-class demonstration in small groups/partners (although there are many online options – see the Activity Procedure below)

- ****Important Safety Notes:***
  - *These activities are not meant to be diagnostic (if a student notices something wrong with their vision, they should contact their doctor/medical professional!)*
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*

Estimated Time: 10-20 minutes

Activity Procedure:

1. In-Class Color Vision Tests
   a. Distribute the color tests to students and have them look through them
      i. Depending on the color tests you choose, there should be instructions that come with them for how to administer them

2. Online Vision Simulators
   a. There are many online color tests/simulators available:
      i. ColBlinder – https://www.color-blindness.com/
         1. This website has several different color deficiency tests including: Ishihara's Test, F-M 100 Hue Test, the Color Arrangement Test and RGB Anomaloscope
         2. It also has a good color deficiency simulator
      ii. While not a "scientific" source, students enjoy taking Buzzfeed's Color Perception Quizzes
         1. Example: Buzzfeed – Only people with perfect color vision can pass this quiz
            a. **Note**: Google "Buzzfeed Color Perception Quiz" for more up-to-date quizzes

Student Questions/Discussion Prompts:

- How good was your vision? How was vision affected in each of the simulations?
- What are the different types of color deficiencies and what causes them?

Additional Resources & Current Connections:

- Current Connections – Color deficiency and perception
  - Neuroscience News (2021) article - Blind People Can't See Color but Understand It the Same Way as Sighted People
  - Neuroscience News (2021) article – Do you see red like I see red?

- New York Magazine (2019) article – Do color-blind glasses actually work?
- American Chemical Society (2021) article – Color blindness-correcting contact lenses

Activity: Logos & Gestalt Principles

Question: What are the Gestalt principles and how do they help us understand how we group items and recognize objects?

Activity Guide & Procedure:

- This activity can be done independently or in groups/partners
- You can either provide students with examples of logos/images (see below for examples) for each Gestalt principle or have students find their own logos/images in the environment that demonstrate the different Gestalt principles

Estimated Time: 10-20 minutes

Student Questions/Discussion Prompts:

- Can you describe the different Gestalt principles (and/or other vision terms) and how they help us recognize objects?
- Can you find/identify a logo/image that represents a Gestalt principle?

Example logos:

 **World Wildlife Fund** *(example of closure)*	 **Toblerone** *(example of figure-ground)*	 **Hotel Association of Canada** *(example of continuation)*	 **McDonald's** *(example of symmetry)*
 **Coca-Cola** *(example of continuation)*	 **IBM** *(example of proximity)*	 **FedEx** *(example of figure-ground)*	 **USA Network** *(example of closure)*
 **Pittsburgh Zoo & Aquarium** *(example of figure ground)*	 **Adidas** *(example of parallelism & symmetry)*	 **Sun Microsystems** *(example of similarity)*	 **Unilever** *(example of proximity & global superiority effect)*

Activity: Optical Illusions

Question: How is your brain "tricked" by different visual illusions?

Activity Guide & Resources:

- There are many types of visual illusions (generally broken down into three categories: physical, physiological and cognitive illusions). Examples include:
  - Size and depth illusions
  - Ambiguous figures
  - Motion illusions
  - Illusory contours
  - Afterimages
  - Color constancy

- **Hands-on activities:** you can recreate many illusions using simple, inexpensive materials (e.g., colored construction paper, images printed on computer paper, scissors, string, straws, pipe cleaners, etc.):
  - American Academy of Ophthalmology – Optical Illusions
    - Includes: a gallery of optical illusions and activities for making a spinning disc and flip book
  - Exploratorium Science Snacks – Optical Illusions
    - Includes: activities for afterimages, ambiguous figure, Ames chair, sliding gray step
  - Ben Balas, PhD – Hands-On Vision Science
    - Includes: activities for illusory contours, color constancy, Ames room, and perspective cues to size and depth

- **Online galleries/resources for visual illusions** *(you can have students find their favorite illusion)*
  - Neuroscience for Kids – Visual Illusions
  - American Museum of Natural History – Optical Illusions and How They Work
  - National Eye Institute – Optical Illusions
  - Neural Correlate Society – Best Illusion of the Year
  - Akiyoshi Kitaoka, PhD – Akiyoshi's illusion pages
    - Professor Kitaoka also regularly posts illusions on his Twitter
  - Journal of Illusion – Latest Articles

Student Questions/Discussion Prompts:

- Describe the physical or psychological processes that lead to the illusion
  - That is, why does the illusion occur and/or what is happening in our visual system that tricks us to seeing the illusion?

Additional Resources & Current Connections:

- Current Connections – Visual illusions and animals
  - Smith, G. E., Chouinard, P. A., & Byosiere, S. E. (2021). If I fits I sits: A citizen science investigation into illusory contour susceptibility in domestic cats *(Felis silvestris catus). Applied Animal Behavior Science, 240*, 105338. https://doi.org/10.1016/j.applanim.2021.105338
    - NPR (2021) article - Cats Take 'If I Fits I Sits' Seriously, Even If The Space Is Just An Illusion

Sound Activities

Activity: Model Pinnae

Question: How does our outer ear shape change our hearing?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Speaker	You can use a speaker on your computer/phone (or any other device) to play music or sounds during this task	Free (or low cost)
Paper (optional)	You can use any sort of paper for this activity (or if you want you can give students multiple types of paper/craft materials, like cardboard or construction paper)	Free (or low cost)
Tape (optional)	Amazon – Amazon Basics Brand Masking Tape ▪ This package has 3 rolls of masking tape *(this can be used in other activities)*	$8
Scissors (optional)	Amazon – Westcott brand Scissors for Kids ▪ The package contains 6 scissors *(these can be used in other activities)*	$5
**Notes: Instead of purchasing paper, tape or scissors for students, you could have students find them from their rooms/homes/offices. There may also be lower cost options for these items at your local dollar/grocery store.*		

Activity Guide & Set-up:

- This activity can be done independently (if there is a speaker/sound source in the room) or, if you do not have a speaker/sound source, you can have students work in pairs or groups so that they can talk to one another during the task
    - If you are using a speaker/sound device, have some music playing (if not, have students talk to one another during the activity to test out their ears)
- If you are using any extra materials for your demonstration (such as paper, scissors and tape) you can distribute them to students

Estimated Time: 10-20 minutes

Activity Procedure:

1. Start by noticing what you are hearing with your regular ears
    - How do the sounds from the speaker (or your partner) change when you move your head?
2. Try giving yourself a new outer ear shape (i.e., pinnae) by folding your hands in different ways around your ears (e.g., cupping their ears, holding their hands flat behind their ears, pinning their ears to their head, etc.)

Task Variations

- Use the paper (or other materials) to create new outer ears (i.e., pinnae) for yourself!
    - You can try folding or rolling the paper in different ways (or if you have more intricate designs, you can cut and tape the materials together)

Student Questions/Discussion Prompts:

- Did your hearing change when you tried the new outer ear shapes? How did it change?
- What are the advantages and disadvantages of changing the shape of your ear? Does one shape work better than the others?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
  - Exploratorium Science Snack – Designer Ears
  - Scientific American Science Buddies – Ears: Do their Design, Size and Shape Matter?
- Current Connections
  - Smithsonian Magazine (2018) article - Doctors 'Grow' Ear for Transplant in Patient's Forearm

Activity: Sound Vibrations & Model Eardrums

Question: How does sound travel through air? How does the eardrum work to transmit sound?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Cups	Option 1: Find/use any drinking cup(s) from your room/home/office Option 2: Amazon – Prestee brand Clear Plastic Disposable Cups ▪ This package contains 200 cups *(these can be used for other activities)*	Free - $25
Plastic Wrap	Amazon – Glad brand ClingWrap Plastic Wrap ▪ This package contains 200 square feet of plastic wrap	$5
Rubber Bands	Amazon – BAZIC bra Multicolor Rubber Bands ▪ This package contains 465 rubber bands of assorted sizes	$4
Sugar Packets	Amazon – Domino brand Sugar Packets ▪ This is a box of 200 individual sugar packets *(these can be used for other activities)* *Note: For an in-class demonstration, if you do not need individual sugar packets for students, a bag of sugar will be much cheaper*	$8
**Notes: You may be able to find cheaper disposable cups, plastic wrap and/or rubber bands at a dollar/grocery store. Also, instead of sugar you could use pepper, rice or any similar substance.*		

Activity Guide & Set-up:

- This activity can be done independently or in partners/groups
- Cut the plastic wrap into squares so that they will completely cover the opening of your cup (the exact size will be dependent on your cup)
- Distribute a cup, plastic wrap, a rubber band and a sugar packet to students (either in-person or via take-home lab kits)

Estimated Time: 15 minutes

Activity Procedure:

1. Stretch the plastic wrap tightly over the opening in the cup and secure it in place with the rubber band, if necessary (the plastic wrap represents the eardrum)
2. Place a pinch of sugar on top of the plastic wrap
3. Make some noise next to your cup (but make sure you do not physically touch the cup) and watch how the sugar moves on the plastic wrap
    a. You can use your own voice or a phone/computer to generate sounds
    b. Experiment with louder and softer sounds (or a variety of different sounds) to see how the plastic moves and the sugar reacts

Task Variations

- If your cup is large enough, you could put your phone or speaker inside the cup (and stretch the plastic wrap over it)
    - **Note:** you need a way to change the sound levels on your phone without touching it (e.g., play a video with multiple sound levels or use an external device, like an Apple Watch, to control sounds)

- As an additional way to demonstrate how sounds vibrate, you feel your own throat while they talk (or hum/make other noises)
    - You can also use pluck the rubber bands to make a variety of sounds and monitor how the rubber bands vibrate with each different sound
- If your budget allows, you could also purchase tuning forks to explore pure tones and sound vibrations
    - **Note**: check the reviews for the quality of tuning forks before your buy online

Student Questions/Discussion Prompts:

- How does sound travel? What are the physical and psychological properties of sound?
- How did the plastic wrap and sugar move for different sounds? How does this relate to how your eardrum (i.e., tympanic membrane) moves in your ear?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Neuroscience for Kids – Hearing (Audition)
- Current Connections
    - The connection between the eyes and ears
        - Gruters, K. G., Murphy, D. L., Jenson, C. D., Smith, D. W., Shera, C. A., & Groh, J. M. (2018). The eardrums move when the eyes move: A multisensory effect on the mechanics of hearing. *Proceedings of the National Academy of Sciences, 115*(6), E1309-E1318. https://doi.org/10.1073/pnas.1717948115
        - Neuroscience News (2018) article - When the Eyes Move, the Eardrums Move Too
    - How sounds travel on Mars
        - NASA (2022) – What sounds captured by NASA's Perseverance rover reveal about Mars

Activity: Sound Conduction

Question: Can sound waves travel through solid objects?

Materials List & Sample Budget:

Activity #1: Bone Conduction

Materials	Example Items/Links	Appr. Cost
String/ Rope	Amazon - Shintop Natural Jute Twine ▪ This roll has ~100 m of twine *(this can be used in other activities)* *Note: You can buy any type of string/rope/yarn that is easy to cut and tie!*	$6
Metal Object	Option 1: Utensils (spoons or forks work well) ▪ Amazon – Tramontina brand Stainless-Steel Teaspoons ○ This is a pack of 36 teaspoons *Note: You could find these from home/school or purchase them*	Free - $25
	Option 2: Metal hangers ▪ Amazon – Fayleeko brand Wire Hangers ○ There are 40 in this package *Note: You could find these from home/school or purchase them*	Free - $25
Scissors	Amazon – Westcott brand Scissors for Kids ▪ The package contains 6 scissors *(these can be used in other activities)*	$5
**Notes. There may also be lower cost options for these items at your local dollar/grocery store or from thrifting the metal hangers or utensils!*		

Activity #2: Telephone Cups

Materials	Link	Appr. Cost
String/ Rope	Amazon - Shintop Natural Jute Twine ▪ This roll has ~100 m of twine *(this can be used in other activities)* *Note: You can buy any type of string/rope/yarn that is easy to cut and tie!*	$6
Scissors	Amazon – Westcott brand Scissors for Kids ▪ The package contains 6 scissors *(these can be used in other activities)*	$5
Small Cups	Amazon – Comfy brand 3 oz small paper bathroom cups ▪ There are 300 small (3 oz) bathroom cups in this package *(these can be used in other demonstrations)*	$13
**Notes. There may also be lower cost options at your local dollar/grocery store.*		

Activity Guide & Set-up:

- Activity #1: Bone Conduction
  - Students can either work independently or in groups/pairs for this activity
  - Cut the string into 60 cm sections
  - Distribute two pieces of string and a metal object of your choice to students (either in-class or via take-home lab kits)

- Activity #2: Telephone Cups
  - Students should work in pairs or groups for this activity
  - Poke small holes in the bottoms of your cups (small enough to thread the string through) and cut pieces of string in ~1.5-3 m increments (the longer the better, but be mindful of space constraints)
  - Distribute two cups and a piece of string to your students

Estimated Time: 10-15 minutes

Activity Procedure:

1. Activity #1: Bone Conduction
   a. Tie one end of each string to the metal object (e.g., either the hook of the metal hanger or the handle of the utensil)
   b. Wind or tie the free end of one of your pieces of string around one of your index fingers a few times
      i. Wind or tie the other string around the index finger on your other hand
   c. Allow your assembly to swing freely from your two fingers
   d. Put your index fingers, with the string wrapped around each, into your ears (**note**: do not push too hard!)
      i. The metal object should be hanging in front of your chest/stomach without touching any other object (see figure)
   e. Lean over and lightly hit the metal object against a hard surface (e.g., desk, door, wall, etc.) or have a partner hit the metal object with a pen or pencil
      i. Make sure to keep your fingers in your ears
      ii. Try varying the amount of force you use when you hit the metal object against the hard surface

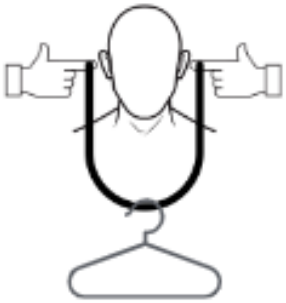


Figure: Example bone conduction set-up with a metal hanger

2. Activity #2: Telephone Cups
   a. Using each end of the string, thread it through the bottoms of the cups, tying a large knot so that the string does not fall out of the cup
   b. You and your partner should move far enough away from one another so that the string is tight
      i. Be sure that the string does not touch any other object and that it remains suspended in air
   c. Taking turns, talk into the cup, while the other person listens by putting the cup to their ear
      i. **Note:** Plug your ear not being used (this is to ensure that you are listening to the transmitted sound via the telephone cups)
   d. Repeat what you hear to the other person to verify what they said!

Student Questions/Discussion Prompts:

- What sounds do you hear? How is possible that you are hearing a sound when you have plugged your ears? How does the sound travel to your ears?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
  - Exploratorium Science Snack – Secret Bells

- Current Connections – What are bone conduction headphones work?
    - Macmillan Community: Psychology Blog (by Sue Frantz) - Bone Conduction Headphones: Getting Questions About These?

Activity: Basilar Membrane Model

Question: What happens to the basilar membrane when you hear a sound?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Slinky® (i.e., "spring toys")	Amazon – Bedwina Rainbow Spring Toy Assortment ▪ This package has 50 spring toys of different shapes (e.g., stars, hearts, etc.) - traditional circle shapes work best, but, overall, the shape does not matter *Note: If doing this as an in-person demonstration you could just purchase 1-2 longer spring toys*	$20
Tape (optional)	Amazon – Amazon Basics Brand Masking Tape ▪ This package has 3 rolls of masking tape *(these can be used in other activities)*	$8

Activity Guide & Set-up:

- This activity can be done independently or in partners/groups
- Distribute a spring toy (and ~15 cm of tape, if you are using it) to students (either in-person or via take-home lab kits)

Estimated Time: 10-15 minutes

Activity Procedure:

1. Stretch the spring toy out along a tabletop
    a. The spring toy represents the basilar membrane in the cochlea as if it were completely uncoiled
2. While holding the spring toy semi-taut, "pluck" the spring toy like you would a string on a guitar
    a. The wave created by the plucking will travel the length of the spring toy and return
    b. Notice how the spring toy moves and compare that to how sound waves travel along the basilar membrane in the cochlea (and where the hair cells along the basilar membrane bend the most)
3. As the basilar membrane is stiffer at the stapes end than the end by the helicotrema, you could tape or hold one end of the spring toy to change how flexible it is and make that end stiffer
    a. When you pluck the spring toy again, notice how the wave that travels along the spring toy does not remain constant as it did before
    b. Plucking the spring toy at the stiff end results in a larger displacement at the flexible end

Student Questions/Discussion Prompts:

- How does the basilar membrane move in response to low and high frequency sounds? How does the brain code for these different frequencies?

Activity: Range of Hearing & Hearing Loss

Question: How good is our sense of hearing (and does it change with age?)

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Speaker	You can use a speaker on your computer/phone (or any other device) to play the sounds during this task	Free
Headphones (optional)	For optimal hearing, wearing headphones while listening is recommended	Free

Activity Guide & Procedure:

- Send students a link to test their hearing online
  - Advise that students be in a quiet place and wear headphones while listening for the best experience:
  - Examples (there are many online versions of this task)**:**
    - Stephane Pigeon – Online Hearing Test and Audiogram Printout
    - Brain Games (YouTube) – Take the High-Frequency Hearing Test
    - AsapScience (YouTube) – How Old Are Your Ears? (Hearing Test)
    - You Oughta Know (YouTube) – Hearing Frequency Test

- ****Important Safety Notes:***
  - *These activities are not meant to be diagnostic (if a student notices something wrong with their hearing, they should contact their doctor/medical professional!)*

Estimated Time: 5-10 minutes

Task Variations

- You could do this as a larger full class demonstration, but the quality of the experience will be dependent on how good your speakers are and how quiet your classroom is
- Have students try this with their friends/family to see if there are individual differences in hearing ability

Student Questions/Discussion Prompts:

- Does our sense of hearing change as we get older? If yes, how does it change? Were you surprised by the frequencies you were able to hear during the hearing test?
- What is going on biologically to cause these changes?

Additional Resources & Current Connections:

- Information on hearing loss and how to protect your hearing (as well as additional hearing activities)
  - Dangerous Decibels – has information on protecting your hearing and an educator guide to hearing
  - CDC – Noise and Hearing Loss Website
  - Audiology Net – has a range of information on different hearing disorders

Activity: Sound Localization & Illusions

Question: How do we determine where sounds are coming from?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Earplugs	Amazon – LYSIAN Ultra Soft Green Foam Earplugs ▪ This package has 60 pairs of earplugs (~120 individual plugs)	$9
Blindfolds (optional)	Amazon – EUICAE brand Eye Mask Sleep Mask Blindfold Eye Cover ▪ This package contains 30 blindfolds (*these can be used for other activities)*	$10
**Notes: There may also be lower cost options for these items at your local dollar/grocery store!*		

Activity Guide & Set-up:

- As students will need to work in groups, this activity would be best as an in-class demonstration

- *****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*

Estimated Time: 10-20 minutes

Activity Procedure:

1. As a class (or in large groups) encourage students to stand (or sit) in a circle
2. Have one student volunteer to stand (or sit) in the middle of the circle
   a. The volunteer should close their eyes (or use a blindfold)
3. As the instructor, point to another student in the circle and have them say one word/sound (e.g., the volunteer's name, "Marco", clap or click their tongue, etc.)
4. The volunteer should try to point in the direction of the voice and/or try to identify who said it
5. Next, give the volunteer one earplug (to close one ear)
6. Repeat steps 3 and 4 to see how accurate the volunteer is using only one ear!
   a. Variation: using a funnel (or a piece of paper rolled into a funnel shape), students can repeat the task while holding the funnel to one ear and keeping their eyes closed
7. Switch students!

Task Variations

- Sound acuity test:
  - Additional materials: a partner, a ruler and stopwatch that makes a ticking sound (or a phone that makes a ticking sound)
  - Procedure:
    - Blindfold the volunteer and plug one ear with an earplug
    - The partner should hold a ticking stop watch close to the volunteer's other ear (the one without the earplug)
      - The volunteer will indicate if they can hear the ticking sound
    - The partner should move the clock away about 10 cm at a time and will note the distance at which the volunteer can no longer hear the ticking
    - Repeat with the other ear

- Localization Version #2
    - Additional materials: hose/pool tubing (long enough so that if students hold one end of the tube at each ear, the tube will hang to approximately waist height)
    - Procedure:
        - Place the ends of the tube at each ear (and let the middle of the tube hang to waist-high)
        - Have a partner tap right in the middle of the tube and then tap again ~1-2 inches to one side and then the other
        - Notice when you can hear the sound with both ears versus when you hear the sound with one ear before the other (see link below for more information)
            - Exploratorium Science Snack – Stereo Sound

Student Questions/Discussion Prompts:

- Was it easier or harder to locate the sound with one ear or two? Why?

Additional Resources & Current Connections:

- For an online demonstration of sound localization try the Virtual Barber Shop (YouTube)
    - For best results, students should be listening to this on their own device in a quiet space with headphones in
- Examples of Sound Illusions
    - Asap Science (YouTube) – Can You Trust Your Ears?
    - Asap Science (YouTube) – Will This Trick Your Ears?
    - Vox (YouTube) – The sound illusion that makes Dunkirk so intense
    - BBC (YouTube) – Try this bizarre auditory illusion

Vestibular Senses Activities

Activity: All About Balance

Question: How does our body maintain a sense of balance?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Body	You will need to use/move your body for the majority of these tasks	Free
String/Rope (optional)	Amazon - Shintop Natural Jute Twine ▪ This roll has ~100 m of twine *(this can be used for other activities)* *Note: You can buy any type of string or rope that will be visible when laid on the floor!*	$6
Tape (optional)	Amazon – Amazon Basics Brand Masking Tape ▪ This package has 3 rolls of masking tape *(this can be used for other demonstrations)*	$8
Blindfolds (optional)	Amazon – EUICAE brand Eye Mask Sleep Mask Blindfold Eye Cover ▪ This package contains 30 blindfolds *(these can be used for other activities)*	$10
Stop watch (optional)	Students can use their phones/computers or a clock in classroom	Free
Balance Boards (optional)	Amazon – Yes4All brand Wooden Wobble Balance Board ▪ This board is more expensive, but would make for a great in-class demonstration	$20

Activity Guide & Set-up:

- These activities can be completed independently or in small groups/partners
- The majority of these activities do not require any equipment
    - However, if you would like to use the string/rope for straight line walking, please cut sections of it into ~3-6 m increments
        - If using the extra materials, you can distribute the rope and blindfolds to students in-class or via take-home lab kits

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
    - *As students will be balancing with and without their eyes closed, make sure that the area surrounding students is clear and that you monitor students (in case they fall)*
        - *Similarly make sure that students know how to use any equipment properly before beginning!*
    - *Some students may feel uncomfortable participating and, therefore, please make these activities voluntary*

Estimated Time: 5-20 minutes (depending on the activities)

Activity Procedure:

1. Activity #1: Challenge your vestibular system through yoga!
    a. Stand on one foot for 30 seconds with your eyes open (students who are familiar with yoga could try tree pose or modified versions of tree pose)

b. Try the same pose as above but with your eyes closed (you can use the blindfolds if easier)
c. Spin around a few times, then close your eyes and balance on one leg
d. **Notes**: feel free to try a variety of different yoga poses to challenge the vestibular system!

2. Activity #2: The connection between visual and vestibular systems
    a. Stand on one foot
    b. Close the eye that is on the SAME side as your raised foot (e.g., if my right foot is raised, my right eye should be closed)
        i. Your other eye should be open and looking at some convenient point or object in front of you
    c. Very carefully and gently press against your eyelid of your open eye with the index finger on the same side of your body (e.g., if my left eye is open, I should press against the left eyelid with my left index finger, gently pushing my eye towards my nose)
        i. As you gently displace the eyeball toward your nose, you should continue looking at the point/object in front of you
            1. After a few moments, you should begin to lose balance and sway to the side of the open eye
    d. Swap sides (i.e., open eye, leg, and finger)
        i. Your upper body should automatically sway toward the side of the eyeball pressed on (because of the distortion in the incoming visual information)

3. Activity #3: Walking in a straight line
    a. Place the string on the floor in a straight line and tape down the ends
    b. Try walking as straight as possible down the length of the string with your eyes open
        i. When you get to the end of the string, try doing it again but with their eyes closed (or using a blindfold)
            1. **Note:** please watch where students are going and be mindful that they do not run into anything/anyone
    c. Variations on this task:
        i. If you choose not to use a piece of string, you can always do this activity by following lines on tiled floor or using a pathway outside
        ii. You can also try a variation of the tandem gait (heel-to-toe) task, where you walk in a straight line with one foot immediately in front of the other (heel-to-toe) with arms down by your side
            1. Once you go 9 steps, you should turn around and go back but this time with their eyes closed

4. Activity #4: Balance boards
    a. Try balancing on the balance boards both with and without your eyes closed (please make sure that the area around the balance board is clear in case people stumble)
        i. Make it a competition to see who can balance the longest (within given time limits!)
        ii. For variations on this task, you can try “tiring” out your leg muscles ahead of time by jumping or doing squats before balancing

Student Questions/Discussion Prompts:

- What sensory and perceptual cues help us to stand up/stay balanced?
    - For any of the activities, why was it harder to balance with your eyes closed? What is the connection between vision and the vestibular system?
- What is the importance of the vestibular senses?

Additional Resources & Current Connections:

- Current Connections
  - Simone Biles gets “the twisties” in the 2021 Summer Olympic games (there are many news stories about this from both Simone’s perspective and other athletes – see below for examples)
    - NPR (2021) article - Simone Biles got the 'twisties' at the Tokyo Olympics. Here's what that means
    - American Academy of Audiology (2021) article – The vestibular system takes home the gold
  - Can we walk in a straight line with our eyes closed?
    - Souman, J. L., Frissen, I., Sreenivasa, M. N., & Ernst, M. O. (2009). Walking straight into circles. *Current Biology, 19*(18), 1538-1542. https://doi.org/10.1016/j.cub.2009.07.053
      - NPR (2010) article – Why Can’t We Walk Straight
  - Medical/clinical connections
    - Neuroscience News (2021) article - Implant Improves Balance, Movement and Quality of Life for People With Inner Ear Disorder
  - Field Sobriety Tests and Neurological Disorders
    - Walk and Turn test (i.e., the tandem-gait test) used to evaluate MS and Parkinson’s patients

Activity: The Vestibulo-Ocular Reflex

Question: How do your eyes stay stable when your head moves?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Body	You will need to use/move your body for the majority of these tasks	Free
Book (optional)	Please use any material that has printed writing on it (e.g., book, piece of paper, written notes, etc.)	Free
Office chair (optional)	Please use any office chair that can rotate/spin a full 360 degrees	Free

Activity Guide & Set-up:

- Some of these activities do not require any equipment and could be done independently
    - However, if you choose to do the office chair demonstration, it would best work as an in-class demonstration

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
    - *As students will be balancing with and without their eyes close, make sure that the area surrounding students is clear and that you monitor students (in case they fall)*
        - *Similarly make sure that students know how to use any equipment properly before beginning!*
    - *Some students may feel uncomfortable participating and, therefore, please make these activities voluntary*

Estimated Time: 5-10 minutes

Activity Procedure:

1. Activity #1: Basic demonstration of the vestibulo-ocular reflex
    a. Hold one of your index fingers ~30 cm front of your face with your eyes focused on the fingertip
    b. Shake your fingertip from side to side (as if shaking your hand saying “no”) and try to track your moving fingertip without moving your head
        i. Notice that your fingertip appears blurry and hard to see clearly
    c. Next, go back to the starting position (with one of your index fingers ~30 cm in front of your face with your eyes focused on your fingertip) but this time you should try shaking your head back and forth (as if saying “no”) while continuing to stare at your fingertip (which should remain still)
        i. Notice that, this time, your fingertip remains clear
    d. **Variations on this task**:
        i. You can do the same thing with a printed piece of paper or book instead of your finger
            1. Notice that you cannot read the text when you move the paper in front of your face, but you can read the text when you shake your head)

2. Activity #2: Chair demonstration of the vestibulo-ocular reflex
    a. Work in groups for this demonstration
    b. Have one student (the volunteer) sit in an office chair that spins 360 degrees with their hands down and eyes closed

c. Have another student spin the volunteer 5-10 times and then have the volunteer open their eyes immediately
d. The other students in the group should observe the test subject's eye movements
e. You can also try spinning the volunteer in the opposite direction

Student Questions/Discussion Prompts:

- How do eye movements change throughout the activities as your head moves?
- What is the purpose of the vestibulo-ocular reflex?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
  - Teach.Genetics – The Vestibulo-Ocular Reflex
- Current Connections
  - Motion Sickness
    - You can purchase motion sickness glasses (from Amazon; 1 pair is ~$20)
    - Smithsonian Magazine (2018) article – Could these glasses cure your motion sickness?

Activity: Semicircular Canal Demonstration

Question: How do the semicircular canals work to sense head rotation?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Body	You will need to use/move your body for this task	Free
Cups	Option 1: Find/use any drinking cup(s) from your home/office Option 2: Amazon – Prestee brand Clear Plastic Disposable Cups ▪ This package contains 200 cups (*these can be used for other activities)* *Note: you should be able to find cheaper disposable cups at a dollar/grocery store*	Free - $25
Paper	You will need some scrap paper for this task *Note: you could also use any small object(s) that float*	Free
Water	You will need water for this task	Free

Activity Guide & Set-up:

- Start by cutting the paper into roughly 2 cm squares
- Distribute cups and paper to students (either in-person or in take-home lab kits)

Estimated Time: 10 minutes

Activity Procedure:

1. Fill a cup with water until it is approximately three-quarters full
2. Place the small paper square (or another small object that floats) in the cup of water
    a. The cup represents the semicircular canal (in this case, the horizontal canal) and the water represents the fluid inside it (the paper is a marker that travels with the water, so you can see the movement)
3. Hold the cup firmly with both hands and rotate/spin one full circle to the left
4. Watch the paper marker as you rotate your body
5. Repeat, watching the paper as you rotate your body in a full circle to the right

Student Questions/Discussion Prompts:

- Does the fluid move in the same direction as the cup, the opposite direction, or not at all?
- How does this relate to the fluid in the semicircular canals?
- How do the semicircular canals work to sense rotation?

Additional Resources & Current Connections:

- The activity was modified and adapted from:
    - Teach.Genetics – Semi-Circular Canal Demonstration

Touch Activities

Activity: Two-Point Touch Threshold

Question: How far apart on the skin must two pointed objects be in order for a person to tell that there are two objects rather than one?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Paperclips (of varying sizes)	Amazon – DANRONG brand Assorted Paper Clips (Small, Medium and Large) ▪ This set contains 650 paperclips of different sizes *(these can be used for other demonstrations)*	$7
Rulers	Amazon – McKesson brand Wound Measuring Guide ▪ This package contains 50 paper rulers (that measure to 15 cm)	$7
**Notes: You can buy two-point discriminators online (they run ~$10 per discriminator). You can also make two-point discriminators using toothpicks, corks and rulers. Paperclips were chosen here due to their inexpensive nature and that they are easy to send home in take-home kits.*		

Activity Guide & Set-up:

- Distribute ~6 paperclips (of varying sizes) and a ruler to each student (either in-class or in take-home lab kits).
    - Note: Students should work in pairs or groups for this demonstration; so, if doing this as a take-home activity, have students ask a friend or relative to help them!

- To create a series of two-point discriminators with the paperclips, start by bending all of your paper clips into a "U" shape - make sure that ends/tips of the "U" are even with each other
    - Starting with your smallest paperclip, adjust the paperclip so that the ends/tips are ~2 mm apart (use your ruler to measure)
    - For your next paperclip, adjust the paperclip so that the ends/tips are ~5 mm apart
    - For your next paperclip, adjust the paperclip so that the ends/tips are ~10 mm apart
    - For your next paperclip, adjust the paperclip so that the ends/tips are ~20 mm apart
    - For your next paperclip (using your largest paperclip), adjust the paperclip so that the ends/tips are ~40 mm apart
    - Adjust one paperclip so you only have 1 end/tip available
        i. **Note:** as there are large jumps in paperclip sizes (e.g., going from 10 to 20 mm), you could also just adjust one paperclip in 2 mm increments and use that as your discriminator throughout this activity

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
    - *Some students may not feel comfortable being touched by others and, therefore, this activity should be only used on a voluntary basis*

Estimated Time: 30 minutes (this is after creating your discriminators); plan on each student taking 15 minutes

Activity Procedure:

1. Ask a student volunteer to sit with their eyes closed (or blindfold them)

   a. With student permission/comfortability, the following body parts should be available to touch: index fingertip, palm, forearm
2. Have a partner (the experimenter) explain that they will be touching different parts of the volunteer's skin and that they (the volunteer) will need to say if they feel one or two pressure points
   a. The experimenter should also let the volunteer know that sometimes they will be using a paperclip with only one point/tip (but that the volunteer won't know when!)
3. Start with the 2 mm paperclip and the index fingertip
   a. Have the experimenter lightly touch the two ends of the paperclip to the volunteer's fingertip (making sure not to press too hard and that both tips/ends of the paperclip touch at the same time)
   b. The experimenter should ask the volunteer if they feel one or two pressure points
   c. If the volunteer reports only feeling one point, have the experimenter move to the 5 mm paperclip and test again
   d. Repeat with the differently sized paperclips until the volunteer reports feeling two points
   e. Every couple of trials, the experimenter should randomly use the paperclip with the single tip/point (making sure not to tell the volunteer)
      i. It is important that the volunteer only reports feeling one point for these trials
   f. Using the table below, write down the threshold distance in millimeters when the volunteer reports feeling two pressure points (make sure that this does not happen in a trial where the one-point paperclip was used!)
4. Repeat the procedure for the different body parts and for all students

Student Questions/Discussion Prompts:

- What parts of the body are most sensitive (i.e. where on the body can two points be detected with the smallest tip separation?)
- What does this tell you about receptor receptive fields in these locations?

Location	Two-point threshold
Fingertip (index finger)	mm
Palm	mm
Forearm	mm

Additional Resources & Current Connections:

- This activity was adapted and modified from:
  - Canada Science and Technology Museum – Testing Skin Sensitivity
  - Neuroscience for Kids – 2-Point Discrimination
  - Neuroscience for Kids – Our Sense of Touch: Two-Point Discrimination

Activity: Tactile Detection Threshold

Question: What is the smallest amount of pressure someone can detect?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Fishing Line (Monofilament)	Amazon – Selizo brand Clear Fishing Line (Invisible Monofilament Nylon) ▪ This set contains 4 rolls of differently sized wire (.2, .3, .4, and .5 mm thick)	$9
Pens	Amazon – BIC brand ball point pen ▪ This package contains 60 pens *(these can be used for other activities)*	$6
** Note: You do not need to purchase fishing line of different sizes unless you want to have students test their sensitivity using the different wires (you may be able to find this cheaper at your local craft or outdoor store). You can also distribute rulers if that helps with students drawing a testing square on their hands/arms).*		

Activity Guide & Set-up:

- Choose one roll of monofilament fishing line and cut pieces that are 3-5 cm in length
    - Note: If you would like to use more than one size of fishing line, repeat this process using a second roll (e.g., cutting pieces of line from both the .2 mm and .5 mm roles)
        - Make sure to mark/label which pieces are which (e.g., you could do this by coloring one end of .2 mm line with red sharpie and one end of the .5 mm line with blue sharpie)

- Distribute ~2-3 lines/monofilaments (of each size, if using more than one fishing line size) and a pen to each student (either in-class or in take-home lab kits)
    - Note: You will want students to works in pairs or groups for this demonstration, so, if doing this as a take-home activity, have students ask a friend or relative to help them!

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
    - *Some students may not feel comfortable being touched by others and, therefore, this activity should be only used on a voluntary basis*

Estimated Time: 20 minutes; plan on each student taking 10 minutes for their turn

Activity Procedure:

1. Roughly draw a 4 cm square on the back of their hand with a pen (if needed, give students a ruler to help with this)
    a. **Note:** the pen markings should be easily removed with soap and water, but students do not need to do this step if they are not comfortable
2. Ask a student volunteer sit with their eyes closed (or blindfold them) and have the back of their hand (with the square) placed on a desk and clearly available
3. Their partner (the experimenter) should touch a piece of the line/monofilament to one section of skin in the square by applying just enough pressure to the line/monofilament to bend it
4. The experimenter should ask the volunteer if they feel anything

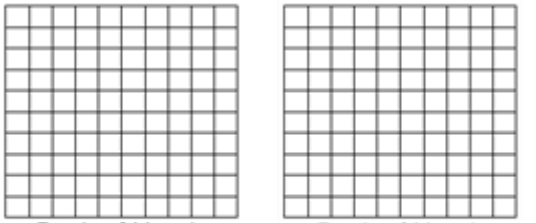
   a. If the volunteer feels the line/monofilament, the experimenter should record the location with an X in the squares below
      i. **Note:** the grid approximates the 4 cm square – students do not need to touch that many locations within the square!
5. The experimenter should repeat this by touching different areas within the 4 cm square with the line/monofilament pieces
6. Switch roles and repeat

Task Variations

- Students could compare results if using lines/monofilaments of different thicknesses
- Students could also compare different parts of the body (e.g., back of the hand, palm, forearm, etc.)
- Students could also test their hot and cold receptors by submerging metal probes in hot and cold water and testing the same square of skin (i.e., do they detect hot and cold uniformly throughout this patch of skin?)

Student Questions/Discussion Prompts:

- Were you surprised by your detection threshold?
- Did the detection threshold change depending on the thickness of the monofilament used?
- Is the detection threshold different for different parts of the body (what is most/least sensitive?) What does this tell you about the densities of the receptors for these locations?



Additional Resources & Current Connections:

- This activity was adapted and modified from:
  - Neuroscience for Kids – Become a Neurologist – Detection Threshold

Activity: Sensing Temperature

Question: How do we sense warm and cold temperature changes?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Bowls	**Option 1** *(for in-class demonstrations or take-home lab kits)*: Find (or have students find) three bowls that are large enough to submerge a hand in when filled with water	Free
	Option 2 *(for in-class demonstrations or take-home lab kits)*: Amazon – Earth's Natural Alternative Store 32oz Compostable Paper Bowls ▪ This set contains 50 bowls *(these can be used for other activities)*	$20
Water and/or ice	Students will need cold, room and hot water for this demonstration	Free - low cost
Stop watch	Students may need/want a stop watch for this activity (they can use a phone or a wall clock for this purpose)	Free
**Note: This activity is relatively simple and requires only that students have access to bowls/pots and water of varying temperatures. The cheapest option would be to find/use bowls from your home/office for this activity and/or get water/ice from your school/dining hall for in-class demonstrations. Please check your local dollar/grocery store for cheaper bowl options.*		

Activity Guide & Set-up:

- Find and/or distribute ~3 bowls to students (either in-person or via take-home lab kits)
  - **Note:** As this requires a bit of set-up, it would work best as a whole class demonstration or have students work in pairs/group
- Fill one bowl with very cold water (you can use tap water and add ice cubes to cool the water)
- Fill a second bowl with room-temperature water
- Fill a third bowl with warm water
  - **Note:** Be sure not to make the water too cold or too hot; you need to be able to comfortably have your hands in this water for a little while (aim for around body temperature water; 98 degrees Fahrenheit/ 37 degrees Celsius – you can test this by using a thermometer)

- **Important Activity Notes:**
  - Make sure to leave enough room in the bowls that you can submerge a hand without spilling the water
  - You may want extra towels handy for students to dry their hands and to clean up any spills
  - Remove anything from your demonstration area than cannot get wet

- ****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
  - *Some students may not feel comfortable putting their hands in warm/cold water and, therefore, this activity should be only used on a voluntary basis*

Estimated Time: 10 minutes

Activity Procedure:

1. Submerge your right hand in the bowl with cold water and your left hand in the bowl with warm water

   a. Classify the temperature of the water in each bowl (i.e., is the water really hot, hot, lukewarm, cold or really cold?)
2. After ~2 minutes classify the temperatures of the water in each bowl again
   a. Does the water feel as hot or cold as it initially did?
   b. Do you think the water in the bowls changed that drastically in this time frame?
3. Next, remove both of your hands and place them in the room temperature water bowl
   a. How would you label the temperature of the water in this bowl (i.e., really hot, hot, lukewarm, cold or really cold?)
      i. Does the label change depending on what hand you pay attention to? That is, do your hands agree or disagree about the temperature of the water?

Student Questions/Discussion Prompts:

- What receptors are responsible for temperature? Do we have a uniform amount of temperature receptors?
- What factors might influence temperature perception?

Additional Resources & Current Connections:

- This activity was adapted and modified from:
  - Scientific American (2015) article – Cold or Warm, Can We Really Tell?

Activity: Sensing Pain *(modified cold pressor test)*

Question: What might influence our perception of pain?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Bowls	**Option 1** *(for in-class demonstrations or take-home lab kits)*: Find (or have students find) three bowls that are large enough to submerge a hand in when filled with ice water	Free
	Option 2 *(for in-class demonstrations or take-home lab kits)*: Amazon – Earth's Natural Alternative Store 32oz Compostable Paper Bowls ▪ This set contains 50 bowls *(these can be used for other activities)*	$20
Water & ice	Students will need very cold ice water for this demonstration	Free – low cost
Stop watch	Students may need/want a stop watch for this activity (they can use a phone or a wall clock for this purpose)	Free
**Note: This activity is relatively simple and requires only that students have access to a large bowl and ice water. The cheapest option would be to find/use bowls from your home/office for this activity and/or get ice from your dining hall for in-class demonstrations. Please check your local dollar/grocery store for cheaper bowl options*		

Activity Guide & Set-up:

- Find and/or distribute bowl(s) to your students (either in-person or via take-home lab kits)
  - Note: This activity would work best as a whole class demonstration or have students work in pairs/groups
- Fill the bowl with water and ice until it is about three-quarters of the way full

- **Important Activity Notes:**
  - Make sure to leave enough room that you can submerge a hand without spilling the water
  - You may want extra towels handy for students to dry their hands and to clean up any spills
  - Remove anything from your demonstration area than cannot get wet

- *****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*
  - *Some students may not feel comfortable putting their hands in ice water and, therefore, this activity should be only used on a voluntary basis*

Estimated Time: 10-20 minutes

Activity Procedure:

1. Submerge one hand in the ice water bowl
   a. Have a partner start a stop watch as soon as your hand enters the ice water bowl
2. You should indicate to your partner when you begin to feel pain/uncomfortable
   a. You partner should note the amount of time that has lapsed (this is called the pain threshold)
      i. Pain threshold time =_____
3. Once the pain becomes unbearable, you should remove your hand
   a. Your partner should note how much time has passed in total

i. Total time passed = _____

b. Pain tolerance is calculated by subtracting the pain threshold from the total time passed
   i. Pain tolerance = _____

Task Variations

- Instead of doing a full ice water bath, you can have students hold ice cubes in their hands (while similarly recording the amount of time it takes for them to feel pain)
- While students have their hands submerged, you can ask them to think about different positive or negative events (or for more mature classes, you can have think about how swearing might influence their pain tolerance)
    - If you wanted to make this a more lab-based activity, you could split your class into different groups and have them do different things while their hands are submerged and see whether that changes overall pain tolerance averages (e.g., a positive vs negative event group, a music versus no music group, a swearing versus not swearing group, etc.)

Student Questions/Discussion Prompts:

- What receptors are responsible for detecting pain? Why might it be beneficial for us to have more than one type of pain receptor?
- What factors might influence pain perceptions?

Additional Resources & Current Connections:

- Background information
    - Mitchell, L. A., MacDonald, R. A., & Brodie, E. E. (2004). Temperature and the cold pressor test. *The Journal of Pain*, *5*(4), 233-237. https://doi.org/10.1016/j.jpain.2004.03.004
    - Neuroscience for Kids – Ouch! Pain and Why it Hurts
- Factors that influence pain tolerance
    - Overview of different factors
        - The British Psychological Society (2011) article – Ouch! The different ways people experience pain
    - Music
        - Garcia, R. L., & Hand, C. J. (2016). Analgesic effects of self-chosen music type on cold pressor-induced pain: Motivating vs. relaxing music. *Psychology of Music, 44*(5), 967-983. https://doi.org/10.1177/0305735615602144
    - Swearing
        - Stephens, R., Atkins, J., & Kingston, A. (2009). Swearing as a response to pain. *Neuroreport, 20*(12), 1056-1060. doi:10.1097/WNR.0b013e32832e64b1
            - Scientific American (2009) article – Why the #$%! Do We Swear? For Pain Relief
        - Stephens, R., & Robertson, O. (2020). Swearing as a response to pain: Assessing hypoalgesic effects of novel "swear" words. *Frontiers in Psychology, 11*, 723. https://doi.org/10.3389/fpsyg.2020.00723
            - Keele University (2020) press release – Only 'Traditional' Swearing Improves our Ability to Tolerate Pain
    - Weather
        - Neuroscience News (2021) article – Weather Can Affect Pain Tolerance
- People who cannot feel pain
    - BBC (2017) article – The curse of the people who never feel pain

Activity: Touch Sensitivity *(Sandpaper Touch Rankings)*

Question: How sensitive is our sense of touch?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Sandpaper (of varying grits)	Amazon – Appex Brand Wet Dry Sandpaper 120 to 3000 Grit (42 pieces) ▪ This set contains 14 different grit sandpapers (with 3 sheets per grit for a total of 42 pieces) ▪ Each sheet is roughly 9 x 23 cm	$9
**Note: You may be able to find cheaper sandpaper options at your local hardware store.*		

Activity Guide & Set-up:

- Before beginning, make sure that each sheet of sandpaper has its grit clearly labeled on the back (so that you can identify them)
- You will want to give each student 5-10 different sandpapers of varying grits
    - Depending on the number of students in your class and how many different sandpaper grits you want each student to sample, you may need to cut up the sandpaper into smaller sections
        - **Note:** As you cut up the sandpaper, make sure you continue to label the back of each strip with the correct grit number!
- Distribute 5-10 different grit sandpapers to each student in a random order (either in person or in take-home lab kits)
    - **Note:** Either make sure to tell students NOT to look at the numbers on the back of the sandpaper until after they have tried the activity OR blindfold students/have students keep their eyes closed while they are doing the task!

Estimated Time: 10 minutes

Activity Procedure:

1. Randomly place the sandpaper strips rough-side up on a table in front of you (and do not to peak at the numbers on the back of the sandpaper strips)
    a. It might be easier to work with a partner for this set-up!
    b. For an extra challenge, you could also close your eyes (or be blindfolded) while doing the task
2. Touch the sandpaper and try to organize the sandpaper strips in order from smoothest to roughest (or vice versa)
3. Once you have their final order, flip the sandpaper over and check the numbers on the back (lower numbered grits are rougher)

Student Questions/Discussion Prompts:

- Did you make any mistakes in the ordering of the sandpaper? If yes, at what grit of sandpaper did you make a mistake?
- Can you describe what touch receptors are active when feeling the sandpaper?

Additional Resources & Current Connections:

- This activity was adapted and modified from:
    - Neuroscience for Kids – Sand Paper Rankings
- Background information on touch
    - Neuroscience for Kids – The Skin or ("Hey! Your epidermis is showing!")

- Background information on sandpaper grit
  - Lowe's (2020) article – Sandpaper Buying Guide
- Current Connections:
  - The 2021 Nobel Prize in Medicine was awarded for research on temperature and touch
    - New York Times (2021) article - Nobel Prize Awarded for Research About Temperature and Touch
    - Vox (2021) article - Our amazing sense of touch, explained by a Nobel laureate
  - Restoring sense of touch
    - EurekAlert (2021) news release - Technology that restores the sense of touch in nerves damaged as a result of injury
    - NPR (2021) article - Scientists Bring The Sense Of Touch To A Robotic Arm

Activity: Proprioception

Question: How can we tell where our body is positioned in space?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Hands	You will need to use your hands for the majority of these tasks	Free
Paper	You can just use scrap paper for this activity!	Free
Pens (or pencils)	Amazon – BIC brand ball point pen ▪ This package contains 60 pens *(these can be used for other demonstrations)* **Note: Students can use any pen/pencil/paper they have available at no cost!*	Free - $6

Activity Procedure:

1. Activity #1 (students might want to be sitting down for this task)
    a. Close your eyes
    b. Try to touch your nose with your right index finger
    c. Repeat with your left index finger
    d. Open your eyes and try again

2. Activity #2 (students might want to be sitting down for this task)
    a. Close your eyes and raise your arms over your head
    b. Keep your left hand totally still with your fingers spread out
    c. With the index finger of your right hand:
        i. First, touch your nose, then quickly touch the tip of your left thumb
        ii. Quickly repeat the entire process for each finger: touch your nose, touch your index finger, touch your nose, touch your middle finger, etc.
    d. Switch hands and try again
    e. Do it again, but this time wiggle the fingers of the hand that is above your head

3. Activity #3
    a. On a piece of paper write the word “neuroscience” with your eyes open
        i. **Note:** make sure your scrap paper is large enough and that you leave more than enough space to write something next to this word
    b. Place your pen/pencil on the same line next to the written word
    c. Close your eyes and try writing “neuroscience” again
    d. Repeat with different words (e.g., your name, short words, long words, etc.)

Estimated Time: 10 minutes

Student Questions/Discussion Prompts:

- How successfully did you do the tasks in Activity #1 and #2? Did you improve with time? Was there a difference when you used your right versus your left hand or when you wiggled your fingertips?
- For Activity #3, was there a difference in the appearance of the two written words?
- What receptors are responsible for proprioception? Why is proprioception beneficial?

Additional Resources & Current Connections:

- This activity was adapted and modified from:
  - Exploratorium Science Snacks – Proprioception
  - Learn.Genetics – Proprioception Test
- Current Connections
  - Vox (2019) article – The silent “sixth” sense

Activity: Haptic Perception

Question: How well can you identify an object by your sense of touch alone?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Containers or bags	**Option 1** *(for in-class demonstrations)*: Medium sized cardboard box (bigger than a shoebox) or pillowcase or tote bag ▪ These should be opaque so that students cannot see anything in the container	Free
	Option 2 *(for either in-class or take-home demonstrations):* Amazon – Jaoul Brand 4 Gallon Black Biodegradable Trash Bags ▪ This pack contains 60 trash bags in total	$6
Small objects	**Option 1** *(for either in-class or take-home demonstrations)*: Find an assortment of small miscellaneous objects from around your home /office ▪ Examples: paper clips, magnets, small figurines or trinkets, rocks, balls, marbles, rubber bands, feathers, candles, corks, pens, pencils, utensils, blocks, erasers, game pieces (like dice or playing pieces) *Note: If students are collecting these objects from home, have them find a friend or relative to help (so that they do not know what all of the objects are!)*	Free
	Option 2 *(if you cannot find small objects around your home/office, you can purchase them, but this will become expensive it you are giving them out in take-home kits)*: ▪ Example 1: Amazon – Big Mo's Toys brand Party Pack Mini Wild Jungle Animals ○ This set contains 100 animal figurines (~10 pieces of ~10 different animal types) ▪ Example 2: Amazon – MAGTIMES brand Magnetic Letters and Numbers ○ This set contains 112 plastic letters and numbers	$10 - $20
Medical Gloves	Amazon – Med Pride brand Medical Vinyl Examination Gloves ▪ This is a pack of 100 large latex-free (to accommodate the majority of hand sizes and for allergies) disposable medical examination gloves	$10
**Notes: There are several different ways you can do this activity, with the most cost-effective way being to use containers and objects from your home/office in an in-class demonstration. You could also try a variety of different gloves (e.g. medical examination gloves, gardening gloves, winter gloves).*		

Activity Guide & Set-up:

- Option 1: In-class demonstration
  - Get your container(s) of choice ready (e.g., cardboard box(es), pillowcase(s), tote-bag(s) - anything big enough to put your objects in without students being able to see/identify what they are)
    - If you are using a cardboard box, cut a hole in the side of the box that is big enough to put a hand through
    - You can choose whether to have students work in groups or as a whole class demonstration with student volunteers
      - **Note:** If you are having students work in groups, you will need one container per group (therefore, pillowcases or tote-bags may be easier than carboard boxes)

- Start by putting 2-3 of your small objects in your container(s)
  - You can add objects to make this task more difficult or take away some if you want to make it easier (or if you have particularly difficult objects)
  - **Note**: you can use any small objects from around your home/office for this task
    - However, if you need to buy them, small plastic animals or magnetic/wooden letters/numbers or cookie cutters work best for this task (and are relatively inexpensive)

- Option 2: Take-home demonstration
  - For the container, give each student a black, opaque trash bag in their take-home lab kit
    - **Note:** You could ask students to find a pillowcase or tote-bag as a free option (but some students may not have these readily accessible and trash bags are an inexpensive option)
  - For the small objects:
    - If you are having students find their own small objects from around their room/house, ask them to work with someone else (so that they do not know what all of the objects are ahead of time)
    - If you have purchased small objects for students (like small plastic animals or magnetic/wooden letters/numbers), include 2-3 objects in their take-home lab kit
      - **Note:** In order to keep these objects hidden from students, you should put the objects in the trash bag (and tell students not to peek in the bag until after the activity is over)
  - Include 1-2 medical examination gloves in kits

- ****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while working in groups and sanitize equipment properly if sharing*

Estimated Time: 10-15 minutes; plan for each student to take 5 minutes for their turn

Activity Procedure:

1. Without looking in the container, put one hand in the container and feel the small object(s)
   a. **Notes:**
      i. You could close your eyes (or be blindfolded) to ensure you are not using your vision!
      ii. If doing this as a whole classroom demonstration, ask a student volunteer to come to the front of the class
2. Using only your sense of touch, guess the what the small objects are in the container
   a. **Notes:**
      i. If using the small plastic animals or magnetic letters/numbers, help them by asking them to identify the correct animal or shape
      ii. As a variation on this game, if you have two of the same objects (e.g., two paperclips), you could put one in the container with other objects and then show the other to the student and have them try to find it
3. After you have attempted to identify a few of the objects, put on a medical examination glove and try to identify some new objects with your gloved hand
   a. **Notes:** For in-class demonstrations, you could have students try several different types of gloves (e.g., medical examination gloves, gardening gloves, winter gloves)

Student Questions/Discussion Prompts:

- How easy/hard was it to identify the objects in the containers?

- What kinds of strategies did you use to feel the objects (e.g., what parts of your hand did you use the most, what kinds of hand movements/motions did you make, etc.)?
    a. Is their a difference between active and passive haptic perception (and what could your strategies be categorized as?)
- What kinds of touch receptors might be active during this task?
- Was it easier or harder to identify the objects when you had a glove on? Why or why not?

Additional Resources & Current Connections:

- This activity was adapted and modified from:
    - Neuroscience for Kids – Brain Box (Bag) of Science
- Current Connections
    - Touch and artificial intelligence
        - Science News for Students (2021) article - A sense of touch could upgrade virtual reality, prosthetics and more

Chemical Senses Activities

Activity: Identifying Smells

Question: How good is your sense of smell?

Materials List & Sample Budget:

Option 1 *(less expensive):*

Materials	Example Items/Links	Appr. Cost
Scratch & Sniff Stickers	Amazon – Horiechally brand (reward stickers) ▪ This has over 700 stickers and includes 16 different scents with designs that do not give away the scent!	$15

Option 2 *(more expensive):*

Materials	Example Items/Links	Appr. Cost
Fragrance Oils	Amazon – Good Essential Fruity Fruits brand ▪ This is a pack of 10 fruity fragrance oils (5 ml each)	$12
Cotton Balls	Amazon – Diane Brand Cotton Balls ▪ This is a pack of 100 cotton balls	$3
Plastic containers	Amazon – Comfy Packaging Brand ▪ This is a pack of 100 "condiment-style" containers (2 oz) with lids (to use if you are planning to distribute the fragrance/cotton balls to students for at-home smell kits)	$10
** Notes: You can get different sets of fragrance or essential oils at different price points! Similarly, you should be able to find less expensive cotton balls at a dollar/grocery store.*		

Activity Guide & Set-up:

- Option 1: Stickers
  - Make note of what color/design stickers are which odor (there should be descriptions or labels on the sheet of stickers)
  - Cut up the stickers so that each student receives approximately 3-5 different stickers
    - You can vary how many stickers each student receives based on class size
  - Distribute the stickers to each student in class (or put them in each student's take-home lab kit)

- Option 2: Fragrance Oils
  - For take-home lab kits (each student receives 3 smell containers)
    - Separate the plastic containers into 3 even groups
      - Using a pen/sharpie, mark each group of plastic containers with a distinct number/color/symbol (e.g., mark the plastic containers in one group with an asterisk)
        - This is to make sure you know which scent is in which container (e.g., an asterisk = banana smell)
    - Choose three of the fragrance oils
      - Put 1-3 drops of your first fragrance oil (your first scent) on a cotton ball and immediately place in a container (and close the lid)
        - Repeat until you have enough containers for scent 1 for your class
      - Repeat this process for your other two scents
  - For in-class lab kits

- You do not need to put the scents into containers – instead put 1-3 drops of your desired scents on cotton balls and distribute the cotton balls to each student
- If you want to make the activity more challenging, include a cotton ball that does not have any of the fragrance oils on it!

Estimated Time: 10 minutes

Activity Procedure:

1. Sniff each sticker (or the cotton ball in each container)
2. Fill in the data sheet below to signify if you can detect, recognize and/or identify the scent
    a. In column 1, mark the sticker or container color/number/symbol (so you can check to see if you correctly identified the scent at the end of the activity)
    b. If you can detect a scent put an X in column 2 (that is, mark an X in this column if you smell anything on the sticker/cotton ball)
    c. If you recognize the scent put an X in column 3 (that is, is this scent familiar to you or have you smelled it before)
    d. If you identify the scent write down what you think it is in column 4
    e. For column 5, check with your instructor to see if you correctly identified the scent!

Sticker or Container Label	**Can you detect a scent?**	**Do you recognize the scent?**	**Can you identify the scent** ***(****if, yes, write down what you think it is here)*****?**	**Did you guess the scent correctly** *(yes or no)***?**

Task Variations

- You could also calculate olfactory fatigue times by closing one nostril and with the other continuously smelling one scent (making sure to keep one nostril closed and exhaling through the mouth and inhaling through the nose)
    - Record the time it takes until the smell is no longer detected (you may want to repeat this a few times and calculate an average time)

Student Questions/Discussion Prompts:

- Compare and contrast detection, recognition and identification of different odors (i.e., what is the difference between these terms?)
- What is the anatomical pathway for your sense of smell?

Additional Resources & Current Connections:

- Additional smell activities and background information on smell
    - Neuroscience for Kids – The Nose Knows
    - Neuroscience for Kids – Smell Experiments
- Students may enjoy learning about the connection between olfaction and careers in perfumery or as a sommelier
    - You can purchase an "Introduction to Perfumery Kit" for $40
    - Royet, J. P., Plailly, J., Saive, A. L., Veyrac, A., & Delon-Martin, C. (2013). The impact of expertise in olfaction. *Frontiers in Psychology, 4*, 928. DOI: 10.3389/fpsyg.2013.00928

- Banks, S. J., Sreenivasan, K. R., Weintraub, D. M., Baldock, D., Noback, M., Pierce, M. E., & Leger, G. C. (2016). Structural and functional MRI differences in master sommeliers: a pilot study on expertise in the brain. *Frontiers in Human Neuroscience, 10*, 414. https://doi.org/10.3389/fnhum.2016.00414
    - Cleveland Clinic press release for the above research by Banks et al. (2016)
- The connection between COVID and smell/taste loss
    - Nature News Explainer (2021) article - COVID's toll on smell and taste: What scientists do and don't know
    - How "smell training" may help with olfactory loss
        - Hummel, T., Rissom, K., Reden, J., Hähner, A., Weidenbecher, M., & Hüttenbrink, K. B. (2009). Effects of olfactory training in patients with olfactory loss. *The Laryngoscope, 119*(3), 496-499. https://doi.org/10.1002/lary.20101
        - The New York Times (2021) article – COVID stole your sense of smell? Try physical therapy for your nose
        - Huart, C., Philpott, C. M., Altundag, A., Fjaeldstad, A. W., Frasnelli, J., Gane, S., & Hummel, T. (2021). Systemic corticosteroids in coronavirus disease 2019 (COVID-19)-related smell dysfunction: An international view. *International Forum of Allergy & Rhinology.* https://doi.org/10.1002/alr.22788
            - EurekAlert press release for the above research by Huart et al. (2021)

Activity: What is Flavor?

Question: What is the connection between smell, taste and flavor?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Jelly Beans	Amazon – Jelly Belly Jelly Beans (individual "trial-size" packs) ▪ There are 80 individual packs of jelly beans in this container	$27
**Note: You could use any candy of your choice for this demonstration as long as the candy has different flavors to it and/or are individually packaged to distribute in take home lab-kits (e.g., Starbursts).*		

Activity Guide & Set-up:

- Distribute a pack of jelly beans (or your chosen candy) to each student (either in-person or in take-home lab kits)

- *****Important Safety Note:***
  - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
  - *As students will be consuming candy/food, make sure that this activity is voluntary and that the nutritional information is available for students*

Estimated Time: 10 minutes

Activity Procedure:

1. Open the packet of jelly beans
2. Close your eyes (so you do not try to guess based on color) and eat a jelly bean as you would normally
   a. Can you identify the jelly bean flavor? Try a different Jelly Bean
   b. **Note**: you might want to cleanse your palate in jelly beans between with a sip of water
3. While your eyes are still closed, plug your nose with one hand (i.e., give yourself an "artificial cold") and eat a jelly bean with your nose blocked
   a. Can you still identify the jelly bean flavor? Try another Jelly Bean
   b. **Note:** Please make sure to chew with your mouth open (so you can breathe)
4. Alternate eating the candy normally and with your nose blocked (and/or with or without your eyes closed)

Student Questions/Discussion Prompts:

- When eating the jelly beans normally, could you identify what flavor of jelly bean you had? How good were you at this task?
- Did your experience of eating the jelly beans change when plugged your nose?
  - If yes, why do you think your experience of the jelly bean changed and can you explain the psychobiological process (i.e., retronasal olfaction) that causes this experience?
- Did your experience of eating the jelly beans change when your eyes were open versus closed? Why do think this might be?

Additional Resources & Current Connections:

- This activity was adapted and modified from the following source:
  - Yuhas, D. (November 22, 2012). *Savory Science: Jelly Bean Taste Test*. Scientific American. https://www.scientificamerican.com/article/bring-science-home-jelly-bean-taste-smell/

Activity: Taste Buds & the Tongue Map Myth

Question: How does your tongue sense tastants?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Small Cups	Amazon – Comfy brand 3 oz small paper bathroom cups ▪ There are 300 small (3 oz) bathroom cups in this package *(these can be used in other activities)*	$13
Water	You will need water for this activity	Free
Salt Packets	Amazon – N'Joy brand Iodized Salt Packets ▪ This is a box of 1,200 individual salt packets *(these can be used for other taste activities)*	$10
Sugar Packets	Amazon – Domino brand Sugar Packets ▪ This is a box of 200 individual sugar packets *(these can be used for other taste activities)*	$8
Cotton swabs	Amazon – Sky Organics brand Cotton Swabs ▪ There are 500 cotton swabs in this package	$8
Phone Camera (or Mirror)	You can have students look in a mirror or take a picture of their tongue with their phone cameras	Free
Method for dying your tongue	**Option 1** *(would work better for in-class demonstrations):* Food Coloring: Amazon – Spice Supreme brand Assorted Food Colors ▪ There package contains 4 food colors (red, blue, green, yellow)	$5
	Option 2 *(would work for both in-class and take-home demonstrations):* Blue Candy ▪ Example: Amazon - Dum Dum brand Black Cherry Lollipops ○ This package contains 75 Dum-Dums ▪ Example: Amazon – BGM brand Blue Raspberry Jolly ranchers ○ This package contains ~70 jolly ranchers	~$15
**Notes: Please know that there may be cheaper options at your local dollar/grocery store for these supplies! You also could add bitter or sour substances if doing this in class (e.g., cocoa powder or lemon juice), however, these are harder to distribute via take-home lab kits.*		

Activity Guide & Set-up:

- Distribute supplies to students (either in class or via take-home lab kits)
  - Each student should receive:
    - 4 small cups, 1 sugar packet, 1 salt packet, ~5 cotton swabs and a piece of blue candy (if using candy instead of food coloring; see below for set-up instructions with food coloring)
- To set up:
  - Add a small amount of water to 2 cups and dissolve a sugar and salt packet in each
    - You may also want to fill a cup with drinking water in order to cleanse your palate
  - If using food coloring, add 1-2 drops of dark (e.g., blue or green) food coloring to a pinch of water in an additional extra cup (you want this food coloring as dark as possible to stain the tongue; do not dilute it too much)
    - **Note**: Most food coloring should not have a taste, but you can add water to the mixture if students report disliking the consistency

- ***Important Safety Notes:**
  - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
  - *As students will be consuming food, make sure that this activity is voluntary and that the nutritional information is available for students*

Estimated Time: 20-30 minutes

Activity Procedure:

1. Activity #1: The myth of the tongue map
   a. **Background:** While the version of the tongue map with different regions dedicated to sensing the different primary tastes (e.g., sweet, salty, bitter and sour) is a myth (see links below for more information), it is true that different types of papillae/taste buds are not evenly distributed across your tongue
   b. To determine where different types of papillae/taste buds are located you will be using the salty and sweet water
      i. Dip a cotton swab in the salty water
      ii. Touch it to the center, side, tip and back of your tongue
         1. **Notes**:
            a. Please follow all sanitation guidelines for handling food and please do not "double-dip" your cotton swab (especially if sharing supplies!)
            b. You may need to take a sip of water in between each dab to cleanse your palate
      iii. Repeat with the sweet liquid
      iv. If using bitter or sour liquids, repeat with those as well!

2. Activity #2: Investigate your taste buds
   a. Dip a cotton swab in the food coloring and place it on the tip of your tongue OR eat a piece of blue candy
      i. You can take a swish of water to move the food coloring around your tongue (but you might want to spit it out after)
      ii. Swallow a few times to dry your tongue
   b. The food coloring/candy should stain and highlight your papillae/taste buds
   c. Using a mirror or phone camera (you or a partner can take a picture of your tongue) to investigate your tongue and the different types of papillae on it
      i. Pay particular attention to the larger papillae (known as fungiform papillae) that should appear as lighter or pink bumps
      ii. To make this more lab-based you can count the number of fungiform papillae you see on the tip of your tongue
         1. See scientific American Science Buddies – Super-Tasting Science: Find Out if You're a "Supertaster"!

Student Questions/Discussion Prompts:

- What are the different types of papillae (the structures where taste buds are located) and what are their functions?
- Do you think different places on your tongue will taste the liquids more intensely? Where on your tongue do you think the liquids will taste strongest? How does this relate to where the different types of papillae are located?

Additional Resources & Current Connections:

- This activity was adapted and modified from the following source:
  - Scholastic Parents – At-Home Science Experiments: Tongue Maps
- The myth of the tongue taste map
  - Smithsonian Magazine (2017) article – The Taste Map of the Tongue You Learned in School is All Wrong

Activity: Umami as a Basic Taste?

Question: What is umami and should it be considered a basic taste?

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Doritos	Amazon – Doritos "Nacho Cheese Flavored" Tortilla Chips ▪ This is a pack of 40 snack bags	$15
Potato Chips	Amazon – Lays "Classic" Potato Chips ▪ This is a pack of 40 snack bags	$15
**Notes: you might be able to find cheaper snack bag options at a dollar store/grocery market but make sure that you get the Doritos "Nacho Cheese" flavor (for the umami) and the Lays "Classic Flavor" (or any classic potato chip) to compare with the Doritos. If getting individual snack bags is not a concern, you can also find larger bags of these chips for sale at a lower price point and then distribute the chips on paper plates.*		

Activity Guide & Set-up:

- **Background** *(see links below for more information)***:** Umami has been described as a savory "meaty" taste, but can be found in non-meat foods like parmesan cheese, tomatoes and mushrooms. It comes from monosodium glutamate (MSG), which you can buy as a food additive in grocery stores (it looks very similar to traditional salt). Historically, there was pushback on the use of MSG for human consumption (as too much can cause side effects, like headaches and flushing, in some sensitive individuals, but these are very rare). By itself, MSG does not taste like much (if you dissolved it in water it would taste similar to chicken broth). However, there are some foods that are rich in MSG, including "Nacho Cheese" Doritos. Doritos contain many sources of MSG including several different types of cheeses, pure MSG and flavor enhancers like disodium inosinate (IMP) and disodium guanylate (GMP), and, therefore, are a great way to experience umami!

- Distribute one pack each of Doritos and potato chips to each student (either in-person or in take-home lab kits)

- *****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
  - *As students will be consuming food, make sure that this activity is voluntary and that the nutritional information is available for students*

Estimated Time: 5-10 minutes

Activity Procedure:

1. Open the packet of Doritos and the packet of potato chips
2. Eat a Dorito by itself and then try a potato chip (to remind yourself of what they taste like)
   a. **Note**: you might want to cleanse your palate in between each with a sip of water
3. Now, plug your nose with one hand (i.e., give yourself an "artificial cold") and eat a few more Doritos with your nose blocked
   a. What do you taste with your nose blocked?
   a. **Note**: Please make sure to chew with your mouth open (so you can breathe)
4. With your nose still plugged, try a potato chip

a. Are there any similarities or differences in your taste experience between the Doritos and potato chips?

5. **Note**: Potato chips and Doritos are relatively matched for salt content, but, unlike Doritos, potato chips do not have MSG
   a. Therefore, students should experience an umami taste with the Doritos that they do not experience when eating the potato chips with their nose plugged

Student Questions/Discussion Prompts:

- What did umami taste like (did you notice a difference between the Doritos and the potato chips with and without your nose blocked?)
- Do you think umami should be considered a fifth basic taste? Why or why not?

Additional Resources & Current Connections:

- This activity was adapted and modified from:
  - Teaching of Psychology Idea Exchange (ToPIX; may require login)
- Background reading on Umami
  - Vox (2018) article – "But what does umami taste like?"
  - Smithsonian Magazine (2013) article – "It's the Umami, Stupid. Why the Truth About MSG is So Easy to Swallow"
  - Wired (2013) article – "Peak Umami"
- Background reading on Doritos (and their taste profile)
  - Serious Eats (2018) article – "Why Nacho Cheese Doritos Taste Like Heaven"
  - The New York Times (2013) article – "The Nacho Dorito"

Activity: Confusing the Senses *(Miracle Berry Demonstration)*

Question: Can our sense of taste be tricked (i.e., what are the neural mechanisms of sweet taste receptors and the psychophysical nature of taste perception?)

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Miracle Berries	Amazon – mBerry "Miracle Fruit Tablets" ▪ This is a 2-pack of powdered miracle berry tablets (each pack contains 10 tablets for a total of 20 tablets)	$28
Salt Packets	Amazon – N'Joy Brand Iodized Salt Packets ▪ This is a box of 1,200 individual salt packets *(these can be used for other taste demonstrations)*	$10
Sugar Packets	Amazon – Domino Brand Sugar Packets ▪ This is a box of 200 individual sugar packets *(these can be used for other taste demonstrations)*	$8
Sour Patch Kids	Amazon – Sour Patch Kids "Big Individually Wrapped Soft and Chewy Candy" ▪ This is a box of 240 individual sour patch kids	$25

**Notes:*

- *Each mBerry tablet allows for an experience that lasts ~30 minutes. As these are on the pricier side, you can cut these tablets in half (and the experience will still last ~15 min)*
- *Miracle Fruit also comes in a variety of other commercial forms. For example, you can buy the actual fruit (which may need to be overnight shipped to your school to preserve the freshness) or a freeze-dried version of the fruit or as powder/juice extract.*
  - *Please choose whichever option works best for your budget/logistical needs! The mBerry tablets used here where chosen for their: 1) cost and 2) due to the fact that they could be easily given to students in take-home lab kits.*
- *For this demonstration, you can use any sweet, sour, bitter or salty products (as described below, the mBerry tablets turn sour products sweet, so make sure to have sour examples). The sugar, salt and Sour Patch Kids were chosen for ease of access and so that students could take them home in their lab kits.*
  - *For example, for in class demonstrations you could use different pieces of fruit and vegetables (e.g., lemons, limes, strawberries, broccoli), chips (e.g., potato chips, goldfish), cheese (e.g., cream or goat cheese), or candies (e.g., jelly beans) – really anything!*
  - *In pre-pandemic times, having students ingest small quantities of lemon juice was also fun (as it tastes like lemonade with the mBerry tablets).*
- *Please know that there may be cheaper options at your local dollar/grocery store for the food products!*

Activity Guide & Set-up:

- **Background** *(see links below for more information)***:** Miracle Fruit or Berries (produced by the plant *synsepalum dulcificum,* which is native to Africa) contain a taste-altering ingredient known as miraculin. While the exact mechanism behind how miraculin works is not entirely clear, it is thought that miraculin binds to sweet taste receptors on the tongue. However, it only activates these sweet taste receptors in the presences of acidic (i.e., sour) compounds, which have an abundance of protons (i.e., H+ ions). These protons cause a structural change in the miraculin that activates the sweet taste receptor, causing sour substances to taste sweet (therefore, by itself, the miracle berries (or mBerry tablets) do not taste sweet).

- Option 1: Distribute an mBerry tablet (you can cut the blister pack to give one tablet to each student without breaking the seal), 1-2 salt packets, 1-2 sugar packets and 1-2 Sour Patch Kids to each student (either in-person or in take-home lab kits

- Option 2: If you are using fruits or vegetables (or any food that is not individually wrapped), please slice them up and/or distribute them to your students in paper plates or bowls (e.g., lemon slices along with an mBerry tablet)
    - **Note:** Please follow all food and safety guidelines (check your university/school policies) when distributing foods to students (e.g., wear gloves and used properly sanitized surfaces/utensils)

- ****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
    - *As students will be consuming food, make sure that this activity is voluntary and that the nutritional information is available for students*

Estimated Time: 20-30 minutes

Activity Procedure:

1. First, try a pinch of salt, sugar and one Sour Patch Kid to remind yourself of what these substances taste like (if doing option 2, try all of the foods given)
    a. **Notes:**
        i. If looking for a more lab-based experiment, you could have students rate the intensity of each of the substances using the following scales:
            1. Sour Scale: 0(not sour)-1-2-3-4-5-6-7-8-9-10(very sour)
            2. Bitter Scale: 0(not bitter)-1-2-3-4-5-6-7-8-9-10(very bitter)
            3. Salty Scale: 0(not salty)-1-2-3-4-5-6-7-8-9-10(very salty)
            4. Sweet Scale: 0(not sweet)-1-2-3-4-5-6-7-8-9-10(very sweet)
        ii. You might want to cleanse your palate in between each with a sip of water
2. Next, dissolve an mBerry tablet on your tongue
    a. It should take about 3 minutes to fully dissolve, however, you can move it around your mouth to help it dissolve more quickly (just make sure it coats your tongue, so try not to crush it with your teeth or swallow it whole)
3. After your mBerry tablet has dissolved, try another pinch of salt, sugar and another Sour Patch Kid
    a. **Note:** If doing ratings, have students fill out the intensity scales again:
        i. Sour Scale: 0(not sour)-1-2-3-4-5-6-7-8-9-10(very sour)
        ii. Bitter Scale: 0(not bitter)-1-2-3-4-5-6-7-8-9-10(very bitter)
        iii. Salty Scale: 0(not salty)-1-2-3-4-5-6-7-8-9-10(very salty)
        iv. Sweet Scale: 0(not sweet)-1-2-3-4-5-6-7-8-9-10(very sweet)

Student Questions/Discussion Prompts:

- Did your perception of the foods change with the mBerry tables? (If you are using the rating scales, you can have students calculate the pre- and post-mBerry tablet means for each of the foods).
    - What taste perceptions were altered the most?
- Did the taste of some foods change more than others? Where there any that surprised you?
- If doing this as an in-class demonstration, you can ask about individual differences in taste perception (e.g., for some people the mBerry tablet may not work as strongly)

Additional Resources & Current Connections:

- This activity was adapted and modified from the following sources:
  - Lipatova, O., & Campolattaro, M. M. (2016). The Miracle Fruit: An Undergraduate Laboratory Exercise in Taste Sensation and Perception. *Journal of Undergraduate Neuroscience Education, 15*(1), A56-A60.
  - James, B. (n.d.). *Can it really be that sweet?* Neuroscience for Kids. https://faculty.washington.edu/chudler/sweet.html
- Current Connections
  - Miracle Berries have been used to help cancer patients during chemotherapy and may even be able to help COVID-19 patients with lost senses of taste and smell (although there is not much research on this connection yet)
    - Wilken, M. K., & Satiroff, B. A. (2012). Pilot study of "miracle fruit" to improve food palatability for patients receiving chemotherapy. *Clinical Journal of Oncology Nursing, 16*(5), E173.
    - Chicago Tribune (2016) article – "For cancer patients who lost their taste buds, a miracle arrived in this tiny berry"
    - COVID-19 & Miracle Berries
  - How sugar enhances flavor
    - University of California San Francisco Magazine (2019) article – Sugar's Sick Secrets
    - FDA and added sugars - https://www.fda.gov/food/new-nutrition-facts-label/added-sugars-new-nutrition-facts-label

Activity: Confusing the Senses *(Gymnema sylvestre Tea Demonstration)*

Question: Can our sense of taste be tricked (i.e., what are the neural mechanisms of sweet taste receptors and the psychophysical nature of taste perception?)

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
Gymnema sylvestre Tea	**Option 1**: Amazon – Organic Thailand brand organic *Gymnema sylvestre* loose-leaf tea ▪ This contains 30 packets of loose-leaf tea, where 1 packet will make ~1 liter of tea (~34 fl oz, which is ~30 servings if using a small bathroom cups)	$20
	Option 2: Amazon – Horbaach brand super concentrated *Gymnema sylvestre* leaf extract ▪ This 2 fl oz bottle contains ~1500 drops of gymnema extract ▪ The instructions say to use 28 drops (~1 ml) with a small amount of water, however, you only need to use ~2-3 drops in ~1.5 fl oz (~half a small bathroom cup of water) to get the desired effects	$16
Small Cups	Amazon – Comfy brand 3 oz small paper bathroom cups ▪ There are 300 small (3 oz) bathroom cups in this package *(these can be used for other demonstrations)*	$13
Salt Packets	Amazon – N'Joy Brand Iodized Salt Packets ▪ This is a box of 1,200 individual salt packets *(these can be used for other taste demonstrations)*	$10
Sugar Packets	Amazon – Domino Brand Sugar Packets ▪ This is a box of 200 individual sugar packets *(these can be used for other taste demonstrations)*	$8
Equal Packets	Amazon – Equal brand Sweetener Packets ▪ This is a box of 115 Equal packets	$6
Sour Patch Kids	Amazon – Sour Patch Kids "Big Individually Wrapped Soft and Chewy Candy" ▪ This is a box of 240 individual sour patch kids	$25
M&M's	Amazon – M&M brand fun size packets of original M&Ms ▪ This is box of 70 packets of original M&M's	$20

**Notes:*

- *Drinking ~1-2 fl oz of tea allows for an experience that lasts ~30 minutes.*
  - *There are different brands of Gymnema tea available, however, it was found that the loose-leaf tea worked best if brewed and consumed the same day (within ~6 hours or less). As this is not feasible for some instructors, the Gymnema extract may be a good alternative option as 2-3 drops can be added to a small cup of water for each student (without having to brew tea ahead of time).*
- *For this demonstration, you can use any sweet, sour, bitter or salty products (as described below, Gymnema tea blocks sweet taste receptors, so make sure to have sweet examples). The above ingredients were chosen for ease of access and so that instructors would not have to handle the food substances before giving them to students.*
- *Please know that there may be cheaper options at your local dollar/grocery store for the food products!*

Activity Guide & Set-up:

- **Background** *(see links below for more information)*: *Gymnena sylvestre* is an Indian herb that, when brewed as a tea and ingested, can block sweet taste receptors on the tongue. It has also been used in pill form to help lower blood glucose levels in an effort to curb obesity and diabetes.
    - ***What does Gymnema sylvestre tea taste like?*** The tea (and the extract diluted in water) tastes similar to spinach or cabbage soup. While not unpleasant or super bitter, it is also not the best tasting liquid (and can definitely elicit some reactions from students!)

- As you will need to distribute liquids to students, this activity may not be suitable for take-home lab kits!

- Option 1: If using the loose-leaf tea packets, follow the instructions on the packaging for how to brew (the instructions below are for the brand listed in the Materials List):
    - Boil 1 liter of water
    - Once the water has boiled, add 1 tea bag and let sit for ~5 min (then remove the tea bag)
    - Serve by filling a small bathroom cup in half for each student (~1.5 fl oz)
        - You can either serve it hot immediately, or put in a thermos for later, or let cool and serve at room temperature or with ice (though do not add too much ice as this could dilute the tea)
        - It works better the sooner you serve it (after about 4-6 hours it is not as potent and students may have a shorter/less intense experience)
        - 1 tea bag in 1 liter of water makes ~30 servings.
    - Distribute 1-2 salt packets, 1-2 Equal packets, 1-2 sugar packets, 1 M&M packet and 1-2 Sour Patch Kids to each student

- Option 2: if you are not able to brew the tea before class (or would like an option that requires less preparation), try using the *Gymnema* leaf extract:
    - Fill your small bathroom cups halfway with water for each student (~1.5 fl oz)
    - Add 2-3 drops of *Gymnema* leaf extract to each bathroom cup and swirl to make sure that it is diluted throughout
        - You can always add more drops of extract if students do not perceive a change!
    - Distribute 1-2 salt packets, 1-2 Equal packets, 1-2 sugar packets, 1 M&M packet and 1-2 Sour Patch Kids to each student

- *****Important Safety Notes:***
    - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
    - *As students will be consuming food, make sure that this activity is voluntary and that the nutritional information is available for students*
        - *As the tea has antidiabetic properties, students with diabetes should not participate*
        - *Similarly, as noted on the Gymnema sylvestre tea packaging, students who may be pregnant should also avoid this activity*

Estimated Time: 20-30 minutes

Activity Procedure:

1. In the following order, try a pinch of salt, Equal, sugar, 1-2 M&M's and one Sour Patch Kid to remind yourself of what these substances taste like (the reason for this order is because the tea does not seem to have a huge effect on Equal (aspartame), and therefore, you may want to have students try it before they taste the sugar, especially after drinking the tea!)
    a. **Notes**:

i. If looking for a more lab-based experiment, you could have students rate the intensity of each of the substances using the following scales:
    1. Sour Scale: 0(not sour)-1-2-3-4-5-6-7-8-9-10(very sour)
    2. Bitter Scale: 0(not bitter)-1-2-3-4-5-6-7-8-9-10(very bitter)
    3. Salty Scale: 0(not salty)-1-2-3-4-5-6-7-8-9-10(very salty)
    4. Sweet Scale: 0(not sweet)-1-2-3-4-5-6-7-8-9-10(very sweet)
ii. You might want to cleanse your palate in between each substance with a sip of water

2. Next, swish some *Gymnema sylvestre* tea in your mouth for 30 seconds
    a. Try to coat all areas of your mouth with the tea (the tea can be swallowed but give students the option to spit in out in a sink if they would prefer)
3. After you have finished swishing your tea, in the following order, try another pinch of salt, Equal, sugar, 1-2 M&M's and another Sour Patch Kid
    a. **Note**: If doing the ratings, have students fill out the intensity scales again for each substance:
        i. Sour Scale: 0(not sour)-1-2-3-4-5-6-7-8-9-10(very sour)
        ii. Bitter Scale: 0(not bitter)-1-2-3-4-5-6-7-8-9-10(very bitter)
        iii. Salty Scale: 0(not salty)-1-2-3-4-5-6-7-8-9-10(very salty)
        iv. Sweet Scale: 0(not sweet)-1-2-3-4-5-6-7-8-9-10(very sweet)

Student Questions/Discussion Prompts:

- Did your perception of the foods change with the Gymnema tea? (If you are using the rating scales, you can have students calculate the pre- and post-tea means for each of the foods).
    - What taste perceptions were altered the most?
- Did the taste of some foods change more than others? Where there any that surprised you?
- If doing this as in-class demonstration, you can ask about individual differences in taste perception (e.g., for some people the tea may not work as strongly).

Additional Resources & Current Connections:

- This activity was adapted and modified from the following source:
    - Schroeder, J. A., & Flannery-Schroeder, E. (2005). Use of the Herb Gymnema sylvestre to Illustrate the Principles of Gustatory Sensation: An Undergraduate Neuroscience Laboratory Exercise. *Journal of Undergraduate Neuroscience Education, 3*(2), A59–A62.
    - Another variation on this experiment can be found in the April 2020 "Neuroscience for Kids" Newsletter
- Background information on *Gymnema sylvestre*:
    - Kanetkar, P., Singhal, R., & Kamat, M. (2007). Gymnema sylvestre: A Memoir. *Journal of Clinical Biochemistry and Nutrition, 41*(2), 77–81. https://doi.org/10.3164/jcbn.2007010
- Current Connections:
    - Washington Post (2018) article – "There's some science behind claims that gymnema can curb sugar cravings"
    - However, research has also shown the opposite effect in that people who have a diminished sense of taste choose sweeter foods!
        - Noel, C. A., Sugrue, M., & Dando, R. (2017). Participants with pharmacologically impaired taste function seek out more intense, higher calorie stimuli. *Appetite, 117*, 74-81. https://doi.org/10.1016/j.appet.2017.06.006
            - Link to article press release

Activity: Individual Differences in Taste Perception *(PTC Strips)*

Question: Do all people experience taste the same way (i.e. how do genes influence taste perception?)

Materials List & Sample Budget:

Materials	Example Items/Links	Appr. Cost
PTC & Control Tasting Strips	Amazon – Bartovation Brand Genetic Taste Testing Experiment Kit (with PTC and Control Strips) ▪ This kit contains a vial of PTC test paper strips and a vial of control paper strips (there are 100 strips in each vial)	$10
**Notes: you might be able to find cheaper PTC kits elsewhere! If you needed more strips, you also could cut the strips in half.*		

Activity Guide & Set-up:

- **Background** *(see links below for more information)*: Phenylthiocarbamide (PTC) is chemical that tastes bitter to ~70% of the population. While it is not present in food, related chemicals are and could explain why some people enjoy alcohol/cigarettes or bitter foods, like coffee or certain vegetables (although the links between tasting PTC and food preferences are uncertain and more research is needed). The ability to taste (or to taste only a bit, or to not taste at all) the bitterness of PTC is caused by a single gene for a taste receptor on the tongue (known as the TAS2R38 taste receptor gene). In total, humans have ~30 genes that code for bitter taste receptors and allow us to taste a variety of bitter compounds.

- Distribute a control strip and PTC strip to each student (either in-person or in take-home lab kits)
  - Make sure that they know which strip is which!

- *****Important Safety Notes:***
  - *Please be mindful of any public health/social distancing policies on your campus while eating and/or drinking*
  - *As students will be tasting things make sure that this activity is voluntary*

Estimated Time: 5-10 minutes

Activity Procedure:

1. Ask students about their taste preferences (such as: what foods they enjoy or crave? If they add a lot of salt to their foods? If they think cilantro tastes like soap? If they are a picky eater? If they like bitter foods, like Brussels sprouts or broccoli? If they like hot or spicy foods?)
   a. Based on the answers to liking bitter foods, you can try to predict whether some students will be able to taste PTC or not
2. Taste the control strip by placing it on your tongue and noting/writing down what it tastes like
   a. **Note:** The strips only need to be placed on the tongue for a few seconds
3. Taste the PTC strip by placing it on your tongue and noting/writing down what it tastes like (you may want to have water or candy available for those who can taste it)
   a. Ask the students who are able to taste the PTC (about 7 out of 10 students should taste the PTC) to describe it and how intense it is (e.g., rate the intensity on a 1 to 10 scale)
4. **Variation:** Get a class average of who can taste the PTC (by asking students to indicate if they could taste it or not)

Student Questions/Discussion Prompts:

- Could they taste PTC (and, if so, what did it taste like?)
- Discuss how genes can influence human behavior, like food choice?
    - What other factors may influence food preference?

Additional Resources & Current Connections:

- This activity was adapted and modified from the following source:
    - Fromme, A. (2009). *Picky Eaters or Superior Tasters?* NOVA scienceNOW. https://www.pbs.org/wgbh/nova/teachers/activities/0404_01_nsn.html
- Background information on PTC:
    - Guo, S. W., & Reed, D. R. (2001). The genetics of phenylthiocarbamide perception. *Annals of Human Biology, 28*(2), 111-142. https://doi.org/10.1080/03014460151056310
    - Learn.Genetics – PTC The Genetics of Bitter Taste
    - Phillips, M. L. (2003). *Scientists Find Bitter Taste Gene.* Neuroscience for Kids. https://faculty.washington.edu/chudler/bitter.html
- Current Connections
    - Distaste for raw vegetables (like Brussels sprouts) could be in your genes
        - Sandell, M. A., & Breslin, P. A. (2006). Variability in a taste-receptor gene determines whether we taste toxins in food. *Current Biology, 16*(18), R792-R794. https://doi.org/10.1016/j.cub.2006.08.049
        - NPR (2019) article – From culinary dud to stud: How Dutch plant breeders built or Brussels sprouts Boom
        - Better Homes & Gardens (2019) article – It's Not Your Imagination, Brussels Sprouts Really Do Taste Better Now
    - Olfactory receptor gene responsible for perception of cilantro
        - Huffington Post (2017) article (with link to SciShow video) – Science explains why does cilantro taste like soap for certain people.
        - Today (2020) article – Do you hate cilantro?