

# Sowing the Seeds of Neuroscience

**If Worms Drank Coffee:**

**Investigating the Effects of Plant Extracts  
on Planaria Movement**



# If Worms Drank Coffee: Investigating the Effects of Plant Extracts on Planaria Movement

**Activity Time:** Three 50 minute periods, with additional time for homework assignments.

## Lesson Summary:

In this lesson, students will observe and count planaria (flatworms) movements with and without the addition of a plant extract. Plants and herbs have been used around the world for millennia to alter brain function; in most places, plants are used daily to alter mental function. For example, coffee and black tea help people to wake up in the morning and chamomile tea helps people to relax in the evening. Some people regularly use alcohol, nicotine, and illegal drugs such as cocaine; these drugs are derived from plants and have large effects on the human nervous system.



In this lesson, students will explore how plant extracts act as stimulants or depressants and affect planaria movement. Planaria are a widely used model organism.

## STUDENT UNDERSTANDINGS

### Big Idea & Enduring Understanding

- **Neuroactive Properties of Plants:** Naturally produced plant chemicals can affect animal movement.

### Essential Questions

- Do plant extracts affect the speed at which planaria move?
- Do plant extracts affect the way that planaria move?

### Neuroscience Core Concepts

- The nervous system controls and responds to body functions and directs behavior.
- Neurons communicate using electrical and chemical signals.
- Neuroscience research must be done in an ethical manner.
- The plant world is filled with species that contain chemicals with medical properties, including neuroactive properties.
- There are many people with mental and neurological disorders in our society.

## **Learning Objectives**

### ***Students will know...***

- Humans have a complex nervous system that evolved from a simpler one.
- Electrical signals in muscles cause contraction and movement.
- Experiments on animals provide insights about the human brain and help to make healthy lifestyle choices, prevent disease, and find cures for disorders.
- Testing chemicals or plant extracts on animals is a way to determine their likely effect on humans.
- It is likely that many plants with medicinal uses/neuroactive properties have not been “discovered by modern science” yet.
- Humans are intimately connected with the natural world and can use plants to solve modern problems, including problems in neuroscience.
- Plant extracts may contain chemicals which can treat mental and neurological disorders.

### ***Students will be able to...***

- Demonstrate lab safety procedures.
- Follow the procedures to successfully conduct an investigation of the effects of a plant extract on planaria movement.
- Observe and count planaria movement using a timer and clicker counter.
- Use a graduated cylinder and plastic pipette to precisely measure water and plant extracts to produce proper dilutions.
- Generate and record data of planaria response to different concentrations of chemical extracts found in plants.
- Evaluate class data to understand and explain the effects of plant extracts on planaria movement.

## Standards Alignment

| <b>Washington State Essential Academic Learning Requirements (EALRs): Science</b>   |
|---|
| Science EALR 1: Systems <ul style="list-style-type: none"><li>• 6-8 SYSA</li></ul>  |
| Science EALR 2: Inquiry <ul style="list-style-type: none"><li>• 6-8 INQA—Question</li><li>• 6-8 INQC—Investigate</li><li>• 6-8 INQD—Investigate</li><li>• 6-8 INQF—Explain</li><li>• 6-8 INQI—Consider Ethics</li></ul> |
| <b>Next Generation Science Standards (NGSS)</b>   |
| From Molecules to Organisms: Structures and Processes <ul style="list-style-type: none"><li>• MS-LS1D-3</li><li>• MS-LS1D-8</li></ul>   |
| <b>Common Core Standards: Mathematical Practice</b>   |
| Statistics & Probability <ul style="list-style-type: none"><li>• CCSS.Math.Content.6.SP.B.5c</li><li>• CCSS.Math.Content.8.SP.A.1</li></ul>   |
| <b>Common Core Standards: English Language Arts (ELA)</b>   |
| Reading Standard for Literacy in Science and Technical Subjects: Key Ideas & Details <ul style="list-style-type: none"><li>• CCSS.ELA-Literacy.RST.6-8.1</li><li>• CCSS.ELA-Literacy.RST.6-8.3</li></ul>                |
| Writing Standard for Literacy in Science and Technical Subjects: Text Types & Purposes <ul style="list-style-type: none"><li>• CCSS.ELA-Literacy.WHST.6-8.2d</li><li>• CCSS.ELA-Literacy.WHST.6-8.2f</li></ul>          |
| Language Standard 4c & 6: Vocabulary Acquisition & Use <ul style="list-style-type: none"><li>• CCSS.ELA-Literacy.L.6.4c</li><li>• CCSS.ELA-Literacy.L.6.6</li></ul>   |

## TEACHER PREPARATION

### Materials

#### Classroom Materials

| Item   | Quantity      |
|--|---------------|
| Copies of <i>Planaria Movement Background Reading—Student Handout</i>                  | 1 per student |
| Copies of <i>Planaria Movement Sketches—Student Handout</i>                            | 1 per student |
| Copies of <i>Planaria Movement Pre-Lab Planning—Student Handout</i>                    | 1 per student |
| Copies of <i>Ethics of Research with Animals—Student Handout</i> (located in Appendix) | 1 per student |
| Student lab notebook   | 1 per student |
| Classroom computer with internet access and projector to show online video             | 1             |

#### Laboratory Materials

Review the materials with your students. It will be helpful to show them each piece of lab equipment and mention how it will be used in this activity.

Most lab materials are provided in the Sowing the Seeds of Neuroscience classroom kit. There are enough materials in the classroom kits for ten groups to do this laboratory. Depending on class size, groups should be made of two to three students.

| Item  | Quantity                                    |
|---|---|
| Copies of <i>Planaria Movement Lab Procedure—Student Handout</i>  | 1 per student                               |
| Copies of <i>Planaria Movement Data Sheet—Student Handout</i>   | 1 per group                                 |
| Copies of <i>Planaria Movement Results &amp; Conclusions—Student Handout</i>  | 1 per student                               |
| <b>Optional:</b> Copies of <i>Planaria Movement Vocabulary Quiz—Student Handout</i>   | 1 per student                               |
| Student lab notebook  | 1 per student                               |
| Graph paper—2 lines per cm paper can be downloaded from <a href="http://incompetech.com/graphpaper/">http://incompetech.com/graphpaper/</a> and cut to size (6.5 cm by 6.5 cm or 13 squares on each side) | 3 pieces per group (1 sheet makes 6 pieces) |
| Pen   | 1 per student                               |
| Permanent marker  | 1 per group                                 |
| Lab tape for labeling   | 1 per group                                 |
| Timer   | 1 per group                                 |
| Clicker for counting planaria movement  | 1 per group                                 |
| Planaria housed in a large beaker or aquarium   | 3 planaria per group                        |
| Paintbrush  | 1 per group                                 |
| Square hinged-lid plates  | 2 per group                                 |
| 100 ml beaker   | 2 per group                                 |

|  |                   |
|--|-------------------|
| <ul style="list-style-type: none"> <li>• One beaker for conditioned water.</li> <li>• One beaker for “recovery”—the planaria will go here after the experiment to rinse off any extracts before they go back to their aquarium.</li> </ul> |                   |
| Conditioned water  | ~150 ml per group |
| Plastic pipette  | 3 per group       |
| Plant extracts obtained as a result of <i>Infusions and Decoctions</i> lab.  | 2 per group       |
| Medicine cup (aka “ketchup cup”) for plant extracts  | 2 per group       |
| 10 ml graduated cylinder   | 1 per group       |

### Safety Materials

| Item            | Quantity           |
|-----------------|--------------------|
| Safety goggles* | 1 per student      |
| Gloves*         | 1 pair per student |

\*Safety materials are provided in the classroom kit only if you requested them.



### Lab Safety

- Students must wear gloves and safety goggles when handling the plant extracts.
- Students must not eat or drink anything in the lab.
- Students must never taste any of the plant extracts.

### Preparation

- Photocopy Student Handouts.
- Download graph paper (2 lines per cm), make copies, and cut to size (6.5 cm<sup>2</sup> or 13 squares per side).
- Assign the *Planaria Movement Background Reading—Student Handout* to students as homework; this reading should be completed before students begin the lab. Students should wait to develop a hypothesis for each of plant extracts they will be testing until instructed to do so.



- Plan your timing: It may work best to do this lab activity over three days.
  - On Day One, conduct the *Engage* activities, demonstrate any necessary lab procedures, and guide students through a review of the background reading, learning goals, and vocabulary.
  - On Day Two, challenge student groups to conduct the investigation as described in the *Explore* and *Explain* sections of the lesson plan.
  - On Day Three, bring the class together for the *Elaborate* and *Evaluate* sections of the lesson plan. Additional homework time may be needed for students to complete the assessment(s).
- Determine how best to set up your classroom for the lab: Most lab materials are provided in the Sowing the Seeds of Neuroscience classroom kit. There are enough materials in the classroom kits for ten groups to do this laboratory. Depending on class size, groups should be made of two to three students.
- Students will be using the plant extracts that they obtained as a result of the *Infusions and Decoctions* lab. In that lab, you may have instructed student groups to produce one, two, or three extracts. In today's lab, each student group will need to test a water control and two plant extracts. Depending on the number and type of extracts produced during the *Infusions and Decoctions* lab, you may choose one of these options:
  - All groups test a water control and the same two extracts as everyone else.
  - Each group tests a water control, tobacco extract, and the extract of their choice.

| Critical Plant Extract | Plant Extracts with Interesting Results    | Optional Plant Extracts  |
|------------------------|--|--|
| Tobacco                | Coffee<br>Black tea<br>Green tea<br>Ginger | Cayenne<br>Chamomile<br>Valerian<br>Skullcap<br>Any other plant extract! |

Students can try anything that they think might increase or decrease the planaria's movement. What kinds of compounds might change the rate at which these worms move? Plant extracts that people take to relax or to help them wake up and get moving might be interesting. Some stimulants to try include green tea, black tea, and coffee extracts. Some depressants to try include chamomile, valerian, or skullcap extracts. Ginger and cayenne also change the way the planaria move and may be interesting to try.

- As needed, have students review the topic of movement in simple organisms such as planaria.
- If you haven't already discussed the ethics of using animals in research—including the use of animals in the science classroom—please do so before delivering this lesson. If students haven't

already read the *Ethics of Research with Animals—Student Handout*, assign this now. In addition, please refer to the *Teacher Background & Resources* section of this lesson plan for a list of helpful teaching resources on this topic.

Specifically, it is important to discuss that this lab will require students to expose a planarian (flatworm) to plant extracts. Emphasize the importance of respect for animals, and the gentle handling of the planaria during this investigation. Explain that experiments on animals are a part of medical and scientific research because: 1) experiments on animals provide insights about the human brain and help to make healthy lifestyle choices, prevent disease, and find cures for disorders; and 2) testing chemicals or plant extracts on animals is a way to determine their likely effect on humans.

- Consider an alternate activity that can be provided for students who have an ethical objection to the use of animals in the science laboratory. A list of activities is included in the *Appendix* to this curriculum.

## TEACHER PROCEDURE

### Day One

#### Engage

1. Explain the purpose of the lesson and review *Big Idea*, *Enduring Understanding*, and *Essential Questions*.
2. If students did not read the *Background Reading* as homework, they should do so now.
3. Review the story of the Jamaican women from the *Background Reading*. The narrator's mother used coffee as a way of self-medicating to control her shaky hands. Ask the students to discuss:
  - Why do people drink coffee to feel alert in the morning?
  - What is the neuroactive chemical in coffee? (*Caffeine*)
  - How do you think this chemical acts on the human nervous system to both cause and treat shaking hands?

4. Share the following with students:

*Caffeine is a chemical with neuroactive properties that many people ingest every day. The caffeine contained in extracts of coffee or tea plants can help people feel more alert. Too much caffeine can cause some people to feel jumpy and have shaky hands. For people who are used to having a certain amount of caffeine every day, they can suffer from caffeine withdrawal symptoms—including headaches and shaky hands—when they have a sudden decrease in their usual amount of caffeine intake. What is the treatment for those withdrawal symptoms? Another cup of coffee!*

5. Explain to students that, as stated in the *Background Reading*, some plant extracts contain chemicals with neuroactive properties—like caffeine—that may be useful in the prevention and treatment of neurological diseases and their symptoms. Coffee is just one example of a plant with neuroactive properties that may be useful in treating neurological disorders. In order for researchers to discover plants with neuroactive properties, they must test these chemicals on animals as a way to determine their likely effect on humans. Tell students that in today’s investigation, they will be testing the effects of the plant extracts that they obtained via infusion or decoction methods. They will test the effects that their plant extracts have on the movement of flatworms called planaria.
6. Distribute copies of the *Planaria Movement Pre-Lab Planning—Student Handout*, one per student. Provide instruction on how student groups should decide which plant extracts they will be testing (see the *Teacher Preparation* section for more information).
7. Allow time for student groups to choose their plant extracts and to develop a hypothesis for each extract, as prompted on the handout.
8. Ask students to share their hypotheses. Create a class list charting the plant extracts that will be tested and the hypotheses that will be challenged during the lab investigation. You will return to this list later.

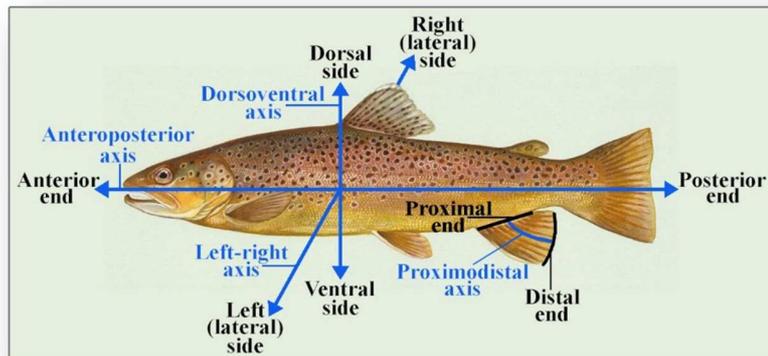
## Day Two

### Explore

9. Encourage students to conduct a free exploration and observation of planaria: Take a planarian out of the jar and put it in a petri dish. Watch it. What do they observe? Can they identify the **anterior** and **posterior** sides? The **dorsal** and **ventral** sides? The **eyespots**?

10. Prompt students to draw the planarian in their lab notebooks or on the *Planaria Movement Sketches—Student Handout*. They should draw and label these parts:

- Anterior side
- Posterior side
- Dorsal side
- Ventral side
- Eyespots



Example of anatomical planes.

(A scoring rubric for this learning task has been provided).

11. Using the classroom computer and projector, show students two short videos from the Sowing the Seeds of Neuroscience website. These videos show the different ways that a planarian can move. Help students to understand the differences between moving forward, moving backward, curling, trying to crawl out of the water, twitching, not moving, floating, or twisting.

**“Planaria Movement” Video** (32 seconds)

<http://www.neuroseeds.org/About-Neuroseeds/Lessons/wormmove>

**“All Planaria Movement Behaviors” Video** (1:36 mins)

<http://www.neuroseeds.org/About-Neuroseeds/Lessons/wormmove>

12. Review lab safety information with student. Remind your students to put on their gloves and safety goggles. Remind them to be gentle when handling the planaria.
13. Hand out copies of the *Planaria Movement Lab Procedure—Student Handout* (1 per student) and the *Planaria Movement Data Sheet—Student Handout* (1 per group). Review the lab procedures.

14. Some practice in dilution and measurements of solutions will be helpful for the students. Demonstrate how to measure using a graduated cylinder (6 ml) and a pipette (1 ml, 2 ml, and 3 ml). If needed, allow time for students to practice these skills.
15. Demonstrate how to count with and reset the clicker counters.
16. Acknowledge that some students might think it is silly or confusing to start this investigation by adding drops of water to the planarian and recording behavior. Explain why a “control” is an important part of a scientific investigation. In this case, adding water to water as the **controlled variable** allows students to observe that it is not the amount of liquid in the box that affects the planarian’s behavior. In this investigation, the **independent variable** is the concentration of the plant extract added to the box and the **dependent variable** is the planarian’s behavior. Using the water control ensures that the changes to the planarian’s behavior is a result of the bioactive chemicals in the plant extracts, not from the amount of liquid in the box or the planarian’s reaction to water.
17. Encourage students to work through the procedures on the Student Handout and to record their data on the data sheets.



18. When all groups have completed the lab, provide instruction on how you would like students to clean up their lab stations and put away lab equipment. Each lab group should return their planarian to their recovery beaker to allow time for the organisms to recover from the investigation. The next day, return all the planaria back to the aquarium/beaker used to house them.

### Explain

19. Distribute copies of the *Planaria Movement Results & Conclusions—Student Handout*, one per student. Allow time for students, in their lab groups, to respond to the questions on the handout. (A scoring guide for this learning task has been provided at the end of this lesson plan).
20. Bring the class back together to discuss the results of their investigations. Ask each lab group to share with the class their results and conclusions. If more than one group tested the same plant extract, were each group’s results similar? In what ways?

## Day Three

### Elaborate

21. Explain to students that, as they have seen with caffeine, some plant extracts contain chemicals with neuroactive properties that may be useful in the prevention and treatment of neurological diseases and their symptoms. Parkinson's disease (PD) is one such neurological disorder. In fact, the consumption of caffeine and coffee may lower a person's risk for Parkinson's disease (PD) and slow the progression of the disease. But what is PD? Please read aloud the following essay, written by a woman with PD:

"If you read the medical definition of Parkinson's, it sounds like a drawn out oxymoron. Parkinson's is a degenerative neurological disease characterized by involuntary movements and lack of movement. What?

"I like to think of Parkinson's as a communications problem. My brain is saying one thing and my body is doing something else.

"It reminds me of a boy I knew in high school. He had an older car, a fixer upper. This car seemed to have a mind of its own. One day, you would turn on the radio and the headlights would come on. The next day, you would turn on the wipers and the horn would blow or the turn signals would come on. It seemed like gremlins were re-wiring the car while he slept. It drove him crazy. He never knew what was going to happen when he got in the car to drive to school in the morning. Every weekend, he would search under the hood for the problem and find nothing. No blown fuses, no burned wires, everything looked kosher.

"Then one day he saw some seeds on the floorboard. That's strange, he thought. The car was closed up tight and locked. Next day he found some more. He did some digging and found that a squirrel had been nesting inside his dash. Scrambling around all night and sneaking out in the morning. This was the cause of his electrical problems, seeds, twigs, pieces of trash all hidden behind the dash.

"Parkinson's is a lot like that squirrel in the dash, messing around so you don't know what will happen when you try to blow your horn."

~Posted by Bev Ribaud on August 06, 2011 to Parkinson's Disease Foundation,  
[http://www.pdf.org/en/personal\\_stories/view/story/1204](http://www.pdf.org/en/personal_stories/view/story/1204).

22. Explain to students that the contraction of muscles and ability of the body to move is governed by electrical signals. The following information is provided on the *Planaria Movement Background Reading—Student Handout*. Review it with students:

“Communication of information between neurons is accomplished by movement of chemicals across a small gap called the synapse. Chemicals, called neurotransmitters, are released from one neuron, cross the synapse and may be accepted by the next neuron at a specialized site called a receptor. Some plants have chemicals that mimic the action of natural chemicals found in the body. These neuroactive plant chemicals can therefore cause the same behavior as the body’s. Other chemicals can block the action of natural chemicals in the body.”

23. Share the following information with students:

The “squirrel in the dash” as described by PD patient Bev Ribaud is the decay and death of nerve cells in the brain that normally produce a neurotransmitter chemical called dopamine. As a neurotransmitter, dopamine is critical for sending messages between the body and brain about muscle activity and movement. As Bev described, without the dopamine to act as a messenger, “My brain is saying one thing and my body is doing something else.” This dopamine deficiency can cause tremors and shaking, movement problems, and stiffness in limbs. For the actor Michael J. Fox, his first symptom of young-onset PD was the uncontrolled shaking of his little finger.

PD affects men and women, usually after age 60. There is no cure for PD although symptoms can be treated with pharmaceutical drugs. Neuroactive plant chemicals can impact the communication that occurs in the nervous system. Caffeine shows some promise in helping prevent or slow the progression of PD. Researchers are also exploring how herbs such as ginkgo, cowhage, and brahmi can help treat the disease. Some exciting current research focuses on the potential power of fava beans in treating PD and its symptoms.

A common drug used to treat PD contains the chemical levodopa, which is converted into dopamine in the body. Other medications used to treat PD either mimic dopamine in the brain, increase the release of dopamine, or slow down the metabolism of dopamine so that it stays around longer.

Fava beans (*Vicia faba*) are an edible plant in the legume family. The entire fava plant contains levodopa, the chemical that is converted within the body into dopamine. Current research shows that when a person eats fresh fava beans, the level of levodopa in their blood increases. This increase of levodopa can help PD patients—especially those with mild symptoms—experience an improvement in control over their movement and muscle activity. While more research needs to be conducted to fully understand the potential beneficial use of fava beans, it is exciting for



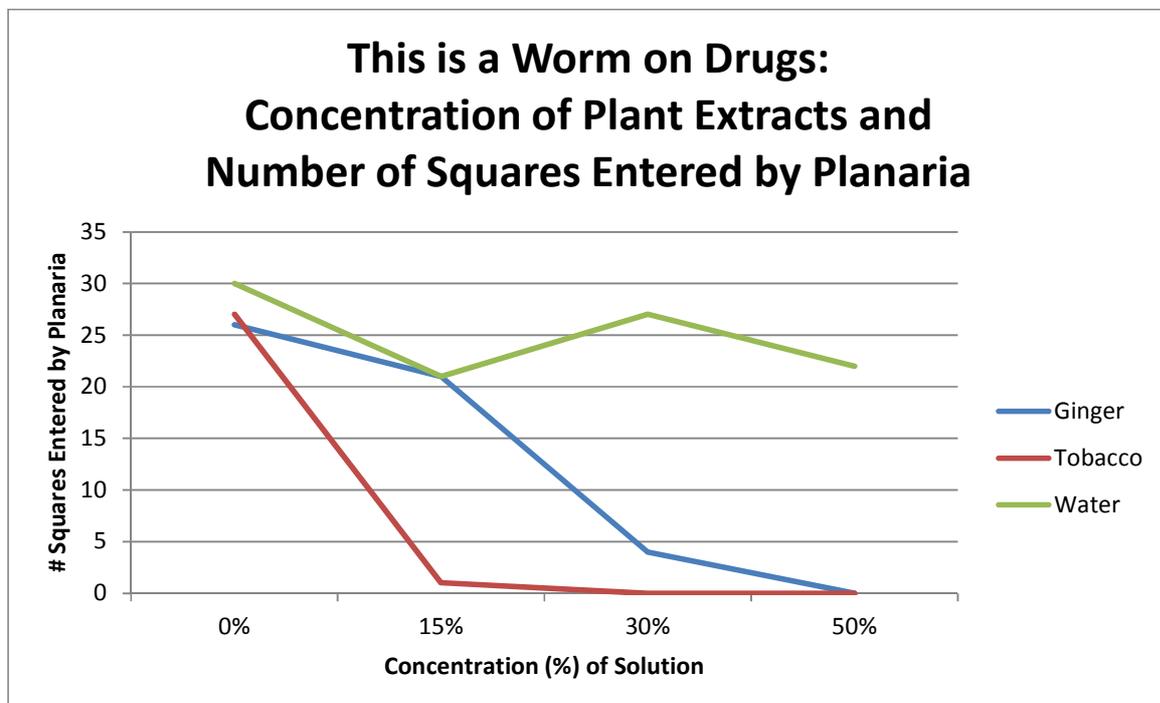
PD patients that a natural, delicious, readily-available food may provide therapeutic benefits.

24. Explain to students that the link between caffeine and shaky hands, and between fava beans and Parkinson's disease, are just two examples of plants with neuroactive properties that may be useful in treating neurological disorders. In order for researchers to discover plants with neuroactive properties, they must test these chemicals on animals as a way to determine their likely effect on humans.
25. Next, students will take a deeper look at their data and the collective data of the class.

### Evaluate

26. Challenge each group to graph the data from their three data tables. You can hand out sheets of graph paper or ask students to complete this task on a computer using Microsoft® Excel. This can be done during class or assigned as homework. Remind students to write all group members' names on their graph.

Students should place **concentration** on the X axis and **number of squares the planarian entered** on the Y axis. (A scoring guide for this learning task has been provided at the end of this lesson plan). A sample graph set-up is shown below:



27. **Optional:** If you instructed all student groups to test one plant extract in common (such as having everyone test tobacco), then challenge each group to graph the data for the entire class for that particular plant extract and the water control. Students could graph the mean of the number of squares moved through at each concentration; they could also indicate the range.
28. As a class, review the list you created in the *Engage* phase of the lesson which charted the plant extracts that student groups were planning to test and the hypotheses that they were planning to challenge during the lab investigation.
29. As a class, share the groups' findings by discussing each plant extract that was tested. For each plant extract, ask each group that used that extract to share their answers to the following questions:
- What happened as you increased/decreased the concentration of plant extract?
  - Did the extract affect the movement of your planarian?
  - What evidence do you have to support your answer?
  - Was there a threshold concentration at which point the extract seemed to start having an effect on the planarian's movement?
30. Next, create a class data table on the board or overhead projector. Choose a concentration (for example, 33%), and record the +/- change in the number of squares entered from the water control at that concentration that was observed by each group for each plant extract. Then, calculate the mean of the change at that concentration for each plant extract. Your specific classroom data will be unique and therefore your chart will need to accommodate the number and range of extracts tested by your students, but a sample class table is provided below:

**+/- Change from Water Control at 30% Concentration**

| <b>Student Group</b>  | <b>Water Control</b> | <b>Coffee</b> | <b>Tobacco</b> | <b>Cayenne</b> | <b>Peppermint</b> |
|-----------------------|----------------------|---------------|----------------|----------------|-------------------|
| Jackson's Group       | 33                   | -15           | -33            | -18            |                   |
| Sofia's Group         | 34                   | -21           |                | -15            | +3                |
| Minh's Group          | 30                   |               | -30            | -12            |                   |
| Janelle's Group       | 11                   |               |                | -5             | +1                |
| Connor's Group        | 18                   | -9            | -18            |                |                   |
| <b>MEAN OF CHANGE</b> | <b>25.2</b>          | <b>-15</b>    | <b>-25.3</b>   | <b>-12.5</b>   | <b>+2</b>         |

31. Discuss the class data. In the development of this lab, we discovered that some of the plant extracts seemed to act as a depressant on the nervous system of the planaria, slowing down the planaria's movement. However, the plant extracts that would usually be thought of as stimulants, such as coffee, did not increase the planaria's movement; instead these extracts caused a noticeable change in the planaria's behavior and ultimately appear to be somewhat toxic to the planaria, so as the concentration of extract increases, the planaria "shut down" and slow down their movement. Do these findings match your students' data?
  
32. Ask students: Imagine that you are a federal agency who wants to fund research into potential plant-based therapies for neurological disorders. Based on the results of this laboratory investigation, which two plants do you think merit further research into their neuroactive properties? Why?
  
33. **Optional:** Assign a vocabulary quiz using the terms introduced on the Student Handouts. Hand out copies of *Planaria Movement Vocabulary Quiz—Student Handout* and administer it like a quiz, with no peeking at lab notebooks or the Background Reading. An answer key is provided in the *Scoring Guides* section of this lesson plan.

## SCORING GUIDES

### Answer Key for Vocabulary Quiz

#### 17 possible points.

The unscrambled words appear in this order in the left-hand column:

- |                       |                      |
|-----------------------|----------------------|
| 1. Anterior           | 10. Nerve            |
| 2. Bilateral symmetry | 11. Nerve cords      |
| 3. Caffeine           | 12. Neurotransmitter |
| 4. Chemoreception     | 13. Posterior        |
| 5. Depressant         | 14. Receptor         |
| 6. Dorsal             | 15. Stimulant        |
| 7. Eyespots           | 16. Synapse          |
| 8. Ganglia            | 17. Ventral          |
| 9. Meniscus           |                      |

In the right-hand column, the definitions appear for the following words in this order:

- |                       |               |
|-----------------------|---------------|
| 1. Nerve cords        | 10. Synapse   |
| 2. Meniscus           | 11. Anterior  |
| 3. Chemoreception     | 12. Dorsal    |
| 4. Eyespots           | 13. Posterior |
| 5. Receptor           | 14. Ventral   |
| 6. Bilateral symmetry | 15. Ganglia   |
| 7. Neurotransmitter   | 16. Caffeine  |
| 8. Stimulant          | 17. Nerve     |
| 9. Depressant         |               |

A line should be drawn to connect each unscrambled word with the correct definition.



## Scoring Rubric for Pre-Lab Planning Handout

11 possible points

| Dimension  | Needs Work<br>(0 Points)                       | Basic<br>(1 Point)  | Proficient<br>(3 Points)  | Advanced<br>(5 Points)   |
|--|--|---|---|--|
| <b>Record the names of your chosen extracts.</b>   | Incomplete or incorrect.                       | Correctly names the two plant extracts chosen by group.   | N/A   | N/A  |
| <b>For each of your chosen plants, write a brief summary based on previous research.</b> | Does not provide any summary information.      | Only provides a summary for one plant extract.  | Provides a summary for both plant extracts which include:<br><br>Whether the plant effects the nervous system.<br><br>Whether it is a stimulant, depressant, or neither.<br><br>Its potential medical benefits, if any. | Provides a well-written and exceptionally clear summary for both plant extracts which include all required elements as described in the "Proficient" category.   |
| <b>As a group, develop a hypothesis for each of your two chosen plant extracts.</b>      | Needed adult assistance to develop hypotheses. | Independently developed one hypothesis somewhat substantiated by previous web research or observation of similar phenomena.<br><br>Or developed two hypotheses but did not use the "If, Then" format. | Independently developed two hypotheses somewhat substantiated by previous web research and observation of similar phenomena.<br><br>Used the "If, Then" format.   | Independently developed two hypotheses well-substantiated by previous web research and observation of similar phenomena.<br><br>Both hypotheses communicated how student thinks the extract might affect the movement of a planarian.<br><br>Used the "If, Then" format. |

### Scoring Rubric for Data Tables from Lab Procedures Handout

3 possible points

| Dimension               | Needs Work<br>(0 Points)                                 | Basic<br>(1 Point)                              | Proficient<br>(3 Points) | Advanced<br>(5 Points) |
|-------------------------|--|---|--------------------------|------------------------|
| <b>Water Control</b>    | Data in the table is not accurate and/or cannot be read. | Data in the table is accurate and easy to read. | N/A                      | N/A                    |
| <b>Plant Extract #1</b> | Data in the table is not accurate and/or cannot be read. | Data in the table is accurate and easy to read. | N/A                      | N/A                    |
| <b>Plant Extract #2</b> | Data in the table is not accurate and/or cannot be read. | Data in the table is accurate and easy to read. | N/A                      | N/A                    |

Rubric created at Rubistar.4teachers.org

### Scoring Rubric for Questions from Results & Conclusions Handout

22 possible points

Results

| Dimension  | Needs Work<br>(0 Points) | Basic<br>(1 Point)   | Proficient<br>(3 Points) | Advanced<br>(5 Points) |
|--|--------------------------|--|--------------------------|------------------------|
| <b>Names the two plant extracts tested by their group.</b> | Incomplete or incorrect. | Correctly names the two plant extracts.  | N/A                      | N/A                    |
| <b>Provides the hypothesis for each plant extract.</b>     | Incomplete or incorrect. | Provides a hypothesis for each of the two plant extracts tested by their group. Hypothesis is the same as what was recorded previously, as | N/A                      | N/A                    |

|   |  |  |   |   |
|---|--|--|---|---|
|   |  | prompted by the <i>Background Reading</i> handout.   |   |   |
| <p><b>Describes the similarities and differences between the water control and each plant extract.</b></p> <p><b>Includes a description of the changes in the numbers of squares the planarian moved through and any differences you noted in the way the animal moved.</b></p> | <p>Adult help needed to identify and define the similarities and differences for the water control and both plant extracts.</p> <p>No description provided for either plant extract.</p> | <p>Independently identified the similarities and differences for one plant extracts but adult help needed for the other plant extract.</p> <p>Clearly described the changes in the planarian's movement and differences in the way the animal moved for only one plant extract or provided only a somewhat clear answer for both plant extracts.</p> | <p>Independently identified the similarities and differences for both plant extracts and the water control.</p> <p>Clearly described the changes in the planarian's movement and differences in the way the animal moved for both plant extracts.</p> | <p>Independently identified and clearly defined the similarities and differences for both plant extracts and the water control.</p> <p>Clearly described the changes in the planarian's movement and differences in the way the animal moved for both plant extracts and supported the description with evidence.</p> |
| <p><b>States whether observations supported or refuted hypothesis for each plant extract. Supports this statement with evidence.</b></p>  | <p>No conclusion provided.</p>   | <p>Student states whether observations supported or refuted hypothesis for only one of the plant extracts.</p>   | <p>Student states whether observations supported or refuted hypothesis for both plant extracts.</p>   | <p>Student clearly states whether observations supported or refuted hypothesis for both plant extracts. Conclusion clearly based on the data.</p>   |

## Conclusions

| <b>Dimension</b>   | <b>Needs Work<br/>(0 Points)</b>               | <b>Basic<br/>(1 Point)</b>   | <b>Proficient<br/>(3 Points)</b>  | <b>Advanced<br/>(5 Points)</b>   |
|--|--|--|---|--|
| <b>States whether or not either plant extract contains chemicals similar to chemicals found naturally in the planarian's body.</b> | No conclusion was apparent.                    | Student provided a conclusion with some reference to the data and the hypothesis statement(s). Important details were overlooked | Student provided a somewhat detailed conclusion clearly based on the data and related to the hypothesis statement(s). | Student provided a detailed conclusion clearly based on the data and related to previous research findings and the hypothesis statement(s). Explained the potential role of the naturally occurring chemicals. |
| <b>Names a neurological disorder that would benefit from one of the plant extracts.</b>  | No disorder provided for either plant extract. | Disorder provided for one plant extract, but lacking explanation or evidence.  | Disorder provided for both plant extracts, but lacking explanation and evidence.                                      | Disorder provided for one or both plant extracts. Includes explanation and supporting evidence.  |

Rubric created with help from Rubistar.4teachers.org

## Scoring Rubric for Graph of Laboratory Data

### 15 possible points

Graph the data from each of your group's data tables. Place **concentration** on the X axis and **number of squares the planarian entered** on the Y axis.

| Dimension                       | Needs Work<br>(0 Points)  | Basic<br>(1 Point)  | Proficient<br>(3 Points)  | Advanced<br>(5 Points)  |
|---------------------------------|---|---|---|---|
| <b>Title and Legend</b>         | Title and legend are not present.                               | A title is present at the top of the graph or a legend is present at the bottom or side of the graph, but not both. | Title clearly relates to the problem being graphed and is printed at the top of the graph and legend is present at the bottom or side of graph. | Title is creative and clearly relates to the problem being graphed. Legend is clear and color-coded.  |
| <b>Labeling of X and Y axes</b> | The axes are not labeled.                                       | Only one axis is labeled.   | Both axes have a clear label.   | Both axes have a clear, neat label. Correct units are included for the independent and dependent variables.                                       |
| <b>Accuracy of Plot</b>         | Points are not plotted correctly or extra points were included. | All points are plotted correctly.   | All points are plotted correctly and are easy to see.   | All points are plotted correctly and are easy to see. A ruler is used to neatly connect the points, if not using a computerized graphing program. |

|                                    |  |   |  |  |
|------------------------------------|--|---|--|--|
| <b>Neatness and Attractiveness</b> | Appears messy and "thrown together" in a hurry. Lines are visibly crooked. | Lines are neatly drawn but the graph appears quite plain. | Neat and relatively attractive. A ruler and graph paper (or graphing computer program) are used to make the graph more readable. | Exceptionally well designed, neat, and attractive. Colors that go well together are used to make the graph more readable. A ruler and graph paper (or graphing computer program) are used. |
|------------------------------------|--|---|--|--|

Rubric created at Rubistar.4teachers.org.

## EXTENSIONS

- Many pharmaceutical drugs are composed of synthetic versions of chemicals found in plants. Challenge students to research the neuroactive properties of these plant-based chemicals. Some examples of neuroactive plant-based pharmaceuticals include: Morphine (opium poppy) used for pain relief; Atropine (*Atropa belladonna*) acts as an anticholinergic; Caffeine (tea, coffee, cacao) acts as a central nervous system stimulant; and Physostigmine (*Physostigma venensum*; Calabar bean) used as a cholinesterase inhibitor.
- This lab uses planaria as model organisms for scientific experiments. Ask students to brainstorm other invertebrates that could be used in a similar experiment. Challenge students to write an explanation of how they would test their hypothesis in a different invertebrate. Which lab procedures would be the same? What would need to change?
- Freshwater planaria can be collected in their natural environment—in ponds, lakes, rivers, and streams. In particular, they prefer to cling to the underside of rocks and vegetation. If your school is located close to one of these aquatic habitats, take students on a planaria collecting field trip. The following website has tips on collecting planaria by washing off objects or by baiting with chunks of liver.

### Working with Planaria

WARD'S Natural Science

<http://resources.wardsci.com/livecare/working-with-planaria/>

- Challenge students to choose one of the careers listed in the *Career Connections* section of this lesson plan and to consider how a person in that career might use plant extracts or conduct research on animals.

## TEACHER BACKGROUND & RESOURCES

### Resources

#### **The Science and Ethics of Animal Research**

A curriculum for grades 6-12 from the Northwest Association for Biomedical Research.  
<http://nwabr.org/curriculum/animals-research>

#### **Speaking Honestly – Animal Research Education (SHARE)**

A program designed to guide educators in leading a discussion-based classroom activity on the different views on the use of animals in research. The activity requires a single class period of 50-75 minutes.  
<http://sharehappens.org/>

#### **Effects of Caffeine on the Nervous System**

Kid-friendly information from Neuroscience for Kids.  
<http://faculty.washington.edu/chudler/caff.html>

#### **Does Drinking Coffee Prevent Parkinson’s Disease?**

Kid-friendly information from Neuroscience for Kids.  
<http://faculty.washington.edu/chudler/parkinc.html>

#### **Michael J. Fox Foundation for Parkinson Research**

<https://www.michaeljfox.org/>

#### **Using Model Organisms**

Sowing the Seeds of Neuroscience  
<http://www.neuroseeds.org/links/model-organisms>

#### **About Planaria**

Sowing the Seeds of Neuroscience  
<http://www.neuroseeds.org/links/planaria>

### Career Connections

**Aquarist:** An aquarist is a caretaker for aquatic plants and animals. An aquarist might work for a public aquarium, caring for the fish, coral, and other organisms that are on display. Alternatively, an aquarist might work for a research organization that conducts research with aquatic species.

**Biologist:** A scientist that studies living organisms and their environments. Biologists may specialize in botany (the study of plants), zoology (the study of animals), or many other specialties.

**Neurologist:** A physician who has specialized in neurology, the study of the brain and nervous system. Neurologists are trained to diagnose and treat neurological disorders.

**Neuroscientist:** A scientist that studies the brain and nervous system. Neuroscientists are primarily concerned with research.

**Pharmacologist:** A biomedical scientist that studies the interactions between drugs and cells, tissues, organs, or entire organisms. Pharmacologists are primarily concerned with research.

**Physician:** A medical doctor who provides healthcare for his or her patients. In the United States, a physician must have a M.D. (Doctor of Medicine), O.D. (Doctor of Osteopathic Medicine), or N.D. (Doctor of Naturopathic Medicine) license to practice medicine.

**Traditional healer:** A person who provides medical treatment and advice based on the traditional healing practices of his or her culture. May include shamans, diviners, acupuncturists, and herbalists. Traditional healers use plants and natural remedies instead of synthetic medications.

### **Illustrations and Photograph Credits**

Fava Bean *Vicia faba* Photograph. Courtesy of Wikimedia Commons, Tuinboon\_zaden\_in\_peul. A derivative of a work by Hohum and Rasbak. 12 October 2011.

Anatomical Planes Diagram. Courtesy of Wikipedia, Esseh. 3 April 2007. Derivative work of original image from U.S. NOAA.

Planarian and Laboratory Procedures Photographs. Photos taken by Eric Chudler and Kristi Straus.

Planarian Nervous System Diagram. Courtesy of Wikimedia Commons, Putaringonit. 30 May 2012.

Jamaican Blue Mountain Coffee Photograph. Courtesy of Wikimedia Commons, Mariordo Mario Roberto Duran Ortiz. 10 May 2010.

“In Jamaica” Historical Photograph. Digital file from original glass negative. Courtesy of Library of Congress. Bain News Service, no date on record. Call Number: LC-B2- 5008-3 [P&P].

Synapse Diagram. Courtesy of Wikimedia Commons, Edk006. 26 November 2011.

## Bibliographic Credits

Glow-Worm. "Benefits and Dangers of the Broad Bean." *PJ Online*, 2010. Web. 23 January 2013.  
<[http://www.pjonline.com/blog\\_entry/glow-worm\\_benefits\\_dangers\\_broad\\_bean](http://www.pjonline.com/blog_entry/glow-worm_benefits_dangers_broad_bean)>.

Holden, Kathrynne Holden. "Fava Beans, Levodopa, and Parkinson's Disease." *Societa Scientifica di Nutrizione Vegetariana*, n.d. Web. 23 January 2013.  
<<http://www.scienzavegetariana.it/nutrizione/favabeans.html>>.

"Parkinson's Disease." University of Maryland Medical Center, 2011. Web. 23 January 2013.  
<<http://www.umm.edu/altmed/articles/parkinsons-disease-000123.htm>>.

Rabey JM, Vered Y, Shabtai H, Graff E, Harsat A, Korczyn AD. "Broad Bean (*Vicia faba*) Consumption and Parkinson's Disease." *Adv Neurol.* (1993): 60:681-4. Web. 23 January 2013.  
<<http://www.ncbi.nlm.nih.gov/pubmed/8420210>>.

## PLANARIA MOVEMENT LAB BACKGROUND READING STUDENT HANDOUT

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### A Neuroseeds Story: The Power of Jamaican Coffee

Most people in the highlands of Jamaica drink tea. Though I grew up in Jamaica, my mother always drank coffee. She said she liked coffee because it prevented her hands from shaking.

Every morning she would make a cup of very strong coffee. First she would grind the coffee with a heavy mahogany mortar and pestle blackened from years of use. Next she would light the stove to boil the water and I could smell the kerosene from my bed. The smell signaled to me it was almost time to get up. Using her tin measuring can, she placed the ground coffee into a homemade, muslin coffee bag, placed the bag in a pot and poured the boiling water into the bag. This made a really strong coffee that you could smell from a mile away! My mother said she needed the strong coffee to prevent her hands from shaking. I often wonder why the coffee stopped her hands from shaking and why other people say “I am shaking because I drank too much coffee.”



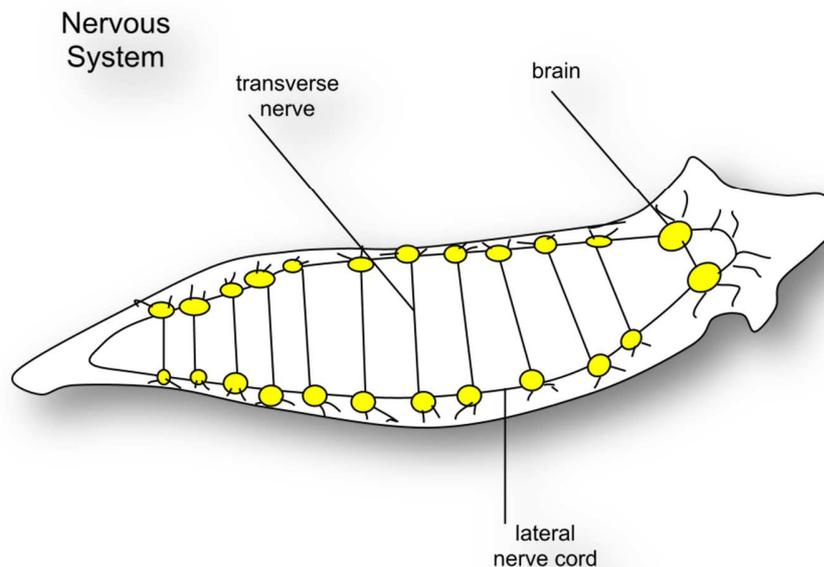
~Phyllis Harvey-Buschel



People throughout the world have been drinking coffee for a long time. Why do people drink coffee to feel alert in the morning? What is the neuroactive chemical in coffee? How do you think it acts on the human nervous system to both cause and treat shaking hands?

## A Nervy Worm

This lesson uses planaria, a widely used model organism. Planarians are in the flatworm phylum, Platyhelminthes. Like all flatworms, planaria are **bilaterally symmetrical** which means that the left and right halves are mirror images of one another. The planaria nervous system is an anterior “brain” consisting of large **ganglia**. From the ganglia, two **ventral nerve cords** run the length of the body. Short **transverse nerves** connect the two **ventral nerve cords** like the rungs of a ladder.



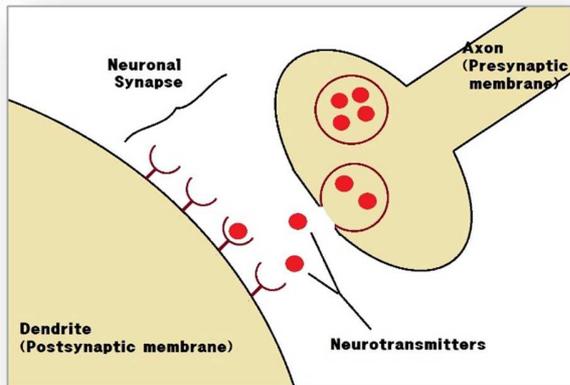
Planaria have two **eyespots** in their head. The eyespots sense light but don't see images. Planaria also have **chemoreception**—specialized places on their heads where they sense chemicals. Humans have chemoreception too—we sense chemicals using both smell and taste. The human nervous system is a more complex system that evolved from a simpler one like that found in planaria. This is part of the reason why studying planaria might help us learn about the human nervous system.

## Speeding Up and Slowing Down with Plant Extracts

Plants and herbs have been used around the world for millennia to alter brain function. In most places around the world today, plants are used daily to alter mental function. For example, the **caffeine** in coffee and black and green tea is a **stimulant** that helps people to wake up in the morning. Chamomile tea helps people to relax in the evening and is considered to be a **depressant**. Some people regularly use alcohol, nicotine, and illegal drugs such as cocaine; these drugs are derived from plants and have large effects on the human nervous system.

Some plants have chemicals that mimic the action of natural chemicals found in the body. These neuroactive plant chemicals can therefore cause the same behavior as the body's. Communication of information between neurons is accomplished by movement of chemicals across a small gap called the

**synapse**. Chemicals, called **neurotransmitters**, are released from one neuron, cross the synapse and may be accepted by the next neuron at a specialized site called a **receptor**.



In this lab investigation, you will observe and count planaria movements with and without the addition of a plant extract. Experiments on animals are a regular part of medical and scientific research because: 1) experiments on animals provide insights about the human brain and help to make healthy lifestyle choices,

prevent disease, and find cures for disorders; and 2) testing chemicals or plant extracts on animals is a way to determine their likely effect on humans.

### Planaria Movement Lab: Vocabulary List

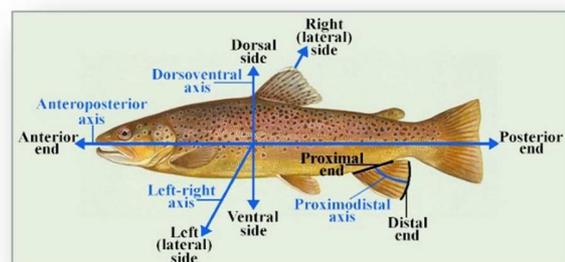
**Anterior:** A directional term used in the field of biology to describe something located in the front part of the body. In humans, this is our front side. In animals, this is near the head.

**Bilateral symmetry:** The left and right halves are mirror images of each other.

**Caffeine:** A central nervous system **stimulant** that reduces drowsiness and increases alertness. It is a chemical found in plants including coffee and tea.

**Chemoreception:** The ability to sense chemicals in the environment. Humans sense chemicals dissolved in the air using their sense of smell and chemicals dissolved in water using their sense of taste. Animals may have different way of sensing chemicals in their environment.

**Conditioned water:** Tap water that has set out uncovered for at least 24 hours to allow chlorine to evaporate.



**Depressant:** Chemicals that decrease mental or physical function by decreasing alertness and increasing sleepiness.

**Dorsal:** A directional term used in the field of biology to describe something located in the back part of the body (in animals with a spinal cord, this is towards the spinal cord).

**Eyespots:** Simple eyes that can detect light from dark but cannot form images.

**Ganglia:** A cluster of nerve cells (neurons).

**Meniscus:** In the field of chemistry, the meniscus is the curve seen at the top of a liquid inside of a container. When measuring a liquid in a container, such as a graduated cylinder, measure according to the center of the meniscus at eye level. For most liquids, this is the bottom of the concave curve.

**Nerve:** A bundle of fibers composed of neurons through which the brain and body communicate.

**Nerve cords:** The long nerves running from the ganglia in the head of a planarian through its body. Nerves connect the nerve cord like the rungs of a ladder.

**Neurotransmitter:** Chemicals that transmit information across the synapse to communicate from one neuron to another.

**Posterior:** A directional term used in the field of biology to describe something located towards the back of the body, generally away from the head.

**Receptor:** An area of the neuron that is specialized for receiving a neurotransmitter

**Stimulant:** Chemicals that increase mental or physical function by increasing alertness and decreasing sleepiness.

**Synapse:** Chemical or electrical junctions that allow electrical signals to pass from neurons to other cells. A synapse includes the synaptic terminal, synaptic gap, and dendrite.

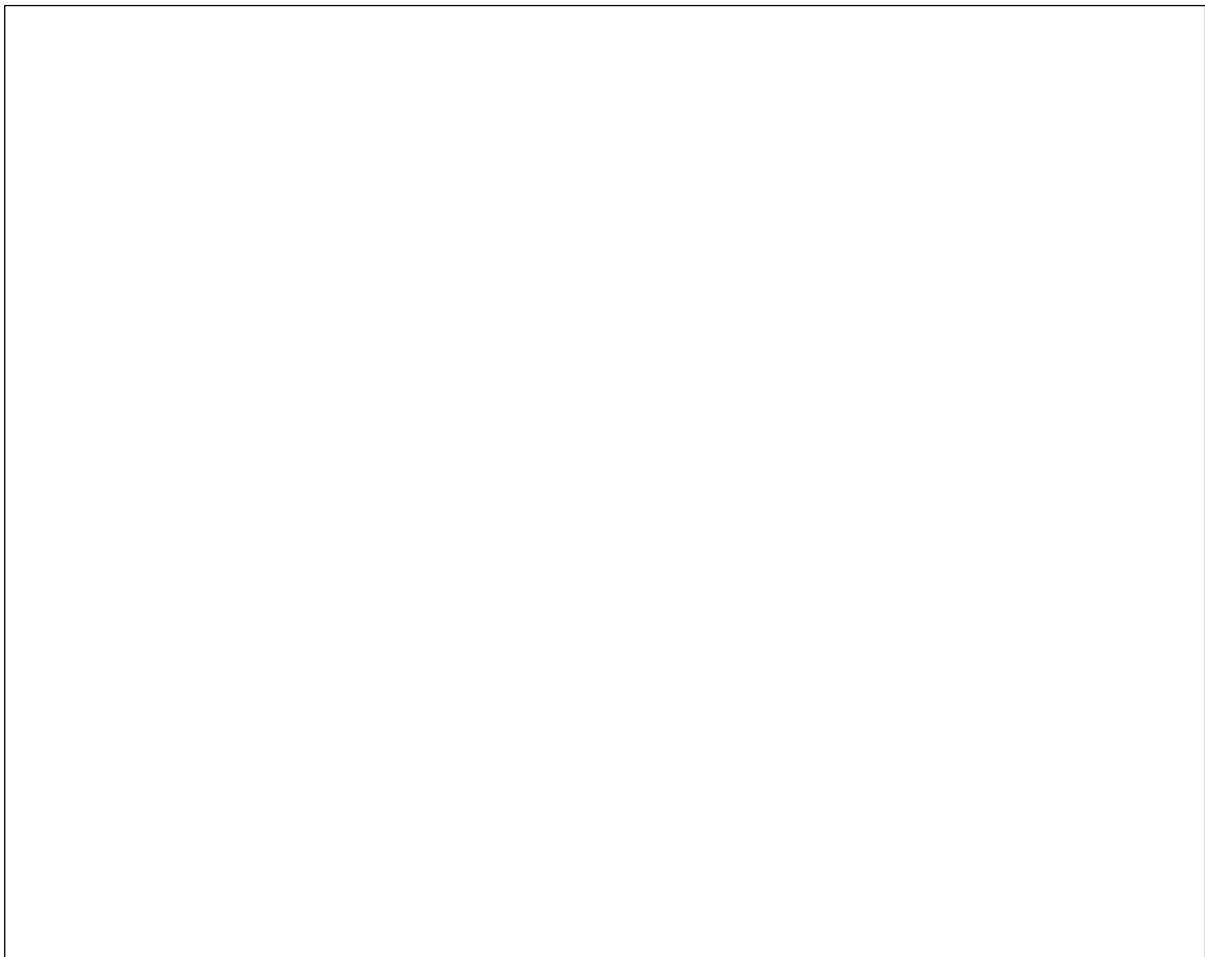
**Ventral:** A directional term used in the field of biology to describe something located in the front part of the body. In animals, this is usually the surface towards the ground.

## PLANARIA MOVEMENT SKETCHES STUDENT HANDOUT

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

**Directions:** Observe and sketch a planarian. Your drawing should include labels of these structures:

- Eyespots
- Anterior side
- Posterior side
- Dorsal side
- Ventral side



## PLANARIA MOVEMENT PRE-LAB PLANNING STUDENT HANDOUT

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

1. As a group, choose two plant extracts to test during this lab. You will be using the extracts that your class produced during the previous *Infusions and Decoctions* lab. Your teacher will provide you with specific instructions on how to choose the extracts. Record the names of your chosen extracts.

Plant Extract #1:

Plant Extract #2:

2. For each of your chosen plants, write a brief summary of whether the plant affects the nervous system, whether it is a stimulant, depressant, or neither, and its potential medical benefits, if any.

You may have already done some research on this plant as part of the *Infusions and Decoctions* lab. If not, ask your classmates to find someone who previously researched this plant extract and ask them to share their findings. Use that information to write a summary.

Summary for Plant Extract #1:

Summary for Plant Extract #2:

3. As a group, develop a hypothesis for each of your two chosen plant extracts. The hypothesis should communicate how you think the extract might affect the movement of a planarian. Write down your two hypotheses using the “If, Then” format.

Plant Extract #1:

Plant Extract #2:

**PLANARIA MOVEMENT LAB PROCEDURE  
STUDENT HANDOUT**

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

**Lab Procedure for Observing Planaria Movement**

Decide on which group member will take on each of the following roles:

**Scribe, Solutions Master, Timer, and Counter.**

If you have two people in your group, one person should be the **Scribe & Timer** and the other person should be the **Solutions Master & Counter**. If you have three people in your group, one person can be both the **Scribe & Solutions Master**.

**Your group will need the following laboratory materials:**

| Item   | Quantity per Lab Group |
|--|------------------------|
| Goggles and gloves   | 1 per student          |
| Student lab notebook   | 1 per student          |
| Pen  | 1 per student          |
| Graph paper  | 1 piece                |
| Permanent marker   | 1                      |
| Lab tape for labeling  | 1                      |
| Timer  | 1                      |
| Clicker for counting planaria movement   | 1                      |
| Planaria   | 3 planaria             |
| Paintbrush   | 1                      |
| Square hinged-lid plates   | 1                      |
| 100 ml beaker <ul style="list-style-type: none"> <li>• One beaker for conditioned water.</li> <li>• One beaker for “recovery”—the planaria will go here after the experiment to rinse off any extracts before they go back to their aquarium.</li> </ul> | 2                      |
| Conditioned water  | ~150 ml                |
| Plastic pipette  | 3                      |
| Plant extracts   | 2                      |
| Medicine cup (aka “ketchup cup”)   | 2                      |
| 10 ml graduated cylinder   | 1                      |

### Set Up Your Lab Station:

1. **Solutions Master:** Use a piece of lab tape and a permanent marker to label your two medicine cups with the name of each plant extract you will be testing—one extract per cup. For example, you might have a cup labeled “Coffee” or “Cayenne.”
2. **Timer:** Your group should have two 100 ml beakers to label. Using lab tape and a permanent marker, label one “Conditioned Water” (your control) and the other “Recovery”. Fill each beaker half way with conditioned water (water that has set out for several days). The planaria will go into the recovery beaker after the experiment to rinse off any extracts before they go back to their aquarium.
3. **Scribe:** Write all of your group members’ names and the date on your data sheet. There are three tables on this sheet for you to work with. The top table is for your “Water Control”. For the other two tables, write in the names of the plant extracts you will test.
4. **Counter:** Tape the graph paper to the bottom of the square hinged-lid plate. Line up the paper so that the sides of the plate align with a row of squares on the paper. Be careful to tape the sides of the plate so that you do not cover the squares of graph paper with the tape, as shown in *Figure 1*.



**Figure 1:** Square hinged-lid plate with graph paper taped to its sides.

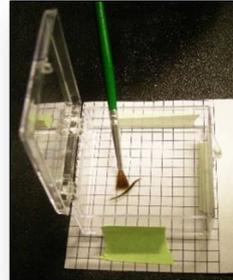
### Lab Procedure:

5. **Solutions Master:** Use a graduated cylinder to measure 6 ml of conditioned water, making sure to look at the bottom of the **meniscus** when measuring. Pour the conditioned water into a square plate and swirl it around so that the whole bottom of the plate is covered with water.

6. **Counter:** Use a soft paintbrush to gently remove a planarian from the wall of the beaker/aquarium, as shown in **Figure 2**. Gently place the planarian into the plate (to which you have just added conditioned water), as shown in **Figure 3**.



**Figure 2:** Use a paintbrush to remove one planarian.



**Figure 3:** Gently transfer the planarian to the plate.

7. **Scribe:** Estimate the size of your planarian based on the number of squares it takes up when it is fully stretched out. Most planaria are between 1 and 4 squares long. We don't think that size affects planaria movement, but collecting this data will help us to know this for sure. Write the size on your data sheet where it says "Approximate Planarian Size."
8. **Timer:** Set the timer for one minute. Start the timer. This minute is for your planarian to adjust to the new environment before you start counting.
9. It is time to count the planarian's movements.

- **Timer:** Set your timer for one minute again. Next, you will count how many squares the planarian's head enters during this minute.
- **Counter:** Use your clicker counter to count each time the planarian's **whole head** enters a new square—but not if it goes back into the square from which it came, during one minute. If your planarian is crawling up the side of the plate, do your best to estimate the number of squares that the planarian would have moved through. See **Figure 4**.



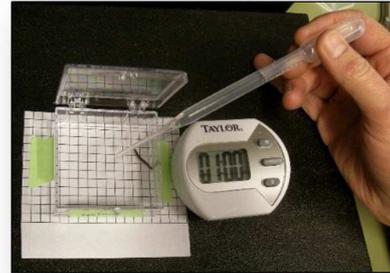
**Figure 4:** Use the clicker counter to count the number of squares that the planarian's head enters in one minute.

10. **Scribe:** Record on the data sheet the number of squares the planarian entered. This should be in the first row of the "Water Control" table. Additionally, check the box for any movements you

observe in your planarian such as: move forward, move backward, curl, try to crawl out of the water, twitch, stop moving, float, or twist.

11. **Counter:** Reset your clicker counter to 0.
12. **Solutions Master:** Using a plastic pipette, add 1 ml of conditioned water (and swirl your plate around to mix). See **Figure 5**.

13. **Timer:** Start a one minute timer to allow the planarian to get used to the new conditions.
14. **Timer:** Next, set the timer again for one minute.  
**Counter:** Count your planarian's movements as before—counting the squares the whole head enters in one minute.



**Figure 5:** Use the plastic pipette to add additional conditioned water or plant extract to the plate.

15. **Scribe:** Record the number of squares the planarian entered and your observations about the planarian's movement.
16. Follow these same protocols after the **Solutions Master** adds 2 ml and 3 ml conditioned water to the plate (as is written on your data sheet). On the plastic pipette, 1 ml and 2 ml are marked with a line. If you have any questions about how to measure using the pipette, please ask your teacher.
17. As a reminder, the steps to be followed by the **Timer**, **Counter**, and **Scribe** are:
  - a. Reset your clicker counter.
  - b. Add the correct number of milliliters (ml).
  - c. Allow the planarian to adjust for one minute.
  - d. Count the planarian's movement for one minute.
  - e. Record the data on the number of squares and movement observations.
18. **Scribe:** When you are done, please use the paintbrush to gently move the planarian to the recovery beaker. Your teacher will return these planaria to their beaker/aquarium tomorrow.
19. You have now finished testing your water control. **Scribe:** On your data sheet, be sure that your table for the water control is complete before moving on to testing Plant Extract #1. Follow the same steps (#5-18) to test Plant Extracts #1 and #2. Starting at step #12, instead of adding conditioned water, add your plant extracts. Make sure to fill out the plant extract table, too.
20. Listen to your teacher's instructions on how to clean up your lab station and put away lab equipment.

**PLANARIA MOVEMENT DATA SHEET  
STUDENT HANDOUT**

Group Members' Names: \_\_\_\_\_

Date: \_\_\_\_\_ Period: \_\_\_\_\_

**Data Sheet for Recording Planaria Movement**

Approximate Planarian Size: \_\_\_\_\_ squares

For each of your trials, record the number of squares the planarian's whole head enters each minute in the "# Squares" column.

| <b>Water Control</b>                   |                  |                  |  |
|--|------------------|------------------|--|
| <b>Add This Much Conditioned Water</b> | <b>% Extract</b> | <b># Squares</b> | <b>Did Planarian Do Any of the Following Movements?</b>  |
| <b>0</b>                               | <b>0%</b>        |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>1 ml</b>                            | <b>15%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>2 ml <u>more</u></b>                | <b>30%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>3 ml <u>more</u></b>                | <b>50%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |

| <b>Plant Extract #1</b>      |                  |                  |  |
|------------------------------|------------------|------------------|--|
| <b>Name:</b>                 |                  |                  |  |
| <b>Add This Much Extract</b> | <b>% Extract</b> | <b># Squares</b> | <b>Did Planarian Do Any of the Following Movements?</b>  |
| <b>0</b>                     | <b>0%</b>        |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>1 ml</b>                  | <b>15%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>2 ml <u>more</u></b>      | <b>30%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>3 ml <u>more</u></b>      | <b>50%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |

| <b>Plant Extract #2</b>      |                  |                  |  |
|------------------------------|------------------|------------------|--|
| <b>Name:</b>                 |                  |                  |  |
| <b>Add This Much Extract</b> | <b>% Extract</b> | <b># Squares</b> | <b>Did Planarian Do Any of the Following Movements?</b>  |
| <b>0</b>                     | <b>0%</b>        |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>1 ml</b>                  | <b>15%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>2 ml <u>more</u></b>      | <b>30%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |
| <b>3 ml <u>more</u></b>      | <b>50%</b>       |                  | <input type="checkbox"/> move forward <input type="checkbox"/> move backward <input type="checkbox"/> curl<br><input type="checkbox"/> try to crawl out of the water <input type="checkbox"/> twitch <input type="checkbox"/> stop moving<br><input type="checkbox"/> float <input type="checkbox"/> twist |

## PLANARIA MOVEMENT RESULTS & CONCLUSIONS STUDENT HANDOUT

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Results

1. In this investigation, the water was the **controlled variable**. The **dependent variable** was the planaria's behavior. The concentration of the plant extract was the **independent variable**. What two plant extracts did you test?

2. What was your hypothesis for each of these plant extracts?

Plant Extract #1:

Plant Extract #2:

3. Describe the similarities and differences between the results obtained from the water control and each plant extract. Include a description of the changes in the numbers of squares the planarian moved through and any differences you noted in the way the animal moved.
4. Did your observations support or refute your hypothesis for each plant extract? What evidence do you have?



## PLANARIA MOVEMENT LAB VOCABULARY QUIZ

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

Unscramble the words. Then match each word to the definitions on the right by drawing a line to connect them.

|                           |   |
|---------------------------|---|
| RNAROETI<br>_____         | <ul style="list-style-type: none"><li>• The long nerves running from the ganglia in the head of a planarian through its body.</li></ul>   |
| RSIEYALRMYBTMALE<br>_____ | <ul style="list-style-type: none"><li>• The curve seen at the top of a liquid inside of a container. Usually the bottom of the concave curve.</li></ul>                           |
| NEICFFAE<br>_____         | <ul style="list-style-type: none"><li>• The ability to sense chemicals in the environment.</li></ul>  |
| COHRTMPEONEICE<br>_____   | <ul style="list-style-type: none"><li>• Simple eyes that can detect light from dark but cannot form images.</li></ul>   |
| EATDNSEPSR<br>_____       | <ul style="list-style-type: none"><li>• Part of the neuron specialized for receiving neurotransmitters</li><li>• Left and right halves are mirror images of each other.</li></ul> |
| ARLODS<br>_____           | <ul style="list-style-type: none"><li>• Chemicals that send information from one neuron to another.</li></ul>   |
| SEYTPEOS<br>_____         | <ul style="list-style-type: none"><li>• Chemicals that increase mental or physical function by increasing alertness and decreasing sleepiness.</li></ul>                          |
| LAGNGAI<br>_____          | <ul style="list-style-type: none"><li>• Chemicals that decrease mental or physical function by decreasing alertness and increasing sleepiness.</li></ul>                          |
| CINUMSSE<br>_____         | <ul style="list-style-type: none"><li>• A small gap between neurons.</li></ul>  |
| ENREV<br>_____            | <ul style="list-style-type: none"><li>• A directional term used to describe something located in the front part of the body, or towards the head.</li></ul>                       |
| CNOVESRDRE<br>_____       | <ul style="list-style-type: none"><li>• A directional term used to describe something located in the back part of the body (for example, toward the spinal cord).</li></ul>       |
| SENITMTOAURRTREN<br>_____ | <ul style="list-style-type: none"><li>• A directional term to describe something located towards the back of the body, away from the head.</li></ul>                              |
| TOOSRIRPE<br>_____        | <ul style="list-style-type: none"><li>• A directional term to describe something located in the front part of the body. Usually the surface towards the ground.</li></ul>         |
| OTRRECPE<br>_____         | <ul style="list-style-type: none"><li>• A cluster of nerve cells (neurons).</li></ul>   |
| TSLTUNIMA<br>_____        | <ul style="list-style-type: none"><li>• A central nervous system stimulant that reduces drowsiness and increases alertness. Found in plants including coffee and tea.</li></ul>   |
| NAEYPSS<br>_____          | <ul style="list-style-type: none"><li>• A bundle of fibers composed of neurons through which the brain and body communicate.</li></ul>  |
| ANVTRLE<br>_____          |   |