Sowing the Seeds of Neuroscience

Appendix

ETHICS IN ANIMAL RESEARCH
STUDENT HANDOUT

Name:_____ **Date:**_____ **Period:**_____

Animals are incredibly important to our lives. For example, we may use their wool or skin to provide clothing or we may eat them as food. Our pets may be among our best friends. Animals are used around the world for farming and transportation. Animals are also used in research. From cockroaches to worms and mice to monkeys, many animal species contribute to medical breakthroughs every year. Through research with animals, scientists have discovered ways to cure or prevent many diseases—and save millions of human lives.

Scientists use animals for research because the human body is similar to animal bodies in many ways. By studying animals, we can learn more about how our bodies work. Experiments on animals can help people to make healthy lifestyle choices, prevent diseases, and find cures for disorders. Testing new medicines or products on animals is a way to determine their likely effect on humans. Additionally, testing new medicines or products on animals to determine their safety is more ethical than testing on humans before these safety tests have been carried out.

The benefit to human health is commonly given as a reason to support animal research. However, animal research is also done in science classrooms because such hands-on work helps people learn. Animal research also benefits other animals. For example, your dog or cat may get vaccines to prevent disease—and these vaccines were tested on animals before being approved for use in pets. Your pets are also probably spayed or neutered and they probably had anesthesia for this process—how do you think scientists determined what pain relieving drugs worked for surgery in animals?

When scientists do research on animals, they must do so ethically. To help them do so, scientists always follow the **three Rs of animal research**. First, they work to **REDUCE** the number of animals needed for the experiment—they use the fewest number of animals possible that will still give them meaningful data. Scientists must also **REFINE** the experiment to minimize pain and distress on the animals. Finally, scientists must **REPLACE** animals with "lower species" or computer models when possible.

In the *Sowing the Seeds of Neuroscience* curriculum, you will use invertebrates such as planaria worms, *Lumbriculus* worms, and cockroaches in experiments. In one lesson, you will remove a leg from a cockroach. We do not know if cockroaches feel pain, but we make the assumption that they do, so we anesthetize them using ice water first. You will use this leg to learn about how neurons communicate with one another in your body, and learn whether plant extracts affect this communication. In another lesson, you will cut a planaria worm in half. When we do this, we mimic what happens in planaria reproduction: their bottom part attaches to a rock and the top pulls away and splits off. In nature, both of these pieces will grow to become a whole planarian. In the laboratory, you will investigate whether the plant extracts that you've made either speed up or slow down this regeneration.

Although we are doing research on these animals, we must always respect them and handle them gently during investigations. If you are uncomfortable with the idea of this research, please talk with your teacher. You can participate in the lab activities but opt out of being the "surgeon" who cuts the planaria or the cockroach leg. If you'd rather stay away entirely, talk to your teacher about an alternative assignment.

ALTERNATIVE ACTIVITIES
TEACHER RESOURCE

Some students may chose not to be involved in any of the *Sowing the Seeds of Neuroscience* experiments involving animals. If possible, suggest that your students stay involved in the lab but opt out of being the "surgeon" who cuts the planaria or cockroach leg, or the "Solutions Master" who adds the plant extract to the planaria. If students would rather stay away entirely, here are a few options for an alternative assignment.

1. Conduct an internet search on one of the plants that student groups are testing in today's lab. Recommended websites include:

   University of Maryland Medical Center Alternative Medicine
   http://www.umm.edu/altmed/

   National Center for Complementary and Alternative Medicine
   http://nccam.nih.gov/

   National Institute of Health Dietary Supplements Fact Sheets
   http://ods.od.nih.gov/factsheets/list-all/

   Have them do the following:
   a. Sketch the whole plant
   b. Determine whether the plant affects the nervous system, including whether it is a stimulant, a depressant, or neither
   c. Record the potential medical benefits of the plant
   d. Develop an experiment testing the safety and efficacy of the plant without using animals.

2. Color the neuron model (see attached coloring page) and label and define the terms listed.

3. Do the math problems on the Mouse Math Worksheet. This worksheet shows how math might be used every day if your job was caring for laboratory animals. It can downloaded here:

   Mouse Math Worksheet
   Kids 4 Research
   http://www.kids4research.org/downloads/tflmousemath.pdf

4. Fill out the Scientific Criss-Cross. This puzzle shows students how many scientific and medical terms are made up of prefixes, stems, and suffixes derived from a variety of languages such as Latin, Old English, and Greek. Students need to use the prefixes, stems, and suffixes listed to complete the crossword puzzle. It can be downloaded here:

   Scientific Criss-Cross
   Kids 4 Research
   http://www.kids4research.org/downloads/tflcrisscross.pdf

5. If the student opts out of the SpikerBox experiment, encourage them to explore the other entry level experiments using SpikerBoxes at the Backyard Brains website and answer the following questions
   - Which experiment would they most like to conduct?
   - Why?
   - How does it work?

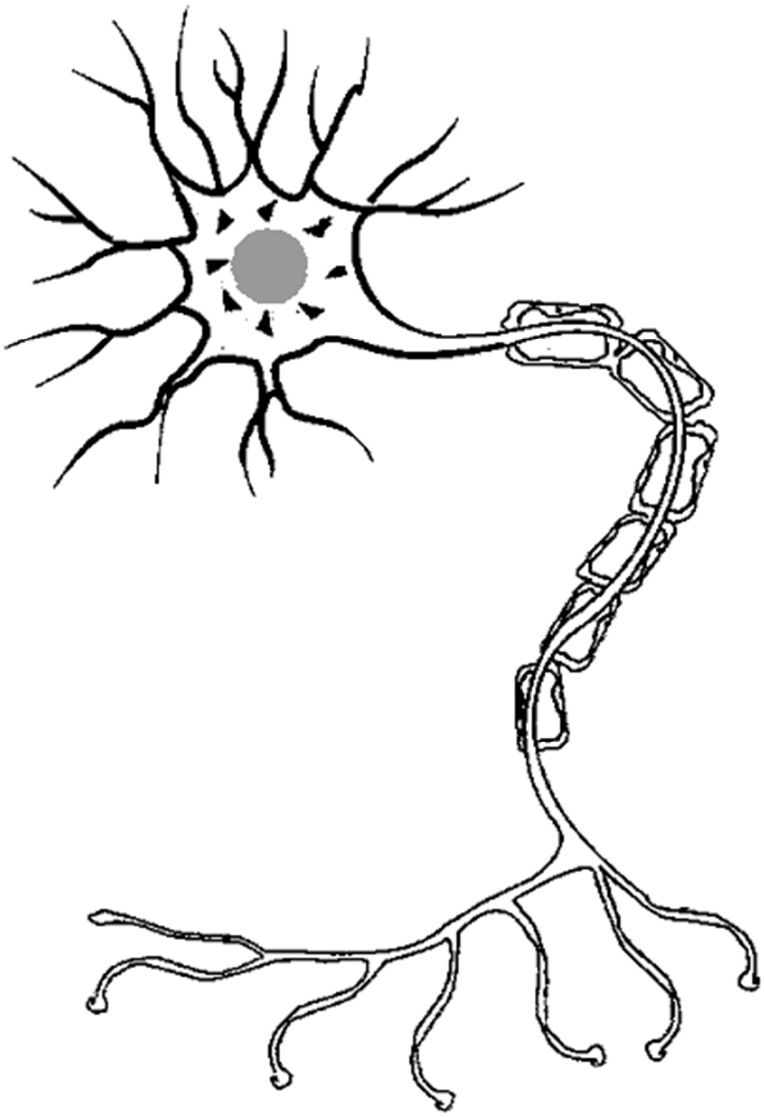
   Backyard Brains Experiments
   https://www.backyardbrains.com/experiments/

NEURON MODEL COLORING SHEET
STUDENT HANDOUT

Name:_____ **Date:**_____ **Period:**_____

Directions: Color this Neuron Image then **label** and **define** the following terms:

- Axon
- Dendrites
- Cell Body
- Synaptic Terminal



From: Neuroscience for Kids.

ANIMAL CARE INFORMATION
TEACHER RESOURCE

Care and Feeding of Your Experimental Animals

Your animals should all arrive with directions! You can follow those directions, or follow these if you prefer.

Worms: Planaria and *Lumbriculus*

Your planaria and *Lumbriculus* worms should arrive in small jars. The first thing you should do is pour them into a small aquarium, large beaker, or large tupperware type storage container, keeping planaria separate from *Lumbriculus*. Metal containers may leach chemicals and should be avoided. Containers with shallow water and a large surface area for oxygen exchange with the air are better than deep containers. Your worms do not need a lid—if you do cover with a lid, make sure it is loose fitting so air can circulate. Planaria and *Lumbriculus* worms will do well in pond water, spring water, or "conditioned" tap water.

Conditioned tap water is simply water that has been left out for a few days to ensure that the chlorine has evaporated out of it. You can use a bubbler to bubble oxygen into the water which also circulates the water and speeds the process of evaporating the chlorine.

Planaria and *Lumbriculus* should be maintained at room temperature or colder.

Disposal: When you are done with your worms, ***do not*** release them into the wild. Bring them back to us, donate them to another teacher, or dispose of them in 10% bleach.

- **10% Bleach:** Add enough one part bleach for every nine parts culture water and let soak for 24 hours. For example, if your culture is 900 ml, add 100 ml bleach. After bleaching for 24 hours, pour the culture water down the drain and run the water until you can no longer smell bleach.

***Lumbriculus* Details**

- Add strips of brown paper towel or cut up grocery bag to the bottom of your *Lumbriculus* tank. This serves as food and substrate for your worms.
- *Lumbriculus* do not have to be fed if you have them less than a month. If you plan on keeping them longer than a month, you should purchase sinking fish food and provide them one or two pellets every week or so. Overfeeding is a much bigger issue than underfeeding.
- Water lost to evaporation should be replaced by adding more water (pond, spring, or "conditioned").
- Every month or so, the water should be changed. Pour the water off, rinse the paper and worms with water, and refill (with pond, spring, or "conditioned" water). After changing the water, replace the paper towel at the bottom of the tank.

Planaria Details

- Planaria should be fed about once every week or two. Planaria like beef. You can buy a small piece of beef from the butcher. Cut it into small portions (playing-dice sized chunks work well) and store in the freezer—individual portions should be wrapped separately in plastic wrap or aluminum foil so you can thaw one chunk at a time. Feed the planaria one chunk each week. It is a good idea to feed them in the morning, let them eat all morning (1-4 hours, until they are no longer eating), then remove the beef and change their water. The water ***must*** be changed after the planaria eat.
- The easiest way to change the water is simply to pour off the old water and replace with new. Some planaria may be floating at the surface, so be careful not to pour out the planaria. The water should be changed once a week, and any time the planaria eat.
- Before using your planaria for a regeneration experiment, they should have one to two weeks to acclimate to your classroom. During this time, you can feed and observe them. You can also do movement experiments with them.

Cockroaches

Your roaches will arrive loose in the shipping box—be ready to deal with them when you open the box! That said, these are non-pest insects and don't thrive without proper care—so don't worry about an infestation in your school.

Home: Please immediately put your cockroaches in the small terrarium provided for you in the Sowing the Seeds of Neuroscience kit. Do not use another type of container. Add some toilet paper rolls, paper towels, or part of an egg carton for them to burrow under.

Food and water: Give your roaches a small dish of water to drink, and ensure they have water throughout the week. It is helpful to cut a piece of sponge and use this to soak up most of the water. Roaches have been known to drown in their water dish. Feed them once a week or so—pet food, lettuce, or carrots all work well. You can feed them whatever you have (they are cockroaches after all!); just throw away the food and replace it weekly.

Disposal: When you are done with your cockroaches, ***do not*** release them into the wild. Bring them back to us, donate them to another teacher, or dispose of them by placing them in a plastic bag in the freezer. After 24 hours in the freezer, they can be thrown away.

Bacteria

Your *Micrococcus luteus* bacteria and your penicillin discs should be stored in the refrigerator until you are ready to use them.

Master List of Career Connections

Aromatherapist: A practitioner of aromatherapy, which is the therapeutic use of plant-based essential oils and aromatic substances to affect a person's physical and emotional wellbeing.

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.

Bioengineer: Also called biomedical engineers. These scientists apply their knowledge of biology, medicine, and engineering to design solutions to health and medical problems—such as new devices, instruments, or procedures. They may work in research facilities, universities, or manufacturing within the medical industry.

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.

Botanist: A biologist specializing in plant science. Botanists study more than 400,000 species of living organisms, from tiny algae to giant trees.

Cardiologist: A physician who specializes in the diagnosis and treatment of diseases related to the heart and cardiovascular system. Some cardiologists are trained as heart surgeons.

Chemist: A scientist specializing in chemical science. A chemist studies the properties of matter. Biochemistry, a specialty within the field of chemistry, is focused on the chemical processes that occur among living organisms, such as plants.

Entomologist: A zoologist (biologist that focuses on animals) that specializes in the study of insects. There are a wide variety of careers within entomology, including using insects to study disease transmission in humans.

Ethnobotanist: A biologist that studies the relationships between plants and people, in particular how people from different cultures use plants in daily life.

Herbalist: A practitioner of herbalism, which is the study and use of medicinal plants.

Microbiologist: A microbiologist is a scientist who studies microscopic organisms, such as bacteria and fungi; they also study viruses. A microbiologist may work in the fields of medicine, veterinary medicine, or pharmaceuticals studying disease-causing agents. They also may work in the fields of food safety or environmental science.

Naturopathic doctor: A doctor of naturopathic medicine (N.D.) is a medical doctor that uses alternative medical treatments (including medicinal plants and herbs) in partnership with traditional medical treatments. While a N.D. may use prescription medication with a patient, they prefer to use natural healing agents.

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. Areas of specialty include neuroanatomy, neurobiology, neurochemistry, neurophysiology, neuropsychology, and more.

Nurse: A nurse may work in doctor's offices, hospitals, or nursing homes. They also may work in schools, correctional facilities, and military facilities. They perform a variety of medical tasks, including taking vital signs, giving injections, drawing blood, and helping with personal hygiene. School nurses may review students' vaccination records to ensure they meet the district's requirements. Two types of nurses include registered nurse (RN) and licensed practical nurse (LPN). Each must obtain a degree in nursing, work in a clinical setting, and pass a licensing examination.

Perfumer: An expert who composes perfumes for the fragrance industry. A perfumer must have a delicate and refined sense of smell.

Pharmacist: A healthcare practitioner with a specialty in pharmaceuticals and the safe use of these medications and therapies. Pharmacists are trained in understanding the biochemical mechanisms of drugs and their interactions with the human body. In the United States, a pharmacist must have a Doctor of Pharmacy (Pharm.D.) degree and licensure.

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.

Research scientist: A scientist of any scientific discipline (such as biology, chemistry, or medicine) who focuses on conducting research in order to contribute to the knowledge of their field. Most research scientists work for universities, government agencies, non-profit research organizations, and private research companies.

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.

Vaccine scientist: A vaccine scientist conducts research to develop new vaccines to immunize people or animals against a bacteria or virus. These scientists typically study biology, immunology, or zoology in school. They work in research and development (R&D) laboratories, usually in university, government, or corporate settings.

Master Glossary

Acetylcholine: A chemical neurotransmitter responsible for communication between neurons and muscle cells.

Action potential: An electrical signal carried along the axon of a neuron. It is an "all-or-none" impulse that transmits information within the nervous system. The action potential is sometimes called a spike.

Adenosine: A chemical neurotransmitter that suppresses activity in the central nervous system and may help promote sleep.

Anesthetize: To numb or reduce pain.

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.

Antibiotic: A medicine that is used to fight a bacterial infection. **Penicillin** is a commonly used antibiotic.

Anxiety: Anxiety or nervousness is a normal emotion that everyone experiences some of the time—for example, you may feel anxious or nervous before taking a test. However, severe anxiety is a neurological disorder where constant worry and fear interferes with everyday life.

Axon: The part of the neuron that takes information ***away*** from the cell body.

Bacteria: Single celled organism that lack a nucleus. Also called prokaryotes.

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

Bioactive chemical: A chemical that interacts with or affect cells or tissues in animals.

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

Capsaicin: The chemical found in hot peppers that makes them spicy. Capsaicin is also used as an ingredient in skin creams to reduce pain.

Cell body: Also called the soma; the part of the cell that contains the nucleus.

Central Nervous System (CNS): The brain and spinal cord.

Chemical transmission: Neurons communicate using both electrical and chemical signals. Chemical transmission is when a neurotransmitter is received by a dendrite, causing an action potential to occur in that cell.

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.

Chromatography: A laboratory technique used to separate the components of a complex mixture.

Chromatogram: The paper strip on which the components of the mixture have been separated.

Chromatograph: A graph produced by a chromatograph machine which shows peaks and patterns for the different chemicals in the solution.

Circulatory system: The body system that contains the heart, blood vessels, and blood. The circulatory system circulates blood through the body, delivers nutrients, and removes wastes. Also called the cardiovascular system.

Conception: In humans, the fertilization of the ova by the sperm; the union of male and female gametes.

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

Dendrites: Extensions from the neuron cell body that bring information ***to*** the cell body.

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

Depression: A neurological disorder affecting about 1 in 10 adults in the United States. Depression is characterized by feelings of deep sadness, helplessness, hopelessness, or worthlessness that last for weeks (or more) and interfere with everyday life.

Differentiation: The process of a cell becoming a specific type of cell. Omnipotent stem cells can differentiate into blood cells, nerve cells, or any other type of cell.

Distill: A way to separate mixtures using differences in volatilities.

Dopamine: A chemical neurotransmitter that is produced by nerve cells in the brain. As a neurotransmitter, dopamine is critical for sending messages between the body and brain about muscle activity and movement.

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).

Electrical transmission: Neurons communicate using both electrical and chemical signals. Electrical transmission is the electrical signal that is carried along the receiving neuron after a chemical neurotransmitter is passed from one neuron to another. The response received by the dendrite increases or decreases the chances that the receiving neuron will generate an action potential.

Electrodes: A conductor through which electricity enters or leaves an object. The electrodes in the SpikerBox are pins attached to wires.

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

Filter paper: A porous type of paper for filtering liquids or separating liquids in paper chromatography.

Foxglove: A plant with bell-like purple and white flowers. The plant contains two chemicals that are extremely potent heart drugs: digitoxin and digoxin.

Gamma aminobutyric acid (GABA): A neurotransmitter that regulates neurons and tends to calm anxiety.

Ganglia: A cluster of nerve cells (neurons).

Glia: Non-neural support cells of the nervous system.

Heart failure: Heart failure doesn't mean that the heart suddenly stops working. Instead, heart failure occurs when the heart pumps more weakly than usual. When this happens, the heart moves blood through the body too slowly to provide enough oxygen and nutrients to meet the body's needs.

Meningitis: A serious neurological illness that results in inflammation of the **meninges**. Meningitis is usually caused by bacteria or a virus.

Meninges: The protective membranes surrounding the brain and spinal cord.

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.

Model organism: A non-human organism that scientists study to better understand something. The hope is that discoveries made on this organism can be used to help understand other organisms, including humans. *Lumbriculus*, planaria, mice, fruit flies, and the bacteria *E. coli* are all common model organisms.

Mortar and pestle: Together, a mortar and pestle are used to crush or grind up solid substances. The **mortar** is the cup in which ingredients are ground or crushed. The **pestle** is the heavy bat-like tool with a rounded bottom that grinds or crushes the ingredients in the mortar.

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

Nerve cord: The long nerve running from the ganglia (a cluster of nerve cells) in the head of a planarian through its body. Nerves connect the nerve cord like the rungs of a ladder.

Nervous system: An organ system that controls and responds to body functions and directs behavior.

Neuroactive chemical: A chemical that interacts with or affects the brain or other nervous system cells in animals.

Neuroanatomy: The structure of the nervous system.

Neurological: Having to do with the nervous system.

Neuron: A nerve cell.

Neurotoxin: Poison that affects the nervous system.

Neurotransmitter: Chemical that transmits information across the synapse to communicate from one neuron to another.

Nutrient agar: Agar is a substance used in science labs to grow bacteria in a petri dish. Agar looks like jelly and is made from red algae that grows in the ocean. Nutrient agar has nutrients added to it to help the bacteria grow. The nutrient agar used in this lab is Tryptic soy agar which gets its nutrients from soybeans and milk protein.

Omnipotent cells: Stem cells capable of differentiating into ***any*** other type of cell. A single omnipotent cell is theoretically capable of growing into an entire organism. Also called totipotent cells.

Penicillin: A group of **antibiotics** that are commonly used to treat bacterial infections, such as ear infections.

Peripheral Nervous System (PNS): The part of the nervous system containing all of the nerves outside of the brain and spinal cord.

Plant extract: A liquid that contains plant chemicals. Types of plant extracts include infusions, decoctions, juices, essential oils, and tinctures.

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

Regenerate: To replace a lost or damaged body part or organ by growing new tissue. Many animals have this ability, including planaria, some lizards, starfish, sea cucumbers, and more.

Respiratory system: The body system that includes all the parts of an animal's body that help it to breathe; these parts bring in oxygen and release carbon dioxide gases. In humans and other mammals, the anatomy of the respiratory system includes the lungs, the airways, and the respiratory muscles.

Sensory stimuli: Information from the senses. Sensory stimuli include anything you see, hear, taste, smell, or feel.

Serotonin: A neurotransmitter that regulates mood, appetite, and sleep. Low levels of serotonin are associated with depression.

Solvent: A chemical that dissolves another chemical.

Spike: Another word for **action potential**. An electrical signal carried along a neuron. It is an "all-or-none" impulse that transmits information within the nervous system.

Steep: To soak in water.

Stem cells: Undifferentiated cells that can make more of themselves and develop into different cell types (differentiate)—but may not be able to differentiate into all cell types

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.

Synaptic gap: The area between neurons that allows neurotransmitters to pass between neurons**.** It is the functional connection between an axon of one neuron and a dendrite of another.

Synaptic terminal: A bulge in the axon that stores and releases neurotransmitters.

Vagus nerve: An extremely long nerve that extends from the brain stem all the way to the intestines. The vagus nerve carries many signals to and from the brain and regulates many instinctive responses in the body, including heart rate. The vagus nerve also helps to control breathing and the digestive tract.

Valerian: A bushy plant from Europe and Asia that has been used for nervous system disorders such as sleep problems, anxiety, and depression.

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.

Volatile: Chemicals that evaporate rapidly.

Zone of Inhibition: The clear area (with no bacteria) on your petri dish. Because you covered the petri dish with bacteria, this clear area demonstrates the absence (or inhibition) of bacteria due to the plant extract or penicillin.