

Subject: Biology

Estimated Time: 1.5-2 hours

Title: “The effects of agonist and antagonist drugs on Daphnia Heart Rate”

Synopsis: Students will study the effects of the neurotransmitters nicotine, caffeine, ethanol, and acetylcholine on Daphnia Heart Rate. This experiment will be conducted with 1 partner.

Purpose: Students will observe and learn about cellular communication and its importance in multi cellular organisms.

Vocabulary:

Neurons

Neurotransmitters

Agonist

Antagonist

Ligands

Binding Sites

Pre-Requisite Knowledge:

Basic Biology

Neurons

Next Generation Science Standards:

Students who demonstrate understanding can:

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [*Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.*]

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.] [*Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.*]

HS-LS1-3.

Plan and conduct an investigation to provide evidence those feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [*Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.*]

Objectives:

- Will learn how parts of the body communicates with each through neurons
- Determine the effects and difference of agonist and antagonist
- Recognize real world applications of the neurotransmitters
- Learn the anatomy of Daphnia

Introduction/ Near-Peer Information: Unlike unicellular organisms such as amoebas, multicellular organisms such as humans consist of many cells that work together to carry out functions. It is important to identify cell communication pathways and the effects different neurotransmitters have on the overall cellular system.

Agonist:

Nicotine (1% Concentration)

Acetylcholine (1% Concentration)

Antagonist:

Ethanol (1% Concentration)

Caffeine (1% Concentration)

Economical Alternatives to Drugs:

Energy Drinks (Caffeine)

Maple Syrup (Ethanol)

Egg Yolk (Acetylcholine)

Materials:

- Compound Light Microscope
- Thick Depression Well Plate
- Pipets (plastic)
- Microscope Slides
- Drug Solutions (Antagonist and Agonist)
- Timer
- Blank Paper
- Pencil
- Distilled Water
- Reagent Spatula
- Daphnia

Career Connection:*Entomologist*

- Studies Daphnia in detail
- Understands the make-up of Daphnia and its connection to other organisms

Neurologist

- Studies and understands the effects of neurotransmitters in cell communication
- Determines which drug produces a certain reaction

Procedures:

1. Transfer one Daphnia into one of the thick depression well plate with a transfer pipette
2. For a control group, transfer the Daphnia to a microscope slide without any drug solution
3. Add one drop of Detain to the slide and place under the light microscope
4. At 10X magnification, locate the heart of the Daphnia
5. Sketch a diagram of Daphnia
6. Record the number of heart beats by tapping a pencil on a blank sheet of paper for each heart beat seen
7. Count for 15 seconds and multiply the number of pencil marks on the paper by 4 to determine the beats per minute
8. Repeat these steps for each drug solution and record the results

Discussion Material:

- Are these drugs found in common, everyday products?
- (Yes. Caffeine can be found in coffee and soda and Nicotine in cigarettes)
- Do you think we can take advantage of the effects of these drugs?
- (Yes. Caffeine is used to keep us energized and Acetylcholine is found in food like eggs and allows us to concentrate and help our memory)

Questions to Engage the Students/Analysis:

- Why do we use Daphnia in this lab?
- (Small enough organism to be looked at through a compound microscope and has visible organs)
- How were the agonist and antagonist neurotransmitters different from each other?
- (Depending on the effect of the certain neurotransmitters, agonist should have a positive, stimulant effect while antagonist have a negative, repressive effect)
- What do the results say about cell communication?
- (They show that cells such as neurons communicate through a pathway that can be affected by neurotransmitters. These neurotransmitters are able to speed up or slow down communication between each neuron.)
- **<https://www.youtube.com/watch?v=MJCnZ0pB3q4> (Video with Daphnia that students can use to measure heart rate as an example)**

Summary: (Background Information for the Teacher)

Cell communication is the system that allows multicellular organisms to function and survive in nature. The multicellular organism *Daphnia* has a circulatory system that depends on cell communication, namely the regulation of heart rate. Drugs act as ligands in the system and elicit effects on *Daphnia* heart rate through cell surface receptors on the heart. This event is mediated by guanine nucleotide binding proteins (G proteins). In this experiment, we demonstrate the effects of nicotine, caffeine, ethanol, and acetylcholine on *Daphnia* heart rate and determining which receptors bind to the drugs. *Daphnia* was transferred onto a depression slide and put under the compound light microscope to count the resting/basal heart rate. *Daphnia* was immersed in a few drops of drug solution in a thick depression well plate and observed once more under the compound light microscope, where its heart rate was counted. Nicotine and caffeine were found to increase the heart rate of *Daphnia*, while ethanol and acetylcholine were found to decrease the heart rate. These results show that there are specific receptors to these drugs on the heart cells that affect the heart rate of *Daphnia*. This shows how important cell communication is for carrying out tasks for the multicellular organism.

*Daphnia Heart*

Name _____

Date _____

Follow the procedure below and complete the chart.

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Sketch:**Data:**

	Trial 1	Trial 2	Trial 3
Basal/ Resting Heart Rate			
Ethanol			
Acetylcholine			
Caffeine			
Nicotine			