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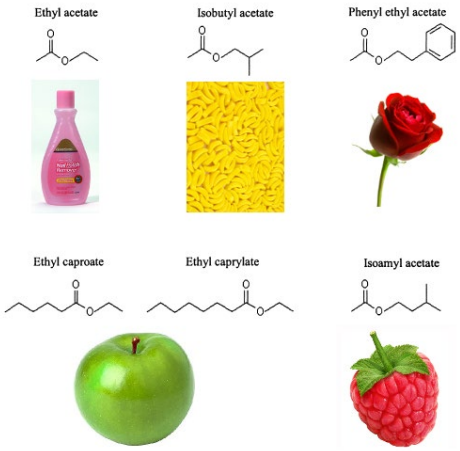
Smelling Cancer Cells Worksheet Answer Key

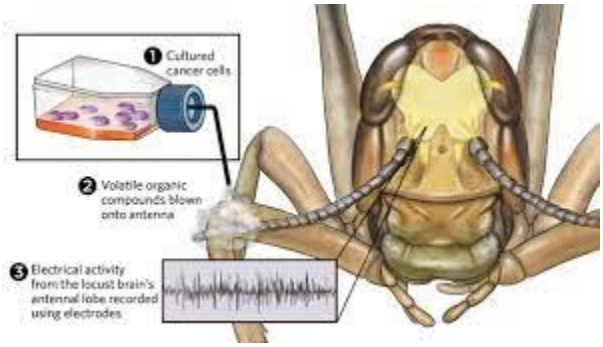
Cell division, also known as mitosis, and cellular respiration are closely linked. Cells going through division require more energy than cells that are in interphase. Dividing cells build, use, and move many materials to successfully split into two daughter cells. Cancer cells undergo rapid and abnormal cell division; therefore, cellular respiration must happen at an increased rate, and the metabolic activities (building, using materials) are different than in healthy cells. If any metabolic products of any type of cell are volatile (i.e., enter and spread to the air easily), it is possible that dividing cells have a smell.

Odor, or smell, is due to molecules in the air that come into contact and stimulate specialized nerve cells that are part of olfactory (smelling) systems. Different odor molecules have different shapes. Each different shape stimulates nerve cells differently and causes a unique pattern of nerve signals to occur in the brain that are perceived as a particular smell. Many types of organisms have a sense of smell, including humans, dogs, fish, and insects—but the structures and level of distinction vary. Insects have a highly evolved sense of smell. Their antennae house olfactory receptors that respond to odors in specific patterns and with much more precision than humans. To the right are the molecules associated with various fruits.

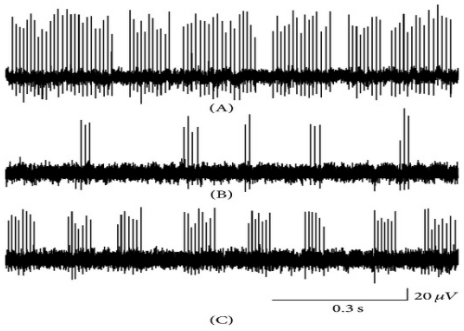


Can insect brains, specifically locust antennae, be used to detect cancerous cells versus healthy cells? If so, could we design an artificial locust brain that would allow us to detect cancer based on someone's breath? Researchers sought to answer this question with a setup like the one below. In this activity, an artificial locust brain will be constructed, and tests will be performed to determine whether it can differentiate between healthy and cancerous cells.

Locust Brain and Odor Setup



Examples of Nerve Signal Patterns



Pre-Lab Questions

1. Below are images of a human brain and a fly brain. Write down similarities and differences below.

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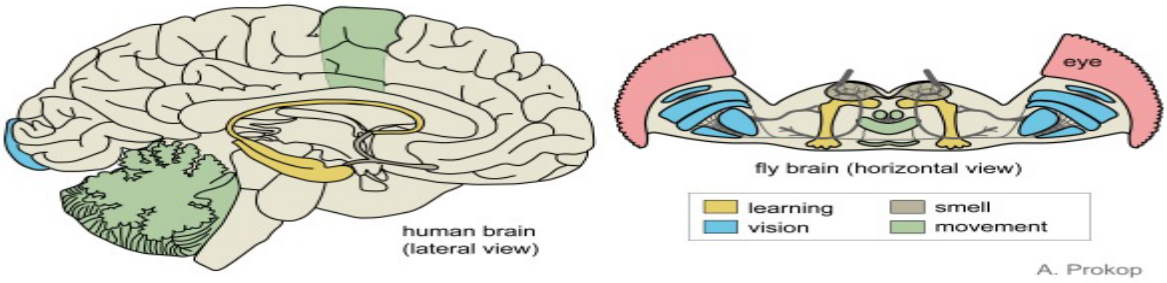

Answers will vary. Similarities: designated areas for different types of sensing, learning and smell centrally located; differences: size, shape, more movement areas in human brain, eyes part of fly brain, etc.

2. Fill in the blanks in the cellular respiration equation.

___oxygen_____ + ___glucose_____ → __carbon dioxide___ + _water_____

Reactants Products

3. **The table below shows names of molecules released during cell metabolism. Draw hypothetical shapes and nerve signal patterns for each one.**

Metabolite Molecule Name	Hypothesized Shape	Hypothesized Nerve Signal Pattern
Acetone	**Answers will vary**	**Answers will vary**
Isoprene		
Hexanol		
Heptanol		

Lab Procedure: Materials

Arduino
wires
sensor
breadboard
resistors
LED light module
control solution
healthy lung cells
healthy throat cells
cancerous lung cells
cancerous throat cells
distilled water

Lab Procedure: Building the Artificial Brain

1. Use the schematics below to set up the artificial locust brain.

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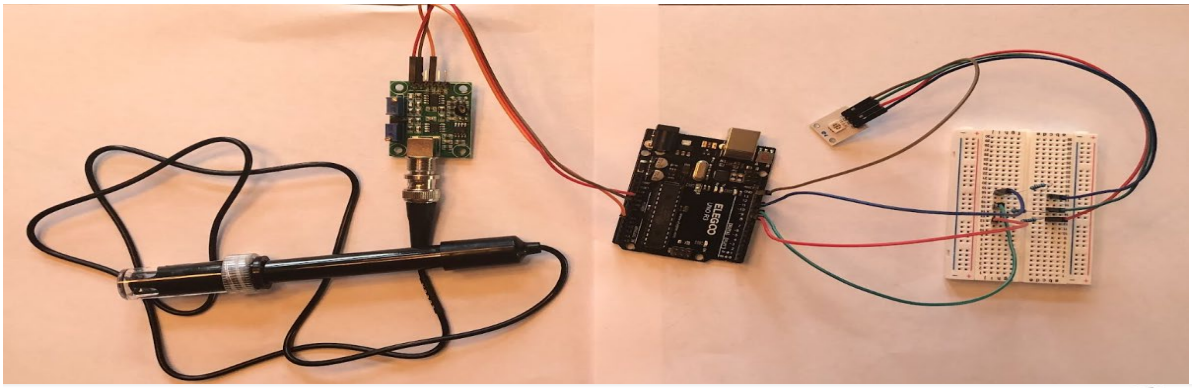

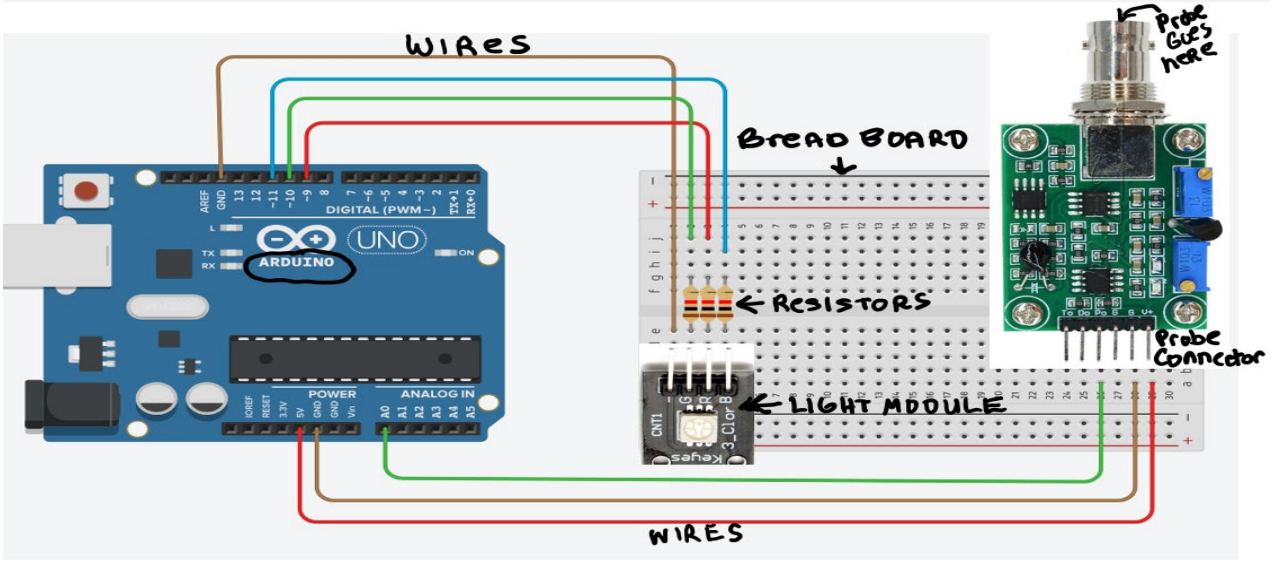

2. Go to https://support.arduino.cc/hc/en-us/articles/360019833020-Download-and-install-Arduino-IDE and download the Arduino website software.
3. Copy/paste code from Smelling Cancer Arduino Code Document (in Google Classroom) into the IDE-> Select Save. When the Arduino is connected to the computer, the code will automatically upload to it.
4. Locate the part of the code that is **bolded**. This line is the algorithm that calibrates the sensor correctly.
5. Attach the Arduino to the computer with the blue cord and upload the code.
6. Calibrate sensor: submerge the sensor in the control solution, select _____, & wait until a stable number shows.
7. Change/edit code in the bolded part by typing in the digit that needs to be added to the control solution measurement to make it total 7 (e.g., if the sensor measures 3, place a “+4” in the code).

Lab Procedure: Testing

1. Clean the sensor by dipping it into the distilled water cup.
2. Dip the sensor into the control solution. Use a ruler to determine the depth at which the sensor will give the correct reading, which should be the value you obtained in the calibration step. Record this information in Data Table 1 and in the Control Row of Data Table 2.
3. Clean the sensor by dipping it into the distilled water cup.
4. Test each solution once, record results, and be sure to clean the sensor with distilled water in between tests.
5. Repeat with known sample.

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6. Go to the class lab table and select 2 unknown samples. Repeat the procedure with these.

Data Table 1: Sensor Calibration & Optimal Depth

Change in Code for Control Value	Minimum Sensor Depth (mm)	Maximum Sensor Depth (mm)	Optimal Depth Range
Answer should be the difference between 7 and the raw calibration reading			

Data Table 2: Neural Response to Odors Released by Solutions

Solution Type	Trial 1 Results # measurement Lighting response	Trial 2 Results # measurement Lighting response	Other Comments
Control - No Cells, Neutral Solution	pH between 6.8-7.2; green		
Healthy Lung Cells	pH over 7.2; yellow		
Healthy Throat Cells	pH over 7.2; yellow		
Cancerous Lung Cells	pH under 6.8; red		
Cancerous Throat Cells 1	pH under 6.8; red		
Unknown Sample 1			
Unknown Sample 2			

Analysis:

Discuss with your lab partners: Does there seem to be a pattern of response for cancerous cells versus healthy cells? Write the main points of your discussion below. Yes, healthy solutions had a numerical measurement reading above 7.2 and caused a light to turn yellow. Cancerous solutions had a numerical measurement below 6.8 and cause a light to turn red.

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Design two graphs to represent the data—one to represent the numerical data, and another to represent the lighting signal data. Graph 1: X axis = names of solutions; Y axis number scale. Graph 2: X axis = names of solutions; Y axis color spectrum. Other options are possible, and a student could design a graph to show both things at once.

Write a Claim, Evidence, Reasoning (CER) for the question above. Can the artificial locust brain detect cancerous cells versus healthy cells? Claim: An artificial locust brain can detect cancerous cells versus healthy cells. The Arduino setup used to represent the locust brain produced numbers under 6.8 for cancerous cell solutions, and a red light appeared. For healthy cells, the setup measured produced numbers over 7.2, and a yellow light appeared. Because two different ranges of numbers and two different lights appeared for healthy versus cancerous cells, it is hypothesized that the artificial locust brain can differentiate between the two types of cell solutions.

Are the unknown samples cancerous or healthy? Support your answer with explained evidence.

Answers will vary based on which samples were tested and what the instructor has made them from.

Wrap-Up Questions

What would be the advantages of testing for cancer with breath contents or urine over blood or tissue tests?

Less invasive, maybe quicker, easier, perhaps a lesser amount could be detected so diagnosis would be earlier.

How do you think the probe works? Draw an idea below.

Answers will vary. The student could show little shapes entering or interacting with the probe and different signals being sent through it to the Arduino.

Explain why cancer cells and healthy cells create different odors. Include information about cell division, cellular respiration, metabolism, and molecular structure.

Cancer cells are actively multiplying at a greater rate than healthy cells. This means that the need for energy is greater, and cellular respiration must be increased due to the building and breaking down of more and possibly different materials. This difference in metabolism causes different compounds to be released, and some might be volatile, causing an odor difference.