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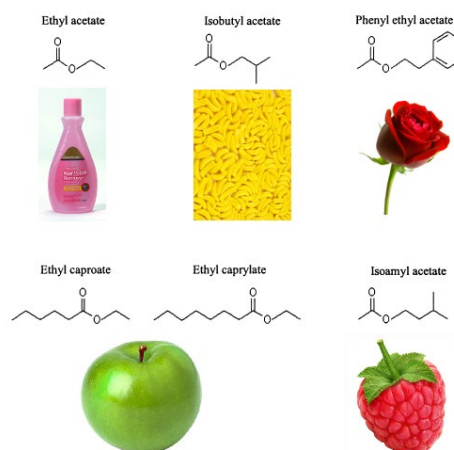
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## Smelling Cancer Cells Worksheet

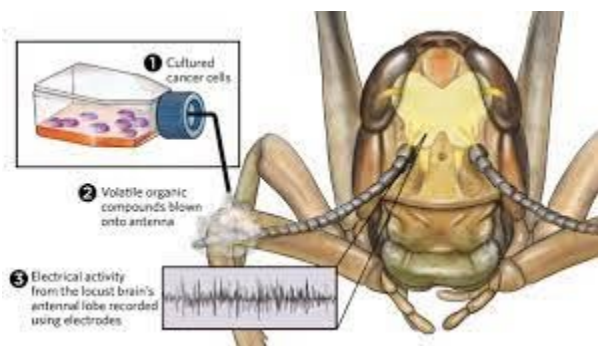
Cell division, also known as mitosis, and cellular respiration are closely linked. Cells going through division require more energy than cells that are in interphase. Dividing cells build, use, and move many materials to successfully split into two daughter cells. Cancer cells undergo rapid and abnormal 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.

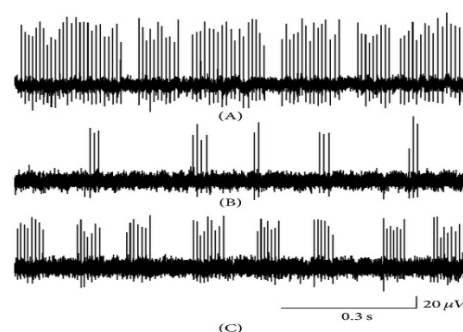
Can insect brains, specifically locust antennae, be used to detect cancerous cells versus healthy cells? If so, could we design an artificial locust brain that would allow us to detect cancer based on someone's breath? Researchers sought to answer this question with a setup like the one below. In this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



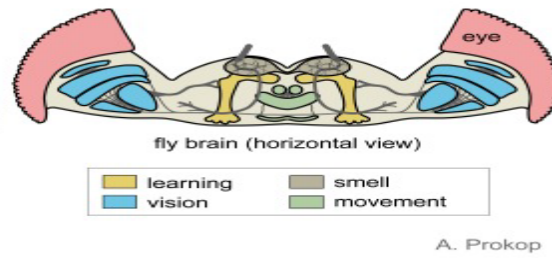
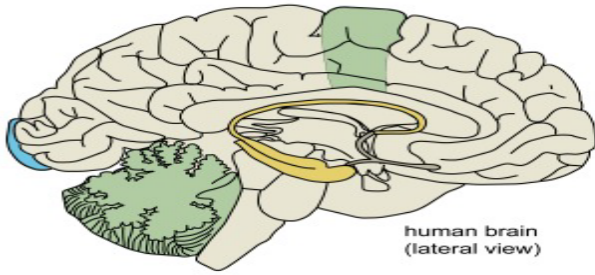
### Pre-Lab Questions

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

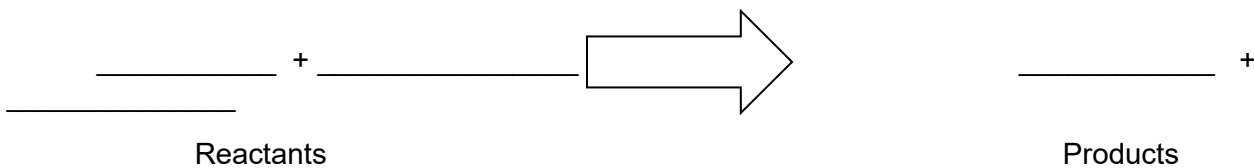
Name:

Date:

Class:



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



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		
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

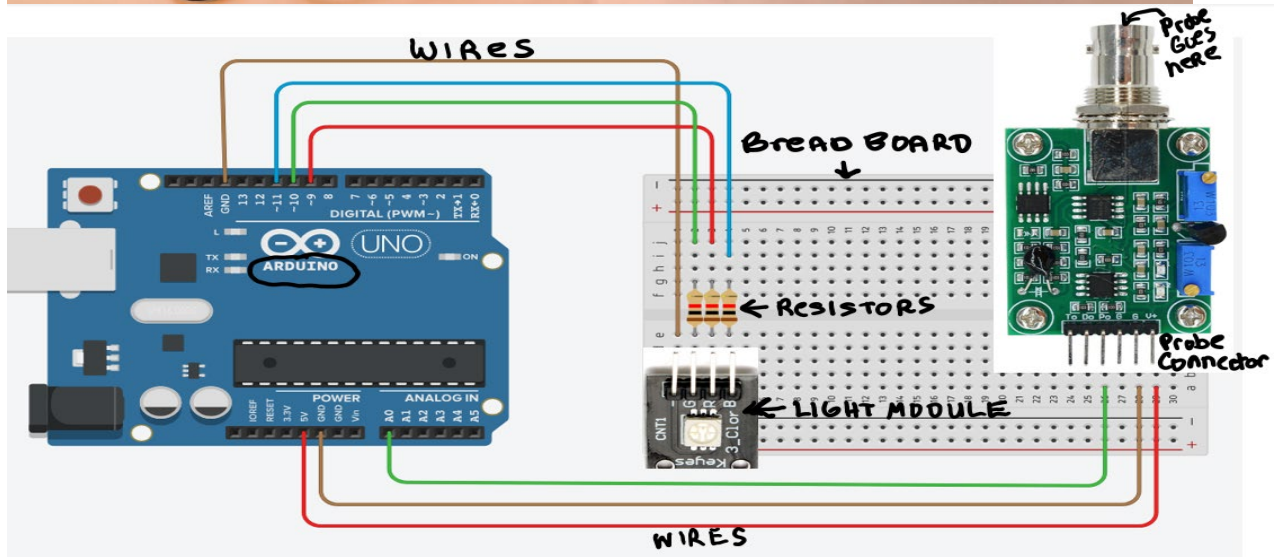
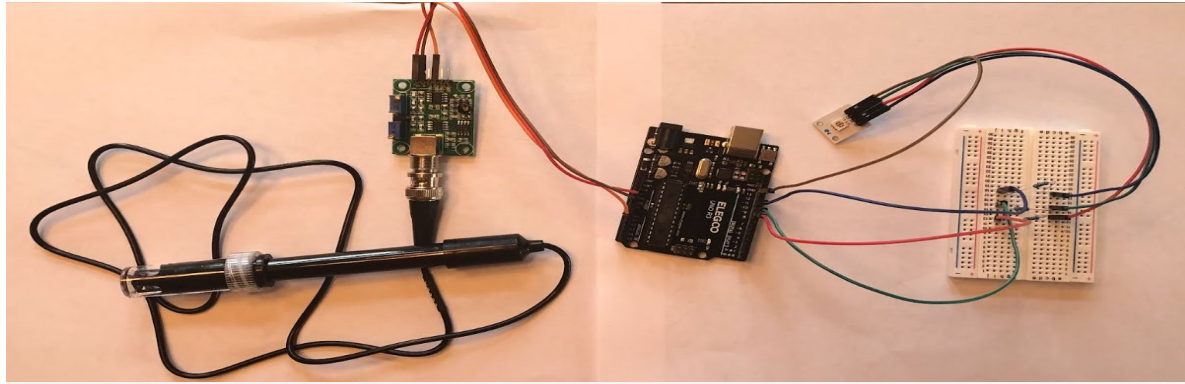
**Lab Procedure: Building the Artificial Brain**

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

Name:

Date:

Class:



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

Name:

Date:

Class:

**Data Table 1: Sensor Calibration & Optimal Depth**

Change in Code for Control Value	Minimum Sensor Depth (mm)	Maximum Sensor Depth (mm)	Optimal Depth Range

**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			
Healthy Lung Cells			
Healthy Throat Cells			
Cancerous Lung Cells			
Cancerous Throat Cells 1			
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.

Name:

Date:

Class:

Design two graphs to represent the data—one to represent the numerical data, and another to represent the lighting signal data.

Write a Claim, Evidence, Reasoning (CER) for the question above. Can the artificial locust brain detect cancerous cells versus healthy cells?

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

### Wrap-Up Questions

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

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

Name:

Date:

Class:

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