Cellular Respiration

AP Biology

Cellular respiration refers to the process of converting the chemical energy of organic molecules into a form useable by cells of organisms. Commonly, it is glucose that is oxidized in the reaction. If the reaction occurs in the absence of oxygen, an **anaerobic** process, glucose is only partially oxidized and some potential energy remains in the products. If oxygen is available for **aerobic** respiration, glucose is completely oxidized and the oxygen reduced, forming water. The energy unlocked from the glucose is used to convert ADP into ATP. All eukaryotic kingdoms, including fungi, plants, and animals, oxidize glucose for energy.

Yeast are fungi, species of which are used to make bread and root beer. These heterotrophs are **facultative anaerobes**; that is, they can respire both aerobically and anaerobically. When O2 is absent, yeast metabolize glucose via **fermentation**, producing alcohol.

Seeds store embryo plants until the conditions are right for **germination** and growth. Plant embryos respire using starch stored in the seed; once the embryo sprouts, photosynthesis begins. At germination, the stored starch (**amylose**) is metabolized into glucose, and cellular respiration transforms the glucose to ATP to use as fuel for growth. Once sprouted, plants perform photosynthesis, consuming CO2 during the daylight hours, and making the sugars they – and mot other multicellular life - will use for generating ATP via respiration.

**Ectothermic** animals, such as reptiles and insects, use heat from their surroundings to increase their internal temperature. Once warmed, these animals can metabolize food quickly via respiration and increase their activity rate correspondingly.

1. **Introductory Investigation:**

***Th****e CO2 produced by yeast can be detected using the indicator bromthymol blue. When combined with water, carbon dioxide creates carbonic acid, lowering the pH of the solution. This pH change is indicated by bromthymol blue; with no CO2 the solution is basic and appears blue; higher CO2 content turns the solution acidic, changing to yellow.*

***Wear Goggles***

1. Fill a test tube with water; pour into a beaker. Addbromthymol blue solution to color the beaker. Add NaOH by the drop to bring the color to a true blue. Pour into each of two test tubes. Set aside.

2. Heat a flask with 100mL water to 40 C. Remove; set on cardboard to insulate. Stir in

2g yeast and 2.5g sugar. Swirl to mix.

3. Immediately stopper the flask. Direct the tubing from the flask into the test

tube. Look for indications the yeast are respiring.

*Discuss ways to quantify the amount of respiration.*

1. **Inquiry investigation**

Respiration can be quantified by measuring both O2 and CO2 changes in the environment.

For this part of the lab, you will use a Vernier gas sensor to measure the concentration of either (or both) in a closed chamber.

Design and run an experiment(s) to investigate the respiration of seeds, plants, crickets, isopods or yeast using the LabQuest sensors. Variables to consider include temperature, germination, size, amount, light, fuel source.

***Take care when using the LabQuest. Use only as directed. Never get the probes wet.***

**C. EXTENSION**

*Root beer – respiration at it’s tastiest!*

Materials: 2 500mL water bottles

112g sugar

4mL root beer extract

0.2g champagne yeast

1. Pour ¼ of each water bottle (125mL) into the pan. Pour from each to leave just over half in each bottle. Set aside.
2. Add the sugar; heat, stirring, until dissolved. Stir in the extract.
3. Cool to 38-43C
4. Add yeast, stirring to fully dissolve. Wait at least 5 minutes to proof yeast.
5. Divide equally to refill bottles. Leave a little space in each.
6. Cap tightly and tape shut. Lay on side 3-4 days at room temperature, then move to a cool dark spot. Total aging takes about a week. Do not over age – pressure might blow the cap off, or you might produce some alcohol.
7. Yeast will settle to the bottom. Pour carefully so as to not taste the yeast!

Does temperature influence the rate of respiration of germinating seeds? We can measure the rate with a set of respirometers. A respirometer is assembled as below:

Absorbent cotton saturated

with15% KOH peas , beans or a combo

pipette tip

Snapshot 2011-01-23#E9C01B

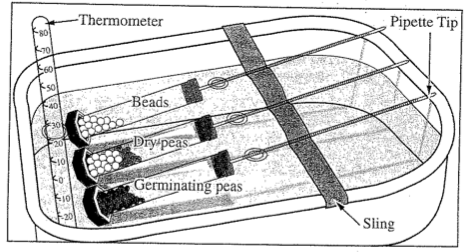
non-absorbent cotton

Each respirometer has at its base cotton soaked in potassium hydroxide (KOH). The KOH reacts with CO2 gas to make a solid, potassium carbonate (K2CO3). Thus, changes in O2 alone will affect the air pressure in the system. As the O2 is consumed, water will seep into the pipette. The changes in air volume of the pipette will indicate the amount of respiration the seeds are undergoing. The control trial is at room temperature; the experimental is at 10C.

One respirometer contains germinated seeds. The second has the same number of dry seeds plus beads in a volume equal to that of the experimental trial. The third is all beads in a volume equal to that of the germinating seeds.

***Cautions: KOH is a base; do not get it on your skin. Wash immediately and tell the teacher if you do. Keep the inside of each respirometer free of both water and KOH.***

Fill the water bath and make a sling of tape to rest the pipettes on while the system equilibrates (equalizes), as below. Equilibrate for at least 5 minutes.



Add a drop of food dye to the tip of each pipette and submerge them. Arrange them so you will be able to read the pipette. Equilibrate another 2 minutes. Record the initial gas/water level in each pipette. Do not disturb the respirometers during the trial. Record the changes in the air volume in each respirometer every 5 minutes.

Trial temperature\_\_\_\_\_\_\_\_\_\_ Pea variety\_\_\_\_\_\_\_\_\_\_\_\_ Germinating time\_\_\_\_\_\_\_\_\_

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Time  Min | Beads Alone | | | Germinated Peas | | | | | Dry peas and beads | | | |
| Reading | Total  Difference | Reading | | | Total  Difference | | Adjusted  Total  difference | Reading | Total  Difference | | Adjusted  Total difference |
| Initial  0 |  |  |  | |  | |  | |  |  |  | |
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| 25 |  |  |  | |  | |  | |  |  |  | |
| 30 |  |  |  | |  | |  | |  |  |  | |

Discussion Questions:

1. What kinds of organisms undergo cellular respiration? Which organisms specifically in these two labs?
2. What type of respiration occurred in both trials? Justify.
3. Explain how CO2, despite being a colorless, odorless gas, can be detected.
4. Why is sugar used in trial A? Is it necessary? Explain.
5. In lab B, you investigated two different independent variables – explain.
6. Why did water move into the pipette?
7. Why is it necessary to correct the readings from the peas with the beads trial? What might account for any change in this respirometer?
8. Explain the effect of germination on respiration.
9. What is the purpose of KOH in this experiment?
10. Infer the results of a similar respiration study using insects instead of peas.
11. Predict the results of an experiment on peas germinated for different lengths of time.

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| Time  Min | Beads Alone | | | Germinated Peas | | | | | Dry peas and beads | | | |
| Reading | Total  Difference | Reading | | | Total  Difference | | Adjusted  Total  difference | Reading | Total  Difference | | Adjusted  Total difference |
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Trial temperature\_\_\_\_\_\_\_\_\_\_ Pea variety\_\_\_\_\_\_\_\_\_\_\_\_ Germinating time\_\_\_\_\_\_\_\_\_

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| Time  Min | Beads Alone | | | Germinated Peas | | | | | Dry peas and beads | | | |
| Reading | Total  Difference | Reading | | | Total  Difference | | Adjusted  Total  difference | Reading | Total  Difference | | Adjusted  Total difference |
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