**? Question**

1. Which is the high energy form – ADP or ATP?

ATP

2. Define aerobic respiration.

Its when organism use Oxygen to turn fuel into chemical energy.

3. Where in our body does anaerobic respiration occur?

It occurs primarily in muscle cells during exercise.

4. What substance builds up when we shift to anaerobic respiration?

The substance that builds up is lactic acid.

5. Some of the cells of your body have many mitochondria and other cells have few mitochondria. Why would there be differences?

There is different amounts of mitochondria because they need more or less energy.

6. Complete the following table comparing aerobic and anaerobic respiration.

**Table 8.1. Comparison of Aerobic and Anaerobic Respiration.**

| Comparison | Aerobic | Anaerobic |
|---|---|---|
| **Is oxygen necessary?** | Yes | NO |
| **Which came first on the planet?** | 2 | 1 |
| **What are the end products?** | $Co^2$ and $H^{20}$ | Lactic acid |
| **How much ATP energy is generated?** | 38 ATP / 36 net | 4 ATP / 2 net |
| **Where in the cell does it happen?** | Mitochondria | cytoplasm |

Mouse in a sealed jar with enough air but no food. ⟶ **Experimental Results:** Mouse loses weight. Mouse produces water. Air gets heavier.

The chemists soon learned that:

- Mouse Tissue can be represented by the formula for sugar - $C_6H_{12}O_6$.
- Light Air is oxygen - $O_2$.
- Water is $H_2O$.
- Heavy Air is carbon dioxide – $CO_2$.

The general equation for the metabolic process became:

Mouse Tissue + Light Air ⟶ Water + Heavy Air

**? Question**

1. Write the molecular formulas below the words in the general equation (above) for metabolism.

C6H12O6 + O2 + H2O + CO2

2. When radioactive isotopes of oxygen atoms are put into $O_2$ molecules and the mouse is allowed to metabolize in a chamber with that "labeled" oxygen, only the $H_2O$ produced by the mouse is radioactive. Based on that evidence, draw dotted lines to show where each atom on the left side of the equation goes to on the right side of the equation.

Mouse tissue + light air + water + Heavy Air

3. Where does the $CO_2$ that you breathe out specifically come from during metabolism? Draw dotted lines to show this.

It comes from the food we eat.

4. Where does the $O_2$ that you breathe in specifically go to during metabolism? Draw dotted line to show this.

It goes into your lungs a passes into your blood - stream,

The total metabolic rate is the product of BMR plus all daily activities. Physical activity can increase metabolism to 10X BMR. This is the dominant influence on metabolic rate. We will examine the details of metabolic rate during physical activities in another lab.

Important factors affecting BMR are shown in Figure 8.3. The effect of size on BMR is best described by surface area and not by weight. If a 100 lb person has a BMR of X, then the BMR of a 200 lb person won't be 2X. It will be X plus about 30% more. Smaller people metabolize faster per pound even though larger people eat more food. This can be somewhat frustrating for one of your larger clients to accept. They may naturally think that they need much more food than a smaller person. They don't.

Sex and age also impact BMR. The female is usually 5-10% lower than a same-size male, and BMR drops about 0.2% each year after the age of 2 or 3. Another determinant of BMR is the amount of thyroid hormone. This hormone directly influences the speed of carbohydrate and fat metabolism. Thyroid hormone can increase BMR to 2X normal, and it is part of the stress reaction. Another part of the stress reaction is the sympathetic nervous system which can increase BMR almost as much as thyroid hormone, but its effects last only an hour or two. Diet and environmental temperature have smaller effects on metabolic rate. The BMR can be increased 10-30% after eating. The stronger effect comes after meals that are higher in protein.

Finally, the influence of environmental temperature is significant, and we will study it next. Our metabolic rate increases in a cold environment in order to produce more heat for maintaining a normal constant body temperature.

**? Question**

1. Why would measuring the amount of heat given off by an organism be useful for estimating metabolic rate?

Because it raises the temp of the tissue to levels that enhance the rates biochemical reactions.

2. Why is the oxygen consumption method the usual way to estimate the metabolic rate? If the oxygen requirement of a resting person is known, then that value can be compared to the oxygen used during excercise.

3. Does a 200 lb person metabolize twice as much as a 100 lb person?

NO, it would be plus 39% more.

**? Question**

1. During cell respiration a mouse will consume $O_2$, and $CO_2$ will be produced in its place. If no $CO_2$ absorber had been used in your experiment, would you have seen a change in air volume?

Yes, you would see a change in air volume.

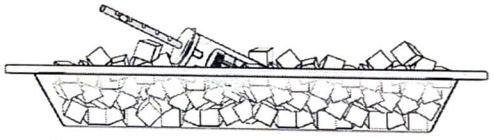
2. If you use a $CO_2$ absorbing substance in the Metabolic Chamber, then what happens to the $CO_2$ that is produced during cell respiration?

The $Co^2$ leaves the chamber.

3. Now, with the absorbing substance in the chamber, what happens to the air volume during your experiment as the $O_2$ is consumed during cell respiration?

The air volume decreases.

**Experimental Design - Packed In Ice**



**Procedure**

- If ice is packed around a Metabolic Chamber like the type we are using, the temperature inside will stabilize at 5°C. This cold temperature will not harm the mouse as long as it is removed before 45 minutes. Our experiment will take less than 20 minutes.
- Let the "Packed in Ice" chamber equalize temperature for 10 minutes before applying the "gushy" soap bubble. (The chamber should be sealed during this 10 minute period.)
- After the 10 minutes of temperature equilibrium, apply a "gushy" soap bubble and perform three separate measurements of metabolic rate. Record the results.

| Time for Mouse to Consume 5 ml of Oxygen | |
|---|---|
| Trial 1 | 4 min |
| Trial 2 | 2min |
| Trial 3 | 7min |

- Disassemble the chamber and carefully return your mouse to its home. Return the $CO_2$ absorber to its storage container, and dump feces into the special waste jar. Don't wash the apparatus unless you are told to do so. The chamber must be dry for the next lab class. Wash your hands!

## Calculations of Metabolic Rate

You must convert the mouse's $O_2$ consumption to an hourly metabolic rate. Calculations 1 and 2 will make that conversion. This is accomplished by dividing the bubble time (in seconds) into 3,600 (the number of seconds in one hour). The resulting number is to be multiplied by 5 (5 ml of $O_2$ used in each trial).

### Calculation 1

Calculate the average time of the three trials at room temperature.

5 ml $O_2$ consumed in __VR__ seconds. (Room Temperature - ≈20°C)

Calculate the average time of the three trials packed in ice.

5 ml $O_2$ consumed in __14__ seconds. (Packed in ice - ≈5°C)

### Calculation 2

Based on Calculation 1, how much $O_2$ would your mouse consume in one hour? (There are 3600 seconds in one hour.)

$$\frac{3600}{\text{Calculation 1}} \times 5 = \underline{167}\ \text{ml } O_2 \text{ consumed in one hour}$$

$O_2$ consumed in one hour at room temperature = __1.10__ ml.

$O_2$ consumed in one hour packed in ice = __1.67__ ml.

**Calculation 3**

In order for the metabolic rate of a mouse to be compared with a bigger or smaller animal, we must correct the calculations considering the mouse's weight. Use the following equation.

$$\frac{\text{Calculation 2}}{\text{Weight of Mouse}} = \underline{2.7}\ \text{ml } O_2 \text{ per hour per gram of weight}$$

Metabolic Rate of your mouse at room temperature (20°C) = 14 ml $O_2$ per hour per gram of weight

Metabolic Rate of your mouse packed in ice (5°C) = 11 ml $O_2$ per hour per gram of weight

***Time for graphing.***

- Put a dot on the graph in Figure 8.10 for each of the metabolic rate values in your experiment.
- Draw a line between those two dots.
- Write the word "endotherm" on that line.
- Check with other lab groups to see how your calculations compare with theirs.

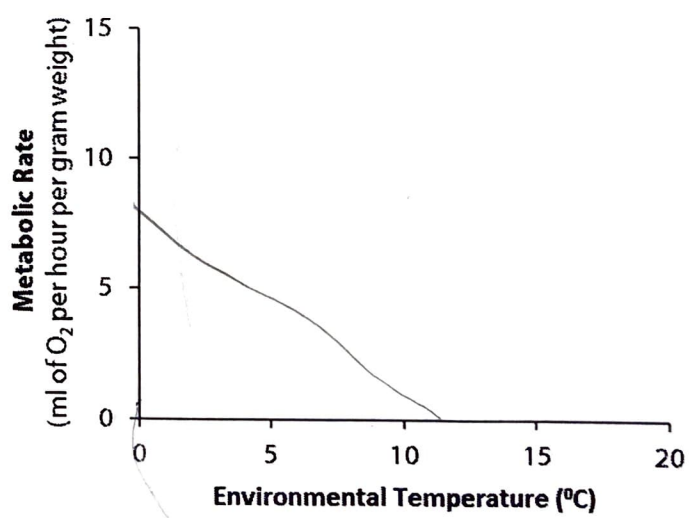



**Figure 8.10. Effects of environmental temperature on the metabolic rate of an endotherm (mouse).**

## Exercise #4
## Comparison of Endotherm and Ectotherm

*A frog in the cold is cold!*

An ***ectotherm*** (ecto means outside) gets its heat from the environment. The body temperature of an ectotherm is warm when the environment is warm, and the body is cooler when the environment is cold. The following results are taken from experiments that measured the metabolic rate of a frog (ectotherm) of about the same size as your mouse.

**Table 8.2. Measurement of the Metabolic Rate of a Frog at Different Environmental Temperatures.**

| | **Metabolic Rate** Packed in Ice (5°C) | **Metabolic Rate** Room Temperature (20°C) |
|---|---|---|
| **Frog #1** | 0.05 | 0.30 ml O2 / hour / gm |
| **Frog #2** | 0.03 | 0.28 |
| **Frog #3** | 0.04 | 0.25 |

**Procedure**

- Calculate the average metabolic rate for the three frogs at each of the two temperatures.
- Put a dot on the graph in Figure 8.11 for each of the average values.
- Draw a line between those two dots.
- Write the word ectotherm on the line.

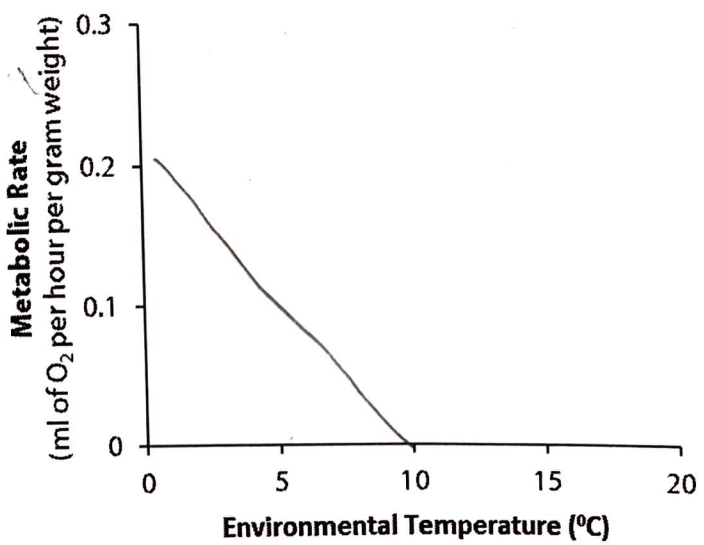



**Figure 8.11. Effects of environmental temperature on the metabolic rate of an ectotherm (frog).**

**? Question**

1. Which organism has the slower rate of respiration?
   endotherm or ectotherm

2. Which organism needs less food to survive?
   endotherm or ectotherm

3. How much food does the ectotherm need compared to the endotherm? Hint: Divide metabolic rates.

Endothermic because it eats 5% more.

4. Which organism would do better if the amount of food is very limited, but the environment is fairly warm?

The Ectotherms/Frogs would do better.

5. What kind of environment is described by question #4?

A tropical environment is being described.

6. Which organism would do better in a cooler environments where the food is plentiful?
   endotherm or ectotherm

7. Will the organism in question #6 do fine in warmer environments if the food is plentiful?

   Why or why not?

Yes because they have warm bodies and require a lot of food.

## Exercise #5
## Food Demand for Humans

***How much food does a student need to survive one hour of biology lab class?***

We can borrow data from experimental research to help us estimate the amount of food that is required to support a human. Our calculations will be based on grams of sugar as the nutrient. Also, notice that the word Calorie is capitalized. When capitalized, this term represents 1000 times the value of a single calorie (not capitalized).

The Caloric demand for food varies greatly for a human depending on activity and environmental conditions. The energy demand might be as slow as 50 Cal per hour during sleep to as fast as 2,000 Cal per hour during extreme exercise. (That high rate of metabolism could be maintained for only about 2 minutes without total exhaustion.) An average student in biology lab class uses about 100 Calories per hour if they aren't walking around.

### Information

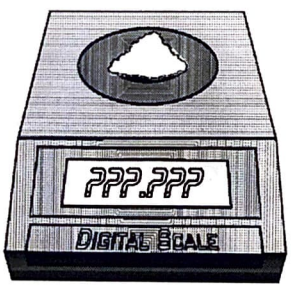
- Assume a food demand of 100 Cal/hour for students.
- A human gets about 4 Cal of energy from 1 gram of sugar.

### Procedure

- How many grams of sugar are required to "fuel" an average student during one hour of biology lab class?

  25 grams of sugar used in one hour

- Weigh out that much sugar and show it to your instructor.




***Use a weighing paper or tray for the sugar.***