Topic 4: Energetics – 4a. Combustion vs. Respiration

Resources: Campbell et al. *Biology: Exploring Life*. Prentice Hall, pp. 135-142.

Campbell et al. *Biology: Concepts and Connections.* Pearson, pp. 88-92.

Miller and Levine. *Biology*. Prentice Hall, pp. 221-232.

Building on: Cells need energy to live. Basic biochemistry including chemical reactions, bonding, enzymes and activation energy should have already been discussed. Also, cell parts and functions should have been taught so that you can refer back to the mitochondria as the "powerhouse of the cell."

Links to Chemistry: Chemical bonds
Chemical reactions
Organic chemistry

Links to Physics: Kinetic and potential energy
Pressure changes with temperature

Stories: It is often surprising to me in doing this lab the number of times that students will tell me that they do not know how to light a match; after all, mom always says "never play with matches!" So you may need to demonstrate this life skill (in the controlled, safe environment of the science laboratory). Also, students do not know what condensation is; answers will range from oxygen to carbon dioxide to "fog" (which they do not realize is water). They may need some help with this. The other concept that eludes many students is, "what is the fuel for the candle?" Many students believe that the wick is the fuel and the wax is simply there to hold the wick in place and that it "melts away" as the candle burns.

Lab Instructions and Materials for the Teacher:

This lab requires quite a bit of set-up and materials. Large finger bowls can be ordered from a science supply company. We obtained the large jars that we use from the cafeteria at our school; I think they were pickle jars. They should be large enough to fit over a candle without it burning out immediately. The lab can be modified and is still useful without the items in Part B.

- Large finger bowl
- Plastic Petri dish bottom
- Bromothymol blue solution
- 250 ml beaker
- Small test tube
- Test tube clamps
- 3 small candles
- Gallon jars
- Matches
- Straws
- Large test tube w/cork stopper
- Test tube racks

Combustion vs. Respiration

Purpose: "Mechanists" believed that it is possible to relate non-living systems to living ones.The laws that govern one must also apply to the other. In this lab, you will study the relationship between a burning candle (combustion) and cellular respiration. Think about the **reactants** and the **products** of both.

Materials:

Large finger bowl	3 small candles
Plastic Petri dish bottom	Gallon jar
Bromothymol blue solution	Matches
250 ml beaker	Straw
Small test tube	Large test tube w/cork stopper

Procedure and Questions:

A. Get a small candle and light it. Watch it burn for a *few* minutes, then answer these questions:

1. What two types of energy are released by the burning candle? 1. _____
2. Identify the fuel used by the candle to produce energy. 2. _____
3. Your body cells use sugar (glucose) as a fuel. What type of energy does your body release when you burn sugar? 3. _____
4. Matches play a role in this experiment that is similar to that of a catalyst. In living cells, what special protein plays a role of a catalyst? 4. _____
5. Place a beaker over the candle. What happens? 5. _____

B. Read questions 6-10 *before* starting this section!!! Get a large finger bowl and put about 1 inch of water in the bottom. By melting some wax on the Petri dish bottom, secure and float the lit candle on the surface of the water and carefully cover the gallon jar. *Do not sink the candle!!!*

6. Describe what happens. 6. _____

7. How long did it take for the one candle to burn out? 7. _____

8. Explain what happened to the water in the finger bowl? 8. _____

9. What substance in the jar allows the candle to burn? 9. _____

10. Repeat the process with two and then three candles. How long did it take for two candles to burn out? How long did it take for three candles to burn out? 10. _____

11. Compare the changes in water levels and burning times for one, two, and three candles. Formulate a hypothesis to explain these differences. 11. _____

12. What would happen to a mouse or a small boy placed inside the jar, instead of the candle? Explain. 12. _____

13. The candle and the mouse both require the same substance. What gas is in the jar that both the mouse and the candle need in order to burn a fuel and release energy? 13. _____

C. Wipe out the inside of a jar with a paper towel and place the jar on top of the lit candle once again. *This time do not use the finger bowl with water.* Place the candle on the lab table on the Petri dish cover.

14. What do you see forming on the inside of the jar? Maybe if you "feel it," you can identify. 14. _____

15. Take a test tube and exhale into it several times. What forms on the inside of the test tube? 15. _____

16. According to #14 and #15, the candle and you both produce the same end product as a result of releasing energy while burning a fuel. What is this end product? 16. _____

D. Light a candle. Using a test tube clamp, hold an empty, inverted test tube over the candle for several minutes. Immediately stopper the test tube.

Get about 3 ml of bromothymol blue and quickly pour it into the test tube. Be careful not to let much of the collected gas escape! Re-stopper the test tube and shake. Note any color change.

17. What color change occurred? 17. _____

18. Greenish yellow color indicates the presence of CO_2 gas. What gas is released by a burning candle? 18. _____

E. Get a fresh supply of bromothymol blue (3 ml) and put it in a small test tube. Using a straw, blow air into the bromo blue for about one minute *carefully*.

19. What does the above experiment demonstrate? 19. _____

20. Identify the gas that is released by both you and the candle in this "exercise." 20. _____

Conclusion:
The energy releasing reaction for a living system can be summarized as follows:

$$C_6H_{12}O_6 + O_2 \xrightarrow{\text{enzymes}} CO_2 + H_2O + ATP$$

21. Summarize the reaction for the candle by filling in all four spaces below:

Wax + _____ _____ _____ + _____ + _____

22. How is the burning candle similar to a living organism? There are several similarities; list five below:

_____

_____

_____

_____

_____