# Cellular Respiration

## Cellular Respiration Text, Diagrams, Assessments, and Link to Standards

**Focus Questions**

1) What is cellular respiration?
2) How is cellular respiration connected to breathing?
3) If you are an athlete that exercises extensively, what organelles might you expect to see more of in your cells?
4) How does eating food give our cells energy?

When we eat and digest food, it is broken down into smaller and smaller units until it becomes small enough to be used in our cells as **glucose molecules.** At the same time, we are breathing in **oxygen** that travels from our lungs through our bloodstream into small and smaller blood vessels until it reaches our cells. When the glucose and oxygen reaches our cells, we have the materials we need to perform **cellular respiration**. This process starts in the cells' **cytoplasm** and is completed in the **mitochondria** - the cellular powerhouse. In those tiny organelles, one molecule of glucose with 6 molecules of oxygen are changed into 36 molecules of **ATP** – the energy cells can use to get things done.

**Cellular respiration is going on in every cell in both animals and plants.**

### In Animals

1) Eat a sandwich and start digesting → 2) bread breaks down into **carbohydrate molecules** → 3) carbohydrate molecules break down into **glucose molecules** → 4) glucose molecules (plus oxygen from breathing) are converted in the cells to energy (ATP). Cellular respiration (a three stage process) converts glucose and oxygen to ATP (the cellular form of energy) and releases carbon dioxide and water. This is **cellular respiration**. The exact formula is:

$$C_6H_{12}O_6 \text{ (1 glucose molecule)} + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 36 \text{ ATP (ENERGY)}$$

carbohydrate + oxygen → carbon dioxide + water + ATP energy

**Note that:** 1 molecule of glucose plus 6 molecules of oxygen are changed into about 36 molecules of ATP (energy) plus 6 molecules of water and 6 molecules of carbon dioxide during cellular respiration.

### In Plants

1) **photosynthesis** creates glucose molecules (instead of eating) → 2) this fuels cellular respiration in the plant cells → 3) creates ATP → 4) fuels plant growth and reproduction → 5) provides carbohydrates to animals for ***their*** cellular respiration. The cycle continues. The formula in plants is:

$$6\ CO_2 + 6\ H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 \text{ (glucose)} + 6\ O_2$$

**For what do we use ATP?** ATP is the energy that cells use to do their work. This, in turn, helps the body run smoothly and do *its* work like: breathe, circulate blood, digest, respond to stimuli, create new cells, repair and grow, move our muscles, etc. Everything you do uses energy.

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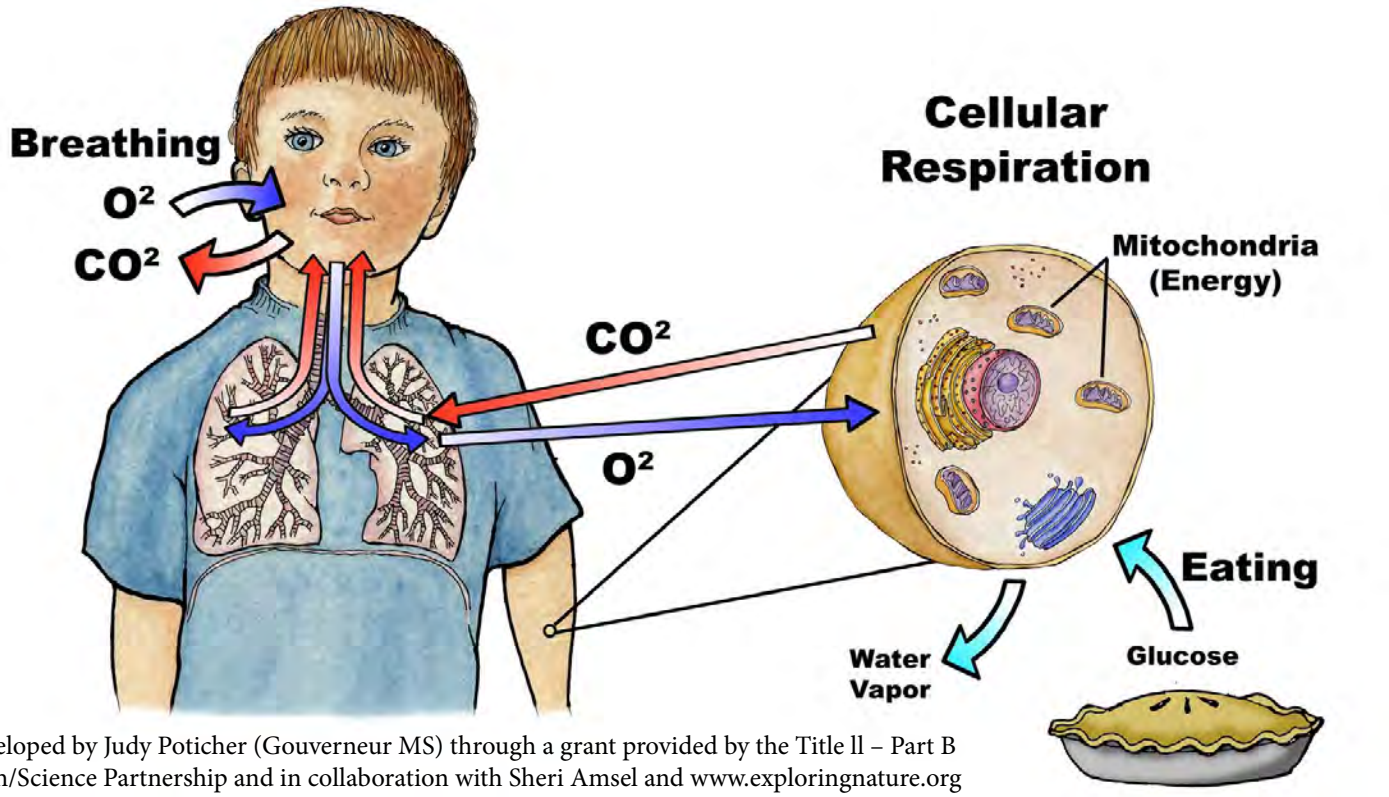
## Authentic Performance

You are a marathon runner and need extra energy for tomorrow's race. How would eating pasta (and pie) help your body produce the energy it needs? Be sure to describe what will happen when you are running the race (and breathing hard). Use the diagram below to help form your answer.




Developed by Judy Poticher (Gouverneur MS) through a grant provided by the Title ll – Part B Math/Science Partnership and in collaboration with Sheri Amsel and www.exploringnature.org

## More About Cellular Respiration

So now we know that cellular respiration is a three stage process that converts glucose and oxygen to ATP and releases carbon dioxide and water. **What are the 3 phases that do this?**

**1) Glycolysis**

**2) Krebs Cycle**

**3) The Electron Transport Chain (ETC)**

This is a very simple overview of these 3 stages:

**Glycolysis (Stage 1)**

Glycolysis is the process where 1 **glucose** molecule, in the cell's cytoplasm, is broken down (through several steps) into 2 molecules of **pyruvate**, which is then used in the **Kreb's Cycle** (stage 2). This break down also releases 2 ATP + 2 H2O + 2 NADH molecules.

**Krebs Cycle (Stage 2)**

To start the Krebs Cycle, pyruvate is pulled into the cell's **mitochondria** and converted to **Acetyl-CoA**. The Acetyl-CoA molecule is then converted (through several steps and two complete turns of the Kreb's Cycle) into 4 $CO_2$ molecules, 6 NADH molecules, 2 ATP molecules and 2 $FADH_2$ molecules.

**The Electron Transport Chain (ETC) (Stage 3)**

The final stage – the Electron Transport Chain (ETC) is found in the mitochondria (in animals) and in the chloroplasts (in plants) and releases 32-34 ATP molecules when the electron transport chain produces a concentration gradient through which hydrogen moves across the membrane releasing energy as ATP (produced via the proton motive force).

## Fermentation

As we saw, cellular respiration needs **oxygen** to progress. **What happens if there is no oxygen where an organism lives (anaerobic conditions)?** In that case, the organism can still create energy, but through the process of **fermentation. Fermentation** happens in the cells' cytoplasm (not in the mitochondria) and helps generate only 2 ATP molecules per glucose molecule (much less effective in generating energy than cellular respiration). **Fermentation uses the pyruvate molecules made by glycolysis from glucose**. The formula is:

$$C_6H_{12}O_6 \text{ (glucose)} \rightarrow CO_2 + 2\ C_2H_5OH \text{ (alcohol) and some energy}$$

In the making of wine and beer (alcohol), **yeast cells** generate ATP by the fermentation of the sugars in fruit and grain (in the absence of oxygen). Yeast can also release carbon dioxide in this process, which is what causes bread to rise.

In animals, the lack of oxygen will drive muscle cells to carry on ***lactate fermentation*** which creates lactic acid causing sore and cramping muscles. This happens when you get so much exercise, say on a very long hike or run, that your body runs low on oxygen for cellular respiration.

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# Understanding Cellular Respiration

Here are **three visual depictions of cellular respiration** – an equation, an output description and an illustration.

**1) Equation:**

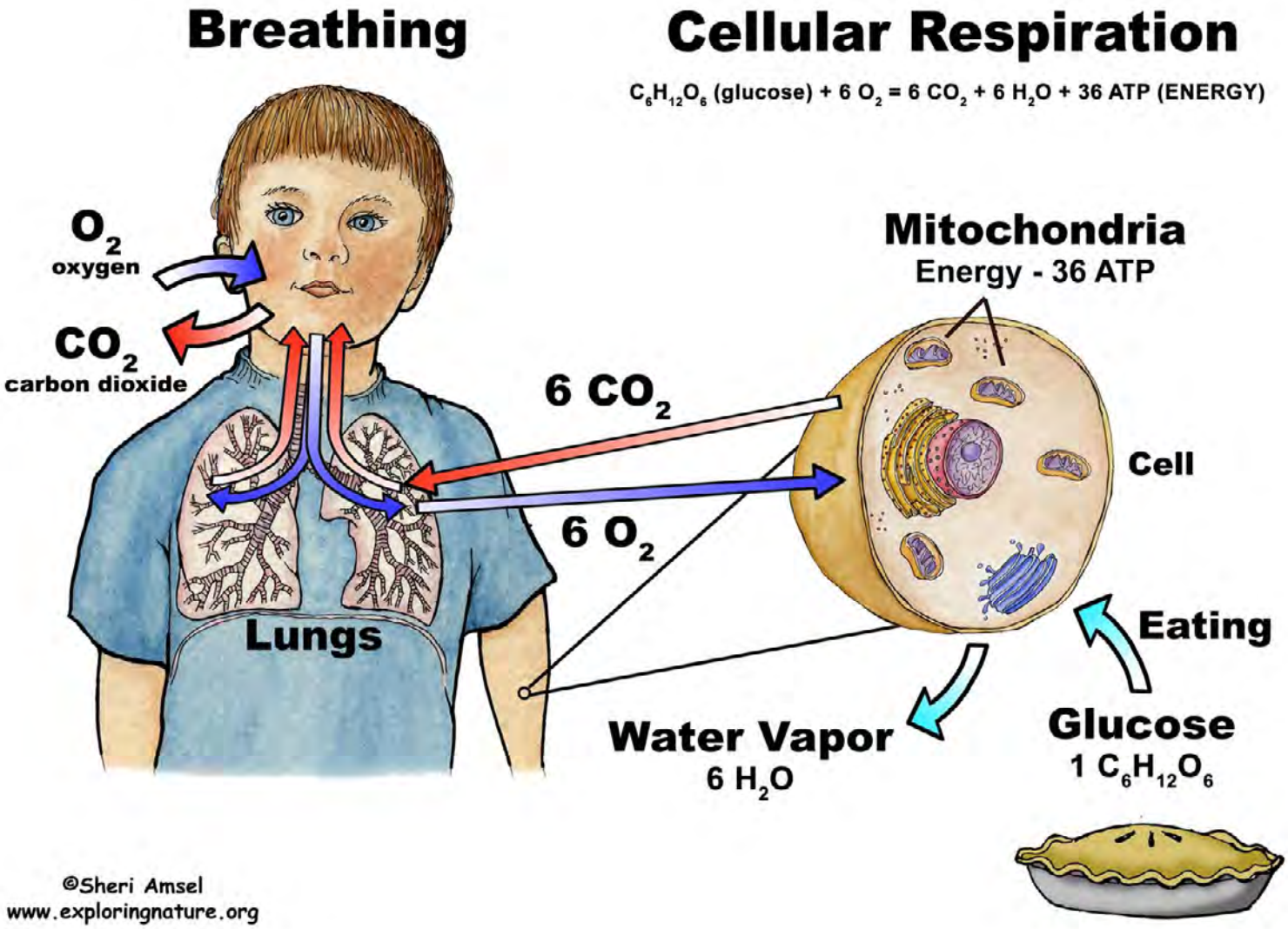
$C_6H_{12}O_6$ (1 glucose molecule) + 6 $O_2$ = 6 $CO_2$ + 6 $H_2O$ + 36 ATP (ENERGY)

**carbohydrate + oxygen = carbon dioxide + water + ATP energy**

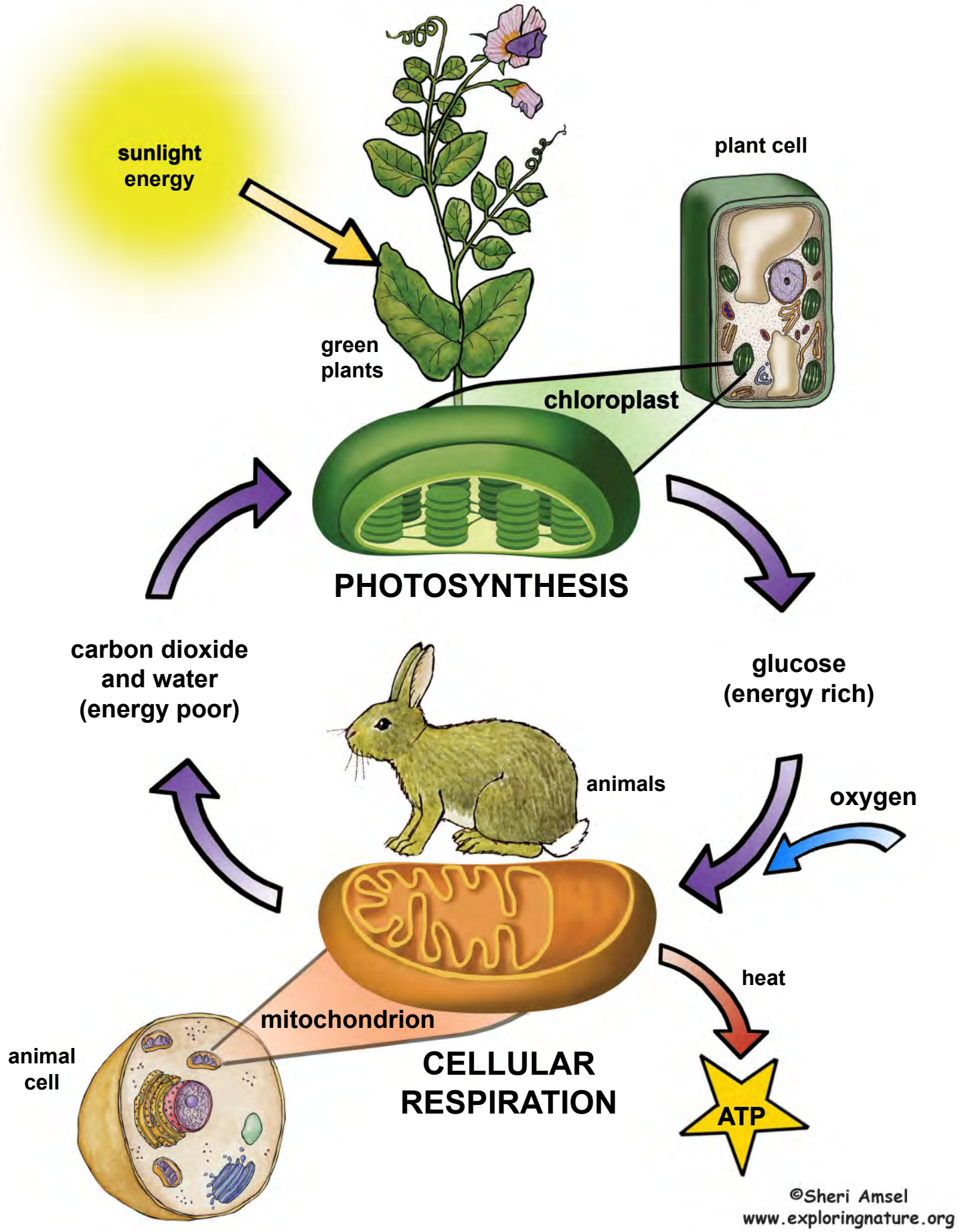
**2) Description of the molecules created in all three stages of cellular respiration:**

| 1 glucose → | Glycolysis → | Acetyl-CoA → | Krebs Cycle |
|---|---|---|---|
| | 2 pyruvate | 2 Acetyl-CoA | 4 $CO_2$ |
| | 2 ATP | 2 $CO_2$ | 2 ATP |
| | 2NADH | 2NADH | 6NADH |
| | | | 2$FADH_2$ |

**3) Illustration:**



# Photosynthesis and Cellular Respiration

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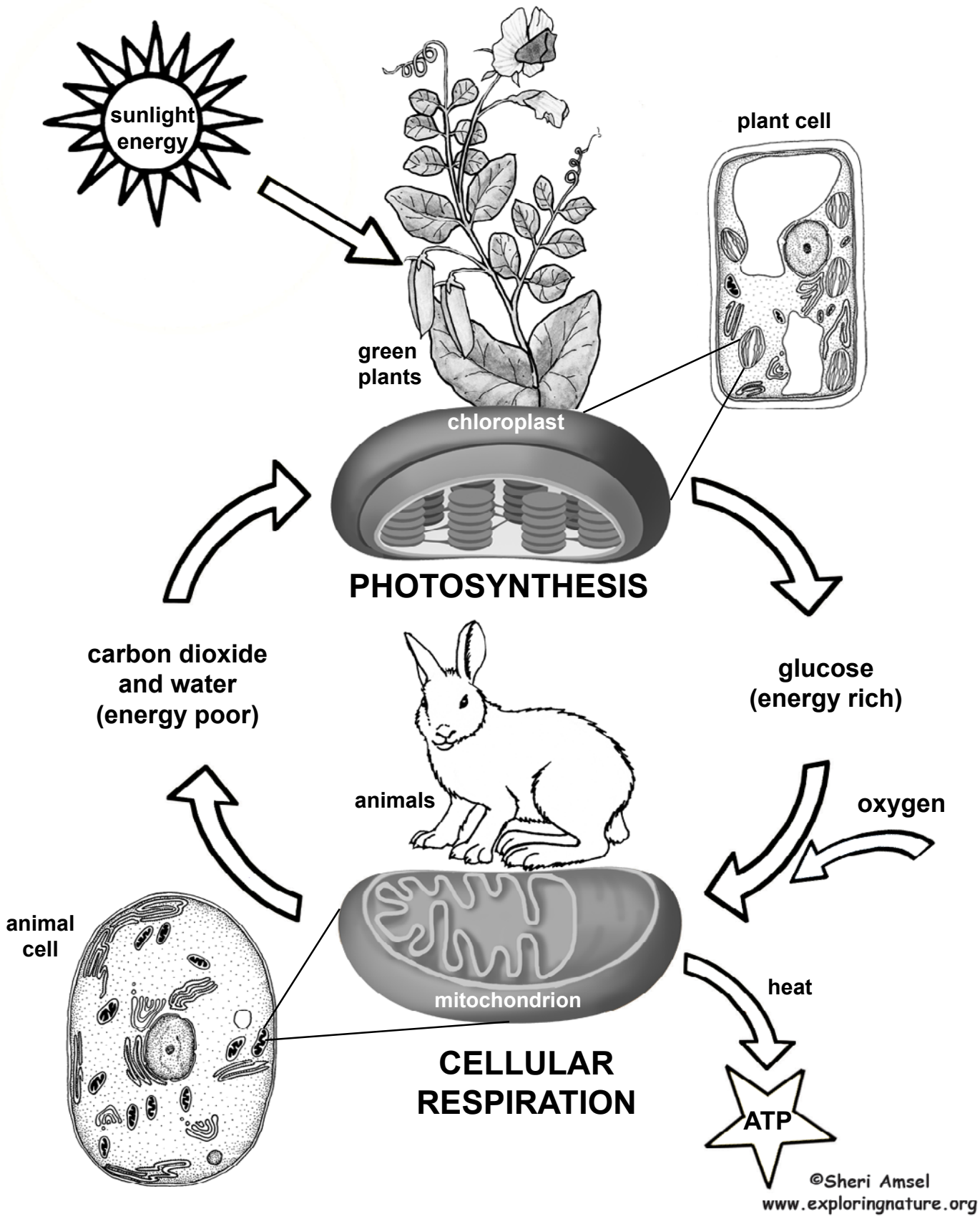
# Photosynthesis and Cellular Respiration

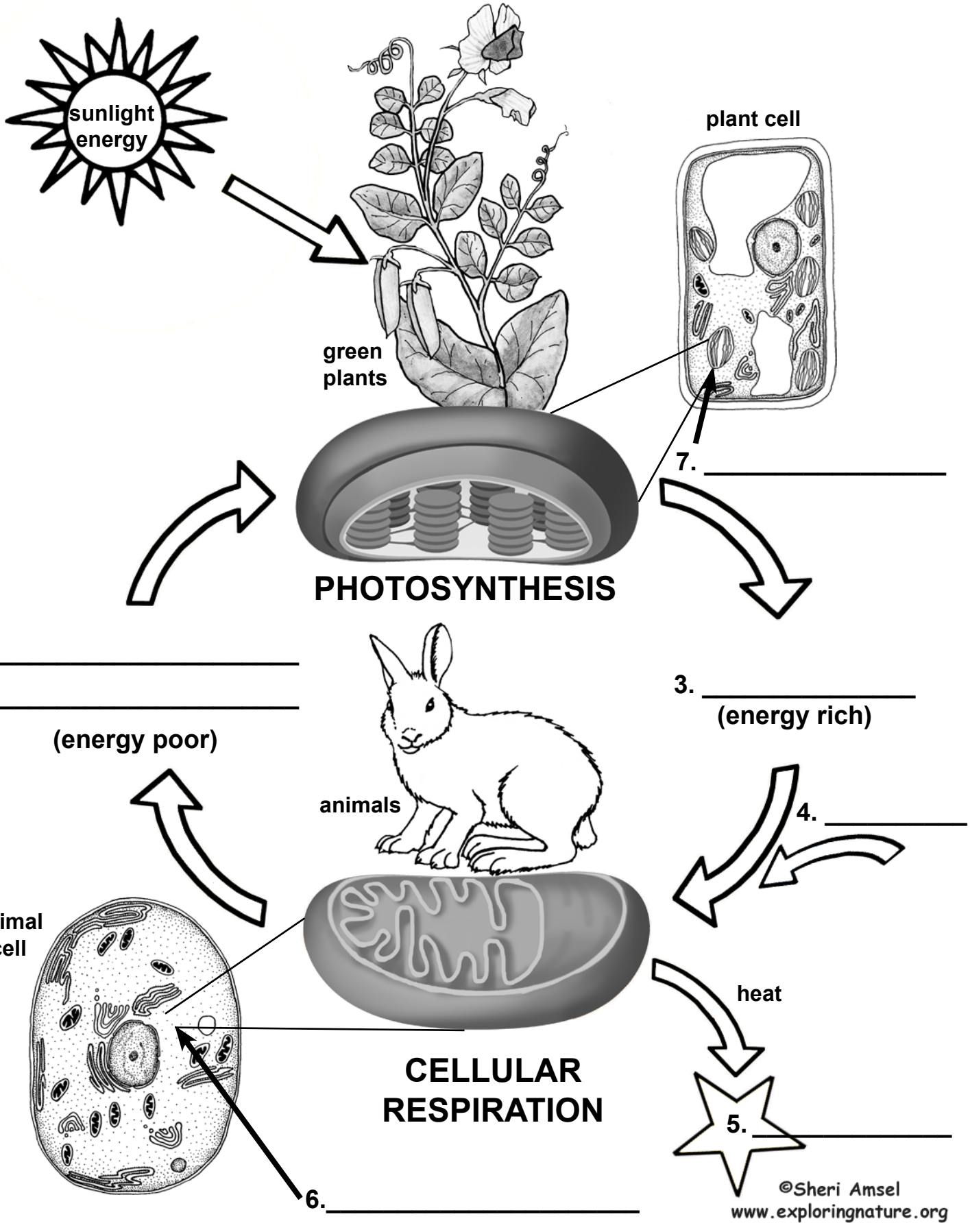
P**hotosynthesis** creates glucose molecules (instead of eating) → this fuels cellular respiration in the plant cells → which creates ATP → which fuels plant growth and reproduction → which provides carbohydrates to animals for ***their*** cellular respiration. The energy cycle continues. The formula in plants is:

$$6\ CO_2 + 6\ H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6\ (\text{glucose}) + 6\ O_2$$



# Photosynthesis and Cellular Respiration Quiz

## Fill in the Blanks



# Cellular Respiration

Name: _____ Date: _____ Class: _____

**1**

The kind of molecule used to drive cellular respiration is:

**A** amino acid
**B** glucose
**C** fatty acid
**D** protein

**2**

The organelle where cellular respiration takes place is the:

**A** nucleus
**B** endoplasmic reticulum
**C** ribosome
**D** mitochondria

**3**

In addition to glucose the cell needs ___ to drive cellular respiration:

**A** oxygen
**B** carbon dioxide
**C** water
**D** hydrogen

**4**

The three phases of cellular respiration include all of the following except:

**A** Glycolysis
**B** Photosynthesis
**C** Kreb's Cycle
**D** The Electron Transport Chain

**5**

Which formula for cellular respiration is correct?

**A** 1 glucose + 6 $O_2$ = 6 $CO_2$ + 6 $H_2O$ + 1 ATP
**B** 1 glucose + 1 $O_2$ = 1 $CO_2$ + 1 $H_2O$ + 36 ATP
**C** 1 glucose + 6 $O_2$ = 6 $CO_2$ + 6 $H_2O$ + 36 ATP
**D** 1 glucose = 6 $CO_2$ + 6 $H_2O$ + 36 ATP

**6**

Another process of making ATP <u>without oxygen</u> is called:

**A** fermentation
**B** breathing
**C** glycolysis
**D** eating

**7**

Cellular respiration is how we:

**A** breath in $O_2$ and exhale $CO_2$
**B** break down ATP into $O_2$
**C** break down glucose (and $O_2$) into ATP
**D** do photosynthesis

**8**

How much ATP is created through cellular respiration with 1 molecule of glucose?

**A** 1 ATP
**B** 100 ATP
**C** 36 ATP
**D** 0 ATP

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# Cellular Respiration Assessments KEY

**Cellular Respiration and Photosynthesis Quiz Key**

1. carbon dioxide
2. water
3. glucose
4. oxygen
5. ATP
6. mitochondiron
7. chloroplast

**Cellular Respiration Multiple Choice Key**

1. B
2. D
3. A
4. B
5. C
6. A
7. C
8. C