Category IV Life Science Examples

Providing practice

Food, Energy, and Growth
The material provides familiar tasks for students to practice using all the key ideas, and, in most cases, the tasks involve novel contexts. Students use:

- the idea that food provides building material to explain (a) why people need to eat (p. **44s**), (b) what happens to a muscle when it grows, (c) how food helps a teenager get taller, (d) how food helps a lizard regenerate a tail that gets torn off, and (e) how food helps a plant increase its size (p. **48s**);
- the ideas that food provides fuel and that animals get energy from oxidizing their food to explain (a) why people get tired when they exercise (p. **43s**) and (b) why they need to eat (p. **44s**);
- the idea that for the body to use food for energy and building materials, the food must first be digested into molecules that are absorbed and transported to cells to (a) show the path digested food takes to get to a cell in a leg muscle or in the brain and (b) write a story describing what happens to a piece of food after it is eaten (p. **34s**);
- all of the ideas mentioned above, along with the idea that matter is conserved, to explain (a) long-term weight gain, (b) how weight gain can be controlled, and (c) why sugar results in weight gain if it is stored as fat, but not if it is used in cellular respiration and to suggest what kind of diet would be good for various situations (p. **51s**).

Students also consider what wouldn't happen if they didn't get either enough protein or enough carbohydrates in their diets (p. **57s** and subsequent lessons).

However, tasks do not consistently increase in complexity, and feedback is not provided for initial tasks and then gradually decreased with subsequent ones.

If you said you get tired when you exercise because you run out of food in your body, that would be a good guess, but most people have extra food—energy-rich fat—stored in their bodies just in case their glucose gets used up. (This is one way that exercise helps people lose weight, by using extra fat.)

What happens if your breathing can't keep up with your exercise?

But your body can't store extra oxygen. You get whatever you need by breathing. When you exercise, do you need more oxygen? Well, if your muscles need more energy to move fast during exercise, then you'll need more oxygen to release that energy from glucose. But if your muscle cells need energy faster than oxygen can be supplied to the cells by breathing, what happens?

Your muscle cells can't use glucose the same way if they don't have 6 oxygen molecules for every glucose molecule. Instead, a different chemical reaction takes place, one that releases *much* less energy than the cellular respiration reaction with 6 oxygen molecules does. And this different chemical reaction also produces an additional by-product (just like when a candle is short of oxygen, it can produce more smoke.) Because this by-product is produced faster than your blood can carry it away, it begins to build up in your muscles, causing pain and fatigue. That's why your muscles ache and you get cramps!

Some forms of exercise automatically rest your muscles after each time you use them. Cross-country skiing is one example. During the normal motion of push-glide, you use your muscles when you push. During this time, your cells release and use energy. Then you rest the muscles while you glide. This allows your body to continue to supply enough oxygen for the amount of energy required. Normal cross-country skiing along flat ground is good exercise for your heart, but doesn't necessarily wear you out!

Think, write, and discuss

5. Please explain in your own words why you need to eat. Don't forget to talk about cells in your explanation.
6. What happens to the air you breathe in?
7. Where does the carbon dioxide in your exhaled breath come from?

On to the next lesson...

Other "real-world" contexts of respiration include yeast in bread-making (as yeast consumes the sugar in the dough, its cellular respiration produces carbon dioxide, making bubbles that make the dough rise) and fermentation.

The by-product is lactic acid, which changes the pH in the muscles and keeps the muscle fibers from relaxing after they contract.

5. Answers will vary but the following key points should be included:

- food supplies the substances needed by the cells for making new materials and for producing energy. (Be sure students include both uses.)
- glucose and oxygen are chemically changed in cells into carbon dioxide and water vapor, releasing energy.
- the process is called cellular respiration.

6. The oxygen from the air you breathe is carried to cells where it is used to release the energy from glucose.

7. It comes from all the cells of the body. It is produced by the cells when glucose and oxygen react chemically to form carbon dioxide and water, releasing energy.

Lesson 11

processes, and we hope that the knowlegde students construct as they search for answers to these questions will be retained by more students into their futures.

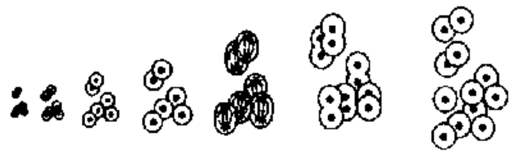
Students' conception of respiration: If students have heard the word "respiration" before, they generally think of it only as breathing. This is where the common confusion about oxygen turning into carbon dioxide in the lungs comes from. With this naive view of respiration, they miss the essential connection between oxygen and *food*, and that a chemical reaction is needed for the production of carbon dioxide.

20!/2 =

G. How many different proteins could be made from various combinations of the 20 amino acids? Could you use a calculator to make some kind of approximation? Try it!

Actually, scientists have analyzed many different proteins to find out which amino acid building blocks they are made of. They have found that protein molecules consists of anywhere from 50 to more than 10,000 amino acid molecules, where each amino acid can be used more than once—in fact, they can be used numerous times. Think that gives nature enough combinations to play with?

All of the proteins that make up our body parts are made by our cells—tiny little factories using amino acids from digested food as raw materials. When you grow, your cells make new proteins, and add them to their own internal structures. As the cell gets larger, it divides and forms new cells. More and more cells are added to your muscles (skin, blood, etc.) as you grow. Your new cells come from the food you eat!



As each cell makes new proteins, they are added to the cell. As the cell gets larger, it divides, forming 2 cells and starting the process all over. This is how you grow!

3. New proteins are made from the amino acids of our digested food. When the cell is big enough, it divides and forms new muscle cells.

4. Vegetable and animal proteins in food are digested into amino acids, which are delivered to the cells by the blood. They are assembled into new proteins inside the cells. Glucose from our food provides the energy needed for all of these growth processes.

5. This process is exactly the same in animals as in humans. In this case, the new proteins are formed in cells in the tail stump.

6. Plants can make their own amino acids from the glucose they make in photosynthesis and the minerals they take in from the soil. Their growth process is essentially the same, then, as in animals.

To review:

3. Explain, as completely as you can, what happens to a muscle when you grow.
4. How does food help a teenager get taller?
5. How does food help a lizard regenerate a tail that gets torn off?
6. How does food help a plant increase its size?

Lesson 12

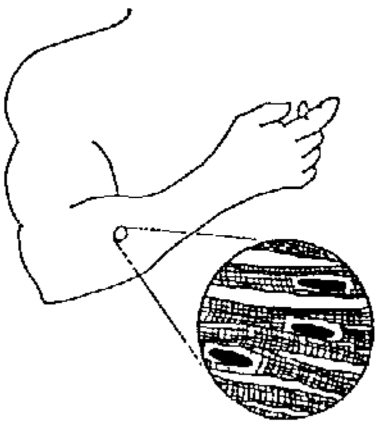
What happens to *extra* material from the food you eat that is *not* needed for energy, or that is *not* used for growing or repairing your body? Your body makes fat cells out of it! Extra food you eat that isn't used for energy and isn't used for new materials is *stored* by your body as fat cells for later use. Some animals do this to prepare for winter, when food is very scarce. Plants store extra food as starch (not fat) so they can live when there's not enough sunlight to make their own food. (People also store extra carbohydrates as starch for short term use.)

Cellular respiration is very similar to the process of producing energy in the form of heat and light when you burn a marshmallow or butter: **Both require oxygen; both release energy stored in the food; both produce carbon dioxide and water.**

There is a difference though: Your body cannot burn food with a flame, and it doesn't need or produce light energy. But it does need and produce heat energy, which is used to keep your body warm—much warmer (usually) than the surrounding temperature of the air.

Also, burning butter provides too much energy too fast. Your body needs energy all of the time in much smaller, controlled amounts. How does it do this? How does cellular respiration release small amounts of energy? By using only small amounts of glucose and oxygen?

Yes, there's not nearly as much glucose in any cell as there is butter in a butter candle. But there's more to this story.



Cells are very complicated. Inside cells, the energy released from glucose isn't used up right away. Most of the energy goes into many special molecules in each cell called ATP molecules. Each of the ATP molecules can store the energy from glucose in very small usable quantities—unlike a candle, which burns quickly and releases energy quickly. These energy-rich ATP molecules travel all over the cell, supplying energy when needed by cells, for motion in muscle cells, for light in the light-producing cells of the firefly, or for electrical signals in brain cells.

TryThis: In your journal, draw an outline picture of a human body, large enough to fill an entire piece of paper. Draw in a cell in a muscle in the forearm. Show in your drawing how food gets from the mouth to the cell. Show how oxygen gets from the mouth or nose to the cell. Show how carbon dioxide gets out of the body.

* * *

Extending what you know	Why do you get tired when you exercise? Why do you sometimes get cramps if you exercise too long and too vigorously?

The chemical formula for fat in the butter candle is different from the formula for glucose. A typical fat present in butter is glyceryl tristearate and the chemical formula is $C_{57}H_{110}O_6$. Notice that both glucose and the fat contain only carbon, hydrogen and oxygen. Both burn to produce carbon dioxide and water, releasing energy.

In our bodies, fats need to be converted to glucose before they can be used in cells for energy.

The heat produced by the process of cellular respiration is used to keep our body temperature at 98.6°F (37°C.) As warm-blooded organisms, our body temperature stays constant and we maintain a stable internal equilibrium. The reason we perspire when we exercise vigorously is to help get rid of excess heat from the additional cellular respiration. As water evaporates from our skin, it takes with it some of the excess heat being produced, thus cooling our skin.

It might be interesting to allow students to ponder these questions for several minutes before continuing to read the page. Let them voice their ideas about why exercise makes one tired. You may want to press them to talk about food and oxygen in their explanations, and what the body needs food and oxygen for.

We are deliberately not going into too much complexity with this discussion of the chemical process of cellular respiration. We have chosen instead to promote students' depth of understanding of cell processes by putting them in the contexts of 1) breathing and exercise (Where does the carbon dioxide we exhale come from? Why do we breathe more quickly when we exercise); 2) growth (Where does the new material come from when we grow? What's the connection between growing and eating well?); and 3) weight gain and weight loss (Why does exercise help us lose weight?) We consider these real-world contexts and these questions to be the substance of scientific literacy, rather than the complexity of cellular

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Lesson 11

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Lesson 11

Students' conception of respiration: If students have heard the word "respiration" before, they generally think of it only as breathing. This is where the common confusion about oxygen turning into carbon dioxide in the lungs comes from. With this naive view of respiration, they miss the essential connection between oxygen and *food*, and that a chemical reaction is needed for the production of carbon dioxide.

Key concepts that should be included are:

- the digestive system includes the mouth, esophagus, stomach, and small intestine.
- digestion begins in the mouth.
- the enzymes in saliva change some starch into sugar.
- enzymes in the stomach begin to break down proteins into amino acids.
- enzymes in the small intestine continue to break down starch and protein while other enzymes in the small intestine break down fats into fatty acids.
- glucose, fatty acids and amino acids are small enough to get out of the small intestine, into and out of the circulatory system (which carries it to cells) and finally into each and every cell.
- all cells use digested food for energy and growth.
- undigested food passes from the small intestine to the large intestine and then out of they body as feces.

You might write a list of words on the board that students should use in their story, such as: digestive system, circulatory system, digest, mouth, small intestine, enzyme, stomach, amino acid, cells, blood vessels, glucose, fatty acids. You might have students participate in formulating the list.

THE DIGESTIVE AND CIRCULATORY SYSTEMS: Putting it all together

Lesson 9

In the first lesson of this cluster, you explored your beginning ideas about the path that food follows in your body and what happens to it along the way. In the lessons that followed, you experimented with chemically changing food, just as it's changed in the digestive system. You also built models of how food moves from the digestive system, through the circulatory system, to the cells, where it's used.

You might have discovered that your ideas about what hapens to food changed as you worked through this cluster. Now would be a good time to finish your second drawing of the human body (from Lesson 6). This will be a good way of organizing all you know about where food goes after you eat it, and what happens to it to prepare for its arrival in the cells.

A. Check your drawing to make sure that it includes the major parts of the digestive system. Label each part with its name.

B. Add to your drawing the path that digested food takes to get to a cell in a leg muscle and maybe a cell in your brain. Label this "path."

C. Think about how a heart would fit into your drawing, to show how blood is pumped around the body. Add the heart and attach it to the blood vessels.

D. Then write a short essay. Pretend that you're a piece of food—pick out one of your favorites—and write a story about what happens to you after you're eaten.

E. How did your ideas about what happens to food inside your body change as you worked through this cluster?

F. What questions do you have at this point about how our bodies use food?

Now get ready to shrink yourself down to the size of a cell and think about what goes on in every living part of your body! On to Cluster 3!

Lesson 9

Lesson Statement: Students complete the picture they made at the beginning of the cluster and write a story about the food trip as a way of solidifying what they learned in this cluster.

Purpose: To pause and think and write about what has been learned about the food trip and to see what questions remain.

Approximate Time: 1 class period.

7. How can you explain long-term weight gain in terms of how our bodies use food? Use the concepts of digestion and cellular respiration in your answer.

8. Explain, in terms of energy, how you can control how much long-term weight you gain or lose?

9. Why does eating sugar result in weight gain if it is stored as fat, but not if it is used in cellular respiration.

10. Tell what kind of diet would be good for each of the following situations. Explain how you made your choice.

a) You are a body builder and want to add muscle to your body.

b) You want to gain weight.

c) You are planning an expedition to the Arctic and want to get your body ready for the trip.

d) What does a bear need to eat as it prepares for hibernation?

Body fat is not a bad thing. If you were exploring in the Arctic, you might have to go without food for several days. Excess food stored by your body as fat can be converted to glucose and used for energy when your body needs it. In times past, people might use body fat if crops failed or hunting was bad; body fat was important. In those situations, some people without some stored energy would weaken and perhaps die. Today, for people who never go hungry, the excess fat their bodies store is no longer useful. Because fat can cause serious health problems such as heart disease and high blood pressure, we need to keep our bodies from storing too much fat.

* * *

11. What do you want for yourself—weight gain, weight loss or just maintain your current weight? Write a plan that will help you achieve your goal. Tell why you think your plan will work.

7. Digested food (primarily amino acids and fatty acids) can be used for growth or for storage of fat; both result in weight gain. If digested food is used for repair or for cellular respiration, there will not be any long-term effect.

8. If you want to gain weight, take in more food for energy than what your body needs. It will be stored as body fat, adding to your weight.

If your body needs more energy than what's stored in the food you eat every day, it will use stored body fat for that extra energy, changing it to carbon dioxide and water, and exhaling the carbon dioxide.

9. When it is stored as fat, it adds to the weight of the body. When it is used in cellular respiration, it is changed into carbon dioxide and water vapor, and expelled from the body.

10. a) A diet rich in protein will provide amino acids needed for building muscle.

b) A diet high in carbohydrates and especially fat will provide the excess needed to gain weight.

c) Fats have twice as much available energy as carbohydrates (that's why they taste so good.) Eat lots of carbohydrates and fat to store up extra energy.

d) Lots of fat to store up extra energy for the body to keep warm and function during the long winter (Although bears don't actually hibernate—their body temperature does not drop significantly—they are much less active because food is much less available. In the same way, plants store food in the form of starch in the roots for use during the spring, before their leaves begin producing their own food.)

11. Answers vary

gram) than others. Generally foods high in calories (by weight) contribute more to body fat than those low in calories. But energy is needed by all people, even if they are dieting, so they have to maintain some minimal caloric intake—this is why bulimia or other forms of not eating are dangerous: Without any food, our bodies have no energy and no materials for growth and repair. New dietary guidelines recognize that foods high in saturated fats contribute more to body fat (and heart disease) than those of similar calorie content that are low in saturated fats.

Lesson 13

DO WE GET WHAT WE NEED FROM WHAT WE EAT?

Cluster 4

Often when people think about getting what they need from what they eat, they immediately start wondering if they have enough vitamins and minerals in their diets. They often don't think about proteins, fats or carbohydrates.

Vitamins and minerals are important, although when people eat good food on a regular basis they get the vitamins and minerals they need. Actually, proteins and carbohydrates really make up most of the food you eat.

If you didn't get enough protein in your daily diet, what *wouldn't* happen?

If you didn't get enough carbohydrates in your diet, what *wouldn't* happen?

In this cluster, you will analyze your diet, and diets of other people around the world, to see if you and they get enough of what you need to grow, to move, and to think.

Cluster 4