What is the function of food for animals? Name___________________

What makes up the food that animals consume?

Activity 1

Purpose

One-way organisms interact is by one organism eating another. In other words, one organism becomes the food for another organism. But what benefit does one organism get from eating or consuming another organism? We will focus specifically on how animals benefit from eating other organisms, or (in other words) how animals benefit from eating food. In this first activity we consider what makes up the food animals consume.

Initial Ideas

On your own: Do you think that all food is basically composed of the same 'stuff' or is it composed of all kinds of different materials? Why?

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If you think that food is made of the same stuff, what do you think that stuff is? If you think that food is made up of different types of materials, what general kinds of materials do you think food is made of?

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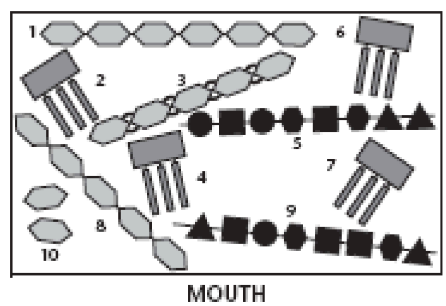
COLLECTING AND INTERPRETING EVIDENCE

Imagine eating a pizza with everything on it. Also, imagine if you could 'see' all the food molecules* that make up that pizza just after it entered your mouth. Those molecules might look like what you see in Figure 2-1.

*(*At this point you can think of food molecules as very small (submicroscopic) bits of substances that make up food.*

FIGURE 2-1



Group the molecules that you see in Figure 2-1 into 2 to 4 groups (based on any criteria that you would like) and then fill in the table below.

TABLE 2-1

GROUP NAME	MOLECULES IN GROUP (list by number)	What are the characteristics that the molecules in this group have in common with each other?
A		
B		
C		
D		

In the table below list differences (if any) among molecules within each particular group.

TABLE 2-2

GROUP	DIFFERENCES (IF ANY) WITHIN GROUP
A	
B	
C	
D	

Food Molecules

Sugar and starch are components of a broader group of molecules called carbohydrates. Sugars are often called simple carbohydrates because they are relatively small and have relatively simple chemical structures. One sugar that is typically found in our blood (as well as in our food) is glucose. Its simple chemical structure is often represented as a hexagon. Other common sugars are sucrose (table sugar), lactose (milk sugar), and fructose.

On your own: What substance(s) in Figure 2-1 might be a sugar molecule? Number _________
What is your evidence?

____

Sugars, particularly glucose, are often linked together like boxcars in a train to form molecules like starch. Starch is typically hundreds to thousands of glucose molecules linked together. Long chained molecules like starch are often called complex carbohydrates. Simple carbohydrates and complex carbohydrates are the two major subdivisions of carbohydrates.

What two types of molecules in Figure 2.1 might be called complex carbohydrates. What is your evidence?

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What is the same about the two types of molecules?

____

What is different?

____

Cellulose is made up of long chains of glucose, hence it is also considered a complex carbohydrate. However, the bonds holding the glucose molecules together in cellulose are different than those found in starch. Nutritionists sometimes simply refer to cellulose as fiber.

The complex carbohydrate with the curve bars linking the glucose molecules is how we represent cellulose in Figure 2-1. The curved bars used to show that glucose molecules are bonded differently in cellulose than in starch. What molecule in Figure 2-1 represents cellulose? Number _________

The complex carbohydrates with glucose molecules linked together *without* the curved bars represents starch. What two molecules in Figure 2-1 represent starch molecules? Numbers _________ and _________.
Proteins are another major component of food. They are composed of smaller subunits called amino acids. Unlike complex carbohydrates, which are made up thousands of only one type of sugar (glucose) linked together, proteins are made up of hundreds of several different types of amino acids. There are actually twenty different types of amino acids. Which large molecule in Figure 2-1 do you think represents proteins? Numbers _________ and _________. What is your evidence?

____

The final major component of food that has been recognized are fats and oils. Fats and oils are greasy feeling and, do not mix well with water and are chemically very similar. Fats are solid at room temperature whereas oils are liquid at room temperature. Unlike complex carbohydrates and proteins, fats and oils are medium sized molecules made up of four smaller subunits. Three of the four small molecules are almost identical and are called fatty acids. These three molecules are each linked to the fourth molecule called glycerol. Which medium sized molecules in Figure 2-1 represent fats or oils? Numbers _________,_________,_________ and _________.

Scientists have found that over ninety-five percent of almost all foods are composed of carbohydrates, proteins, and fats.

On your own: Now, read the *Scientists' Ideas About Food Molecules* to compare your groupings of food molecules with those of scientists.

Scientists' Ideas About Food Molecules
Scientists identify the components of food based on their chemical structure. The parts of living things that we eat as food are mostly made of varying amounts of three substances: carbohydrates, proteins, and fats. In fact, scientists have found that over ninety-five percent of almost all foods are composed of carbohydrates, proteins, and fats, plus varying amounts of water. Other nutrients, such as vitamins and minerals, are present in much smaller amounts.

CARBOHYDRATES
Sugar and starch are both examples of carbohydrates. Sugars are often called **simple carbohydrates** because they are relatively small and have relatively simple chemical structures. One sugar that is typically found in our blood (as well as in our food) is glucose. Glucose, fructose, and galactose are **mono** (single) **saccharides** and the simple chemical structure is often represented as a hexagon. Another common sugar is sucrose (table sugar) which is a **disaccharide**.

Simple sugars, particularly glucose, are often linked together like boxcars in a train to form long sugar molecules called **complex carbohydrates or polysaccharides**. One of these, **starch,** is typically hundreds to thousands of glucose molecules linked together. **Cellulose** is another example of a polysaccharide that is made up of long chains of glucose. Cellulose is different from starch, however, in that the bonds holding the glucose molecules together in cannot be broken down by the digestive enzymes in our systems. As a result, cellulose passes through our system without being digested. In the 19th century chemists analyzed a variety of inedible plant materials like sawdust, cotton, and linins and found that they too were made up of hundreds and thousands of glucose molecules linked together by chemical bonds. A French chemist gave these long chains of glucose the name of cellulose. Scientists later discovered that the bonds holding the glucose molecules together in cellulose were different than the bonds holding the glucose molecules together in starch. Because cellulose is made up of long chains of glucose, it too is considered a complex carbohydrate.   Nutritionists sometimes simply refer to cellulose as fiber. Compare the polysaccharides that are shown in Figure 2-1. The polysaccharide with the curved bars linking the glucose molecules is how we represent cellulose, while the polysaccharide *without* the curved bars represents starch.

PROTEINS

Proteins are another major component of food. They are composed of smaller subunits called **amino acids**. Unlike the complex carbohydrates starch and cellulose, which are made up thousands of only one type of sugar (glucose) linked together, proteins are made up of hundreds of several different types of amino acids. There are actually twenty different types of amino acids. In Figure 2-1, amino acids are represented as different shapes that are strung together in chains to form proteins. Proteins are organic compounds that contain nitrogen in addition to carbon, hydrogen, and oxygen. Proteins (also known as polypeptides) are made of amino acids arranged in a linear (straight) chain and folded into a globular form. The amino acids in a polymer are joined together by the peptide bonds between the carboxyl and amino groups of adjacent amino acid

LIPIDS

The final major component of food that has been recognized are lipids, which include **fats, oils, and waxes**. Fats and oils are greasy feeling, do not mix well with water and are chemically very similar. Fats are solid at room temperature whereas oils are liquid at room temperature. Unlike complex carbohydrates and proteins, fats and oils are medium sized molecules made up of four smaller subunits. Three of the four small molecules are almost identical and are called **fatty acids**. These three molecules are each linked to the fourth molecule called **glycerol**. If every carbon atom in the fatty acid chain is joined to another carbon atom by a single bond, the fatty acid is said to be **saturated** because it contains the maximum number of hydrogen atoms. If a pair of carbon atoms is joined by a double bond, the fatty acid is said to be unsaturated. If the more than one carbon atom in the fatty acid has a double bond it is said to be polyunsaturated.

How does the scientists grouping of food molecules compare to the grouping of food molecules that you suggested in your initial ideas?

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On what basis were you grouping different types of food?

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On what basis did scientists divide food molecules?

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Nutrients in Food I

Using chemical tests, scientists have been able to determine the chemical composition of the foods we eat. The following table lists the composition of several common foods.

Table 2-10 Types of nutrients found in food

Food	Water (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Vitamins & Minerals (%)
Coca Cola	90	10	0	0	<1
Marshmallow	16	75	9	0	<1
Ground beef, lean	56	0	25	19	<1
Lamb chop	44	0	20	36	<1
Chicken breast	62	0	30	8	<1
Corn	70	26	3	1	<1
Beans, refried	74	19	6	1	<1
Rice, brown	71	26	3	<1	<1
Banana	75	24	1	<1	<1
Peanust, dry roasted	1	22	25	48	<1
steak	54	0	27	18	<1
broccoli	88	8	3	0	<1
twinkie	26	60	2	12	<1
oreo	6	71	3	20	<1
kit-kat bar	3	61	7	29	<1

Based on Table 2-10 what do you think is the chemical composition of most plants? What is your evidence?

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____

____

Based on Table 2-10 do you think is the chemical composition of most animals? What is your evidence?

____

____

____

Scientists have also looked at the composition of typical humans. Table 2-11 shows the composition of typical humans.

Table 2-11 Nutrients in humans

	Water (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Vitamins & Minerals (%)
Average Human % composition	58	1	14	22	5

The 5% under the vitamins and minerals category is almost entirely due to the minerals that compose bone. If we exclude minerals in bone from the calculation, the percentage of water, carbohydrates, protein, fats, and vitamins& minerals would be as follows in Table 2-12 below.

TABLE 2-12 **Nutrients in humans not counting bones**

	Water (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Vitamins & Minerals (%)
Average Human % composition	61	1	15	23	<1

Once we exclude bones from our calculation of the chemical composition of humans, what four molecules constitute 99% of the human body?

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Are these the same four molecules that constitute 99% of most food (See Table 2-9), or are there other molecules that constitute 99% of most food.

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Excluding such things as shells and bones, scientists have found that 99% of most organisms are composed of water, carbohydrates, proteins, and fats.

SUMMARIZING QUESTIONS

What are the three major groups of food molecules recognized by scientists? How are these molecules similar to each other? How are they different?

What are the two major types of carbohydrates? What is the distinction between them?

Compare and contrast cellulose and starch. How are they the same? How are they different?

How similar is the composition of the human body to the composition of food?

Which type of food is the body most similar to? Why do you think this is?

Activity 2: How do animals use food to grow?

Purpose: In activity 1, we observed that composition of food is similar to the composition of the food we eat. In this activity, we explore more deeply the relationship between the food we eat and the composition of our bodies.

Initial Ideas: How do you think organisms use the food that they eat to grow (become larger in size)?

COLLECTING AND INTERPRETING EVIDENCE:

You will need: Molecule diagrams and (Time 0 to Time 4) diagrams (see website for diagrams)

CHANGES TO MOLECULES OVER TIME

Scientists have procedures to chemically "label" molecules so they can be traced. Imagine that before the food molecules on the diagrams were consumed by the person, they were "labeled" so that they could be followed through the digestion process. At four different time intervals, samples were taken from different places in the body.

Refer back to Figure 2-1. The molecules represented in that figure are the carbohydrates, proteins, and fats that might be found in a pizza with all the works. As previously pointed out, Figure 2-1 might represent these molecules just after they entered your mouth as you took a big bite out of the pizza.

The data for the different time intervals were recorded and illustrated in the Time 0 through Time 4 diagrams.

With your group:
Observe the changes in location and appearance of the molecules of food for each time interval. Record your observations in the table below.

TABLE 2-13

TIME INTERVAL	OBSERVATIONS
Time 0 - Time 1	
Time 1 - Time 2	
Time 2 - Time 3	
Time 3 - Time 4	

Count all the subunit molecules that are part of the large molecules originally present in the mouth at Time 0. Record your results in the table on the next page.

Count all the subunit molecules at Time 4 in the blood, the typical cell, and the fat cell whether they are 'free' or connected together to form larger molecules, and put your results in the table on the next page.

TABLE 2-14

GROUP	NUMBER OF SUBUNITS AT TIME 0	NUMBER OF SUBUNITS AT TIME 4
		
		
		
		

Did you account for all the building blocks?
Summarize what happened to the molecules that originally entered the mouth over the time period between Time 0 and Time 4.

For each molecule type, write its name, the name of its subunits, and the name of the molecule that was formed once the subunits reached a cell.

Molecule type	what is the name of this molecule type?	to what subunit(s) is the larger moleculebroken down?	in the cell these subunits became part of whatlarger molecule?
			
			
			
			

Digestion and Growth

In the diagrams, you observed that the larger molecules were broken down into subunits before being reassembled in cells. This breakdown facilitates two processes.

1. Distribution

For food molecules to pass from the small intestine to the blood vessels, the food must first pass through the cells that line both the small intestine and blood vessels. The digestive process that goes on in the stomach and small intestine facilitates this transfer by making the molecules small enough to pass more easily into and out of cells.

Cellulose (molecule #3) is a major constituent of plant cell walls that can't be digested by most animals. What this demonstrates is that not all carbon sources can be used for food. Approximately 50% of our waste (feces) consists of cellulose and other indigestible food products and 50% consists of dead bacteria which once lived in the digestive tract. Some microorganisms that live outside our bodies can 'digest' cellulose. Into what subunits might these microorganisms be able to digest cellulose? Explain your reasoning?

____

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2. Reassembly

The breakdown of larger molecules into subunits also facilitates the reassembly of new molecules which are needed for growth and maintenance of organisms' bodies. Sometimes the main function of these reassembled carbohydrates, proteins and fats is to make the structure of the organism. Other times these newly assembled

molecules serve mainly as storage materials for later use within the organism. For example, when plants need more structure they assemble sugar molecules to make cellulose. However when they simply want to store carbohydrates they assemble the glucose subunits into starch.
Animals rarely build their structure out of carbohydrates. They use mostly proteins. They do, however, store sugar molecules in long chains like plants do. This long chained molecule is composed of subunits very similar to starch, but it is called glycogen.
We have not mentioned glycogen previously because it is only a minor constituent of food. Though we store glycogen it never makes up more than about 1.5% of our total body weight. This is typical for almost all animals. Plants, on the other hand, especially certain plant organs like potato tubers can store large quantities of starch.

Summarizing Questions

On your own:

1. Describe how the glucose subunits that compose starch (in say spaghetti) can end up as part of glycogen in one of your cells.

2. What happens to cellulose in our digestive tract?

3. What happens to a fat molecule in our digestive tract?

4. What typically happens to amino acids once they arrive in a cell?

Activity 3: Scientist s' Ideas

How animals use food

INGESTION, DIGESTION, CIRCULATION

The process by which food is taken from the outside of the body and placed into the mouth is call **ingestion**. No food molecules are actually broken down in this process. That is the carbohydrates, proteins, and fats that comprise food remain intact. Which time step (Time 0-4) best represents ingestion? Briefly explain your reasoning.

____

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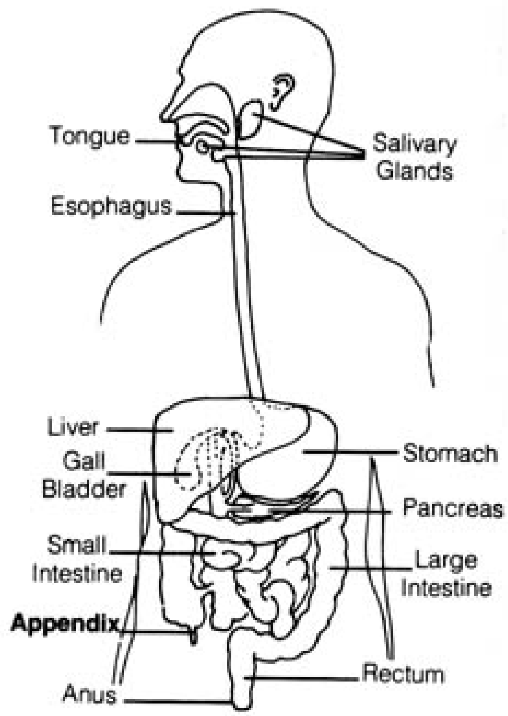

Figure 2-2

As food passes from the mouth to the digestive tract (stomach and small intestine, Figure 2-2), it is broken down into its building blocks in a process called digestion. What building block is starch broken down into?_______________. What building blocks are fats broken down into?______________ & _________________. What building blocks are proteins broken down into? ______________________.

In what time step (Time0-4) are most of the large molecules (carbohydrates, proteins, and fats) broken down into their respective building blocks? ___________________.

The building block molecules then pass from the digestive tract into the blood stream. The blood stream carries these molecules to all cells of the body. This process is called circulation. For food molecules to pass from the small intestine to the blood, the food must first pass through the cells that line both the small intestine and the blood vessels. The digestive process that goes on in the stomach and small intestine facilitates this transfer by making the molecules small enough to pass more easily into and out of cells. Cellulose (molecule #3) is a major constituent of plant cell walls that can't be digested by most animals because we lack the necessary enzymes to break it into smaller subunits. (We commonly refer to cellulose as 'fiber'.) What this demonstrates is that not all carbon sources can be used for food. Approximately 50% of our waste (feces) consists of cellulose and other undigestible food products and 50% consists of dead bacteria which once lived in the digestive tract.

We could summarize the combined processes of ingestion, digestion, and respiration in the following narrative:

> Food enters our mouths from the environment* in the form of carbohydrates, fats and, proteins (ingestion). The carbohydrates, fats, and proteins in food are then broken down to their respective building blocks (glucose, glycerol and fatty acids, and amino acid) during the process of digestion. The building blocks are then transported through our blood system to the various cells of our bodies (circulation).

**The environment is a generic word that is often used in science for everything (every place) outside of something. So we could correctly say that food enters our bodies from the environment.*

Activity Homework
Digestion

1. For the same food item in the previous homework assignment, describe what happen to each of the major food molecules carbohydrates, proteins and fats, describe what happens to each of the major food molecules (carbohydrates, protein, and fats) as it makes its way from your mouth to the cells of your body. Be sure to include how the molecules in your chosen food item could eventually end up comprising the molecules that make up your body.

2. Imagine you ate some fresh vegetables, lettuce or other types of raw plant material.
   a. What type of carbohydrate would these foods likely contain that you could not digest?
   b. Where does this molecule go after digestion?

Why aren't we surrounded by this waste material everywhere we look? Explain.

We are commonly told, "You are what you eat!" Discuss the accuracy of this statement based on what you have learned in the course so far. Be very specific when answering this question