CK-12

flexbook
next generation textbooks

Human Biology 110: Digestive System

Human Physiology 110: Digestive System

Peter MacDonald
Douglas Wilkin, Ph.D.
Jean Brainard, Ph.D.

To access a customizable version of this book, as well as other interactive content, visit www.ck12.org

CK-12 Foundation is a non-profit organization with a mission to reduce the cost of textbook materials for the K-12 market both in the U.S. and worldwide. Using an open-source, collaborative, and web-based compilation model, CK-12 pioneers and promotes the creation and distribution of high-quality, adaptive online textbooks that can be mixed, modified and printed (i.e., the FlexBook® textbooks).

Printed: September 27, 2016

AUTHORS
Peter MacDonald
Douglas Wilkin, Ph.D.
Jean Brainard, Ph.D.

Contents

CONCEPT 1 Digestion

- Compare mechanical digestion to chemical digestion.
- Outline the roles of the mouth, esophagus, and stomach in digestion.

What's the first step in the digestion process?

It all starts with the mouth. Food goes in, you chew it up, swallow it, then what happens? The process of turning that food into energy and proteins and other things necessary for life begins. But it all starts with the mouth.

The Start of Digestion: Mouth to Stomach

Does the sight or aroma of your favorite food make your mouth water? When this happens, you are getting ready for digestion.

Mouth

The mouth is the first digestive organ that food enters. The sight, smell, or taste of food stimulates the release of digestive enzymes by **salivary glands** inside the mouth. The major salivary enzyme is **amylase**. It begins the **chemical digestion** of carbohydrates by breaking down starch into sugar.

The mouth also begins the process of **mechanical digestion**. Sharp teeth in the front of the mouth cut or tear food when you bite into it (see **Figure** 1.1). Broad teeth in the back of the mouth grind food when you chew. Food is easier to chew because it is moistened by saliva from the salivary glands. The tongue helps mix the food with saliva and also helps you swallow. After you swallow, the chewed food passes into the pharynx.

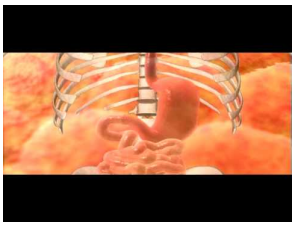
FIGURE 1.1
Teeth are important for mechanical digestion.

Esophagus

From the pharynx, the food moves into the esophagus. The **esophagus** is a long, narrow tube that passes food from the pharynx to the stomach by peristalsis. The esophagus has no other digestive functions. At the end of the esophagus, a muscle called a sphincter controls the entrance to the stomach. The sphincter opens to let food into the stomach and then closes again to prevent food from passing back into the esophagus.

Stomach

The **stomach** is a sac-like organ in which food is further digested both mechanically and chemically. (To see an animation of how the stomach digests food, go to the link below.) Churning movements of the stomach's thick, muscular walls complete the mechanical breakdown of food. The churning movements also mix food with digestive fluids secreted by the stomach. One of these fluids is hydrochloric acid. It kills bacteria in food and gives the stomach the low (acidic) pH needed by digestive enzymes that work in the stomach. The main enzyme is **pepsin**, which chemically digests protein.



MEDIA
Click image to the left or use the URL below.
URL: https://www.ck12.org/flx/render/embeddedobject/1688

The stomach stores the partly digested food until the small intestine is ready to receive it. When the small intestine is empty, a sphincter opens to allow the partially digested food to enter the small intestine.

Summary

- Digestion consists of mechanical and chemical digestion.
- Mechanical digestion occurs in the mouth and stomach.
- Chemical digestion occurs mainly in the small intestine.
- The pancreas and liver secrete fluids that aid in digestion.

Review

1. What is amylase and what is its role?
2. Describe functions of the stomach.
3. What is pepsin?

References

1. Stefan Andrej Shambora. Teeth illustration . CC-BY 2.0

CONCEPT 2

Digestive System Organs

- Identify the organs and functions of the digestive system.
- Describe the gastrointestinal tract.
- Explain peristalsis.
- Compare mechanical digestion to chemical digestion.
- Describe absorption and elimination.

Specifically, our energy comes from what?

The respiratory and circulatory systems work together to provide cells with the oxygen they need for cellular respiration. Cells also need glucose for cellular respiration. Glucose is a simple sugar that comes from the food we eat. To get glucose from food, digestion must occur. This process is carried out by the digestive system.

Overview of the Digestive System

The **digestive system** consists of organs that break down food and absorb nutrients such as glucose. Organs of the digestive system are shown in **Figure** 2.1. Most of the organs make up the **gastrointestinal tract**. The rest of the organs are called **accessory organs**.

The Gastrointestinal Tract

The gastrointestinal (GI) tract is a long tube that connects the mouth with the anus. It is more than 9 meters (30 feet) long in adults and includes the esophagus, stomach, and small and large intestines. Food enters the mouth, passes through the other organs of the GI tract, and then leaves the body through the anus.

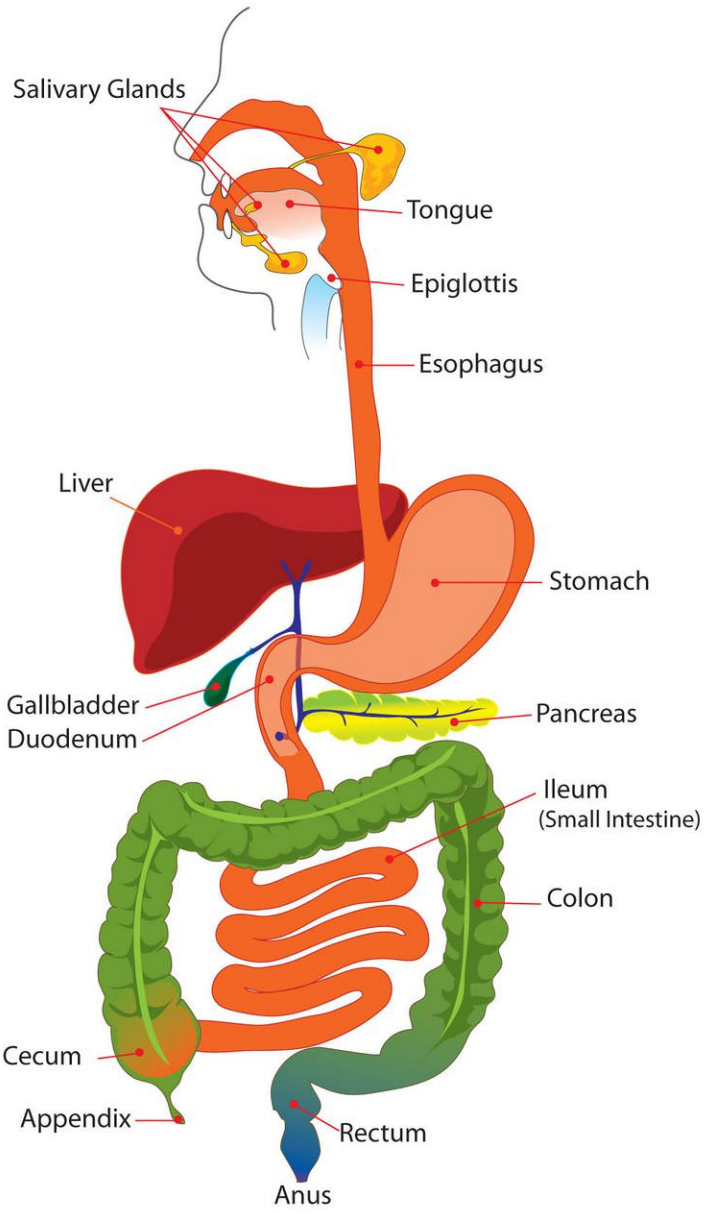
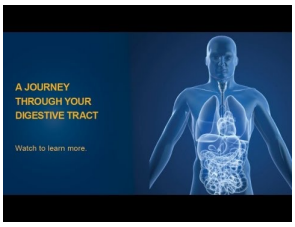


FIGURE 2.1

The digestive system includes organs from the mouth to the anus.



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/64418

The organs of the GI tract are lined with **mucous membranes** that secrete digestive enzymes and absorb nutrients. The organs are also covered by layers of muscle that enable peristalsis. **Peristalsis** is an involuntary muscle contraction that moves rapidly along an organ like a wave (see **Figure** 2.2).

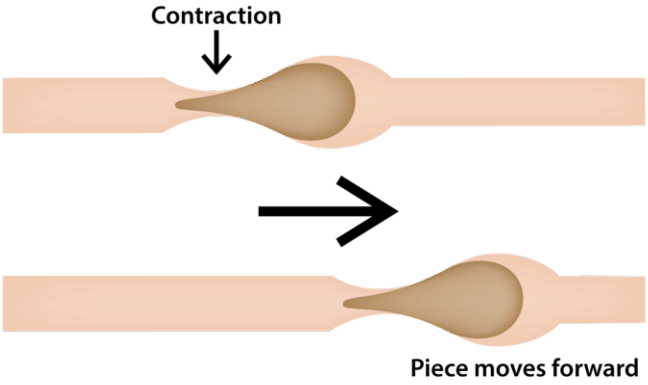


FIGURE 2.2

Peristalsis pushes food through the GI tract.

Accessory Organs of Digestion

Other organs involved in digestion include the liver, gall bladder, and pancreas. They are called accessory organs because food does not pass through them. Instead, they secrete or store substances needed for digestion.

Functions of the Digestive System

The digestive system has three main functions: digestion of food, absorption of nutrients, and elimination of solid food waste. **Digestion** is the process of breaking down food into components the body can absorb. It consists of two types of processes: mechanical digestion and chemical digestion.

- **Mechanical digestion** is the physical breakdown of chunks of food into smaller pieces. This type of digestion takes place mainly in the mouth and stomach.
- **Chemical digestion** is the chemical breakdown of large, complex food molecules into smaller, simpler nutrient molecules that can be absorbed by the blood. This type of digestion begins in the mouth and stomach but occurs mainly in the small intestine.

After food is digested, the resulting nutrients are absorbed. **Absorption** is the process in which substances pass into the bloodstream, where they can circulate throughout the body. Absorption of nutrients occurs mainly in the small intestine. Any remaining matter from food that cannot be digested and absorbed passes into the large intestine as waste. The waste later passes out of the body through the anus in the process of **elimination**.

Summary

- The digestive system consists of organs that break down food, absorb nutrients, and eliminate waste.
- The breakdown of food occurs in the process of digestion.

Review

1. What organs make up the gastrointestinal tract? What are the accessory organs of digestion?
2. Describe peristalsis and its role in digestion.
3. Define mechanical and chemical digestion.

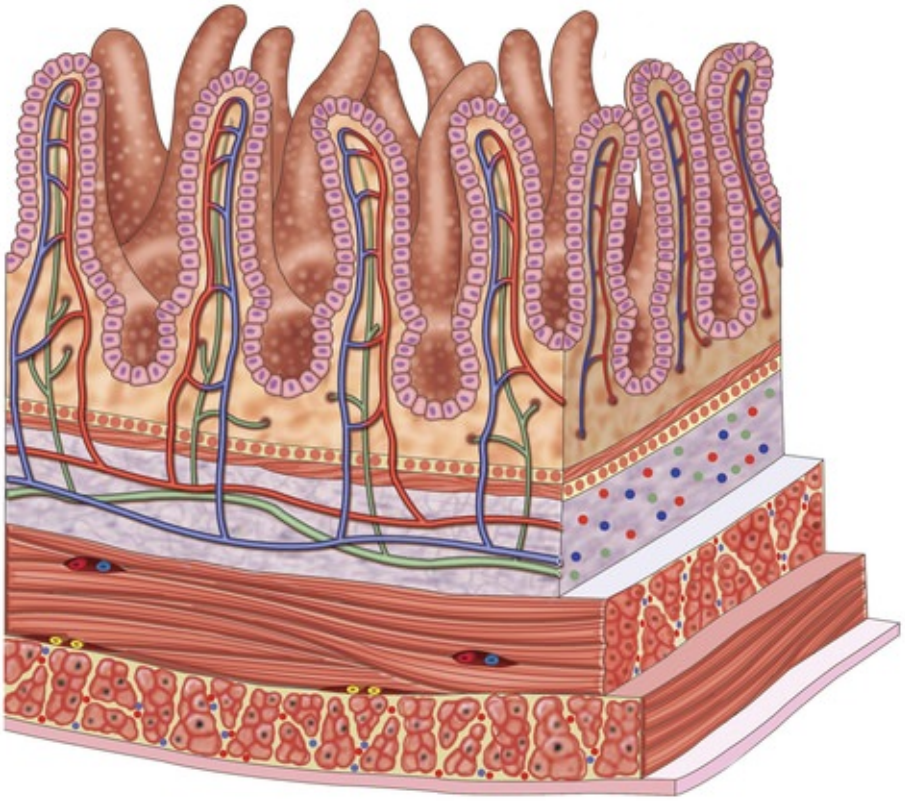
References

1. Mariana Ruiz Villarreal (User:LadyofHats/Wikimedia Commons). Major components of the digestive system . Public Domain
2. Zachary Wilson. Peristalsis illustration . CC BY-NC 3.0

CONCEPT 3

Small Intestine

- Describe the small intestine.
- Explain how digestion and absorption occur in the small intestine.
- Summarize digestive enzymes active in the duodenum.



These projections absorb. Absorb what?

Imagine the inside walls of the 23 feet of your small intestine covered with these finger-like projections. Why? What's their purpose, and why is the small intestine so long? These projections absorb. Absorb what? Minerals and nutrients from food. And the length of the small intestine allows as much of these important substances to be absorbed as possible.

Digestion and Absorption: The Small Intestine

The **small intestine** is a narrow tube about 7 meters (23 feet) long in adults. It is the site of most chemical digestion and virtually all absorption. The small intestine consists of three parts: the duodenum, jejunum and ileum (see the opening figure).

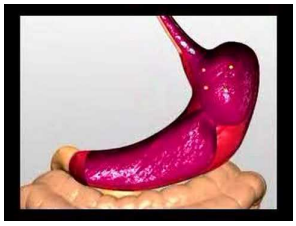
Digestion in the Small Intestine

The **duodenum** is the first and shortest part of the small intestine. Most chemical digestion takes place here, and many digestive enzymes are active in the duodenum (see **Table** 3.1). Some are produced by the duodenum itself.

Others are produced by the pancreas and secreted into the duodenum.

TABLE 3.1: Digestive Enzymes Active in the Duodenum

Enzyme	What It Digests	Where It Is Made
Amylase	carbohydrates	pancreas
Trypsin	proteins	pancreas
Lipase	lipids	pancreas, duodenum
Maltase	carbohydrates	duodenum
Peptidase	proteins	duodenum



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/229

MEDIA

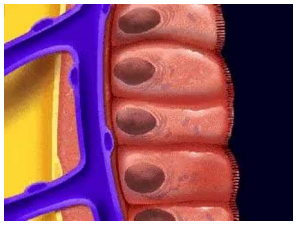
Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/3410

The **liver** is an organ of both digestion and excretion. It produces a fluid called **bile**, which is secreted into the duodenum. Some bile also goes to the **gall bladder**, a sac-like organ that stores and concentrates bile and then secretes it into the small intestine. In the duodenum, bile breaks up large globules of lipids into smaller globules that are easier for enzymes to break down. Bile also reduces the acidity of food entering from the highly acidic stomach. This is important because digestive enzymes that work in the duodenum need a neutral environment. The pancreas contributes to the neutral environment by secreting bicarbonate, a basic substance that neutralizes acid.

Absorption in the Small Intestine

The **jejunum** is the second part of the small intestine, where most nutrients are absorbed into the blood. As shown in **Figure** 3.1, the mucous membrane lining the jejunum is covered with millions of microscopic, fingerlike projections called **villi** (singular, villus). Villi contain many capillaries, and nutrients pass from the villi into the bloodstream through the capillaries. Because there are so many villi, they greatly increase the surface area for absorption. In fact, they make the inner surface of the small intestine as large as a tennis court!



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/1697

FIGURE 3.1
This image shows intestinal villi greatly magnified. They are actually microscopic.

The **ileum** is the third part of the small intestine. A few remaining nutrients are absorbed here. Like the jejunum, the inner surface of the ileum is covered with villi that increase the surface area for absorption.

Summary

- Virtually all absorption of nutrients takes place in the small intestine, which has a very large inner surface area because it is covered with millions of microscopic villi.

Review

1. Name the parts of the small intestine.
2. Where are most nutrients absorbed?
3. What is digested by trypsin, by lipase, and by maltase?
4. Describe the functions of the three parts of the small intestine.
5. What role do villi play in absorption?

References

1. Image copyright Sebastian Kaulitzki, 2014. Magnified image of villi . Used under license from Shutterstock.com

CONCEPT 4

Large Intestine

- Describe the large intestine.
- List functions of the large intestine.
- Describe the roles of bacteria in the large intestine.

Liquid to solid. What does this mean?

Well, that's exactly what the large intestine does. It takes the remains of digested food — that is, food in which all the nutrients and minerals have been removed, and prepares it for elimination.

The Large Intestine and Its Functions

From the small intestine, any remaining food wastes pass into the large intestine. The **large intestine** is a relatively wide tube that connects the small intestine with the anus. Like the small intestine, the large intestine also consists of three parts: the cecum (or caecum), colon, and rectum.

MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/230

Absorption of Water and Elimination of Wastes

The **cecum** is the first part of the large intestine, where wastes enter from the small intestine. The wastes are in a liquid state. As they pass through the **colon**, which is the second part of the large intestine, excess water is absorbed. The remaining solid wastes are called **feces**. Feces accumulate in the **rectum**, which is the third part of the large intestine. As the rectum fills, the feces become compacted. After a certain amount of feces accumulate, they are eliminated from the body. A sphincter controls the anus and opens to let feces pass through.

Bacteria in the Large Intestine

Trillions of bacteria normally live in the large intestine. Most of them are helpful. In fact, we wouldn't be able to survive without them. Some of the bacteria produce vitamins, which are absorbed by the large intestine. Other functions of intestinal bacteria include:

- controlling the growth of harmful bacteria.
- breaking down indigestible food components.
- producing substances that help prevent colon cancer.
- breaking down toxins before they can poison the body.

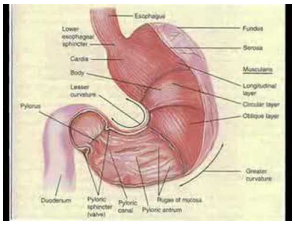
Summary

- The absorption of water from digestive wastes and the elimination of the remaining solid wastes occur in the large intestine.
- The large intestine also contains helpful bacteria.

Review

1. Describe the functions of the three parts of the large intestine.
2. How do bacteria in the large intestine help keep us healthy?

Resources



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/177127

CONCEPT 5 Digestive System Diseases

- Describe common diseases of the digestive system.
- List common food allergies.
- Define ulcer and heartburn.

What's worse than an upset stomach?

You've probably had an upset stomach. Most likely it was due to something you ate. But imagine bleeding from your stomach. That's a little different than your stomach just being upset. Stomach ulcers can be very serious.

Diseases of the Digestive System

Many diseases can affect the digestive system. Three of the most common diseases that affect the digestive system are food allergies, ulcers, and heartburn. Foodborne illnesses and food intolerance are also serious issues associated with the digestive system.

- Food **allergies** occur when the immune system reacts to substances in food as though they were harmful "foreign invaders." Foods that are most likely to cause allergies are pictured in **Figure** 5.1, and include nuts, eggs, grains and milk. Symptoms of food allergies often include vomiting and diarrhea. Symptoms of food allergies include itching and swelling of the lips and mouth. More serious symptoms include trouble breathing. In some instances, a food allergy can trigger anaphylaxis, which is an extremely severe reaction. Emergency medical treatment is critical for this condition, which left untreated, can lead to death.

- **Ulcers** are sores in the lining of the stomach or duodenum that are usually caused by bacterial infections. They may also be caused by the acidic environment of the stomach. Stomach acids may damage the lining of the stomach. Symptoms typically include abdominal pain and bleeding.

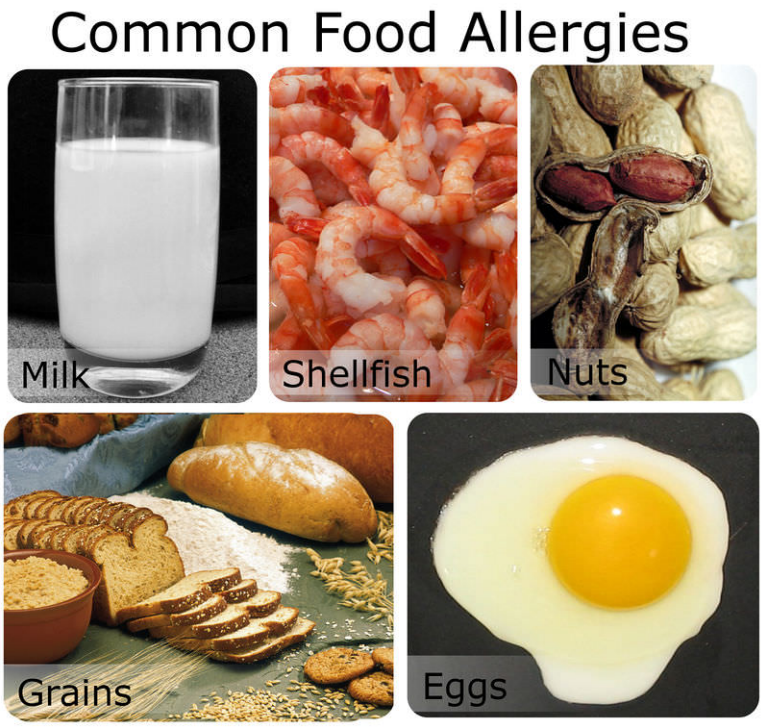


FIGURE 5.1

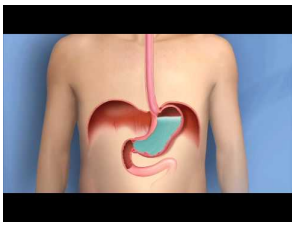
These foods are the most common causes of food allergies.

MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/187059

- **Heartburn** is a painful burning sensation in the chest caused by stomach acid backing up into the esophagus. The stomach acid may eventually cause serious damage to the esophagus unless the problem is corrected.



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/187061

Summary

- Digestive system diseases include food allergies, ulcers, and heartburn.

Review

1. Describe two diseases of the digestive system.
2. List three foods that cause common food allergies.

References

1. Milk: Hobvias Sudoneighm; Shellfish: Frank C. Müller; Nuts: Courtesy of Alice Welch/US Department of Agriculture; Grains: Courtesy of Peggy Greb/Agricultural Research Service; Egg: David Benbennick. Comm on allergic foods: milk, shellfish, grains, egg, nuts . Milk: CC BY 2.0; Shellfish, Nuts, Grains, Egg: Public Domain

CONCEPT 6 Food and Nutrients

- Define nutrient.
- Identify classes of macronutrients and their functions in the human body.
- List common micronutrients and their sources.
- Distinguish between vitamins and minerals.

Are these really good for you?

Fresh fruit and vegetables. Every child's favorite. Especially those vegetables. When your mother tells you to "eat your vegetables," there is a reason for that. Yes, they are actually good for you.

Food and Nutrients

Did you ever hear the saying, "You are what you eat"? It's not just a saying. It's actually true. What you eat plays an important role in your health. Eating a variety of the right types of foods promotes good health and provides energy for growth and activity. This is because healthful foods are rich in nutrients. **Nutrients** are substances the body needs for energy, building materials, and control of body processes. There are six main classes of nutrients: carbohydrates, proteins, lipids, water, vitamins, and minerals. These six classes are categorized as macronutrients or micronutrients depending on how much of them the body needs.

Macronutrients

Nutrients the body needs in relatively large amounts are called **macronutrients**. They include carbohydrates, proteins, lipids, and water. All macronutrients except water can be used by the body for energy. (The energy in food is measured in a unit called a **Calorie**.) The exact amount of each macronutrient that an individual needs depends on many factors, including gender and age. Recommended daily intakes by teens of three macronutrients are shown in **Table** 6.1. Based on your gender and age, how many grams of proteins should you eat each day?

TABLE 6.1: Recommended Intakes of Macronutrients

Gender/Age	Carbohydrates (g/day)	Proteins (g/day)	Water (L/day) (includes water in food)
Males 9-13 years	130	34	2.4
Males 14-18 years	130	52	3.3
Females 9-13 years	130	34	2.1
Females 14-18 years	130	46	2.3

- **Carbohydrates** include sugars, starches, and fiber. Sugars and starches are used by the body for energy. One gram of carbohydrates provides 4 Calories of energy. Fiber, which is found in plant foods, cannot be digested but is needed for good health. Simple carbohydrates are small carbohydrates found in foods such as fruits and milk. These carbohydrates include lactose, fructose and glucose. Complex carbohydrates are much larger molecules. Starch, which is a complex carbohydrate found in vegetables and grains, is made of thousands of glucose units bonded together.
- Dietary **proteins** are broken down during digestion to provide the amino acids needed for protein synthesis. Any extra proteins in the diet not needed for this purpose are used for energy or stored as fat. One gram of proteins provides 4 Calories of energy. Eating protein provides the amino acids for your cells to produce your own antibodies, muscle fibers and enzymes (as well as many other types of proteins).
- **Lipids** provide the body with energy and serve other vital functions, such as protecting neurons and providing the membranes that surround all cells. One gram of lipids provides 9 Calories of energy. You need to eat small amounts of lipids for good health. However, large amounts can be harmful, especially if they contain saturated fatty acids from animal foods.
- Water is essential to life because biochemical reactions take place in water. Most people can survive only a few days without water.

Micronutrients

Nutrients the body needs in relatively small amounts are called **micronutrients**. They include vitamins and minerals. **Vitamins** are organic compounds that are needed by the body to function properly. Several vitamins are described in **Table** 6.2. Vitamins play many roles in good health, ranging from maintaining good vision to helping blood clot. Vitamin B12 is produced by bacteria in the large intestine. Vitamin D is synthesized by the skin when it is exposed to UV light. Most other vitamins must be obtained from foods like those listed in **Table** 6.2.

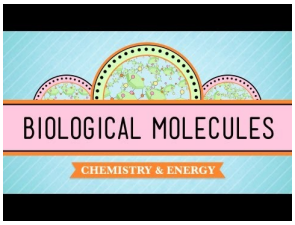
TABLE 6.2: Vitamins

Vitamin	Function	Good Food Sources
A	good vision	carrots, spinach
B12	normal nerve function	meat, milk
C	making connective tissue	oranges, red peppers
D	healthy bones and teeth	salmon, eggs
E	normal cell membranes	vegetable oils, nuts
K	blood clotting	spinach, soybeans

Minerals are chemical elements that are essential for body processes. They include calcium, which helps form strong bones and teeth, and potassium, which is needed for normal nerve and muscle function. Good sources of minerals include leafy, green vegetables, whole grains, milk, and meats.

Vitamins and minerals do not provide energy, but they are still essential for good health. The necessary amounts can usually be met with balanced eating. However, people who do not eat enough of the right foods may need vitamin

or mineral supplements.



MEDIA

Click image to the left or use the URL below.

URL: https://www.ck12.org/flx/render/embeddedobject/169577

Summary

- Nutrients are substances that the body needs for energy, building materials, and control of body processes.
- Carbohydrates, proteins, lipids, and water are nutrients needed in relatively large amounts.
- Vitamins and minerals are nutrients needed in much smaller amounts.

Review

1. Based on your gender and age, how many grams of proteins should you eat each day?
2. Compare and contrast macronutrients and micronutrients. Give examples of each.
3. What are minerals? Give two examples.
4. What is a good source of vitamin A?
5. Why do you need vitamin

CONCEPT 7

Balanced Eating

- Explain balanced eating.
- Summarize how to use MyPlate and MyPyramid.
- Describe the usefulness of food labels.
- Define eating disorder.

Why is the stuff in the smallest segment of this diagram?

If you're like most high school kids, one of the first things you do after school is search for something to eat. And you look for the chips or candy. As this diagram shows, you can eat those. Just not a lot.

Balanced Eating

Balanced eating is a way of eating that promotes good health. It means eating the right balance of different foods to provide the body with all the nutrients it needs. Fortunately, you don't need to measure and record the amounts of different nutrients you each day in order to balance your eating. Instead, you can use MyPlate, MyPyramid and food labels.

MyPyramid and MyPlate

MyPyramid shows the relative amounts of foods in different food groups you should eat each day (see **Figure** 7.1). You can visit the MyPyramid Web site at http://www.mypyramid.gov to learn more about MyPyramid and customize it for your own gender, age, and activity level.

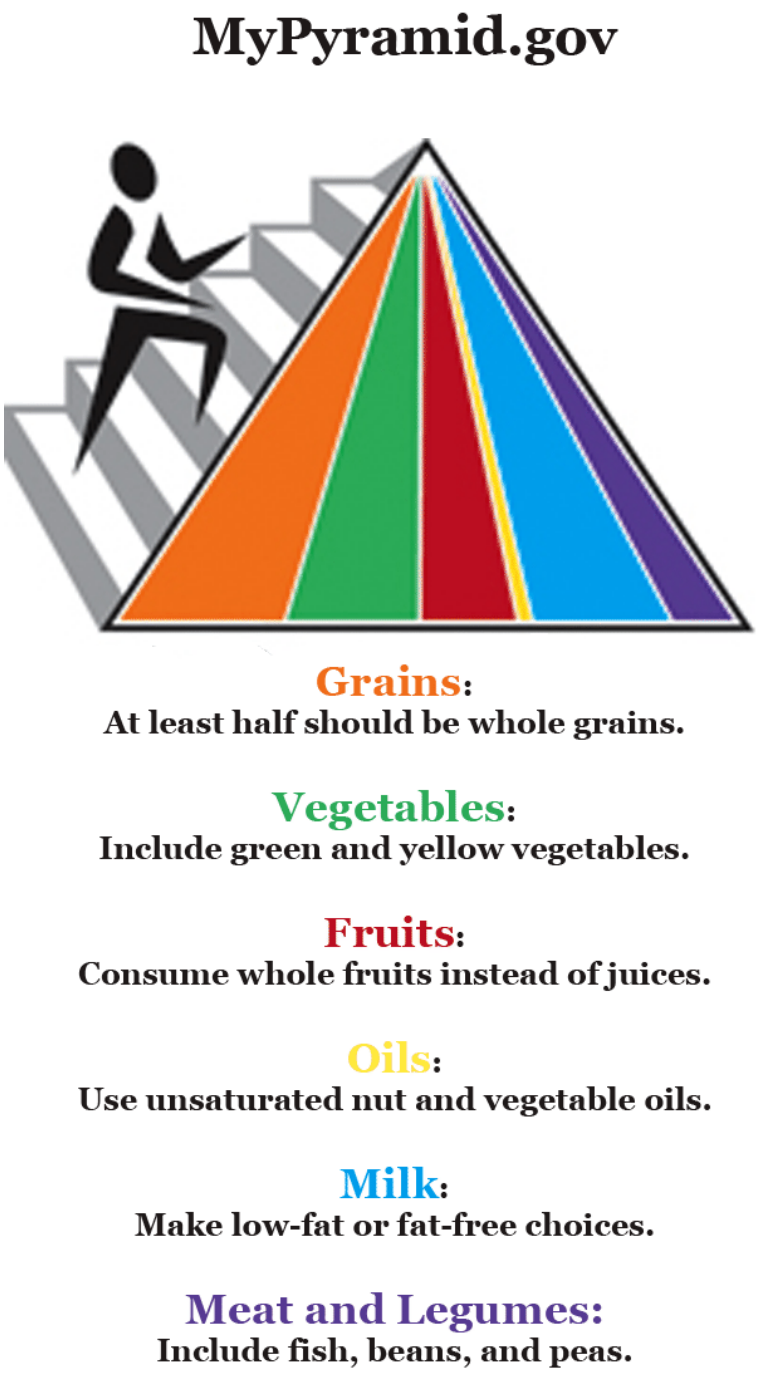


FIGURE 7.1
MyPyramid is a visual guideline for balanced eating.

Each food group represented by a colored band in MyPyramid is a good source of nutrients. The key in **Figure** 7.1 shows the food group each band represents. The wider the band, the more you should eat from that food group. The white tip of MyPyramid represents foods that should be eaten only once in a while, such as ice cream and potato

chips. They contain few nutrients and may contribute excess Calories to the diet.

The figure "walking" up the side of MyPyramid represents the role of physical activity in balanced eating. Regular exercise helps you burn any extra energy that you consume in foods and provides many other health benefits. You should be active for about an hour a day most days of the week. The more active you are, the more energy you will use.

In June 2011, the United States Department of Agriculture replaced My Pyramid with **MyPlate.** MyPlate depicts the relative daily portions of various food groups. See http://www.choosemyplate.gov/ for further information.

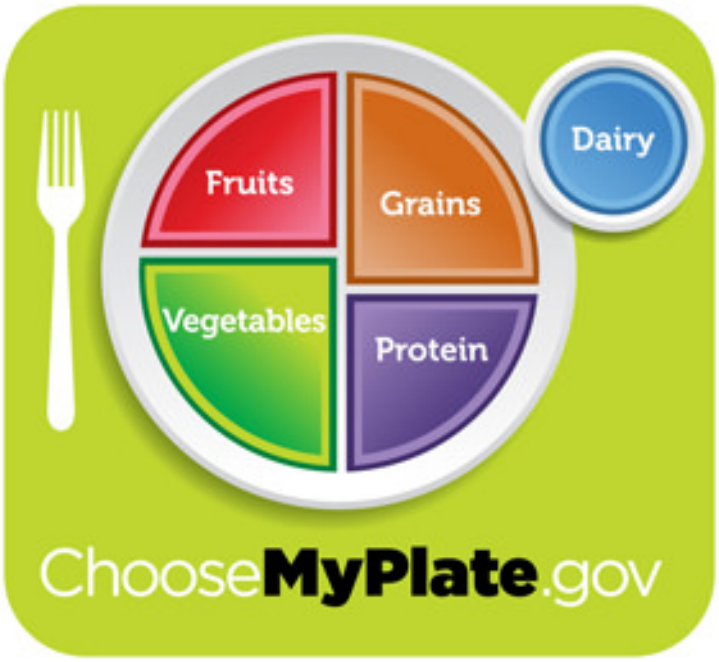


FIGURE 7.2

MyPlate is a visual guideline for balanced eating, replacing MyPyramid in 2011.

The following guidelines accompany MyPlate:

- Balancing Calories
  - Enjoy your food, but eat less.
  - Avoid oversized portions.
- Foods to Increase
  - Make half your plate fruits and vegetables.
  - Make at least half your grains whole grains.
  - Switch to fat-free or low-fat (1%) milk.
- Foods to Reduce
  - Compare sodium in foods like soup, bread, and frozen meals - and choose the foods with lower numbers.
  - Drink water instead of sugary drinks.

MEDIA

Click image to the left or use the URL below.
URL: https://www.ck12.org/flx/render/embeddedobject/187053

Food Labels

Packaged foods are required by law to carry a nutrition facts label, like the one in **Figure** 7.3. The labels show the nutrient content and ingredients of foods. Reading labels can help you choose foods that are high in nutrients you need more of (such as proteins) and low in nutrients you need less of (such as fats).

Nutrition Facts

Serving Size	½ cup (52 g)
Servings Per Container	8
Amount Per Serving	
Calories 200	Calories from Fat 45
Daily Value*	
Total Fat 5 g	**8 %**
Saturated Fat 2.5 g	**13 %**
Trans fat 0 g	
Cholesterol 0 mg	**0 %**
Sodium 160 mg	**7 %**
Total Carbohydrate 37 g	**12 %**
Dietary Fiber 1 g	**4 %**
Sugars 17 g	
Protein 2 g	

Vitamin A	0 %	Vitamin C	0 %	Calcium	0 %
Iron	10 %	Thiamin	10 %	Riboflavin	0 %
Niacin	20 %	Vitamin B_6	0 %	Folic Acid	10 %

*Percent Daily Values are based on a 2000 Calorie diet. Your daily values may be higher or lower depending on your calorie needs.

Ingredients: Enriched wheat flour (wheat flour, iron, Vitamin B_1, folic acid), high fructose corn syrup, vegetable oil (canola and soybean oil, partially hydrogenated palm kernel oil), sugar, salt, raisins, cornstarch, whole grain oats, baking soda, artificial flavor, caramel color

Reading a Nutrition Facts Label:

1. Energy
There are 200 Calories (kilocalories) in one serving. One serving is ½ cup. Therefore, there are 200 kilocalories in ½ cup.

2. Macronutrients
a. The grams on the left show the amounts of macronutrients that are supplied by one serving. For example, 5 grams of total fat are supplied by one serving.
b. The percents on the right show the percents of macronutrient needs that are supplied by one serving. Percents are based on a 2000-kilocalorie/day diet. If you need more than 2000 kilocalories/day, one serving supplies a smaller percent of each macronutrient. If you need less than 2000 kilocalories/day, one serving supplies a larger percent of each macronutrient.

3. Micronutrients
Percents of selected vitamins and minerals supplied by one serving are listed near the bottom of the label.

4. Ingredients
Ingredients in the food are listed in descending order. Those listed first are present in the largest amounts.

FIGURE 7.3

Nutrition facts labels like this one can help you make good food choices.

You should also look for ingredients such as whole grains, vegetables, and fruits. Avoid foods that contain processed ingredients, such as white flour or white rice. Processing removes nutrients. As a result, processed foods generally supply fewer nutrients than whole foods, even when they have been enriched or fortified with added nutrients.

Weight Gain and Obesity

Any unused energy in food, whether it comes from carbohydrates, proteins, or lipids, is stored in the body as fat. An extra 3,500 Calories of energy results in the storage of almost half a kilogram (1 pound) of stored body fat. People who consistently consume more food energy then they need may become obese. **Obesity** occurs when the body mass index is 30.0 kg/m^2 or greater. **Body mass index (BMI)** is an estimate of the fat content of the body. It is calculated by dividing a person's weight (in kilograms) by the square of the person's height (in meters). Obesity increases the risk of health problems such as type 2 diabetes and hypertension.

Eating Disorders

Some people who are obese have an eating disorder, called binge eating disorder, in which they compulsively overeat. An **eating disorder** is a mental illness in which people feel compelled to eat in a way that causes physical, mental,

and emotional health problems. Other eating disorders include anorexia nervosa and bulimia nervosa. Treatments for eating disorders include counseling and medication.

Summary

- Balanced eating promotes good health.
- MyPlate, MyPyramid, and food labels are tools that can help you choose the right foods for balanced eating.
- Eating too much and exercising too little can lead to weight gain and obesity.
- Some people who are obese have an eating disorder. Eating disorders are mental illnesses that require treatment by health professionals.

Review

1. Explain how to use MyPyramid and food labels to choose foods for balanced eating.
2. What is an eating disorder? Give an example.
3. Aleesha weighs 80 kg and is 1.6 m tall. What is her body mass index? Is she obese?

References

1. Courtesy of MyPyramid.gov. MyPyramid logo . Public Domain
2. . MyPlate logo . Public Domain
3. CK-12 Foundation. Nutritional facts label . CC BY-NC 3.0

CONCEPT 8

Vitamins and Minerals

Oranges, lemons, and limes. Why are the important?

Citrus fruits are more than just a good source of vitamin C. Citrus fruits also contain an impressive list of other essential nutrients including carbohydrates (sugars and fiber), potassium, folate, calcium, thiamin, niacin, vitamin B_6, phosphorus, magnesium, copper, riboflavin, pantothenic acid, and a variety of phytochemicals. In addition, citrus contains no fat or sodium and no cholesterol.

Vitamins and Minerals

Unlike the major macronutrients, micronutrients—including vitamins and minerals—do not provide energy. Nonetheless, adequate amounts of micronutrients are essential for good health. The needed amounts generally can be met with balanced eating. However, many people do not eat enough of the right foods to meet their requirements. They may need vitamin or mineral supplements to increase their intake of micronutrients.

Vitamins

Vitamins are organic compounds that are needed by the body to function properly. There are 13 vitamins that humans need. They are described in **Table** 8.1, which also includes recommended daily vitamin intakes for teens.

Vitamins play many roles in good health, ranging from helping maintain vision to helping form red blood cells. Many vitamins are components of enzymes. For example, vitamin K is a component of enzymes involved in blood clotting. Several vitamins, including vitamins C and E, act as antioxidants. An antioxidant is a compound that neutralizes chemicals called free radicals. Free radicals are produced naturally during cellular activities and may cause some types of cancer. Neutralizing free radicals makes them harmless.

Some vitamins, including vitamin B_6, are produced by bacteria that normally live in the intestines, where they help digest food. Vitamin D is synthesized in the skin when it is exposed to UV radiation in sunlight. Most other vitamins must be obtained from foods because the body is unable to synthesize them. Good food sources of vitamins are listed in **Table** 8.1.They include whole grains, vegetables, fruits, milk, and nuts.

Consuming inadequate amounts of vitamins can cause deficiency diseases. For example, consuming inadequate amounts of vitamin D causes soft bones. In children this is called rickets. It can cause permanent bone deformities. Consuming too much of some vitamins can also be dangerous. Overdoses of vitamins can cause problems ranging from diarrhea to birth defects and even death.

Vitamins are either fat-soluble or water-soluble. This determines whether they can accumulate in the body and lead to overdoses.

- Vitamins A, D, E, and K are fat soluble. Excess intakes of these vitamins are stored in fatty tissues of the body. Because they are stored in the body, they can build up to toxic levels, especially if they are taken improperly in supplements.
- Vitamin C and all the B vitamins are water soluble. Excess amounts of these vitamins are excreted in the urine, so they are unlikely to reach toxic levels in the body.

TABLE 8.1: Vitamins

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes f or Ages 14-18 yr
Vitamin A (Retinoids)	Needed for good vision, reproduction, and fetal development.	Carrots, spinach, milk, and eggs.	Males: 900 μg Females: 700 μg
Vitamin B_1 (Thiamine)	Helps break down macronutrients and is essential for proper functioning of nerves.	Whole wheat, peas, beans, fish, peanuts, and meats.	Males: 1.2 mg Females: 1.0 mg
Vitamin B_2 (Riboflavin)	Helps the body process amino acids and fats and acts as an antioxidant.	Milk, liver, green leafy vegetables, almonds, and soybeans.	Males: 1.3 mg Females: 1.0 mg
Vitamin B_3 (Niacin)	Helps release energy from macronutrients and is needed for healthy skin and nerves.	Beets, beef liver, pork, turkey, fish, sunflower seeds, and peanuts.	Males: 16 mg Females: 14 mg
Vitamin B_5, (Pantothenic Acid)	Helps form critical enzymes for synthesis of macronutrients.	Whole grains, legumes, eggs, and meat.	Males: 5 mg* Females: 5mg*

TABLE 8.1: (continued)

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes f or Ages 14-18 yr
Vitamin B_6 (Pyridoxine)	Forms enzymes needed for amino acid synthesis and energy storage.	Cereals, yeast, liver, fish, avocadoes, nuts, and green beans.	Males: 1.3 mg Females: 1.2 mg
Vitamin B_7 (Biotin)	Enables synthesis of fatty acids, helps store energy, and keeps level of blood sugar stable.	None.	Males: 25 μg* Females: 25 μg*
Vitamin B_9 (Folate)	Needed to make red blood cells.	Liver, green leafy vegetables, dried beans, and peas.	Males: 400 μg Females: 400 μg
Vitamin B_{12} (Cyanocobalamin)	Needed for normal functioning of the nervous system and the formation of blood.	Meat, liver, milk, shellfish, and eggs.	Males: 2.4 μg Females: 2.4 μg
Vitamin C (Ascorbic Acid)	Needed to make many biological chemicals and acts as an antioxidant.	Citrus fruits such as oranges, red peppers, broccoli, and kiwi.	Males: 75 mg Females: 65 mg
Vitamin D (Ergocalciferol and Cholecalciferol)	Helps maintain blood levels of calcium and is needed for healthy bones and teeth.	Salmon, tuna, eggs, and mushrooms.	Males: 5 μg Females: 5 μg
Vitamin E (Tocopherol)	Acts as an antioxidant and protects cell membranes from LDL cholesterol damage.	Vegetable oils, nuts, green leafy vegetables, whole grains, and fish.	Males: 15 mg Females: 15 mg

TABLE 8.1: (continued)

Vitamin (Chemical Name)	Functions in the Body	Good Food Sources	Recommended Daily Intakes f or Ages 14-18 yr
	Helps transport calcium and helps blood clot.	Kale, spinach, Brussels sprouts, milk, eggs, and soy products.	
Vitamin K (Naphthoquinone)			Males: 75 μg* Females: 75 μg*

- Recommended daily intakes are not established; figures given are adequate daily intakes.

Minerals

Dietary minerals are chemical elements that are essential for body processes. Minerals are inorganic, meaning they do not contain carbon. Minerals needed by humans in relatively large amounts (greater than 200 mg/day) are listed in **Table** 8.2. Minerals not listed in the table are called trace minerals because they are needed in very small amounts. Trace minerals include chromium, iodine, iron, molybdenum, selenium, and zinc.

TABLE 8.2: Minerals

Mineral Name (Symbol)	Functions in the Body	Good Food Sources	Recommended Daily Intakes (mg) for Ages 14-18 yr
Calcium (Ca)	Needed for nerve and muscle action, builds bone and teeth, and helps blood clot.	Milk, soy milk, green leafy vegetables, and sardines.	Males: 1300* Females: 1300*
Chloride (Cl)	Helps maintain water and pH balances and helps form stomach acid.	Table salt and most processed foods.	Males: 2300* Females: 2300*
Magnesium (Mg)	Needed to form several enzymes.	Whole grains, green leafy vegetables, nuts, and seeds.	Males: 410 Females: 360
Phosphorus (P)	Component of bones, teeth, lipids, and other important molecules in the body.	Meat, poultry, and whole grains.	Males: 1250 Females: 1250

TABLE 8.2: (continued)

Mineral Name (Symbol)	Functions in the Body	Good Food Sources	Recommended Daily Intakes (mg) for Ages 14-18 yr
Potassium (K)	Needed for muscle and nerve function and helps maintain salt-water balance in body fluids.	Meats, grains, orange juice, potatoes, and bananas.	Males: 4700* Females: 4700*
Sodium (Na)	Needed for muscle and nerve function and helps maintain salt-water balance in body fluids.	Table salt and most processed foods.	Males: 1500* Females: 1500*
Sulfur (S)	Necessary component of many proteins.	Whole grains, meats, seafood, and eggs.	Males: 1300* Females: 1300*

- Recommended daily intakes are not established; figures given are adequate daily intakes.

Minerals play many important roles in the body. Most are found in the blood and cytoplasm of cells, where they control basic functions. For example, calcium and potassium regulate nerve and muscle activity. Several minerals, including zinc, are components of enzymes. Other minerals, including calcium, form the bulk of teeth and bones.

Minerals cannot be synthesized by the body. Good food sources of minerals are listed in **Table** 8.2. They include dairy products, green leafy vegetables, and legumes. Mineral deficiencies are uncommon, but inadequate intakes of a few minerals may lead to health problems. For example, an inadequate intake of calcium may contribute to osteoporosis, a disease in which bones become brittle and break easily.

Some minerals may be toxic in excess, but overdoses of most minerals are uncommon. Overdoses are more likely when mineral supplements are taken. Salt (sodium chloride) is added to many foods, so the intake of sodium may be too high in many people. Too much sodium in the diet can cause high blood pressure in some individuals.

Other Micronutrients

Recently, new micronutrients called phytochemicals have been found in plants. They occur primarily in colorful fruits and vegetables like those shown in **Figure** 8.1. Thousands of phytochemicals have been discovered, and some have already been shown to lower the risk of certain diseases. For example, the phytochemical lutein helps reduce the risk of macular degeneration, an eye disease that leads to blindness. Lutein is found in many yellow and orange fruits and vegetables. Several phytochemicals, including some found in berries, have proven to be powerful antioxidants.

FIGURE 8.1
Good sources of phytochemicals.

Summary

- Vitamins play many roles in good health, ranging from helping maintain vision to helping form red blood cells. Many vitamins are components of enzymes.
- Good food sources of vitamins include whole grains, vegetables, fruits, milk, and nuts.
- Vitamins A, D, E, and K are fat soluble, whereas Vitamin C and all the B vitamins are water soluble.
- Dietary minerals are chemical elements that are essential for body processes. Minerals are inorganic, meaning they do not contain carbon.

Review

1. How many vitamins does a human need?
2. What are antioxidants? Which vitamins act as antioxidants?
3. What is the danger of having too much fat soluble vitamins?
4. What are trace minerals?
5. Can minerals be synthesized by the body?

References

1. . Good sources of phytochemicals.. CC-BY-SA

CONCEPT 9

Eating Disorders

Can you eat too little?

Take a look because this is serious. Anorexia nervosa is a disorder where being too thin is seen as the opposite. It has serious health concerns and can easily lead to death.

Eating Disorders

Eating disorders are psychiatric illnesses that involve abnormal patterns of eating. A person with an eating disorder has a compulsion to eat in a way that causes physical, mental, and emotional health problems. Typically, the person has an obsession with food and weight. Eating disorders are more common in females. One reason may be society's focus on female appearance. The most common eating disorders are binge eating disorder, anorexia nervosa, and bulimia nervosa.

Binge Eating Disorder

Binge eating disorder is characterized by compulsive overeating. People with the disorder typically eat very large quantities of food in a short period of time. They may use food as a way to deal with painful emotions or stress. Many people with the disorder are overweight or obese. The disorder is rapidly increasing in prevalence and is now the most common eating disorder in the U.S. The rise in binge eating disorder is one reason for the dramatic increase in obesity in this country.

Anorexia Nervosa

Anorexia nervosa is characterized by greatly restricted food intake and low body weight (BMI less than 17.5 kg/m^2). People with anorexia nervosa usually have a distorted body image. They think they are too fat when they are actually too thin. They have an obsessive fear of gaining weight and voluntarily starve themselves. They may also exercise excessively to help keep their weight low. Females with anorexia nervosa usually stop having menstrual periods. The disorder mainly affects teenage girls and is extremely serious. At least 10 percent of people with anorexia nervosa die from factors related to the disorder.

Bulimia Nervosa

Bulimia nervosa is characterized by cycles of binge eating followed by purging to eliminate the food from the body. Purging may be achieved through intentional vomiting or excessive use of laxatives. People with this disorder typically have normal weight or weight slightly greater than normal. Repeated purging can lead to dehydration. Excessive vomiting can damage the teeth and organs of the digestive system. Bulimia nervosa occurs most often in teenage girls and young women.

Causes and Treatment

People with eating disorders usually have other mental health problems as well, most commonly depression. Both depression and eating disorders may have the same underlying physiological cause: low levels of the brain chemical serotonin. The process of eating causes serotonin to be released and may lead to a temporary "high." The process of purging may also have this effect in people with bulimia nervosa.

Environmental factors play a role in most cases of eating disorders, as they do with depression and other mental health problems. Childhood abuse may be one of these environmental factors. Many people with eating disorders report having been abused as children.

Eating disorders can be treated with psychiatric therapy or psychological counseling. Medications may also be prescribed. Treatment usually includes resolving underlying emotional problems as well as treating depression or other mental health disorders that are also present. In patients with anorexia nervosa, weight gain is also an important goal of treatment.

Summary

- Eating disorders are psychiatric illnesses that involve abnormal patterns of eating. A person with an eating disorder has a compulsion to eat in a way that causes physical, mental, and emotional health problems.
- Binge eating disorder is characterized by compulsive overeating.
- Anorexia nervosa is very serious, and at least 10 percent of people with anorexia nervosa die from factors related to the disorder.
- Causes of eating disorders may include low levels of serotonin, child abuse, and other underlying emotional problems.

Review

1. What is the most common eating disorder in the US?
2. What are some hazards associated with purging when someone has bulimia nervosa?
3. What can be a common cause of depression and eating disorders?