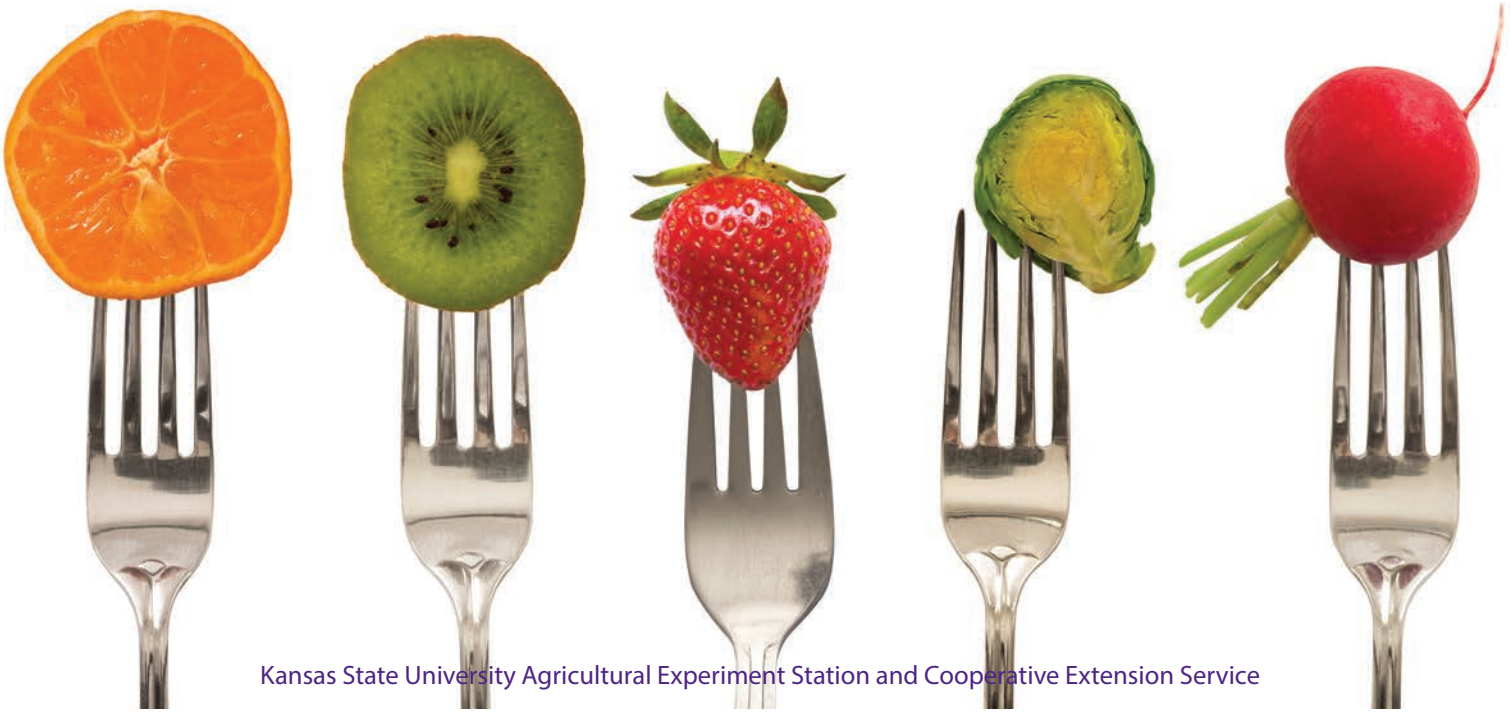
K-STATE
Research and Extension

you are what you eat

student guide



Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Table of Contents

Chapter 1
Cardiovascular System

Important Words

Action potentials: Messages your brain sends throughout the body to communicate and tell different body processes to occur.

Cofactor: Molecules needed to help enzymes make processes occur in the body.

Electrical activity of the heart: Signals that travel throughout the heart and tell it when to beat.

Enzymes: Proteins in the body needed for important bodily processes to occur.

Saturated fats: Fats that are usually solid at room temperature and are not as good for you.

Unsaturated fats: Fats that are usually liquid at room temperature and are better for you.

General Overview

The main purpose of the cardiovascular system is to transport oxygen and nutrients to all the cells throughout the body. This is accomplished through two systems of blood vessels: one going to and from the lungs and the other to and from the rest of the body.

The cardiovascular system consists of your heart and blood vessels — arteries, which carry blood away from the heart, and veins, which carry blood back to the heart. Both carry blood throughout the body. The heart has its own system of arteries and veins to supply its own cells with blood. All parts of your body need oxygen and nutrients found in the blood to carry out their normal functions and keep you alive. Your blood vessels carry the blood to all parts of the body so they can deliver oxygen and nutrients to your other body parts. The heart pumps blood to all the cells in your body. If it were to stop pumping blood, you would die because none of your other organs — such as your stomach, liver, muscles, and brain — would be able to function.

Learning Check

- What does blood transport?

Cardiac Muscle Contraction

The heart (cardiac) muscle is involuntarily controlled, which means you do not have to think about remembering to make your heart contract. In order for a cardiac muscle cell to contract (and, therefore, pump blood throughout the body), the ions sodium and calcium must enter the cell. This extra calcium inside the cell triggers more calcium to come in, which moves a protein and, therefore, allows the cell to contract. A lot of calcium is needed so that the cell pauses in its contraction, which ensures all the blood is pumped throughout the body. After the sodium and calcium have caused the heart muscle to contract, potassium must enter the cell in order to "reset" it to its resting state. Without this influx of potassium, the heart would remain contracted and would not be able to continue pumping blood throughout the body.

Now that you have a general idea of the importance of the cardiovascular system and how it works, consider how different nutrients can affect its health and function.

Learning Check

- Name two ions that are important in the contraction of the heart.

Fats

Effects on Cardiovascular System

Fats are major energy stores in the body. Fats are also necessary to dissolve the fat-soluble vitamins A, D, E, and K. However, eating the "right" kinds of fat is important because fat can also affect your blood cholesterol and lead to cardiovascular problems. Fats have more than double the number of calories as proteins and carbohydrates. This means if you eat too many fats, you are more likely to gain more weight, so you want to be careful not to eat too many of any kind of fat.

One type of fat your food can contain is cholesterol. High-cholesterol diets can lead to build up of cholesterol in your arteries. This leads to a buildup of plaque in your arteries and prevents blood from reaching your heart cells with oxygen and nutrients. Without oxygen, your heart cells will start to die, which will lead to chest pain and, eventually, death. There are two types of cholesterol: LDL (the "bad" cholesterol) and HDL (the "good" cholesterol). One way to remember this is by "L" for lousy cholesterol and "H" for healthy cholesterol. You want low levels of LDL and high levels of HDL.

Blood cholesterol can be illustrated by putting your thumb over a water hose. In this scenario, the hose is a blood vessel, the water is blood, and your thumb is cholesterol. Your thumb blocks the flow of water through the hose, thus making it harder for the water to get out. This demonstrates how your heart must work harder to move blood when cholesterol is blocking a blood vessel. In addition, not as much water can get out of the hose, just as less blood can get back to your heart.

In addition to cholesterol, it is important to look at saturated and unsaturated fats. Saturated fats are fatty acids in which each carbon atom is bonded to another carbon atom by only a single bond. Unsaturated fats have at least one carbon-carbon bond that is a double bond. These unsaturated fats are healthier. Saturated and trans fats can also increase your LDL cholesterol, the "bad" cholesterol. This can lead to clogged arteries, which can block blood flow throughout various parts of your body Replacing these unhealthy fats with unsaturated fats can decrease your blood LDL cholesterol, which decreases your risk for cardiovascular disease. Developing healthy eating habits early in life is important because the food you eat when you are young affects your body as you get older.

Foods Containing Fats

Diets high in fruits and vegetables decrease your risk of heart disease. It is recommended that fats make up 25 to 35 percent of a diet for youth ages 4 to 18. Saturated fat intake should be no more than 10 percent, and trans fat should be kept as low as possible. Foods that contain saturated fats include beef, lamb, pork, poultry fat, lard, milk, cheeses, dairy products made with whole and 2 percent milk, coconut, tropical oils, coconut oil, and cocoa butter. Trans fats can be found in shortening, french fries, donuts, pies, muffins, cookies, and crackers. Instead of these foods, try to eat foods with unsaturated fats. Foods containing unsaturated fats include fish, nuts, seeds, avocados, olives, and walnuts, as well as vegetable oils such as corn, olive, soybean, safflower, and canola.

Learning Check

- _____ is the "good" cholesterol and _____ is the "bad" cholesterol.
- Which type of fat is the healthier type of fat?
- What are three foods that contain this healthy type of fat?

Magnesium

Effects on Cardiovascular System

Magnesium is an important cofactor in the human body. A cofactor is a molecule that helps enzymes in your body carry out reactions and processes necessary to keep you alive. Some processes aided by magnesium include muscle and nerve function, making proteins, blood glucose control, and blood pressure regulation. In addition, it is involved in processes that produce ATP, which is what stores the energy your body uses to keep you alive. It also transports other ions such as calcium and potassium across cell membranes, which is vital to normal muscle contraction and heart rhythm. Magnesium is important to the health of your heart. Deficiency can lead to abnormal heart rhythms and coronary spasms. It can also lead to hypocalcemia (low blood calcium) and hypokalemia (low blood potassium), which can cause additional problems. Hypomagnesemia (low blood magnesium) is associated with insulin resistance, which can lead to diabetes. Diets high in magnesium can reduce a person's risk of developing type 2 diabetes.

Foods Containing Magnesium

Good sources of magnesium include leafy greens, nuts, legumes, whole grains, and seeds. Some foods are also enriched with magnesium, and water contains magnesium. Magnesium can also be obtained from low-fat milk and yogurt. The Recommended Dietary Allowance of magnesium intake for youth aged 9 to 13 is 240 mg per day for both males and females. Research has shown that adolescent females are likely to have lower than recommended intake of magnesium, so it is important that girls especially make sure that they are eating enough magnesium-rich foods.

Learning Check

- T/F A cofactor helps enzymes carry out important processes in your body.
- Name three foods that are good sources of magnesium.

Potassium

Effects on Cardiovascular System

In keeping your blood pressure low, sodium (salt) is your "enemy," while potassium can be your "ally." Sodium and potassium can counteract one another in the body. While sodium raises your blood pressure, potassium can help increase the amount of sodium excreted while relaxing the blood vessel walls, thus lowering blood pressure.

To understand the harm of high blood pressure and how potassium can help lower it, consider how sodium and potassium influence your blood vessels. Your brain communicates to the rest of your body by sending action potentials to tell each part what to do. Action potentials travel through your nerves when sodium rushes into the nerve cell. After the sodium rushes in, potassium must leave the cell to bring the cell back to its resting state so it will be ready when the brain sends another action potential. When an action potential travels through a muscle telling it to contract, the subsequent release of potassium is what allows it to return to a relaxed state. As a result, if you do not have enough potassium, your blood vessels might stay contracted, increasing blood pressure because the blood is flowing through a narrower space. A higher blood pressure puts more strain on the heart because your heart is trying to pump the blood through narrower blood vessels.

As a comparison, imagine pinching a hose between your fingers. By doing this, you are contracting the walls of the hose, much like the walls of a blood vessel remaining contracted. This increases the amount of pressure required to get the water out of the hose, and the water pump must work harder to push the water out. In a similar way, the heart must work harder to pump the blood through narrower blood vessels.

In addition to being important in the regulation of blood pressure, potassium helps control the electrical activity of the heart. While sodium crossing the nerve cell membrane triggers the contraction of the heart, potassium is what brings the cell back to its resting membrane potential, which allows the heart to relax. Without enough potassium, the heart would not beat properly, which could lead not only to heart problems, but to problems throughout the body as the heart would

not be able to properly deliver nutrients and oxygen to the rest of your body. Having enough potassium is important to maintaining normal heart rhythms.

Foods Containing Potassium

Foods rich in potassium include green vegetables, bananas, tomatoes, oranges, cantaloupe, spinach, peas, apricots, fat-free or low-fat milk, and raisins. Consider a food as a whole, not just one aspect of it. For example, potatoes are high in potassium, but they are also high in carbohydrates that rapidly digest. The recommended dietary intake of potassium for adolescents aged 9 to 13 is 4.5 g per day.

Learning Check

- T/F Potassium can help lower blood pressure.
- What would happen to your heartbeats if you did not have enough potassium?

Sodium

Effects on Cardiovascular System

About 97 percent of adolescents consume too much salt. This high salt consumption while they are young puts youth at greater risk for developing cardiovascular disease when they are older. One way salt can harm your heart is by keeping excess fluid in your body.

To understand how salt makes the body keep excess body fluid, you must understand the concept of osmosis. Osmosis describes the movement of water. Water moves from areas of lower concentration to areas of higher concentration, meaning areas that have more molecules such as salt. This is because your body does not want any area to contain too many molecules in comparison to water, so it tries to balance out the concentration of salt by sending more water to where the salt is.

This movement of water can be compared to two rooms containing students and cupcakes. The students are the water molecules and the cupcakes are salt. All the students are in a room with only five cupcakes, but the adjacent room has 20 cupcakes. The students (water) are going to move to the area that contains more cupcakes (salt molecules) to balance out the proportion of students to cupcakes. When water moves to areas with more salt, less water is excreted as urine because your body tries to hold onto more water so it can dilute the abundance of salt now in your body. This means your body is holding onto more water, which makes it harder on your heart because it must work harder to distribute blood throughout the body. Excess water in your body can also increase your blood pressure, which, as already discussed, puts more strain on your heart and can lead to heart disease.

Foods Containing Sodium

Sodium is extremely prevalent in your everyday diets. Many foods that seem healthy may actually be high in sodium content. Foods high in sodium include breads, cold cuts or cured meats, pizza, soups, cheeseburgers, cheese, pasta, chips, pretzels, and popcorn. Processed foods tend to be very high in sodium, so you should try to incorporate more fresh fruits and vegetables into your diet. In addition, try not to add table salt to your food.

Study the nutrition facts labels on food to compare the sodium content. People should try to limit sodium intake to less than 2,300 mg per day, and some people with additional risk factors such as high blood pressure and diabetes should limit sodium intake to less than 1,500 mg per day. Pay attention to how much salt you are consuming so excessive salt consumption does not lead to cardiovascular problems later in life.

Learning Check

- T/F Most Americans do not get enough sodium in their diets.
- What are three foods high in sodium?

Healthy Snacks

- Raisins
- Bananas
- Olives
- Walnuts
- Whole-grain, low-sodium crackers

References

A Primer on Potassium. (2015). *American Heart Association.* Retrieved from http://sodiumbreakup.heart.org/sodium-411/what-about-potassium/

Centers for Disease Control and Prevention. (2014, February 7). Where's the sodium? *CDC Vital Signs.* Retrieved from http://www.cdc.gov/vitalsigns/Sodium/

Cire, B., Contie, V., Defibaugh, A., Ewsichek, B., & Wein, H. (December 2011). Weighing in on dietary fats: Some fats are healthier than others. *NIH News in Health.* Retrieved from http://newsinhealth.nih.gov/issue/dec2011/feature1

Hoehn, K., & Marieb, E. N. (2010). *Human anatomy & physiology* (8th ed.). San Francisco, CA: Pearson Education, Inc.

Institute for Quality and Efficiency in Health Care. (2010, March 10). How does the blood circulatory system work? Retrieved from http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0047056/

Know your fats. (2012, December 10). *American Heart Association.* Retrieved from http://www.heart.org/HEARTORG/Conditions/Cholesterol/PreventionTreatmentofHighCholesterol/Know-Your-Fats_UCM_305628_Article.jsp

National Institutes of Health. (2013a, November 4). Magnesium: Fact sheet for health professionals. *Office of Dietary Supplements.* Retrieved from http://ods.od.nih.gov/factsheets/Magnesium-HealthProfessional/

Sandmaier, M. (2005). *Your guide to a healthy heart* [PDF document]. Retrieved 12/30, 2013, from http://www.nhlbi.nih.gov/health/public/heart/other/your_guide/healthyheart.pdf

Shifting the balance of sodium and potassium in your diet. (n.d.) *Harvard School of Public Health.* Retrieved from http://www.hsph.harvard.edu/nutritionsource/sodium-potassium-balance/

Sodium (Salt or Sodium Chloride). (2014, February 7). *American Heart Assosication.* Retrieved from http://www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/HealthyDietGoals/Sodium-Salt-or-Sodium-Chloride_UCM_303290_Article.jsp

Chapter 2
Respiratory System

Important Words

Alveoli: The sac-like structures in the lungs where oxygen and carbon dioxide move between the air you breathe and your blood.

DNA: The genetic codes for the structure and function of all parts of the body.

Heme iron: Iron that comes from animal products and is better absorbed and used in the body.

Hemoglobin: The part of red blood cells that carries oxygen to all the tissues of the body.

Non-heme iron: Iron that comes from plant sources and is not absorbed and used as well in the body.

General Overview

The respiratory system is made up of a series of tube-like pathways that lead to small sac-like structures in the lungs. These sac-like structures, called alveoli, are where the oxygen from the air you breathe enters your blood circulation, and the carbon dioxide that results from processes in the body enters the sacs, so it can then be exhaled from the body. The oxygen taken in from the air you breathe is important in the process of making ATP, which is the molecule your body uses for energy. Without enough oxygen, your tissues and organs that need ATP would not be able to function properly. In addition, the carbon dioxide produced by the body must be exhaled from the body so it does not accumulate and cause problems.

Adipose tissue is "fat" tissue. The cells that make up this tissue secrete molecules that attract immune system cells that cause inflammation. Increased inflammation, as well as the extra fatty adipose tissue, can push on the airways and make them narrower. As a result, breathing becomes more difficult and asthma symptoms can develop or worsen. It can be compared to the difference between drinking a milkshake through a small straw and a large straw. When the straw (airway) is narrower, it is more difficult to take in more of the milkshake (air) in one breath. In addition, obesity can also reduce the volume of air the lungs can take in because the tissue presses on the lungs, limiting how much they can expand.

Similarly, extra fatty tissue in the body can make it harder for you to breathe because it can restrict the air pathway into and out of the lungs. When your airways are narrower, it makes it more difficult to breathe, and less oxygen and nutrients are being delivered to all your tissues and organs. Maintaining a healthy weight means you can breathe easier.

Learning Check

- T/F A main function of the respiratory system is to take in carbon dioxide for the body to use.
- Oxygen is important for making _____.

  a. Adipose tissue
  b. ATP
  c. Alveoli
  d. Carbon dioxide

- What would happen if you did not have enough oxygen?

Folate

Effects on Respiratory System

Folate is needed for DNA processes that allow cells to properly divide. Without adequate folate in the diet, this process cannot properly be carried out, which can result in a decrease in the number of red blood cells present. In addition, those present are larger and have additional parts to the cell. Red blood cells carry oxygen to all the tissues in the body. This smaller number of red blood cells accompanied by the fact that they are abnormally sized and shaped makes it harder for the body to deliver adequate amounts of oxygen to all the parts of the body.

Foods Containing Folate

Since 1998, U.S. manufacturers have been required to add folic acid (a form of folate) to many grain products including breads, cereals, and pastas. As a result, grain products are often large contributors of Americans' folate intake. Other rich sources of folate are dark green leafy vegetables, fruits, nuts, spinach, asparagus, and seafood.

Learning Check

- Not having enough folate in your diet can decrease the number _____ cells in the body.
- What nutrient is commonly added to grain products?

Iron

Effects on the Respiratory System

Iron is found in hemoglobin in red blood cells and in myoglobin, which is in muscle cells. Hemoglobin is made up of four iron molecules. These iron molecules are what bind the oxygen to the red blood cells to be transported to all your tissues throughout the body. If your body does not have enough iron, there will be less iron available to help with the transportation of oxygen. When your tissues do not get enough oxygen, they cannot make as much ATP to use for energy to carry out their normal functions. As a result, you can experience symptoms such as feeling tired, weak, and dizzy.

The need for iron in the body can increase during times of growth and blood loss (menstruation), making it especially important for adolescents. Women are at an increased risk for developing iron deficiency anemia because of blood loss from the menstrual cycle.

Foods Containing Iron

Foods high in iron include green leafy vegetables, lean red meat, fish, dried fruits, and iron-fortified breads and cereal. Some people's bodies do not absorb iron as well, so this could lead to iron deficiency even if they are consuming adequate amounts. Decreased absorption can be a result of not consuming enough foods that are good sources of heme iron (iron from red meat, poultry, and fish). Heme iron is better absorbed than non-heme iron. Vegetarians must be especially careful of this because iron from plants is non-heme iron, and thus, is not absorbed as well. Non-meat sources of iron include iron-fortified cereals, cooked dry beans and peas, and spinach.

Learning Check

- Iron is important for making what molecule?
- What molecule does iron bind to that is important for making ATP?
- Heme/non-heme iron is absorbed better in the body.
- Name two groups of people who are at an increased risk of not getting enough iron.

Vitamin C

Effects on the Respiratory System

Vitamin C also has an important role in the proper function of your respiratory system. Because vitamin C helps with iron absorption, consume iron-rich foods with vitamin C-rich foods. Vitamin C is important in increasing the amount of non-heme iron that is absorbed. Iron can be found in the body in two different forms, Fe^{2+} or Fe^{3+}. However, only the Fe^{2+} form can be taken up to be used in the body. In order to change Fe^{3+} to Fe^{2+} an enzyme is used. Vitamin C is needed by the enzyme to carry out this conversion of Fe^{3+} to Fe^{2+}, which means that vitamin C can help increase the amount of iron that is ultimately absorbed to be used in the body. As a result, consuming foods with vitamin C along with non-heme iron helps your body absorb and use more of the iron you consume.

Foods Containing Vitamin C

Vitamin C can be found in fruits and vegetables. Foods especially high in vitamin C are red and green peppers, tomatoes, broccoli, green vegetables, and citrus foods.

Learning Check

- Vitamin C increases the absorption of what nutrient?
- Name three foods high in vitamin C.

Copper

Effects on the Respiratory System

Similarly to vitamin C, copper is important in the absorption of iron. As you have learned, vitamin C is important in converting Fe^{3+} to Fe^{2+} so it can be taken into the body. However, once iron is in the body, it must be converted back to the Fe^{3+} form to be able to bind to the molecule that transports it throughout the body. Copper is used in this process, which means that if you do not have enough copper in your diet, you will not be able to use the iron you consume. As you know, iron is important in red blood cells that deliver oxygen to all parts of the body. Without copper, you might not have enough iron in your body to be able to deliver the oxygen.

Foods Containing Copper

Foods that are good sources of copper include whole grains, nuts, beans, dark leafy greens, dried fruits, and potatoes. Shellfish are also good sources of copper.

Learning Check

- What two nutrients are important for the absorption of iron?

Healthy Snacks

- Oranges
- Fruit with low-fat yogurt
- Mixed nuts
- Peppers

References

Centers for Disease Control and Prevention. (23 February 2011). Iron and Iron Deficiency. *Nutrition for Everyone.* Retrieved from http://www.cdc.gov/nutrition/everyone/basics/vitamins/iron.html

Lindshield, B. L. Kansas State University Human Nutrition (HN 400) Flexbook. goo.gl/vOAnR

Medline Plus. (2014a, February 26). *Copper in diet.* Retrieved 5/5/14 from http://www.nlm.nih.gov/medlineplus/ency/article/002419.htm

Medline Plus. (2014b, March 18). *Vitamin C.* Retrieved 4/30/14 from http://www.nlm.nih.gov/medlineplus/vitaminc.html

National Institutes of Health. (2011, September). Your guide to anemia. *National Heart, Lung, and Blood Institute.* Retrieved 4/23/14 from http://www.nhlbi.nih.gov/health/public/blood/anemia-yg.pdf

National Institutes of Health. (2012, December 14). Folate: Dietary supplement fact sheet. *Office of Dietary Supplements.* Retrieved from http://ods.od.nih.gov/factsheets/Folate-HealthProfessional/

National Institutes of Health. (2013b, April 29). *Iron.* Retrieved 4/23/14 from http://www.nlm.nih.gov/medlineplus/druginfo/natural/912.html

Office of Women's Health. (2012, July 16). *Anemia fact sheet.* Retrieved 4/25/14 from http://www.womenshealth.gov/publications/our-publications/fact-sheet/anemia.html

Sideleva, O. and Dixon, A.E. (2014). The Many Faces of Asthma in Obesity. J. Cell. Biochem., 115: 421–426. doi: 10.1002/jcb.24678

Sutherland, E. (2014, February 12). Linking obesity and asthma. *Annals of the New York Academy of Science*. doi: 10.1111/nyas.12357

Chapter 3
Digestive System

Important Words

Complementary proteins: Foods that individually do not contain all the essential amino acids, but when eaten together, include the essential amino acids.

Essential amino acids: The building blocks of proteins the body cannot make, so you must eat foods containing them.

Insoluble fiber: Fiber that adds more substance to your stool, which makes your stool move through your large intestines more quickly.

Nonessential amino acids: The building blocks of proteins the body can make itself, so you do not need to eat foods containing them.

Soluble fiber: Fiber that makes food move more slowly through the digestive system so you feel full longer.

General Overview

The digestive system is responsible for how your body takes in and breaks down the food you eat so it can be absorbed and used in your body. The food you eat is either stored or used for energy to carry out different bodily functions, from standing up to breathing. Food travels from your mouth through a tube called the esophagus to the stomach. From there it travels through the small and large intestines, where it then makes its way out of the body. The majority of nutrients are absorbed into your body through the small intestines. Many digestive enzymes (chemicals that help break down food components) are mixed with your food as it travels through the digestive system. These enzymes, along with the physical mixing the organs such as the stomach and intestines provide, help break the food down into its simplest components, which can then be absorbed and used in the body. Once they are absorbed into the body, they are either stored for later use or used in metabolic processes to provide your body with the energy necessary to carry out your daily lives.

Learning Check

- The majority of nutrients are absorbed in the _____.

  a. esophagus
  b. small intestines
  c. stomach
  d. large intestines

Fiber

Effects on the Digestive System

Fiber is a carbohydrate compound found in plants and cannot be digested. There are both soluble and insoluble forms of fiber. Soluble fiber causes the food to move more slowly from the stomach to the small intestines. This can help make you feel full longer because your food is moving more slowly through your digestive tract. Insoluble fiber is important because it adds bulk to your stool in the large intestines. This added bulk pushes on the walls of the intestines, which makes the waste move through them more quickly. As a result, less of the water is reabsorbed into the body, so your stools are softer, and you do not become constipated. It can also prevent digestive system problems later because it decreases the amount of time that the waste is in contact with the intestinal walls. This means that possibly toxic compounds that could cause different diseases are not touching your intestinal walls for as long.

Foods Containing Fiber

Fiber is only found in plant products. Fruits, vegetables, and whole-grain foods are good sources of fiber. Good sources of insoluble fiber include whole-wheat pasta, brown rice, bran breakfast cereal, carrots, and cucumbers. Good sources of soluble fiber are apples, pears, oatmeal, and beans.

Learning Check

- T/F Fiber is found in animal products
- Fiber can help prevent you from becoming _____.

B Vitamins

Effects on the Digestive System

The B vitamins are a group of several different vitamins that can be dissolved in water. Many of these vitamins are important in the digestive system. Two examples are vitamin B3, also called niacin, and vitamin B2, also called riboflavin. Both of these vitamins are important in making cofactors. Cofactors help enzymes (compounds that your body needs to make reactions occur in the body) carry out their functions. Niacin makes the cofactor nicotinamide adenine dinucleotide (NAD), and riboflavin makes the cofactor flavin adenine dinucleotide (FAD). Both of these are important in the process of making the ATP that the human body uses for energy. During the process of making ATP (called cellular respiration), both NAD and FAD gain hydrogen ions to become NADH and FADH2. They then go to what is called an electron transport chain. In the electron transport chain, they lose their hydrogen ions. The difference between the number of hydrogen ions inside versus outside the cell creates what is called a gradient. When the hydrogen ions move down the gradient, it provides the energy needed to make ATP. Without ATP, your body would not have the energy needed to carry out any of its functions — from throwing a ball, to keeping the heart beating.

Foods Containing B Vitamins

Both niacin and riboflavin are added to flour in the United States. This process is called enrichment, and the flour is called "enriched wheat flour." Riboflavin is not stored in the body, so people must get it from the foods they eat. Riboflavin can be found in whole grains as well as dark green vegetables such as spinach, asparagus, and broccoli. In addition to being added to grains, niacin can also be found in red meats, poultry, and fish.

Learning Check

- What are two vitamins added to flour in the United States?
- What are two cofactors that help make the ATP needed for energy?

Carbohydrates

Effects on the Digestive System

The body does not store many extra carbohydrates because they are what the body prefers to use for energy. Carbohydrates can be broken down into different categories: simple and complex carbohydrates. Simple carbohydrates consist of monosaccharides (one sugar unit) and disaccharides (two sugar units). Complex carbohydrates are called polysaccharides because they consist of many simple sugar units put together. In order to be used for energy, complex carbohydrates and disaccharides must be broken down into the monosaccharides that make them. Glucose is the monosaccharide the body likes to use for energy. Glucose enters a chemical reaction pathway called glycolysis that begins the pathway to make the ATP that the body uses for energy.

Foods Containing Carbohydrates

Simple sugars can be found naturally in foods such as fruits and vegetables. Complex carbohydrates can be found in grain products as well as certain vegetables such as potatoes and corn. When choosing grain products, eat mostly whole grains. This is because whole grains include all the important nutrients found in the grain. Refined grains mean that part of the grain has been removed during processing, so it does not contain all the important nutrients found in whole-grain products. Enriched grains mean that some, but not necessarily all, of the nutrients removed during processing have been added back into the final product. Foods that have a lot of natural sugars can be good for you, such as fruits and vegetables. However, be careful of foods that have a lot of added sugars, which provide extra calories without many nutritional benefits. Typically, the first five ingredients on a nutrition fact label are the ingredients making up the most of the food. When looking at nutrition labels, try to avoid consuming foods that are high in added sugars, such as corn syrup, high fructose corn syrup, sucrose, dextrose, and molasses.

Learning Check

- What are the two categories of carbohydrates?
- Which type of grain contains all of the important nutrients found in grain products?

  a. Refined grains
  b. Whole grains
  c. Enriched grains
  d. Added sugars

Protein

Effects on Digestive System

Proteins also are made up of smaller units called amino acids. There are 20 amino acids found in the human body. Amino acids can be divided into two categories: essential and nonessential. Essential amino acids are those that your body cannot make on its own, so you must get them from the food you eat. Nonessential amino acids, on the other hand, can be made in your body, so you do not necessarily have to eat foods containing them. There are 9 essential amino acids and 11 non-essential amino acids. Proteins are important for many different functions in the body, including the formation of enzymes. As you have learned, enzymes are compounds allowing reactions to occur in the body. Certain enzymes are important in breaking down the food in your digestive system so your body can use the nutrients. Some of these enzymes include amylase, which breaks down carbohydrates, and lipase, which breaks down fats. You need to eat foods containing the essential amino acids so these enzymes can be made and continue to break down the food you eat to get the nutrients you need to keep your body functioning.

Foods Containing Protein

When a food contains all nine essential amino acids, it is called a complete protein. Proteins from animals — such as meat, poultry, fish, and dairy products — are complete proteins. To decrease the amount of fat you eat with your high-protein foods, choose low-fat or lean options when choosing meats, poultry, and dairy products.

It is still possible to get all of the essential amino acids without eating meat. This is done by eating what are called complementary proteins. Complementary proteins are foods that may not contain all the essential amino acids on their own, but together they contain all of them. For example, if one food does not have the amino acid lysine but it does have valine, and another food has lysine but it does not have valine, then they would be called complementary because together they have all the essential amino acids. An example of complementary proteins is rice and dry beans. Each of these foods is lacking some of the essential amino acids, but between both of them they contain all the essential amino acids. Other examples of complementary proteins include peanut butter sandwiches on whole-grain bread, yogurt with nuts, bean tacos, hummus on pita bread, bean soup with bread, and whole-grain cereal with milk.

Learning Check

- T/F All 20 amino acids must come from the foods that you eat.
- What does the enzyme amylase break down?
- Match the following foods to make complementary proteins:

Dry beans	Peanut butter
Whole grain bread	Beans
Taco shells	Rice
Hummus	Whole grain cereal
Yogurt	Pita bread
Milk	Nuts

Healthy Snacks

- Apples with peanut butter
- Low-fat yogurt with nuts
- Carrots with low-fat ranch dip
- Hummus with pita chips

References

"Amino acids." Jane Spehar, Teresa G. Odle, and David Edward Newton, Ed.D. The Gale Encyclopedia of Alternative Medicine. Ed. Laurie Fundukian. 3rd ed. Detroit: Gale, 2009. 4 vols.

Boutin, D. & Guzman, S. (1 May, 2011). What are complementary proteins, and how do we get them? *Bastyr University.* Retrieved from http://www.bastyr.edu/news/health-tips/2011/09/what-are-complementary-proteins-and-how-do-we-get-them

Centers for Disease Control and Prevention (4 October, 2012). Protein. *Nutrition for Everyone.* Retrieved from http://www.cdc.gov/nutrition/everyone/basics/protein.html

Gale Encyclopedia of Diets, 2nd ed., Detroit: Gale, 2013a, pp. 419-422.

Gale Encyclopedia of Diets, 2nd ed., Detroit: Gale, 2013b, pp. 817-821.

Gale Encyclopedia of Diets, 2nd ed., Detroit: Gale, 2013c, pp. 962-965.

Girlshealth. (2014, January 13). *Carbohydrates.* Retrieved 9/5, 2014, from http://www.girlshealth.gov/nutrition/basics/carbs.html

Lindshield, B. L. Kansas State University Human Nutrition (HN 400) Flexbook. goo.gl/vOAnR

Chapter 4
Musculoskeletal System

Important Words

Amino acids: The building blocks of proteins.

Fortified foods: Foods containing certain nutrients not naturally found in them.

Osteoblasts: Cells that build bones.

Osteoclasts: Cells that break down bones.

Osteoporosis: A disease in which the bones become weak and more likely to break.

Secrete: Release molecules into the blood.

Skeletal muscles: Muscles attached to your bones that help you move (example: arm and leg muscles).

General Overview — Muscles

Muscles are what allow your body to move. Skeletal muscles are called voluntary muscles because you can control their movement. For your muscles to contract, sodium and calcium must enter your muscle cell. The calcium moves a protein that then allows your muscle to contract.

General Overview — Bones

Bones are made of calcium and phosphate. As bones are being formed, cells called osteoblasts secrete the minerals calcium and phosphorus to make up the bone. Bones are constantly breaking down old minerals and secreting new minerals. This is also how bones can heal themselves if broken.

Bones are important for providing support and protection for your body. Muscles attach to bones, which allows for body movement. Bones also contain bone marrow, which produces the cells found in blood.

Calcium

Effects on the Musculoskeletal System

As already touched on, calcium plays an important role in the function of both your muscles and your bones. Bones store calcium in them. They regulate the amount of calcium circulating in the blood by either taking calcium from the blood to put into bone or breaking down some of the calcium in bone to release into the blood. The calcium supply in blood must be kept at an appropriate level because calcium is important for muscle contractions.

Calcium plays a major role in allowing your muscles to move. Calcium binds to a protein, which then allows interactions to occur that cause the muscles to contract. Too much or too little calcium can lead to problems with this interaction and affect the ability of your muscles to contract.

It is important to take in enough calcium while your bones are growing. Bones are constantly remodeling, or releasing calcium into the blood and putting down new calcium in the bones. However, once you are about age 30, your bones release more calcium than they put down. This is what can lead to problems with bones later in life such as hip fractures or osteoporosis. As a result, you need to eat foods high in calcium while you are young and still growing.

Foods Containing Calcium

The ability of the body to absorb calcium varies among different foods. Just because a food contains a lot of calcium does not necessarily mean your body can absorb and use the calcium in the food. Typically, when people think of calcium, they think of dairy products. It is true that dairy products such as milk, cheese, and yogurt can be good sources of calcium. But the dairy products you eat must be rich in other good nutrients and low in certain nutrients such as fat or added sugars. Some examples of nondairy sources of calcium are fortified orange juice, turnip greens, mustard greens, kale, cabbage, almonds, soy products, broccoli, and white beans.

Learning Check

- T/F Once your bones are fully grown, they never change.
- T/F Dairy products are the only way you can get calcium in your diet.

Protein

Effects on the Musculoskeletal System

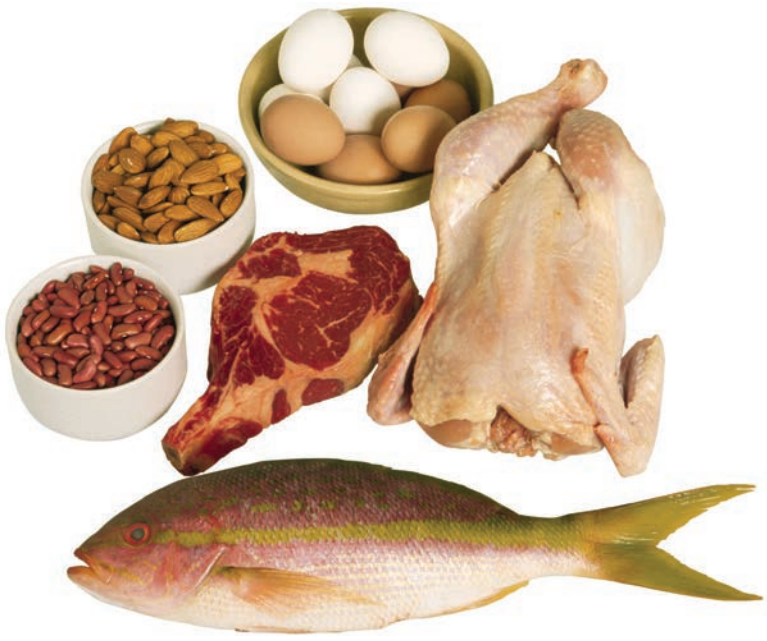
Proteins are used for various processes in the body. Muscles contain almost 40 percent of the protein found in your body. Two important proteins found in your muscles are actin and myosin. As explained in the calcium section, calcium binds to a protein that then allows muscle contraction to occur. The protein calcium binds to, troponin, then moves and allows actin and myosin to interact. The interaction of actin and myosin is what allows muscles to contract.

Foods Containing Protein

Consuming protein in the diet along with exercise is what helps muscles gain more muscle mass. Lean meats, poultry, and fish are all good sources of protein. In addition, there are other good sources of protein. Beans, nuts, seeds, and low-fat dairy products also are sources of protein. As discussed in the digestive system lesson, many non-meat sources of protein do not contain all the amino acids the body needs to function, but when you eat certain protein sources together, called complementary proteins, they can provide all the amino acids the body needs.

✓ Learning Check

- T/F Meats are the only sources of protein.
- A large portion of the protein in the body can be found in _____.



Phosphorus

Effects on the Musculoskeletal System

Along with calcium, phosphorus is the other mineral component of bones. Approximately 85 percent of the phosphorus in your body is found in your bones and teeth. Phosphorus combines with calcium to make a structure called hydroxyapatite, which is what makes up bones. Both calcium and phosphorus are especially important for youth because their bones are still forming. Without enough phosphorus, the bones will become weaker and softer.

Phosphorus is also important in making phospholipids, which make the cell membranes in the body. The cell membranes are what keep all the parts of the cell contained and organized. Cells make up all parts of the body, including bones and muscles. The structure of cells must be contained and organized so they can properly carry out their various functions.

Foods Containing Phosphorus

Good sources of phosphorus include animal products such as dairy products, meat, and fish. Phosphorus can also be found in plant products such as beans, peas, and nuts. However, phosphorus is stored in plants in a form called phytate, and humans do not have the enzyme needed to break down and use this form of phosphorus. As a result, humans are not able to use very much of the phosphorus they get from plant sources.

✓ Learning Check

- 85 percent of phosphorus in the human body is found in bones and _____.
- Humans can use the phosphorus found in animal/plant sources better.

Vitamin D

Effects on the Musculoskeletal System

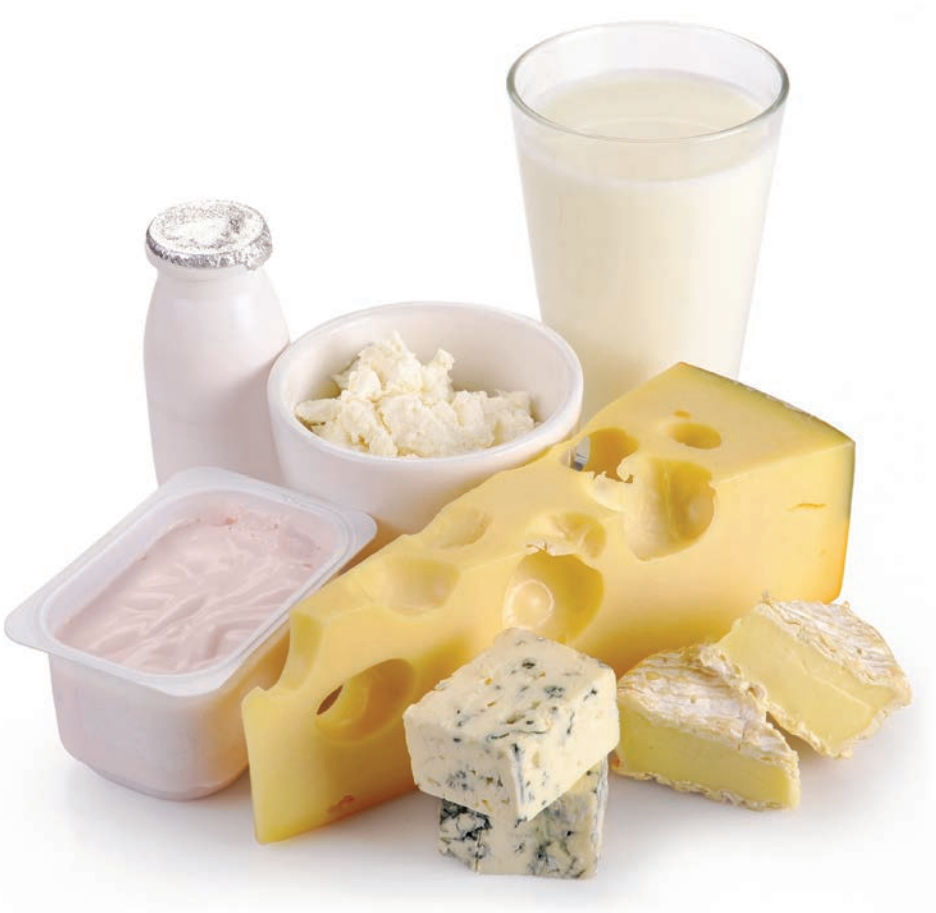
Vitamin D has many important functions, including increasing the absorption of calcium and regulating its levels in the blood and bones. Your body needs vitamin D to help you absorb the calcium in the foods you eat. Without adequate vitamin D, your body will not absorb calcium to build up your bones. Vitamin D also plays an important role in regulating the amount of calcium in your blood. If you do not have enough calcium in your blood, vitamin D tells cells called osteoclasts to break down the calcium in your bones so it can be released into the blood. You need to get enough calcium and vitamin D so this does not happen. Taking calcium out of the bone and putting it into the blood can make bones weaker.

Foods Containing Vitamin D

Vitamin D is unique in that your body can make it to a certain degree. However, this does not mean you do not need to eat foods that have it because there are many factors, such as the season and where you live, that limit the amount of vitamin D your body can make. In addition, since the sun helps your body make vitamin D, and too much sun exposure can lead to skin problems such as skin cancer, you should get a significant amount of vitamin D from the foods you eat and not just from the sun. Fatty fish such as salmon and tuna are the major sources of vitamin D found naturally in foods. Many other foods are fortified with vitamin D (vitamin D is added to them) including milk, orange juice, and some breakfast cereals.

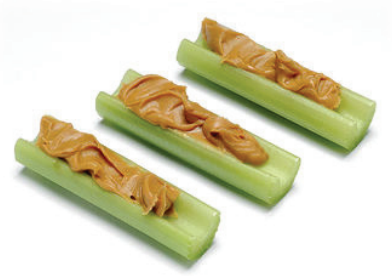
Learning Check

- Vitamin D helps us absorb _____.
- T/F We do not need to eat any foods with vitamin D because our bodies can make it.



Healthy Snacks

- Low-fat cheese
- Low-fat yogurt with fresh fruit and almonds
- Low-fat milk and non-sugary cereal
- Peanut butter and celery



References

Delage, B. (June 2014). Phosphorus. *Linus Pauling Institute.* Retrieved from http://lpi.oregonstate.edu/infocenter/minerals/phosphorus/

DeLuca, H. F. (December 2004). Overview of general physiologic features and functions of Vitamin D1,2,3,4. *The American Journal of Clinical Nutrition, vol. 80 no. 6.* Retrieved from http://ajcn.nutrition.org/content/80/6/1689S.full

Gale Encyclopedia of Nursing and Allied Health, 3rd ed., Detroit: Gale, 2013, pp. 527-528.

Hoehn, K., & Marieb, E. N. (2010). *Human anatomy & physiology* (8th ed.). San Francisco, CA: Pearson Education, Inc.

Lindshield, B. L. Kansas State University Human Nutrition (HN 400) Flexbook. goo.gl/vOAnR

Medline Plus. (2013b, April 30). *Protein in diet.* Retrieved from http://www.nlm.nih.gov/medlineplus/ency/article/002467.htm

Penido, M. G., M., G., & Alon, U. S. (2012). Phosphate homeostasis and its role in bone health. *Pediatric Nephrology, 27*(11), 2039-48. doi:http://dx.doi.org/10.1007/s00467-012-2175-z

"Protein metabolism and exercise." Daniel M. Cohen, PhD. The Gale Encyclopedia of Fitness, Ed. Jacqueline L. Longe. Detroit: Gale, 2012. 2 vols.

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