Chapter 6: Proteins and Amino Acids
Objectives for Chapter 6

- Explain what proteins are and why they are important.
- Describe how your body digests and absorbs proteins.
- Determine your daily protein needs
- Identify healthy sources of protein in the diet.
- Explain the health consequences of consuming too little or too much protein.
- Describe the benefits and risks of a vegetarian diet.
What Are Proteins and Why Are They Important?

• **Proteins** are the predominant structural and functional materials in every cell
  • Contain carbon, hydrogen, oxygen (like carbohydrates and fats)
  • Also contain nitrogen
  • Each amino acid has:
    • Acid group (COOH)
    • Amine group (NH$_2$)
    • Side chain (unique)
  • All proteins consist of a chain of some combination of 20 unique **amino acids**
The Structure of an Amino Acid

**Figure 6.1**

**a Amino acid structure.** All amino acids contain carbon, hydrogen, and oxygen, similar to carbohydrates and fats. They also contain a nitrogen-containing amine group and an acid group.

**b Different amino acids showing their unique side chains.** A unique side chain (shown in yellow) distinguishes the various amino acids.
The Making of a Protein

Figure 6.2

- Amino acids are joined together by peptide bonds in specific sequences to form proteins. This shows part of the sequence of the protein hemoglobin.

- The attractions and interactions between the amino acids cause the protein to spiral, bend, and curl.

- The protein folds into a precise three-dimensional shape.

- Some proteins, such as hemoglobin, consist of several separate protein chains linked together. The shape of the protein determines its function.
The Building Blocks of Proteins
Essential, Nonessential, and Conditional Amino Acids

• Nine essential amino acids
  • Cannot be made by the body
  • It is "essential" to obtain them from the diet
• Eleven nonessential amino acids
  • Can be synthesized in the body from other amino acids or by adding nitrogen to carbon-containing structures
• Conditionally essential amino acids
  • Under certain conditions, some nonessential amino acids cannot be synthesized and must be consumed in the diet
Table 6.1 The Mighty Twenty

<table>
<thead>
<tr>
<th>Essential Amino Acids</th>
<th>Nonessential Amino Acids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine (His)(^a)</td>
<td>Alanine (Ala)</td>
</tr>
<tr>
<td>Isoleucine (Ile)</td>
<td>Arginine (Arg)(^b)</td>
</tr>
<tr>
<td>Leucine (Leu)</td>
<td>Aspartic acid (Asp)</td>
</tr>
<tr>
<td>Lysine (Lys)</td>
<td>Asparagine (Asn)</td>
</tr>
<tr>
<td>Methionine (Met)</td>
<td>Cysteine (Cys)(^b)</td>
</tr>
<tr>
<td>Phenylalanine (Phe)</td>
<td>Glutamic acid (Glu)</td>
</tr>
<tr>
<td>Threonine (Thr)</td>
<td>Glutamine (Gln)(^b)</td>
</tr>
<tr>
<td>Tryptophan (Trp)</td>
<td>Glycine (Gly)(^b)</td>
</tr>
<tr>
<td>Valine (Val)</td>
<td>Proline (Pro)(^b)</td>
</tr>
<tr>
<td></td>
<td>Serine (Ser)</td>
</tr>
<tr>
<td></td>
<td>Tyrosine (Tyr)(^b)</td>
</tr>
</tbody>
</table>

\(^a\)Histidine was once thought to be essential only for infants. It is now known that small amounts are also needed for adults.

\(^b\)These amino acids can be “conditionally essential” if there are either inadequate precursors or inadequate enzymes available to create them in the body. This can happen in certain illnesses and in premature infants.
Denaturation of Proteins Changes Their Shape

- **Denaturation**: the alteration (unfolding) of a protein's shape, which changes the structure and function of the protein
  - Examples: cooking meat, eggs changing texture
  - Stomach acid untangles proteins to aid in digestion
Denaturing a Protein

Heat → Normal protein → Denatured protein
What Happens to the Protein You Eat?

• Dietary proteins are digested and absorbed in stomach and small intestine
  • Stomach acids denature protein and activate pepsin, which breaks down protein into shorter polypeptides
  • In the small intestine, polypeptides are broken down into tripeptides, dipeptides, and amino acids
  • Amino acids enter blood and travel to liver
Protein digestion begins in the stomach with the aid of hydrochloric acid (HCl) and the enzyme pepsin. Other enzymes continue the digestion in the small intestine, breaking the protein down to single amino acids that are absorbed into the bloodstream.

**ORGANS OF THE GI TRACT**

**MOUTH**
Mechanical digestion of protein begins with chewing, mixing food with saliva, and forming a bolus.

**STOMACH**
- Hydrochloric acid denatures protein and activates pepsinogen to form pepsin.
- Pepsin breaks the polypeptide chain into smaller polypeptides.

**SMALL INTESTINE**
- Enzymes continue to cleave peptide bonds, resulting in dipeptides, tripeptides, and single amino acids.
- Enzymes in the lining of the small intestine finish the digestion to yield single amino acids, which can then be absorbed into the bloodstream and travel through the portal vein to the liver.

**ACCESSORY ORGANS**

**PANCREAS**
- Produces enzymes that are released into the small intestine via the pancreatic duct.

**LIVER**
- Uses some amino acids to make new proteins or converts them to glucose. Most amino acids pass through the liver and return to the blood to be picked up and used by body cells.
Your Body Degrades and Synthesizes Proteins

• Amino acids come from:
  • Diet
  • Breakdown of proteins in the body
  • A limited supply is stored in amino acid pools in blood and cells for needed protein synthesis

• Protein turnover: process of continuous breakdown and synthesis of protein from its amino acids
The Fate of Amino Acids in Your Body

**Dietary protein**
- The foods that you eat contain both essential and nonessential amino acids.

**Amino acid “pool”**
- A limited supply of all the amino acids exists in amino acid pools in your blood and inside your cells; this supply is used to create proteins.

**Protein turnover**
- Some amino acids in the pools are used to make nonprotein products, such as some hormones.
- Protein turnover involves the degradation (breaking down) of protein and synthesis of its amino acids into new proteins.
- Amino acids are degraded and their nitrogen-containing amine groups are removed. The nitrogen generates ammonia (NH₃), which is converted to urea and excreted in urine. The carbon-containing remains are either used to make glucose or energy, or are stored as fat.
Amino acids can be used to make:
  • Body proteins
  • Non-protein substances
    • Examples: thyroid hormones, melanin

After amine groups are removed (converted to urea, excreted in urine), amino acids can also be:
  • Burned for energy
  • Stored as fat
  • Made into glucose
Protein Digestion
Protein Absorption
DNA Directs Synthesis of New Proteins

- DNA in the cell nucleus contains instructions for protein synthesis
- **Gene:** DNA segment that codes for specific protein
- Specialized RNA molecules carry out instructions for protein synthesis
  - **Messenger RNA (mRNA)** and **transfer RNA (tRNA)** perform very specific roles during protein synthesis
- When abnormalities occur during protein synthesis, serious medical conditions may result
  - Example: sickle-cell anemia
Protein Synthesis

1. Each strand of DNA holds the code to create specific proteins. Because the DNA can't leave the nucleus of the cell, a copy of the code, called messenger RNA (mRNA) is made.

2. The mRNA takes this information outside the nucleus and brings it to the ribosome.

3. The ribosome moves along the mRNA, reading the code.

4. Another type of RNA, called transfer RNA (tRNA), collects the specific amino acids that are needed to make the protein. There are 20 different tRNAs, one for each amino acid.

5. The tRNA brings the amino acid to the ribosome.

6. The ribosome then builds a chain of amino acids (the protein) in the proper sequence, based on the code in the mRNA.

7. The ribosome continues to move down the mRNA strand until all the appropriate amino acids are added and the protein is complete.

Protein synthesis is the process by which the DNA code within a cell’s nucleus directs the cell’s production of specific proteins.
Protein Synthesis, Continued

Protein Synthesis
How Does Your Body Use Proteins?

- Proteins provide structural and mechanical support and help maintain body tissues
  - **Collagen:** a ropelike, fibrous protein that is the most abundant protein in your body
  - **Connective tissue:** the most abundant tissue type in the body; made up primarily of collagen, it supports and connects body parts as well as providing protection and insulation
- Most enzymes and many hormones are composed of proteins
- Proteins help maintain fluid balance
An Enzyme in Action

1. A compound approaches a specific enzyme.
2. The compound binds to the enzyme.
3. The enzyme changes shape.
4. Two products are released and the enzyme is available for another reaction.
Edema
How Does Your Body Use Proteins?, Continued

• Proteins help maintain acid-base balance
  • **Buffers**: substances that help maintain the proper pH in a solution by attracting or donating hydrogen ions
• Proteins transport substances throughout the body
  • **Transport proteins** shuttle oxygen, waste products, lipids, some vitamins, and sodium and potassium through your blood and into and out of cells through cell membranes
• Proteins contribute to a healthy immune system
  • Specialized protein "soldiers" called **antibodies** eliminate potentially harmful substances
• Proteins can provide energy
• Protein improves satiety and appetite control
Proteins as Transport Channels

Figure 6.9
### The Many Roles of Proteins

**Table 6.2 The Many Roles of Proteins**

<table>
<thead>
<tr>
<th>Role of Proteins</th>
<th>How They Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide structural and mechanical support and maintenance</td>
<td>Proteins are your body’s building materials, providing strength and flexibility to your tissues, tendons, ligaments, muscles, organs, bones, nails, hair, and skin. Proteins are needed for the ongoing maintenance of your body.</td>
</tr>
<tr>
<td>2. Build enzymes and hormones</td>
<td>Proteins are needed to make most enzymes that speed up reactions in your body and many hormones that direct specific activities, such as regulating your blood glucose level.</td>
</tr>
<tr>
<td>3. Maintain fluid balance</td>
<td>Proteins play a major role in ensuring that your body fluids are evenly dispersed in your blood and inside and outside your cells.</td>
</tr>
<tr>
<td>4. Maintain acid-base balance</td>
<td>Proteins act as buffers to help keep the pH of your body fluids balanced within a tight range. A drop in pH will cause your body fluids to become too acidic, whereas a rise in pH can make them too basic.</td>
</tr>
<tr>
<td>5. Transport substances</td>
<td>Proteins shuttle substances such as oxygen, waste products, and nutrients through your blood and into and out of your cells.</td>
</tr>
<tr>
<td>6. Provide antibodies for the immune response</td>
<td>Proteins create specialized antibodies that attack pathogens in your body that can make you sick.</td>
</tr>
<tr>
<td>7. Provide energy</td>
<td>Because proteins provide 4 calories per gram, they can be used as fuel or energy in your body.</td>
</tr>
<tr>
<td>8. Improve satiety</td>
<td>Proteins increase satiety, which can help control your appetite and weight.</td>
</tr>
</tbody>
</table>
How Much Protein Do You Need?

- Healthy adults should be in **nitrogen balance**
  - Amount of nitrogen consumed (in dietary protein) = amount excreted (in urine)
- Nitrogen imbalances
  - **Positive nitrogen balance**: more nitrogen is retained (for protein synthesis) than is excreted
    - Examples: infants, children, pregnant women
  - **Negative nitrogen balance**: more nitrogen is excreted than consumed (body proteins broken down)
    - Examples: starvation, serious injury, or illness
Practical Nutrition Tips Video: Getting Nutrients

Getting the Nutrients You Need within Limitations

with Joan Salge Blake
Nitrogen Balance
Nitrogen Balance and Imbalance

- **Positive nitrogen balance (a)**: Pregnant women, growing children and adolescents, and some athletes tend to be in positive nitrogen balance.

- **Equilibrium (b)**: A healthy adult is typically in nitrogen equilibrium.

- **Negative nitrogen balance (c)**: An individual who is experiencing a medical trauma or not eating a healthy diet is often in negative nitrogen balance.
Not All Protein Is Created Equal

- **Protein quality** is determined by two factors:
  - The protein's **digestibility**
  - The protein's **amino acid profile**: the types and amounts of amino acids (essential, nonessential, or both) that the protein contains.

- **Complete proteins**: all essential amino acids, plus some nonessential amino acids
  - Sources: soy and animal protein

- **Incomplete proteins**: low in one or more essential amino acids
  - Sources: plant foods
Not All Protein Is Created Equal, Continued

- Plant proteins "upgraded" to complete proteins by:
  - Consuming modest amounts of soy or animal protein OR
  - Being complemented with other plant proteins that provide enough of the limiting amino acid
    - Complementary proteins do not need to be eaten in the same meal, only the same day

- **Protein Digestibility Corrected Amino Acid Score (PDCAAS)**
  - Measure of protein quality taking into account digestibility and amino acid profile
  - Basis of protein as percent Daily Value on food labels
You Can Determine Your Personal Protein Needs

- **Protein recommendations (DRI)**
  - 10 to 35 percent of total daily calories from protein
    - Average intake in the United States = 15 percent
  - 0.8 g of protein/kg of body weight needed daily

- **Calculating your daily protein needs**
  - Convert weight to pounds by dividing by 2.2 lb/kg:
    For example: 130 lb ÷ 2.2 = 59 kg
    59 kg x 0.8 g = 47 g of protein/day
### Table 6.3 Calculating Your Daily Protein Needs

<table>
<thead>
<tr>
<th>If You Are</th>
<th>You Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-18 years old</td>
<td>0.85 g/kg</td>
</tr>
<tr>
<td>≥19 years old</td>
<td>0.80 g/kg</td>
</tr>
</tbody>
</table>

To calculate your needs, first convert your body weight from pounds (lb) to kilograms (kg) by dividing by 2.2, like this:

Your weight in pounds: ________________  \( \text{lb} \div 22 = \) ________________ kg

Then, multiply your weight in kilograms by 0.8 or 0.85:

Your weight in kilograms: ________________  \( \text{kg} \times 0.8\text{g} = \) ________________ g/day

What Are the Best Food Sources of Protein?

• Some amount of protein is found in many foods, but it is particularly abundant in meat, fish, poultry, and meat alternatives such as dried beans, peanut butter, nuts, and soy
What Type of Proteins Are Americans Eating?

- **Red meat**: 1970s: 4.2 oz, 2010: 3.3 oz
- **Poultry**: 1970s: 1.2 oz, 2010: 2.4 oz
- **Fish**: 1970s: 0.2 oz, 2010: 0.3 oz

Figure 6.11
Food Sources of Protein

Figure 6.12
It's Easy to Meet Your Daily Protein Needs

<table>
<thead>
<tr>
<th>Food</th>
<th>Amount</th>
<th>Calories</th>
<th>Protein (g)</th>
<th>Vegetable Group (servings)</th>
<th>Fruit Group (servings)</th>
<th>Grain Group (servings)</th>
<th>Protein Group (oz)</th>
<th>Dairy Group (servings)</th>
<th>Oil Group (tsp)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bran flakes</td>
<td>2 cups</td>
<td>256</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Milk, nonfat</td>
<td>1 cup</td>
<td>83</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
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<tr>
<td>Orange juice</td>
<td>8 oz</td>
<td>117</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Turkey and cheese sandwich</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turkey breast</td>
<td>2 oz</td>
<td>69</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Cheese, low fat</td>
<td>2 oz</td>
<td>98</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Whole-wheat bread</td>
<td>2 slices</td>
<td>138</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Tossed salad</td>
<td>3 cups</td>
<td>66</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>Italian dressing</td>
<td>1 tbs</td>
<td>35</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td><strong>Snack</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yogurt, vanilla</td>
<td>8 oz</td>
<td>160</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Banana</td>
<td>1</td>
<td>105</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Dinner</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken breast, skinless</td>
<td>3 oz</td>
<td>144</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Brown rice</td>
<td>1 cup</td>
<td>218</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Broccoli, cooked</td>
<td>1 cup</td>
<td>27</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Margarine</td>
<td>2 tsp</td>
<td>67</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td>1,583</td>
<td>97</td>
<td>2.5</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: A 140-pound adult needs 51 g of protein daily. A 180-pound adult needs 65 g of protein daily.

Practical Nutrition Tips Video: Healthy Snacks

Healthy Snacks to Fuel Your Day

with Joan Salge Blake
Protein Supplements: Are They Necessary?

• Varied products promise many benefits, but not needed with adequate diet
• Protein shakes and powder
  • Made of whey, soy, or rice protein
  • May contain unwanted additives
• Amino acid supplements
  • Sold as remedies for various health issues
  • May have negative effects
• Protein and energy bars
  • Convenient, but expensive and high in calories
### Table 1 Bar Hopping

<table>
<thead>
<tr>
<th>Product</th>
<th>Price ($)</th>
<th>Calories</th>
<th>Protein (g)</th>
<th>Total Carb (g)</th>
<th>Total Fat (g)</th>
<th>Sat. Fat (g)</th>
<th>Sugar</th>
<th>Fiber (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut butter (1 tbs) on 2 slices whole-wheat bread</td>
<td>0.59</td>
<td>215</td>
<td>8.5</td>
<td>27</td>
<td>9</td>
<td>1.75</td>
<td>5%</td>
<td>5</td>
</tr>
<tr>
<td>Balance, Chocolate Craze</td>
<td>$1.29</td>
<td>200</td>
<td>14</td>
<td>21</td>
<td>7</td>
<td>4</td>
<td>14%</td>
<td>2</td>
</tr>
<tr>
<td>Zone Perfect, Chocolate Peanut Butter</td>
<td>$1.19</td>
<td>210</td>
<td>14</td>
<td>24</td>
<td>7</td>
<td>4</td>
<td>12%</td>
<td>3</td>
</tr>
<tr>
<td>PowerBar Protein Plus, Chocolate Brownie</td>
<td>$2.99</td>
<td>330</td>
<td>30</td>
<td>40</td>
<td>9</td>
<td>4.5</td>
<td>22%</td>
<td>5</td>
</tr>
<tr>
<td>Clif Luna, Nutz over Chocolate</td>
<td>$1.39</td>
<td>180</td>
<td>9</td>
<td>25</td>
<td>6</td>
<td>2.5</td>
<td>8%</td>
<td>4</td>
</tr>
<tr>
<td>Slim-fast Meal Options, Chocolate Fudge Brownie</td>
<td>$1.29</td>
<td>200</td>
<td>10</td>
<td>30</td>
<td>4</td>
<td>2.5</td>
<td>10%</td>
<td>9</td>
</tr>
<tr>
<td>Clif Bar, Chocolate Brownie</td>
<td>$1.49</td>
<td>240</td>
<td>9</td>
<td>44</td>
<td>4.5</td>
<td>1.5</td>
<td>18%</td>
<td>5</td>
</tr>
<tr>
<td>Larabar, Chocolate Chip Brownie</td>
<td>$1.59</td>
<td>200</td>
<td>4</td>
<td>31</td>
<td>9</td>
<td>2</td>
<td>23%</td>
<td>4</td>
</tr>
<tr>
<td>Health Warrior Chia Bars, Coconut</td>
<td>$1.29</td>
<td>110</td>
<td>3</td>
<td>13</td>
<td>6</td>
<td>2.5</td>
<td>5%</td>
<td>4</td>
</tr>
</tbody>
</table>

**Key:**  = 1 tsp sugar;  = 1 g fiber

Source: Manufactures’ labels. 2015.
What Happens if You Eat Too Much or Too Little Protein?

• Eating too much protein:
  • May increase risk of heart disease, kidney stones, calcium loss from bones
  • Can displace other nutrient- and fiber-rich foods associated with a reduced risk of chronic diseases
    • Whole grains, fruits, vegetables
ABC News Video: Health Benefits, Downsides to High-Protein Diets

>> Amy Robach: Diets high
Where Are the Protein and Saturated Fat in Your Food?

Figure 6.13

ChooseMyPlate.gov

= Saturated Fat

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What Happens if You Eat Too Much or Too Little Protein?, Continued

- Eating too little protein
  - May lead to reduction of lean body mass, especially in older adults
  - Risk of increased frailty, impaired healing, decreased immune function

- **Protein-energy malnutrition (PEM)**
  - Inadequate calories and/or protein
  - More common in children, because they are growing
  - Factors: poverty, poor food quality, insufficient food, unsanitary living conditions, ignorance, stopping lactation (nursing) too early
Eating Too Little Protein Can Lead to Poor Health and Malnutrition

- **Kwashiorkor**: severe deficiency of dietary protein
  - Signs: edema, muscle loss, skin rashes, hair changes, water and electrolyte imbalances
  - Seen in children weaned to low-protein cereals
- **Marasmus**: severe deficiency of calories
  - Signs: emaciation, lack of growth, loss of fat stores
- **Marasmic kwashiorkor**: worst of both conditions
- Treatment includes a multi-step approach
  - Step 1: address life-threatening factors
    - Severe dehydration
    - Fluid/nutrient imbalances
  - Step 2: restore depleted tissue
    - Gradually provide nutritionally dense kilocalories and high-quality protein
  - Step 3: transition to foods and introduce physical activity
How Do Vegetarians Meet Protein Needs?

- Vegetarians can meet protein needs by consuming:
  - Variety of plant foods
  - Protein-rich meat alternatives:
    - Soy
    - Dried beans and other legumes
    - Nuts
    - Eggs, dairy (lacto-ovo-vegetarians)
## The Many Types of Vegetarians

**Table 6.5 The Many Types of Vegetarians**

<table>
<thead>
<tr>
<th>Type</th>
<th>Dietary Patterns Does Eat</th>
<th>Dietary Patterns Doesn’t Eat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semivegetarian</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts, dairy foods, eggs</td>
<td>Meat, fish, and poultry, except on occasion</td>
</tr>
<tr>
<td>Pesco-vegetarian</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts, dairy foods, eggs, and fish</td>
<td>Meat and poultry</td>
</tr>
<tr>
<td>Lacto-ovo-vegetarian</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts, dairy foods, eggs</td>
<td>Meat, fish, and poultry</td>
</tr>
<tr>
<td>Lacto-vegetarian</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts, dairy foods</td>
<td>Meat, fish, poultry, and eggs</td>
</tr>
<tr>
<td>Ovo-vegetarian</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts, eggs</td>
<td>Meat, fish, poultry, and dairy foods</td>
</tr>
<tr>
<td>Vegan</td>
<td>Grains, vegetables, fruits, legumes, seeds, nuts</td>
<td>Any animal foods, meat, fish, poultry, dairy foods, and eggs</td>
</tr>
</tbody>
</table>
Potential Benefits and Risks of Vegetarian Diets

• **Benefits**
  • May reduce risk of heart disease, high blood pressure, diabetes, cancer, stroke, and obesity
  • Vegetarian diet food staples are rich in fiber and low in saturated fat and cholesterol

• **Risks**
  • Potential deficiencies of nutrients found in animal foods
    • Protein, iron, zinc, calcium, vitamin D, riboflavin, vitamins B₁₂ and A, omega-3 fatty acids
My Vegan Plate

Vegan
MY PLATE

- Fruits
- Grains
- Vegetables
- Protein

Calcium
leafy greens, calcium-fortified soymilk and juices, tofu, etc.
## Table 6.6 Nutrients That Could Be MIA (Missing in Action) in a Vegetarian Diet

Vegetarians need to take care in planning a diet that meets all their nutritional needs. Here are the nutrients that a vegetarian diet could fall short of, some vegetarian food sources for these nutrients, and tips on how to enjoy these foods as part of a balanced diet.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Risks</th>
<th>Vegetarian Food Sources</th>
<th>Table Tips</th>
</tr>
</thead>
</table>
| Protein  | A vegetarian’s protein needs can be met by consuming a variety of plant foods. A combination of protein-rich soy foods, legumes, nuts, and/or seeds should be eaten daily. | Soybeans, soy burgers, tofu, tempeh, nuts, peanuts, peanut butter, legumes, sunflower seeds, milk, soy milk, yogurt, cheese | • Add nuts to your morning cereal.  
• Add beans to your salads, soups, and main entrees.  
• Have a soy burger for lunch.  
• Use tofu in stir-fries, rice and pasta dishes, and casseroles.  
• Snack on a soy milk and banana or berry shake. |
| Iron     | The form of iron in plants is not as easily absorbed as the type in meat, milk, and poultry. Also, phytate in grains and rice and polyphenols in tea and coffee can inhibit iron absorption. The iron needs of vegetarians are about 11/2 times higher than those of nonvegetarians. Vitamin C enhances the absorption of the iron in plant foods. | Iron-fortified cereals, enriched grains, pasta, bread, oatmeal, potatoes, wheat germ, cashews and other nuts, sunflower seeds, legumes, soybeans, tofu, bok choy, broccoli, mushrooms, dried fruits, raisins | • Make sure your morning cereal is iron fortified.  
• Add soybeans to your lunchtime salad.  
• Eat bread with your salad lunch or make a sandwich.  
• Pack a trail mix of dried fruits and nuts for a snack.  
• Add vitamin C–rich foods (broccoli, tomatoes, citrus fruits) to all your meals. |
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Risks</th>
<th>Vegetarian Food Sources</th>
<th>Table Tips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>The absorption of zinc is enhanced by animal protein. Eating a vegetarian diet means that you lose out on this benefit and are more likely to develop a deficiency. Phytate in grains also binds zinc, making it unavailable to your body. A vegan’s zinc needs may be as much as 50 percent higher than a nonvegetarian’s.</td>
<td>Soybeans, soy milk, tofu, tempeh, fortified soy burgers, legumes, nuts, sunflower seeds, wheat germ, fortified ready-to-eat cereals, mushrooms, low-fat or nonfat milk, yogurt, and cheese</td>
<td>• Douse your morning cereal with low-fat milk. • Add low-fat cheese and soybeans to your lunchtime salad. • Snack on sunflower seeds. • Top an afternoon yogurt with wheat germ. • Add soybeans to your dinner rice.</td>
</tr>
<tr>
<td>Calcium</td>
<td>Calcium is abundant in lean dairy foods such as nonfat or low-fat milk, yogurt, and cheese, so obtaining adequate amounts shouldn’t be difficult if you consume these foods. Calcium-Fortified soy milk and orange juice, as well as tofu, can provide about the same amount of calcium per serving as is found in dairy foods. Green vegetables can also provide calcium in the diet.</td>
<td>Low-fat or nonfat milk, yogurt, and cheese, fortified soy milk, soy yogurt, and soy cheese, calcium-fortified orange juice, legumes, sesame tahini, tofu processed with calcium, bokchoy, broccoli, kale, collard greens, mustard greens, okra</td>
<td>• Add milk to your morning cereal and coffee. • Have at least one yogurt a day. • Have a glass of calcium-fortified orange juice with lunch. • Snack on low-fat cheese or yogurt in the afternoon. • Eat green vegetables often at dinner.</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Some vegetarians will need to consume vitamin D–fortified milk or soy products.</td>
<td>Low-fat or nonfat milk, egg yolk, fortified yogurt, soy milk, soy yogurt, ready-to-eat cereals; a vitamin supplement</td>
<td>• Have a glass of milk or soy milk at breakfast every day. • Make sure your morning cereal is vitamin D fortified. • Use fortified evaporated skim milk as a base for cream sauces. • Snack on fortified cereals. • Have a fortified yogurt each day.</td>
</tr>
</tbody>
</table>
### Table 6.6 (continued) Nutrients That Could Be MIA (Missing in Action) in a Vegetarian Diet

Vegetarians need to take care in planning a diet that meets all their nutritional needs. Here are the nutrients that a vegetarian diet could fall short of, some vegetarian food sources for these nutrients, and tips on how to enjoy these foods as part of a balanced diet.

<table>
<thead>
<tr>
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<th>Vegetarian Food Sources</th>
<th>Table Tips</th>
</tr>
</thead>
</table>
| Vitamin B₁₂    | Animal foods are the only naturally occurring food source of B₁₂, so it is extremely important that vegetarians, especially strict vegans, look to fortified cereals and soy milk or a supplement to meet their daily needs. | Low-fat and nonfat milk, yogurt, or cheese, eggs, fortified soy milk, ready-to-eat cereals, soy burgers, egg substitutes; vitamin supplement | • Make sure your morning cereal is fortified with vitamin B₁₂.  
• Drink a cup of milk or fortified soy milk with your meals.  
• Top an afternoon yogurt snack with a fortified cereal.  
• Try an egg-substitute omelet for lunch.  
• Use fortified soy “meat” alternatives at dinner. |
| Vitamin A      | Vitamin A is found only in animal foods. However, vegetarians can meet their needs by consuming the vitamin A precursor, beta-carotene. | Fortified low-fat or nonfat milk and soy milk, apricots, cantaloupe, mangoes, pumpkin, kale, spinach | • Enjoy a slice or bowl of cantaloupe in the morning.  
• Snack on dried apricots.  
• Add spinach to your lunchtime salad.  
• Drink a glass of fortified milk or soy milk with dinner.  
• Try mangoes for a sweet dessert. |
| Omega-3 fatty acids | If your vegetarian diet doesn’t include fish, you may not be consuming enough of the essential omega-3 fatty acid called alpha-linolenic acid | Fish, especially fatty fish such as salmon and sardines, walnuts, flaxseed and flaxseed oil, soybean and canola oil | • Add walnuts to baked breads and muffins.  
• Try canned salmon on top of your lunchtime salad.  
• Top your yogurt with ground flaxseed.  
• Have fish regularly for dinner.  
• Cook with canola and flaxseed oil. |
How Does a Vegetarian Meal Compare?

Table 6.7 How Does a Vegetarian Meal Compare?

Similar to meat meals, vegetarian meals can provide a robust amount of protein and iron with less heart-unhealthy saturated fat and cholesterol. While a tofu stir-fry doesn’t provide as much zinc or vitamin \( B_{12} \) as meat, it is a fabulous source of calcium, a mineral many adults are falling short of.

<table>
<thead>
<tr>
<th></th>
<th>Beef Stir-Fry (per Serving)</th>
<th>vs.</th>
<th>Tofu Stir-Fry (per Serving)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protein</strong></td>
<td>38 grams</td>
<td></td>
<td>26 grams</td>
</tr>
<tr>
<td><strong>Saturated Fat</strong></td>
<td>3.3 grams</td>
<td></td>
<td>1.8 grams</td>
</tr>
<tr>
<td><strong>Dietary Cholesterol</strong></td>
<td>105 milligrams</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>3.9 milligrams</td>
<td></td>
<td>5.1 milligrams</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>34 milligrams</td>
<td></td>
<td>450 milligrams</td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>6.8 milligrams</td>
<td></td>
<td>2.9 milligrams</td>
</tr>
<tr>
<td><strong>Vitamin ( B_{12} )</strong></td>
<td>2.5 micrograms</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
Nutrition in the Real World: The Joy of Soy

• Benefits of soy
  • High-quality protein source
  • Low in saturated fat
  • Contains *isoflavones* (phytoestrogens)
  • Lowers blood cholesterol levels
  • May reduce risk of heart disease, certain cancers
What's on the Soy Menu?

**Tofu**
- Cooked, pureed soybeans that are processed into a silken, soft, or firm texture; has a neutral flavor, which allows it to blend well.
- Use the silken version in dips, soups, and cream pies. Use the firm variety in stir-fries or on salads, or marinate it and then bake or grill it.

**Soy Flour**
- Made from ground, roasted soybeans.
- Use it in baked goods such as pancakes, muffins, and cookies. It can also substitute for eggs in baked goods: Use 1 tbs soy flour combined with 1 tbs of water for each whole egg.

**Edamame**
- Tender young soybeans; can be purchased fresh, frozen, or canned.
- Use them in salads, grain dishes, stir-fries, and casseroles.

**Soy Milk**
- A soy beverage made from a mixture of ground soybeans and water.
- Use it in place of cow’s milk. Combine soy milk with ice and fruit in a blender for a soy shake.
What's on the Soy Menu?, Continued

**Tempeh**
- Made from cooked whole soybeans that are condensed into a solid block
- Can be seasoned and used as a meat substitute

**Miso**
- A flavorful paste of fermented soybeans used to season foods
- Use it in soups, stews, and sauces.

**Soy Meat Analogs**
- Products such as hot dogs, sausages, burgers, cold cuts, yogurts, and cheese that are made using soy
- Use them as meat substitutes at meals and snacks.

**Textured Soy Protein**
- Created from defatted soy flour that has been compressed and dehydrated
- Use it as a meat substitute in foods such as meatballs, meatloaf, chili, tacos, and spaghetti sauce.