What do you think of when you hear the word “protein”?

Proteins have many roles in the body, but their basic structure is the same.

Hair, skin, eyesight, and the health of the whole body depend on protein from food.
Chapter 6 - What are Proteins?

Proteins are made of amino acids.

- Contain carbon, hydrogen, oxygen (like carbohydrates and fats)
- In addition, also contain nitrogen
- Each amino acid has:
  - Acid group (-COOH)
  - Amine group (-NH₂) (nitrogen) is 16% of the molecule
  - Side chain (unique)
  - Twenty different amino acids found in proteins
Amino Acids

The diagram illustrates the structure of an amino acid. It consists of a backbone, an amine group, and an acid group, connected by a side chain.
Essential Amino Acids

- It is the “side chain” that makes the amino acid differ in size, shape and electrical charge. (+, -, or neutral)

- Side chains that are electrically charged are attracted to water

- Side chains that are neutral are repelled by water and attracted to each other.
valine  leucine  tyrosine
Single amino acids with different side chains...
can bond to form…

a strand of amino acids, part of a protein.
Essential and Nonessential 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
9 Essential Amino Acids

- Histidine
- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine
Amino Acids
For Brain and Body Functions

Proteins control almost every biochemical reaction in the body. Every protein is made from amino acids, which are commonly called the building blocks of life. All of the nearly 40,000 distinct proteins found in the human body are made up from only 20 amino acids called the proteogenic amino acids.
Making of a Protein

Figure 6.3

- 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.
Protein Function Altered by Denaturation

- **Denaturation**: unfolding of protein shape by heat, acids, agitation, bases or salts
- Change of protein shape alters its function
  - Examples: cooking meat, eggs changing texture (frying-becomes a firmer, better tasting egg or the curdling of milk when lemon juice is added)
  - Stomach acid untangles proteins to aid in digestion.
Denaturation

Figure 6.4
What Happens to the Protein You Eat?

Dietary proteins are digested in the stomach and continue being digested in the stomach and absorbed in the small intestine

- **Stomach acids** (hydrochloric acid) denature (unfolding) protein which
  - Activate pepsin (protein-digesting enzyme) which breaks down protein into shorter polypeptides
  - In the small intestine, polypeptides broken down into tri-, dipeptides and amino acids are absorbed
  - Remaining amino acids enter blood and travel to liver
Digesting and Absorbing Proteins

1. In the stomach, acidic juices denature the protein and activate the enzyme pepsin, which breaks the protein into shorter strands.

2. These strands enter the small intestine. Pepsin is inactivated. Other enzymes further break down the polypeptide strands into tripeptides and dipeptides and single amino acids.

3. These protein remnants are absorbed through the small intestine lining. They are further broken down to single amino acids, which enter the blood and travel directly to the liver.

4. The liver uses some of the amino acids to make new proteins, or glucose or for other purposes. Other amino acids will pass through the liver and return to the blood to be picked up and used by the cells.
Your Body Degrades and Synthesizes Proteins

Amino acids come from:

- Diet
- Breakdown of proteins in the body (the liver and intestines account for 50% of this turnover)
- 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. Our bodies constantly require new proteins to function properly: For example, skin cells live about 30 days. The body’s amino acid pool is used to produce the ‘replacements’
Your Body Degrades and Synthesizes Proteins

- Amino acids can be used to make:
  - Body proteins
  - Non-protein substances
    - Example: thyroid hormone, melanin - pigment
  - After amine (nitrogen) group removed, the nitrogen is converted to urea and excreted in urine. Amino acids can also be:
    - Burned for energy
    - Stored as fat
    - Made into glucose when diet is low in CHO
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.

Nonprotein products

- 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.

Amine groups

- 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, energy, or stored as fat.

Urine

Carbon-containing remains

Glucose Energy Fat

Figure 6.6
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

• Gene mutations can result in errors in protein synthesis (abnormalities).

• Sickle-cell anemia: inherited, abnormal hemoglobin, affects 1 in 12 African Americans and 1 in 100 Hispanic Americans (as carriers of the mutated gene)
Protein Synthesis

1. Each strand of DNA holds the information or code to create specific proteins. Since 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.
Summary of the Functions of Proteins

- **Acid-base balance.** Proteins help maintain the acid-base balance of various body fluids by acting as buffers.
- **Antibodies.** Proteins form the immune system molecules that fight diseases.
- **Blood clotting.** Proteins provide the netting on which blood clots are built.
- **Energy.** Proteins provide some fuel for the body’s energy needs.
- **Enzymes.** Proteins facilitate needed chemical reactions.
- **Fluid and electrolyte balance.** Proteins help to maintain the water and mineral composition of various body fluids.
- **Growth and maintenance.** Proteins form integral parts of most body tissues and serve as building materials for growth and repair of body tissues, such as skin, connective tissues, muscles, organs, and bone.
- **Hormones.** Proteins regulate body processes. Some hormones are proteins or are made from amino acids.
- **Transportation.** Proteins help transport needed substances, such as lipids, minerals, and oxygen, around the body.
How Much Protein Do You Need and What Are Protein-Rich Food Sources?

- Protein quality varies among food sources.
- Depends on digestibility and amino acid composition.
- Complete proteins contain all of the essential amino acids along with the nonessential ones.
  - Examples: animal proteins, soy protein
- Incomplete proteins are low in one or more essential amino acids.
  - Example: plant proteins
The more protein we eat, the higher our intake of vitamin B12.
Protein Quality

Plant proteins “upgraded” to complete proteins by:

- Consuming modest amounts of soy or animal protein, or
- Being complemented with other plant proteins which provide enough of the amino acid
Protein requirements are determined by nitrogen balance studies

- **Nitrogen Balance**: Amount of protein consumed = amount of protein used (nitrogen excreted)

- 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
Nitrogen Balance and Imbalance

Figure 6.11

Occurs in:
- Infants
- Children and adolescents
- Pregnant women
- Athletes training

- Healthy adults
- Teenagers who are no longer growing

- Starvation
- Protein deficient diets
- Serious illness and injury

Protein intake → Positive nitrogen balance → Protein excretion
Protein intake → Equilibrium → Protein excretion
Protein intake → Negative nitrogen balance → Protein excretion

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Protein recommendations (DRI):

- 10 – 35% of total daily calories from protein
- Average intake in U.S. = 15%
- 0.8 g of protein/kg of body weight needed daily

Calculating your daily protein needs:

- Convert weight by dividing by 2.2 lbs/kg:
  
  If you weigh: 130 lbs ÷ 2.2lbs/kg = 59 kg
  
  59 kg X 0.8 g = 47 g of protein/day
How Much Protein Do People Really Need?

- The DRI recommendation for protein intake depends on size and stage of growth
- Minimum is 10 percent of total calories
- Athletes may need slightly more (1.0 gram per kg)
Providing Energy and Glucose

- Carbohydrate: 4 calories per gram
- Fat: 9 calories per gram
- Protein: 4 calories per gram
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 Happens if You Eat Too Much or Too Little Protein?

- Eating too much protein:
  - May increase risk of heart disease (raised blood cholesterol), kidney stones, calcium loss from bones (osteoporosis)
  - Can displace other nutrient- and fiber-rich foods associated with a reduced risk of chronic diseases:
    - Whole grains, fruits, vegetables
    - Can cause weight gain if protein is coming from high calorie source (high fat content in meat, skin on chicken, whole milk)
What Happens if You Eat Too Much or Too Little Protein?

• Eating too little protein:
  • Low-protein diets associated with loss of bone mass
  • **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
Protein Energy 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
Comparison of Kwashiorkor and Marasmus

A classic sign of Kwashiorkor is edema.

Marasmus results in an emaciated appearance.
Positive Health Aspects of Meat Eater’s Diet

- This 5 oz steak provides over half of the daily maximum servings of meat recommended by the USDA Food Guide. (2 to 3 oz. is one serving)
Vegetarians can meet protein needs by consuming:

- **Variety of plant foods**
- **Protein-rich meat alternatives:**
  - Soy – considered a complete protein
  - Dried beans and other legumes
  - Nuts
  - Eggs, dairy (lacto-ovo-vegetarians)
Both vegetarian and meat-containing diets, if not properly balanced, can lack nutrients.

Poorly planned meat eater’s diets may lack vitamin A, vitamin C, folate, and fiber, among others.

Poorly planned vegetarian diets typically lack iron, zinc, calcium, omega-3 fatty acids, vitamin D, and vitamin B\textsubscript{12}.

Although rich in important vitamins, fruit, provides little if any, protein.
## The Many Types of Vegetarians

<table>
<thead>
<tr>
<th>Type</th>
<th>Does Eat</th>
<th>Doesn’t Eat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semivegetarian</td>
<td>A vegetarian diet that occasionally includes meat, fish, and poultry</td>
<td>Meat, fish, and poultry on occasion</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, 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, eggs</td>
</tr>
</tbody>
</table>
The Joy of Soy

• Benefits of soy:
  • High-quality protein source
  • Low in saturated fat
  • Contains isoflavones (phytoestrogens)
    • May have anticancer functions
    • May relieve menopausal symptoms
  • Lowers blood cholesterol levels
  • May reduce risk of heart disease, certain cancers
Nutrients in 8 ounces (250 ml) of plain soymilk:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Regular Soymilk</th>
<th>Lite Soymilk (reduced fat)</th>
<th>Whole cow milk</th>
<th>Fat-free cow milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories (g)</td>
<td>140</td>
<td>100</td>
<td>149</td>
<td>83</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>10.0</td>
<td>4.0</td>
<td>7.7</td>
<td>8.3</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>4.0</td>
<td>2.0</td>
<td>8.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>14.0</td>
<td>16.0</td>
<td>11.7</td>
<td>12.2</td>
</tr>
<tr>
<td>Lactose (g)</td>
<td>0.0</td>
<td>0.0</td>
<td>11.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>120</td>
<td>100</td>
<td>105</td>
<td>103</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.8</td>
<td>0.6</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.1</td>
<td>11.0</td>
<td>0.412</td>
<td>0.446</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>80.0</td>
<td>80.0</td>
<td>276</td>
<td>299</td>
</tr>
</tbody>
</table>

**Difference Between Almond Milk and Soy Milk**

Both milks have advantages and disadvantages. When you will try them, you will note the difference in both taste and flavor. **Soy milk has more proteins than almond milk. Almond milk has less fats and sugar than any other type of non-dairy milk.** More varieties of soy milk are easily available as they are more popular than almond milk. **Almond milk can be used as a substitute for milk in sweet dishes. Soy milk may leave distasteful marks when used for such purposes. Soy milk is the best for salad dressing, pasta sauce and mashed potatoes. Soy milk has an acquired taste while almond milk has a natural nice light taste.**
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, low in saturated fat and cholesterol.

Risks:

• Potential deficiencies of nutrients found in animal foods

• Protein, iron, zinc, calcium, vitamin D, riboflavin, vitamins $B_{12}$ and A, Omega-3 fatty acids
Yesterday I went to the doctor for my yearly physical.

My blood pressure was high, my cholesterol was high, I'd gained some weight, and I didn't feel so hot.

My doctor said eating right doesn't have to be complicated and it would solve my physical problems.

He said just think in colors.

Fill your plate with bright colors, greens, yellows, reds, etc.

I went right home and ate an entire bowl of:
And sure enough, I felt better immediately!
I never knew eating right could be so easy...