The Science of Protein

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Understanding Dietary Protein

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Objectives

• Understand the difference between essential amino acids and nonessential amino acids.

• List the steps for protein digestion and absorption in the body.

• Explain the differences between high-quality and low-quality proteins, including food sources of each.

• Understand the recommended protein intake for a given individual.

What do you think about when you hear the word protein?

Foods

Muscle/Body Building

Weight Loss

Supplements
Proteins have many critical roles in the body

- **Enzymes**
  - The vast majority of chemical reactions that occur in the body are catalyzed by enzymes.

- **Transporters**
  - Most substances move in and out of cells with the aid of protein transporters. Many nutrients are also carried in the blood attached to transport proteins.

- **Hormones and Regulation**
  - Numerous protein hormones (like insulin) and many other related proteins regulate the majority of processes in our body. Proteins also allow the body to sense and react to various stimuli.

- **Antibodies**
  - Antibodies are critical for the body’s defense against viruses and bacteria.

- **Fluid Balance**
  - Proteins regulate the distribution of fluids throughout various compartments of the body.

- **pH Scale**
  - Proteins buffer body fluids to aid in maintaining a proper pH.

- **Structure and Movement**
  - Proteins provide critical structural components of the body and even within its cells. Contractile proteins account for 50% of total proteins in skeletal muscle.

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Protein and the Body

• Protein makes up 20-50% of the dry mass of the adult human body.

• Fat is the other major component of the human body.
Amino acids are the building blocks of proteins

**Amino Acid Structure**

All amino acids contain a central carbon atom, an amino group that contains an atom of nitrogen, an acid group, a hydrogen atom, and a side chain.

**Unique Amino Acid Side Chains**

Only the side chain differs for each of the 20 amino acids, giving each its unique properties.

- Glycine (Gly)
- Serine (Ser)
- Tryptophan (Trp)

20 amino acids in varying proportions and sequences make up more than 22,000 proteins in the body

- **9 essential amino acids**
  - Cannot be produced by the body
  - Must be obtained through the diet

- **11 non-essential amino acids**
  - Can be produced by the body
There are 20 different amino acids

- **Glycine (Gly)**
- **Alanine (Ala)**
- **Valine (Val)**
- **Leucine (Leu)**
- **Isoleucine (Ile)**
- **Methionine (Met)**
- **Tryptophan (Trp)**
- **Phenylalanine (Phe)**
- **Proline (Pro)**

**Polar**
- **Serine (Ser)**
- **Threonine (Thr)**
- **Cysteine (Cys)**
- **Tyrosine (Tyr)**
- **Asparagine (Asn)**
- **Glutamine (Gln)**

**Electrically Charged**
- **Acidic**
  - Aspartic Acid (Asp)
  - Glutamic Acid (Glu)
- **Basic**
  - Lysine (Lys)
  - Arginine (Arg)
  - Histidine (His)
The shape of proteins determines their function

• After amino acid chains are made, they fold into a particular shape

• To function properly, proteins must retain their three-dimensional shape
Protein Shapes and Function - *Examples*

- Proteins that give strength and elasticity to body parts.
  - Several strings of amino acids coil together and form rope-like fibers.

- Proteins, like those in blood, are water-soluble, with a globular shape like a ball of steel wool.

- Some proteins are shaped like hollow balls that carry minerals in their interiors.

- Others provide support to tissues.

- The enzymes act on other substances to change them chemically.
Denaturation alters the shape and function of proteins

- Denaturation
  - Caused by heat, light, change in pH, alcohol, or motion
  - Important in the digestion of protein

Denaturation of protein occurs as part of food preparation and cooking.
The digestion of proteins begins in the stomach and is completed within the mucosal cells lining the small intestine

- **Mouth**
  - Mechanical digestion

- **Stomach**
  - Acidic juices
  - Pepsin

- **Small intestine**
  - Pancreatic proteases
  - Absorption of amino acids

Proteins in the body are constantly being broken down and reassembled in a process called protein turnover.
Amino acids are chemically altered to produce many important compounds

- Synthesize proteins in the body
- Metabolized as a source of energy
- Synthesized into glucose or fat
Nitrogen balance reflects whether the body is gaining, losing, or maintaining protein

- Amount of nitrogen we consume = $N_{in}$
- Amount of nitrogen we excrete = $N_{out}$
  - Urine and feces
  - Sweat and other secretions
  - Skin, hair, and nails
Positive nitrogen balance reflects an increase in total body proteins

\[ N_{\text{in}} > N_{\text{out}} \]

For tissue growth to occur, less nitrogen must be excreted than what is taken in. This means that protein synthesis must exceed protein breakdown. (Nitrogen in > Nitrogen out)


Photo Credits: Top Middle: Hero Images/Getty Images; Top Right: Jordan Siemens/Getty Images; Middle Right: Phillip Suddick/Getty Images; Bottom Right: SilviaJansen/Getty Images
Nitrogen balance reflects approximately the same total body protein from day to day

\[ N_{\text{in}} = N_{\text{out}} \]
A negative nitrogen balance reflects a decrease in total body protein

\[ N_{in} < N_{out} \]

The decrease in activity that often accompanies aging results in the loss of skeletal muscle mass. Any illness or dietary inadequacies that may exist will further accelerate this loss as well as lead to a loss of proteins from many other tissues and organs. Because body mass is decreasing, particularly lean body mass, protein breakdown exceeds protein synthesis. (Nitrogen in < Nitrogen out)

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Protein Intake Recommendations

• The Institute of Medicine recommends that adults get a minimum of 0.8 grams (or 2.2 pounds) of protein for every kilogram of body weight per day to keep from slowly breaking down their own tissues.

• That’s just about 8 grams of protein for every 20 pounds of body weight.

• AMDR: Acceptable Macronutrient Distribution Range
  • 10 to 35 percent of total caloric intake
Most Americans exceed their RDA for protein

More than 60% of the protein consumed in the United States comes from animal products
Protein Intake of Americans

Figure 2. Macronutrient intake (percent kcals) by sex in adults aged 20 and over, 1969–2008


NOTE: Kcals are kilocalories.
SOURCE: CDC/NCHS, National Health and Nutrition Examination Survey.
Americans eat more protein in the evening

A. Adequate Protein Distribution

<table>
<thead>
<tr>
<th>Meal</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td>~30 g</td>
</tr>
<tr>
<td>Lunch</td>
<td>~30 g</td>
</tr>
<tr>
<td>Dinner</td>
<td>~30 g</td>
</tr>
</tbody>
</table>

B. Inadequate Protein Distribution

<table>
<thead>
<tr>
<th>Meal</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td>~10 g</td>
</tr>
<tr>
<td>Lunch</td>
<td>~20 g</td>
</tr>
<tr>
<td>Dinner</td>
<td>~60 g</td>
</tr>
</tbody>
</table>

doi: [10.1097/MCO.0b013e32831cef8b](10.1097/MCO.0b013e32831cef8b)
Adults older than age 65 benefit from slightly higher protein intake

- **Protein intake of 1.2 g/kg of body weight/day** is beneficial
  - Reduces loss of lean body mass
  - Improves functionality
  - Reduces risk of disability and death
  - Particularly effective when combined with resistance training program
  - Maximized with an emphasis on consuming plant-based foods

20 year old female – physically active

Late 60’s female – sedentary
Do athletes need more protein?

• What affects the success of an athlete like Michael Phelps?
  • Genes, training, and maybe diet

• Athletes don’t need more protein

• May benefit from “optimal” protein intake for performance advantage
  • 1.2 to 1.7 g/kg body weight
Protein quality is a measure of how well a protein food meets our needs for protein synthesis.

• Based on proportion of essential amino acids (AAs)

  • **Complete** proteins
    • Contain all nine essential AAs

  • **Incomplete** proteins
    • Lack one or more essential AA
      ▪ Limiting amino acid

• **Complementary** protein
  • Combine two incomplete proteins to make a complete protein

• Consuming a wide variety of plant-based foods, including legumes, beans, nuts, and seeds, can meet protein needs.
Choose protein foods wisely to boost fiber and limit saturated fats.
Whey Protein
1 serving = 19 grams protein
100 calories | 1g fat

Low Fat Chocolate Milk
2 cups / 16 ounces = 16 grams protein
280 calories | 5g fat

Fresh Fish
3.5 oz / 100g = 25 grams protein
129 calories | 6g fat

Lean Steak
4 oz = 28 grams protein
204 calories | 6g fat

Skinless Chicken Breast
3.5 oz / 100g = 21 grams protein
114 calories | 3g fat

Pork
3.5 oz / 100g = 20 grams protein
148 calories | 7g fat

Peanut Butter
6 Tablespoons = 24 grams protein
564 calories | 48g fat

Mixed Nuts
3/4 cup / 100g = 17 grams protein
617 calories | 56g fat

Fresh Eggs
4 eggs = 24 grams protein
300 calories | 20g fat
Health Benefits of High Protein Diets

- Increased weight loss
- Improved body composition
- Improved triglycerides
- Improved HDL (good) cholesterol
- Increased satiety
- Decreased muscle loss with age
- Increase calorie burning

Next week – The Science of High Protein Diets
Guest Speaker: Joshua Hudson, PhD (UAMS)
Summary

• Understand the difference between essential amino acids and nonessential amino acids.

• List the functions of protein in the body.

• Explain the differences between high-quality and low-quality proteins, including food sources of each.

• Understand the recommended protein intake for a given individual.
Key Points to Remember About Protein

• More protein does not equal more muscle
• All protein is not created equal
• Eating more protein isn’t better unless you reduce carbohydrate intake
• Eating more protein does not keep your weight down, total calories eaten and physical activity are important factors

http://www.prevention.com/food/6-protein-myths-that-are-messing-with-your-diet/slide/2
Questions?

Next week – The science of high protein diets!