Chapter 6: The Proteins and Amino Acids
Introduction

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
Different Types of Proteins

**Working Proteins**

Body's enzymes

Antibodies

Transport vehicle

Hormones

Cellular pumps

Oxygen carriers
Different Types of Proteins

**Structural Proteins**

Tendons

Ligaments

Scars

Muscle fiber

Cores of bones & teeth

Filaments of hair

Material of nails
The structure of proteins enables them to perform many vital functions. Proteins contain carbon, hydrogen, oxygen and nitrogen. **Amino acids** are the building block. **20 different** amino acids exist.
Amino Acids

- Side chain
- Amine group
- Acid group
- Backbone
valine  leucine  tyrosine

Single amino acids with different side chains...

can bond to form...

a strand of amino acids, part of a protein.
9 amino acids are **essential** - replenished from food

11 amino acids are **nonessential** - body makes it from fragments of carbs or fats

Under special circumstances, a nonessential amino acid can become essential - **conditionally essential amino acids**
Example of conditionally essential amino acid

- Tyrosine is an amino acid that the body makes from Phenylalanine (EAA)
- If the diet doesn't have enough “Pheny”
  - OR
- If the body can't covert “Pheny” to Tyrosine
- Then tyrosine becomes a conditionally essentially EAA.
The body can recycle amino acids from proteins no longer needed.

These amino acids can be used to build new proteins, or provide energy if glucose is lacking in the diet.
How Do Amino Acids Build Proteins?
How Do Amino Acids Build Proteins?

Amino acids link into long strands that coil and fold to make a wide variety of different proteins.

**Peptide bond** = a bond that connects one amino acid with another

Each spot in the coils is either attracted to or repelled from other spots along the length.

Several strands may cluster together into a functioning unit, or a metal ion (mineral) or a vitamin may join to the unit and activate it.
How Do Amino Acids Build Proteins?

A portion of a strand of amino acids.

The strand coils, as this "ribbon" demonstrates.

Coiling the strand. The strand of amino acids takes on a spring-like shape as their side chains variously attract and repel each other.

Folding the coil. Once coiled and folded, the protein may be functional as is, or it may need to join with other proteins or add a vitamin or mineral to become active, as demonstrated in Figure 6-4.
Each type of protein has a distinctive sequence of amino acids and so has great specificity.

Like letters in the alphabet, the sequence of amino acids determines the identity of the protein.

How many different words can you make w/26 letters?

How many different proteins can you make w/20 different amino acids?
The **variety** of possible sequences for amino acid strands is tremendous.

A single human cell may contain as many as 10,000 different proteins, each one present in thousands of copies.
Inherited Amino Acid Sequences

The sequence of amino acids in a protein is determined by heredity.

If an incorrect amino acid is inserted, the result can be disastrous to health.

In sickle-cell disease, a glutamic acid in one strand is replaced with a valine.

- Analogous to spelling a word wrong – it no longer makes “sense”

What a difference one amino acid can make!

Amino acid sequence of normal hemoglobin:
Val – His – Leu – Thr – Pro – Glu – Glu

Amino acid sequence of sickle-cell hemoglobin:
Val – His – Leu – Thr – Pro – Val – Glu
Inherited Amino Acid Sequences

Genes determine the sequence of amino acids in each finished protein.

Genetic information in a cell goes from

DNA $\rightarrow$ RNA $\rightarrow$ protein
Denaturation of proteins

- Proteins can be denatured (distorted in shape by: heat, radiation, alcohol, acids, bases, or salts of heavy meals.

- Denaturation changes the structure of the protein making it unable to function in the body

- In digestion denaturation is good

- Enables stomach acid to open protein's structure and cut the peptide bonds of amino acids

- Cooking eggs frees biotin & iron and helps with digestion
Protein Digestion

1. **Stomach**
   When swallowed food arrives in the stomach, acid denatures the protein strands, and an enzyme cleaves amino acid strands into polypeptides and a few amino acids.

2. **Small Intestine**
   Enzymes from the pancreas and the intestine split peptide strands into tripeptides, dipeptides, and amino acids.

3. **Small Intestine**
   Enzymes on the surface of the small intestine’s lining and within the absorptive cells split tripeptides and dipeptides. The intestinal cells absorb and transfer amino acids to the bloodstream.

4. **Bloodstream**
   The bloodstream transports amino acids to all the body’s cells.

**Key:**
- amino acid
- dipeptide
- tripeptide
- polypeptide
The Roles of Proteins in the Body

Proteins are versatile, unique, and play important roles in the body.

Proteins have been called “the primary material of life.”
The body needs dietary amino acids daily to build protein that grow new cells and to replace worn-out ones

- Red blood cells live 3-4 months
- Skin cells die or rub off

The entire process of breakdown, recovery, and synthesis is called protein turnover.
Amino Acids must be available to build proteins of new tissue in...

- Embryo
- Athlete's muscle
- Growing child
- Replacing new blood cells during menstruation
- Scar tissue that heals wounds
- New hair or nails
The body makes enzymes, hormones, and chemical messengers of the nervous system from its amino acids.

**Enzymes** are proteins that help with chemical reactions.

**Hormones** are chemical messengers that affect specific organs or tissue to elicit a specific response.

Ex: insulin when you have too much glucose, glucagon when you have too little.
Antibodies are proteins that defend against foreign proteins and other foreign substances within the body.

Foreign protein may be part of bacterium, a virus, toxin, or in food that causes allergic reaction.

Each antibody is designed to destroy one specific invader.

Body remembers how it made each antibody, enabling us to have immunity to an invader.
Maintaining Fluid and Electrolyte Balance

Proteins help regulate the body’s electrolytes and fluids.

They help regulate how much water is needed in each compartment of the body.

Too much water in the cell causes it to rapture, too little makes it unable to function.

Proteins attract water so water stays put in the blood vessel.

Too much water in between cells causes edema.
Maintaining Acid-Base Balance

Blood proteins buffer the blood against excess acidity or alkalinity.

Processes of the body produce acids and bases that is carried by the blood to organs.

If blood pH changes too much it can cause coma or death.
Proteins that clot the blood prevent death from uncontrolled bleeding.

Proteins form a stringy net that traps blood cells to form a clot.

Clot then plugs the blood flow from the wound.

As the wound heals, the protein collagen finishes the job by replacing the clot with scar tissue.
When insufficient carbohydrate and fat are consumed to meet the body’s energy need, food protein and body protein are sacrificed to supply energy.

The nitrogen part is removed from each amino acid, and the resulting fragment is oxidized for energy.

No storage form of amino acids exists in the body.
Transporting Substances

• Proteins also transport substances such as: lipids, vitamins, minerals, oxygen around the body

• Hemoglobin carries oxygen from the lungs to the cells

• Lipoproteins transport lipids in the blood
• Glucose is stored as glycogen
• Fat is stored as triglycerides
• Protein is stored as...
• **No storage form of protein**
• Body protein is present only as active working or structural parts of body tissue
During starvation the body will

- Dismantle tissue proteins to get amino acids for energy
- 1st go the small proteins from blood
- 2nd proteins from muscle
- 3rd liver and other organs

starvation leads to the loss of fat as well as body tissue
When there is too many amino acids

- The body can't store them
- It removes the amine group (has nitrogen)
- Uses residues to
  1. meet immediate energy needs
  2. makes glucose to store as glycogen
  3. make fat to store as energy
The Fate of An Amino Acid

To prevent wasting of dietary protein...

– Dietary protein must be of adequate quality

– Must supply all essential amino acids in the proper amounts

– Must be accompanied by enough carbs and lipids
The body’s use of a protein depends in part on the user’s health.

To be used efficiently, protein must be accompanied by ample carbohydrate and fat, vitamins and minerals.

Protein quality is influenced by a protein’s digestibility and its amino acid composition.
Digestibility of protein varies from food to food.

- Amino acids from animal proteins are most easily digested and absorbed (over 90%)
- Amino acids from legumes are next (80 to 90%)
- Amino acids from plant foods vary (70 to 90%)

Cooking with moist heat can improve digestibility whereas dry heat methods impair it.
Cooking with moist heat improves protein digestibility, whereas frying makes protein harder to digest.
Amino Acid Composition

High-quality proteins – provide enough of all of the essential amino acids needed to make new proteins

Low-quality proteins – do not provide all the essential amino acids

- If a nonessential amino acid is unavailable from food, the cell synthesizes it
- If the diet fails to provide an essential amino acid, the cells begin to conserve the amino acid and reduce their use of amino acids for fuel.
If a person does not consume all the essential amino acids it needs, the body’s pools of essential amino acids will dwindle until body organs are compromised.

Proteins lacking essential amino acids can be used only if those amino acids are present from other sources.
Complementary Proteins

\[
\begin{align*}
\frac{3}{4} \text{ c oatmeal} &= 5 \text{ g} \\
\text{Protein total} &= 5 \text{ g} \\
1 \text{ c rice} &= 4 \text{ g} \\
1 \text{ c beans} &= 16 \text{ g} \\
\text{Protein total} &= 20 \text{ g} \\
1\frac{1}{2} \text{ c pasta} &= 11 \text{ g} \\
1 \text{ c vegetables} &= 2 \text{ g} \\
2 \text{ tbs Parmesan cheese} &= 4 \text{ g} \\
\text{Protein total} &= 17 \text{ g}
\end{align*}
\]
## Complementary Proteins

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### Legumes provide:
- Isoleucine
- Lysine

### Grains provide:
- Methionine
- Tryptophan
Who needs to be concerned about mutual supplementation?

- Everyone
- Lacto-ovo vegetarians
- Pregnant women
- Growing children
- Vegans
How Much Protein Do People Really Need?

The DRI recommendation for protein intake depends on size and stage of growth.

DRI recommended intake is 0.8 gram per kilogram of body weight.

Minimum is 10 percent of total calories.

Athletes may need slightly more (1.0 gram per kg).
The DRI recommended intake is 0.8 g/kg

To figure your protein need:

1. Find your body weight in pounds
2. Convert pounds to kilograms (by dividing pounds by 2.2)
3. Multiply kilograms by 0.8 to find total grams of protein recommended
Protein recommendations are based on nitrogen balance studies, which compare nitrogen excreted from the body (through urine, feces, sweat, and skin) with nitrogen ingested with food.
Positive Nitrogen Balance
These people, a growing child, a person building muscle, and a pregnant woman, are all retaining more nitrogen than they are excreting.

Nitrogen Equilibrium
These people, a healthy college student and a young retiree, are in nitrogen equilibrium.

Negative Nitrogen Balance
These people, an astronaut and a surgery patient, are losing more nitrogen than they are taking in.
Protein deficiencies and energy deficiencies are the world’s leading form of malnutrition.

Both protein deficiencies and excess are of concern.
Protein-energy malnutrition (PEM) is the most widespread form of malnutrition in the world today.

PEM takes two different forms:

- Marasmus
- Kwashiorkor
Marasmus

Extreme food energy deficiency
Kwashiorkor is the Ghanaian name for “the evil spirit that infects the first child when the second child is born.”

Each baby is weaned from breast milk as soon as the next comes along. The older baby no longer receives breast milk and is given a watery cereal with scant protein of low quality.
PEM is not unknown in the United States, where millions live on the edge of hunger.

- Inner cities
- U.S. Indian reservations
- Rural areas
- Some elderly people
- Hungry and homeless children
- People suffering from anorexia nervosa
- People with wasting illnesses such as AIDS, cancer, or drug and alcohol addictions
Is it Possible to Consume Too Much Protein?

There is no benefit from eating excess protein. Foods rich in animal protein tend to be rich in saturated fats.
The protein quality of legumes is almost comparable to that of meat.

Soy protein can be considered equivalent to that of meat.
### Table C6-1 Terms Used to Describe Vegetarians and Their Diets

Some of the terms below are in common usage, but others are useful only to researchers.

- **fruitarian** includes only raw or dried fruits, seeds, and nuts in the diet.
- **lacto-ovo vegetarian** includes dairy products, eggs, vegetables, grains, legumes, fruits, and nuts; excludes flesh and seafood.
- **lacto-vegetarian** includes dairy products, vegetables, grains, legumes, fruits, and nuts; excludes flesh, seafood, and eggs.
- **macrobiotic diet** a vegan diet composed mostly of whole grains, beans, and certain vegetables; taken to extremes, macrobiotic diets have resulted in malnutrition and even death.
- **ovo-vegetarian** includes eggs, vegetables, grains, legumes, fruits, and nuts; excludes flesh, seafood, and milk products.
- **partial vegetarian** a term sometimes used to mean an eating style that includes seafood, poultry, eggs, dairy products, vegetables, grains, legumes, fruits, and nuts; excludes or strictly limits certain meats, such as red meats.
- **pesco-vegetarian** same as partial vegetarian, but eliminates poultry.
- **vegan** includes only food from plant sources: vegetables, grains, legumes, fruits, seeds, and nuts; also called strict vegetarian.
- **vegetarian** includes plant-based foods and eliminates some or all animal-derived foods.
Strong evidence links vegetarian diets with reduced incidences of chronic diseases.

- Some benefits include
  - Less obesity
  - Defense against certain cancers
  - Less heart disease
  - Less high blood pressure
  - May help prevent diabetes, osteoporosis, diverticular disease, gallstones, and rheumatoid arthritis
Some of these effects may arise more from what vegetarians include in the diet – abundant fruit, legumes, vegetables, and whole grains – than from what they omit.
A balanced, adequate diet in which lean meats and seafood, eggs, and milk play a part in addition to fruits, vegetables and whole grains can be very healthy.

True meat lovers who shun all vegetables have no adequate substitutions for these foods (unlike vegetarians who can find suitable replacements for meat).
Both meat eaters and lacto-ovo vegetarians can rely on their diets during critical times of life.

A vegan diet can pose challenges. Why?

Meat provides abundant iron, zinc, and vitamin $\text{B}_{12}$ needed by everyone, but in particular by pregnant women, children, and adolescents.
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 $B_{12}$. 
Vegetarian Food Guide

My Vegetarian Food Pyramid

Whole Grains
Vegetables
Fruits
Dairy
Proteins
Fats

Consult your dietitian or physician to determine the amount of water, iodized salt, calcium, vitamin D, and B12 to add to your daily diet.
Both a meat eater’s diet and a vegetarian’s diet are best approached scientifically.

There are many in-between ways of eating that don’t fall into strict categories.

- Some people eat meat as a condiment
- Some people eat meat only once a week
- Many people rely on milk products to meet their protein needs
Why is Meat bad?

Adapted from “The Kind Diet” Alicia Silverstone

1. Meat is bad for your heart

• Heart disease is the #1 killer of women in the U.S.

• Saturated fats from meats = elevated blood cholesterol = plaque to clog arteries = high blood pressure = or heart attack
2. Meat contributes to cancer

• Many studies link meat to cancer

• *British Journal of Cancer* (2007) studied 35,000 women & found that women who ate the most meat were more likely to develop breast cancer

• *Sugar molecule Neu5Gc is found in human cancer tumors that comes from red meat*

• *Humans produce antibodies against Neu5Gc which causes inflammation which helps tumors grow*
• Dioxin is the most toxic chemical and is known to be a carcinogen

• About 93% of our exposure to dioxin comes through eating animal products
  
  beef, lamb, pork, chicken, dairy, eggs, fish

• Dioxin settles and accumulates in fat

• The way we cook meat also contributes to cancer (heterocyclic amines)

• Grilled chicken has 17 times more ha than grilled meat
3. Meat contributes to osteoporosis

- Meat causes blood to become acidic (too much acid in the blood can cause death)

- In order for your body to balance the acid our bones release some of the minerals using bones to become weak

- Main causes of adult bone loss: animal protein, sodium, caffeine, tobacco, inactivity)
4. meat is hard to digest and other issues

- Meat has no fiber
- High meat diets can cause: colitis, diverticulitis, and even colon cancer
- Worsen gout, contribute to rheumatoid arthritis, factor in formation of kidney stones
5. Meat is full of antibiotics

- Animals in factory farms are raised in confined, dirty, and stressful environments so they regularly need antibiotics to keep them from getting sick

- 70% of antibiotic sold in the U.S. go to livestock and farm raised fish

- When you consume meat: your own healthy intestinal bacteria gets wiped out, bacteria develop resistance to the antibiotics and we don't have resistance against them
6. Meat carried pathogens

• During the butchering process their bowels become punctured and intestinal bacteria are splatter on the meat and skin

• e.coli from beef, campylobacter from chickens (70%) and turkeys (90%)
7. meat is full of hormones

- Cattle, pigs, chickens, eggs, and fish are given hormones promote muscle mass
- Excess hormones are linked to cancer including breast and prostate
- When an animal is led to slaughter is releases a stress hormone that gets passed into the meat that you eat