Protein

Learning Objectives

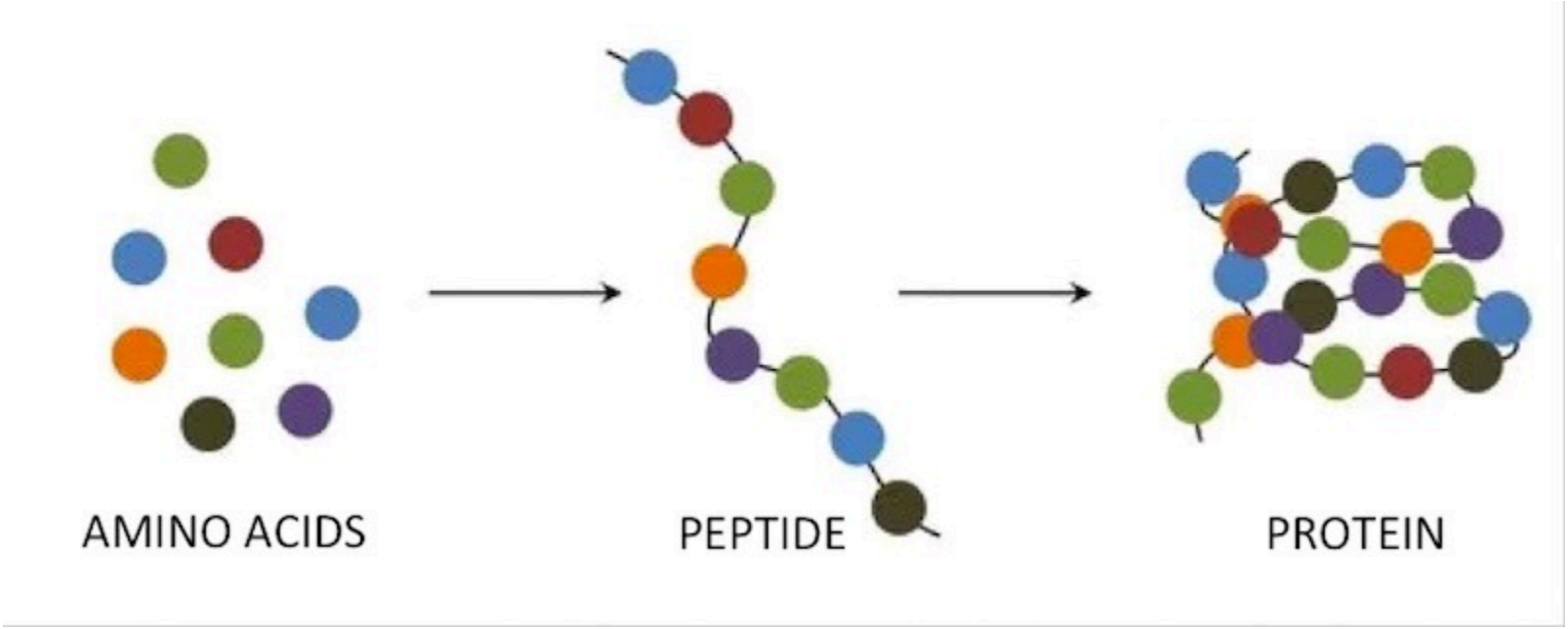
- Define essential and non-essential amino acids and explain how amino acids form proteins.
- Distinguish between high- and low-quality proteins.
- Describe how proteins can complement each other to meet nutritional needs.
- Identify the factors that influence protein needs.
- Explain nitrogen balance states and when they occur.
- Describe how protein is digested and absorbed.
- Describe the differences between the two types of protein-energy malnutrition.
- Explain the symptoms and treatment of food allergies.
- Develop a vegetarian diet plan that meets the body's protein needs.

Overview of Protein

- Form important structures in body, make up key part of blood, help regulate body functions, can fuel body cells
- North Americans generally consume more than they need to maintain health
- Functions
  - Regulates and maintains body functions
  - Provides essential form of nitrogen (in the form of amino acids)

Amino Acids—Building Blocks of Proteins

- 20 different amino acids make up all proteins
- **9 essential amino acids**
- **11 nonessential amino acids**
- Supply 4 kcal per gram



Essential Amino Acids

- **9 essential amino acids**
  - cannot be synthesized by humans in sufficient amounts or at all, must be included in the diet
- **Limiting amino acid**
  - essential amino acid in lowest concentration in food or diet relative to body needs
- **Conditionally essential amino acids**
  - amino acids made from essential amino acids if insufficient amounts are eaten

TABLE 6-1 ► Classification of Amino Acids

Essential Amino Acids	Nonessential Amino Acids
Histidine	Alanine
Isoleucine*	Arginine
Leucine*	Asparagine
Lysine	Aspartic acid
Methionine	Cysteine
Phenylalanine	Glutamic acid
Threonine	Glutamine
Tryptophan	Glycine
Valine*	Proline
	Serine
	Tyrosine

*A branched-chain amino acid

Limiting amino acids in plant sources of protein

Table 7-2 Limiting Amino Acids in Plant Sources of Protein

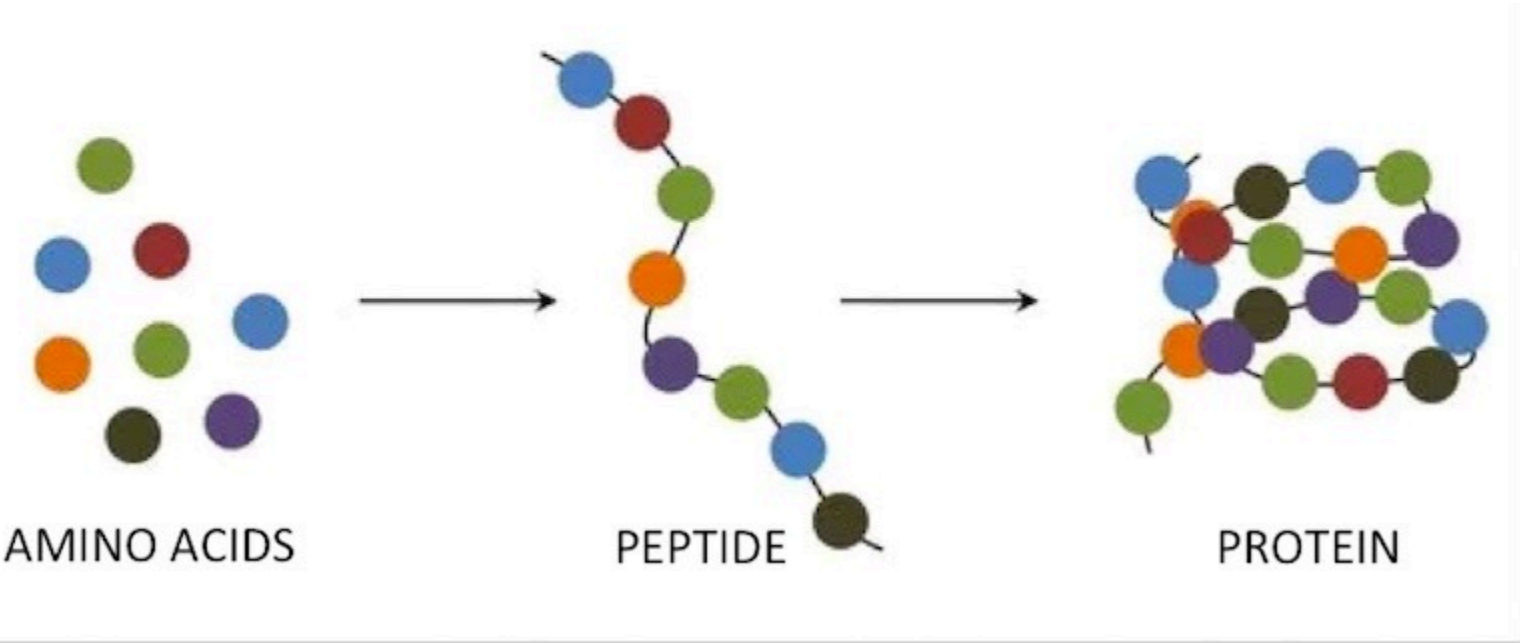
Food	Primary Limiting Amino Acid	Create a Complete Protein By Combining It With	Complementary Food Protein Combinations
Legumes (peanuts, dry beans such as navy, black, and kidney beans) 	Methionine	Grains, nuts, or seeds	Hummus and whole-wheat pita bread Bean burrito White beans and pasta Bean and barley stew Pinto beans and polenta Black-eyed peas and rice
Nuts and seeds (cashews, walnuts, almonds, sunflower seeds) 	Lysine	Legumes	Vegetarian chili with kidney beans and cashews Sesame, buckwheat, and bean bread Salads made with nuts, beans, and seeds
Grains (wheat, rice, oats, corn) 	Lysine	Legumes	Red beans and rice Lentil soup and cornbread Barley and black beans Peanut butter sandwich

Branched-Chain Amino Acids

- “BCAA’s”
- Named for the their chemical structure
- **Leucine, isoleucine,** and **valine**
- Used by muscles for energy needs
- Found in meat, dairy products, and legumes
- Athletes use branched-chain amino acids to improve exercise performance and reduce protein and muscle breakdown during intense exercise.

Protein Synthesis and Organization

- Proteins linked together by chemical bonds, called **peptide bonds**
- Bonds form between amino group of one amino acid and acid (carboxyl) group of another
  - Dipeptides = 2 groups, tri = 3 groups etc.
- Most proteins are polypeptides, 50-2000 groups



Protein Synthesis

- Protein synthesis: creation of proteins from amino acids.
- Proteins linked together by chemical bonds, called **peptide bonds**
  - Order of AA in a protein determines shape
  - Shape determines function
- DNA contains coded instructions for protein synthesis
  - Requires energy
  - **If diet is deficient in calories or one of the essential amino acids, protein synthesis will be limited**

Protein Synthesis

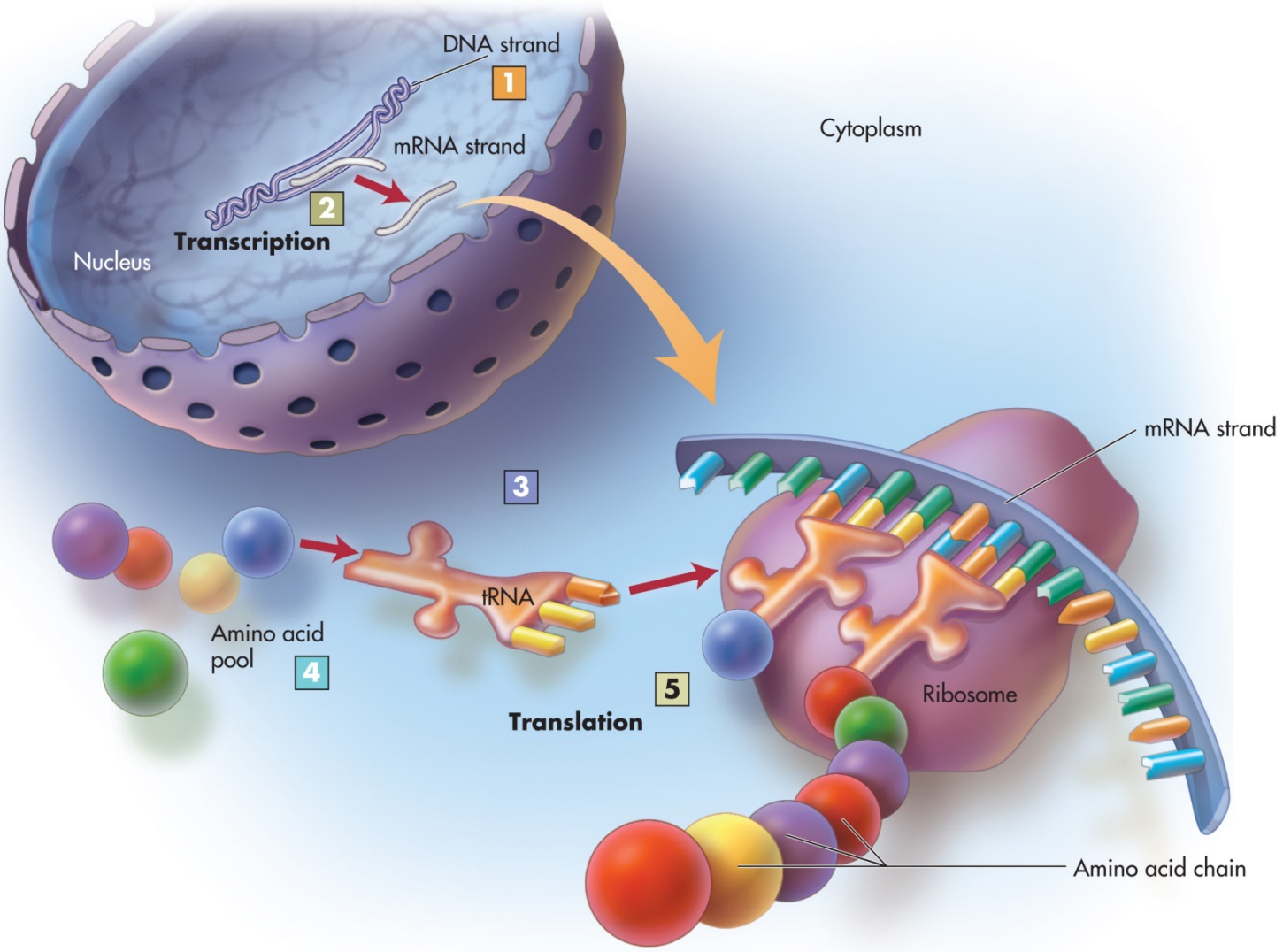
1. DNA contains the information necessary to produce proteins.

2. Transcription or copying of a segment of DNA results in mRNA, a copy of the information in DNA needed to make a protein.

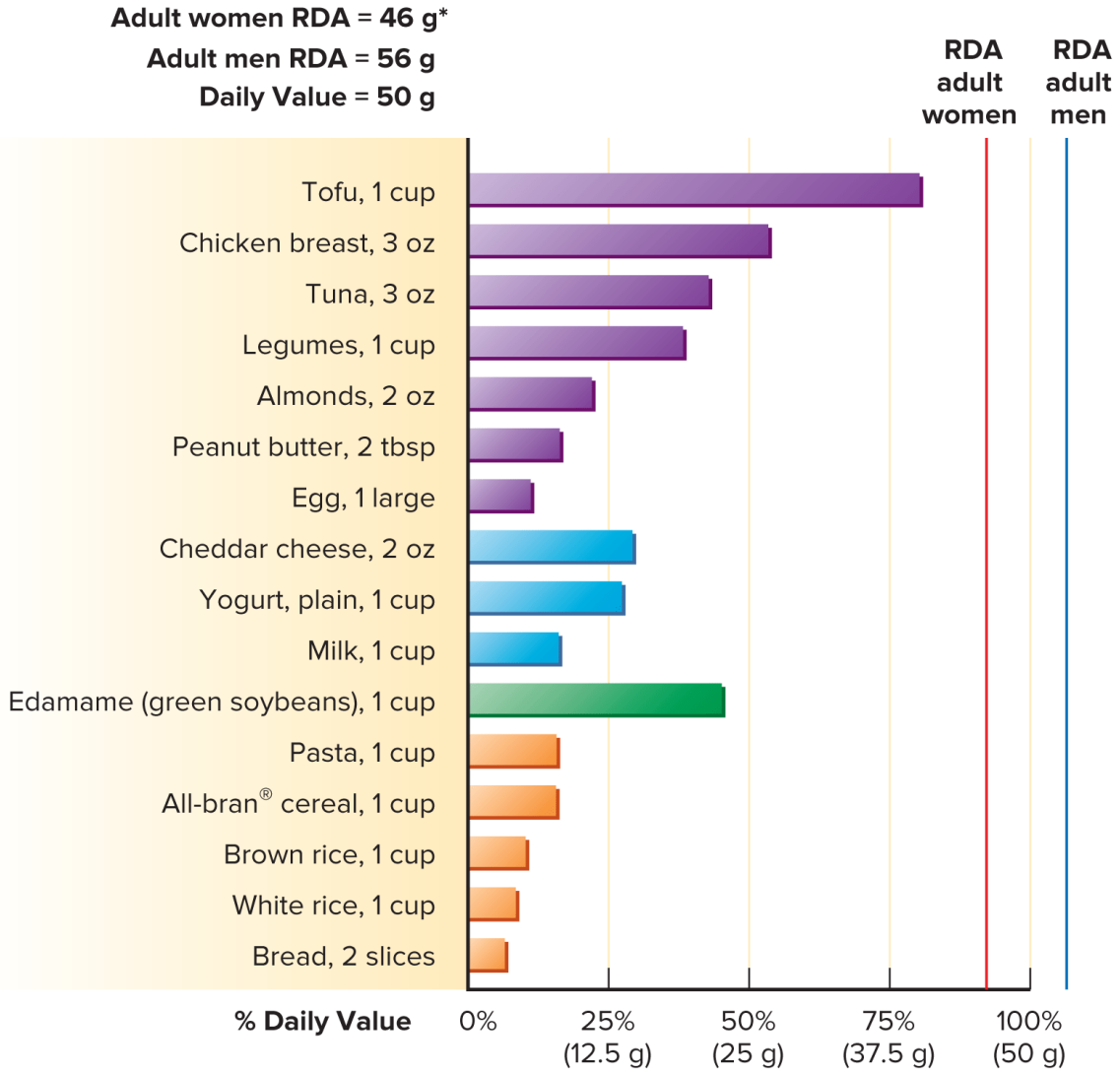
3. The mRNA leaves the nucleus and goes to a ribosome.

4. Amino acids, the building blocks of proteins, are carried to the ribosome by tRNAs containing the code that matches that on the mRNA.

5. In the process of translation, the information contained in mRNA is used to determine the number, types, and arrangement of amino acids in the protein.

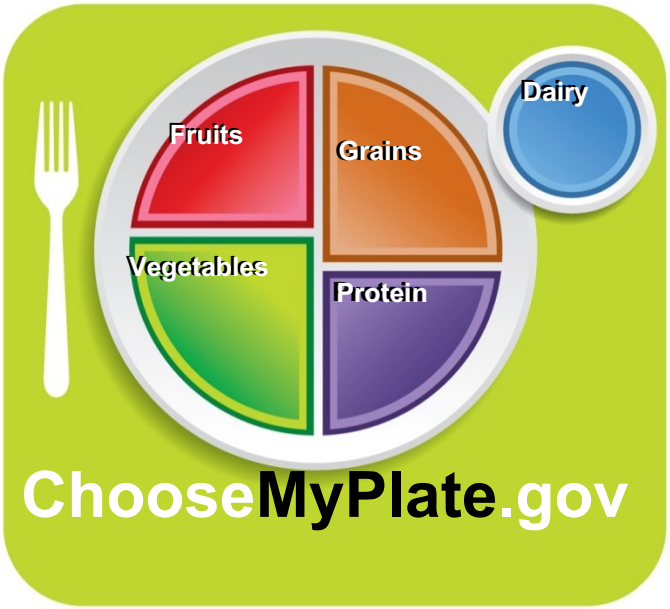


Protein in Foods



*RDA based on 0.8 g/kg body weight for 125 lb (57 kg) woman and 154 lb (70 kg) man.

Protein in Foods



MyPlate:
Sources of Protein

Grains	Vegetables	Fruits	Dairy	Protein
• Bread • Breakfast cereals • Rice • Noodles	• Carrots • Corn • Broccoli	• Apples • Oranges • Bananas	• Milk • Yogurt • Cheese	• Meat • Eggs • Fish • Dry beans • Nuts
2-3 grams per serving	2-3 grams per serving	<1 gram per serving	8-10 grams per serving	7 grams per serving

Types of Vegetarians

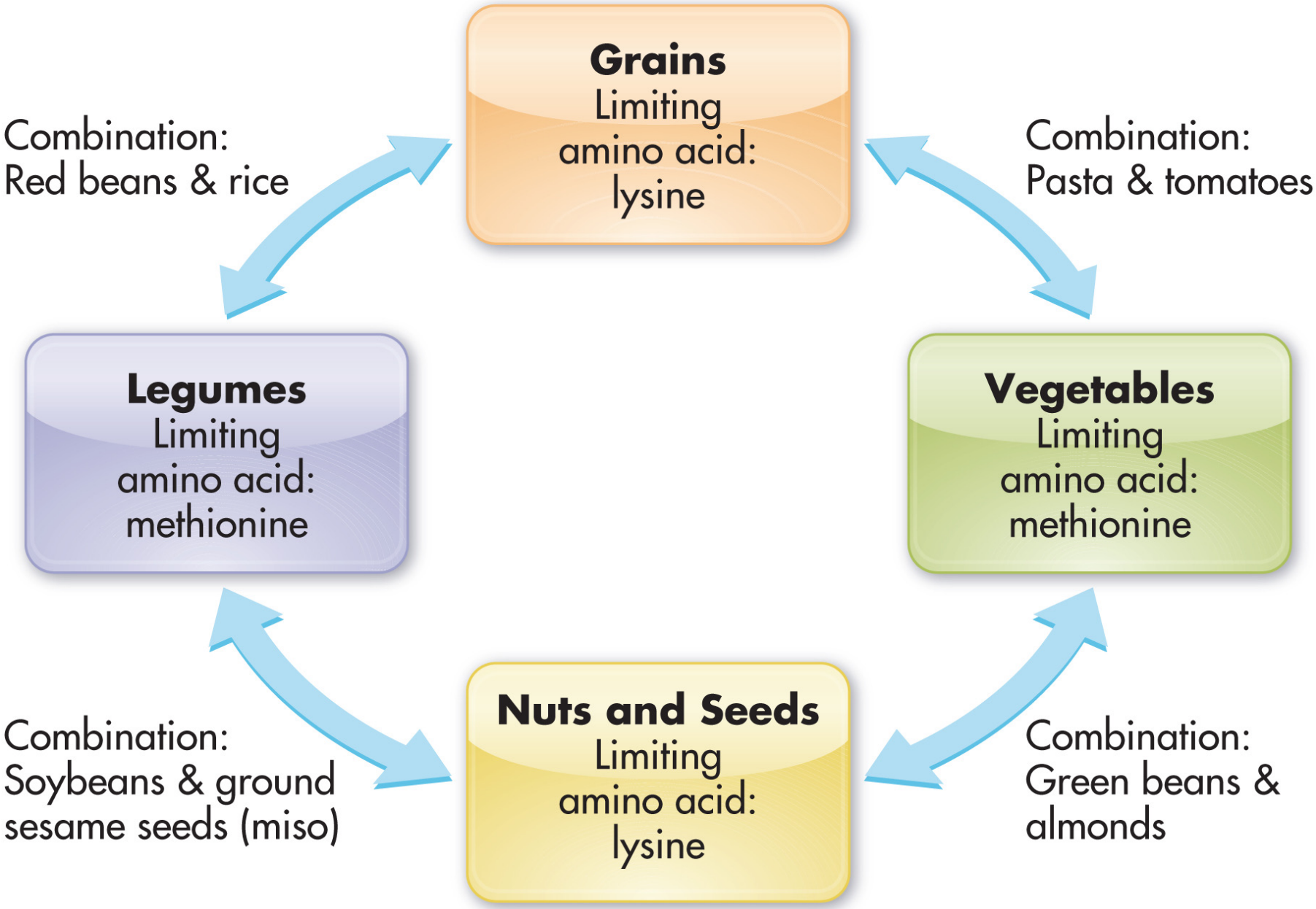
- **Vegan**
  - eats only plant foods
- **Fruitarian**
  - eats fruits, nuts, honey, and vegetable oils
- **Lactovegetarians**
  - plant and dairy products
- **Lactoovovegetarians**
  - plant products, dairy, eggs
- **Special attention to <18**

Vegan Diets

- Complementary proteins
- **Nutrient concerns**
  - Vitamin B12
  - Iron
  - Zinc
  - Calcium
  - Omega-3 fatty acids
  - Vitamin D

Protein Quality

- Animal and plant proteins can differ in proportions of essential and nonessential amino acids
  - Grains, legumes, vegetables, nuts and seeds are low in one or more of the nine essential amino acids
  - Animal protein generally contains all 9 essential amino acids



PAIR THESE → WITH THESE

LEGUMES

Kidney Beans
Black Beans
Lima Beans
Pinto Beans
navy Beans
Green peas, split peas
black-eyed peas.
Chickpeas (Garbanzos)
Lentils
Peanuts

GRAINS

Millet
Oats
Rice
Rye
Triticale
Teff
Kañiwa
Wheat
Barley
Bulgur
Corn

SEEDS

Pumpkin seeds
Seed sprouts
Sesame seeds
Flax seeds

NUTS

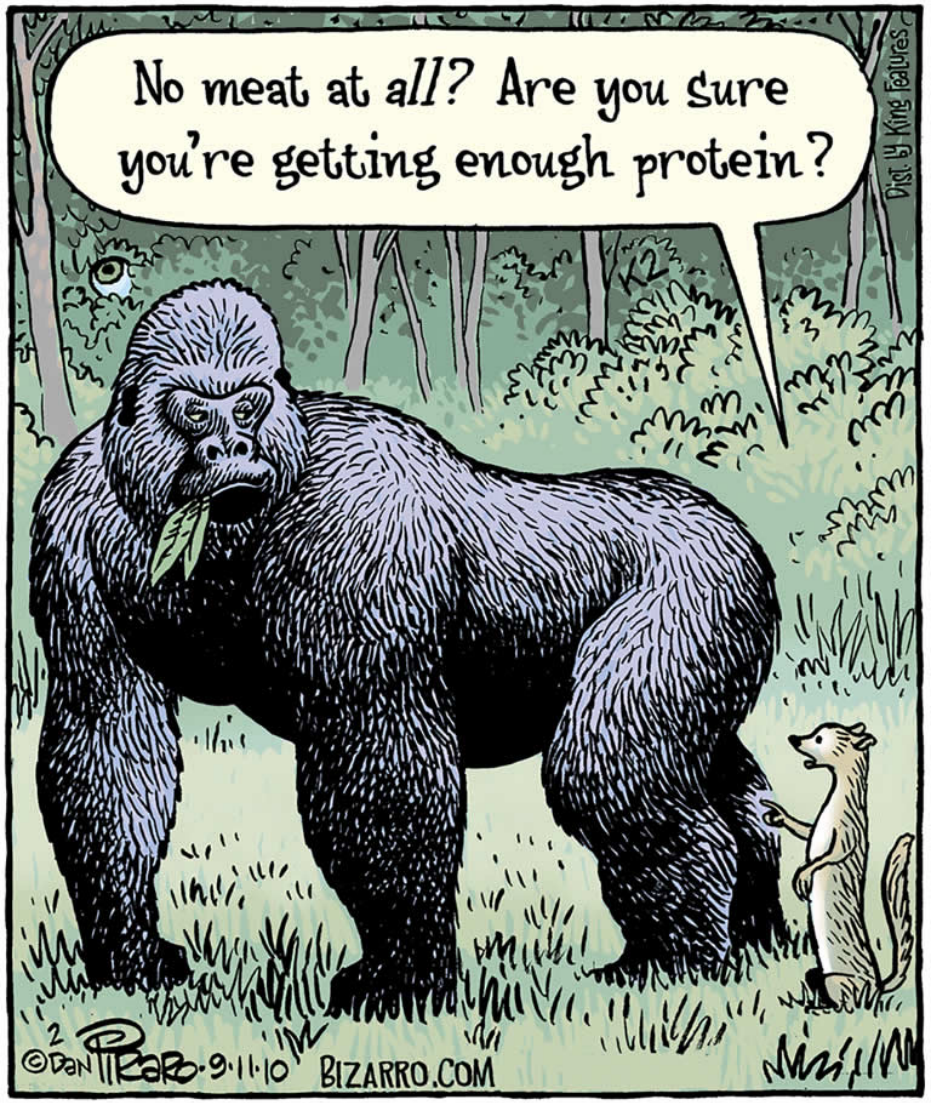
Almonds
Brazil nuts
Cashews
Coconut
Hazelnuts
Macadamia
Peanuts
Pecans
Pine nuts
Pistachio
Walnuts

Dietary Protein

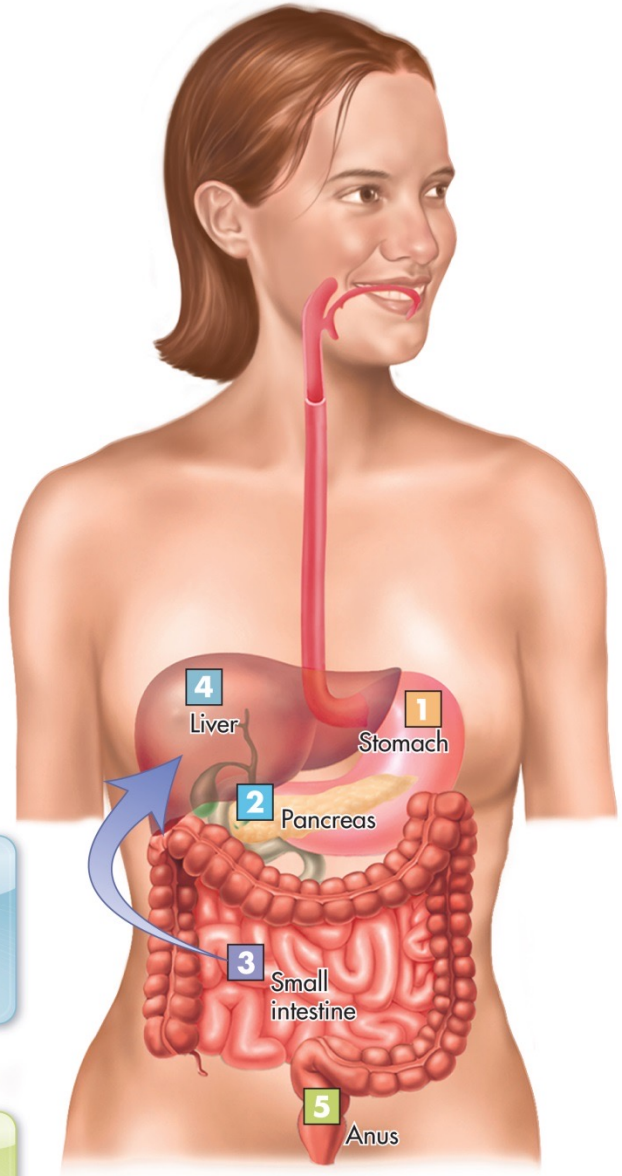
- **Complete proteins**
  - Contain ample amounts of all nine essential
- **Incomplete proteins**
  - Low in or lack one or more essential amino acids
- **Complementary proteins**
  - Two food protein sources that make up for each other's inadequate supply of specific essential amino acids
  - Together they yield a sufficient amount of all nine and so provide high-quality (complete) protein for the diet

Health and Plant Proteins

- Per gram many are great source of nutrients
  - Phytochemicals
  - Protein, vitamin, fiber, phytochemicals
- Heart healthy
- Cancer-fighting
- Bone health
- Better glucose control



Protein Digestion and Absorption



1 Partial protein digestion by the enzyme pepsin and stomach acid.

2 Pancreas releases enzymes that will further digest polypeptides in the small intestine.

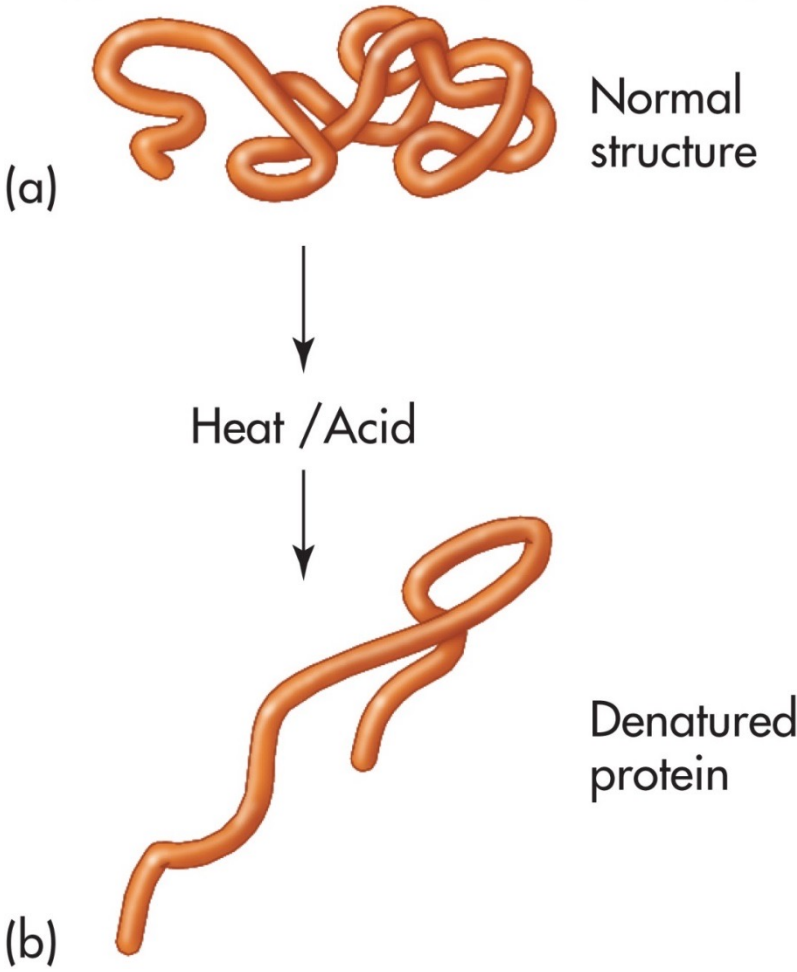
3 Final digestion of amino-acid chains to single amino acids takes place mostly inside cells of the small intestine. Once in the small intestine, the partially digested proteins (and fats) trigger the release of the hormone cholecystokinin (CCK) from the walls of the small intestine. CCK causes the pancreas to release protein-splitting enzymes, such as trypsin.

4 Amino acids absorbed into the portal vein and transported to the liver. From there, they enter the general bloodstream.

5 Little dietary protein is present in feces.

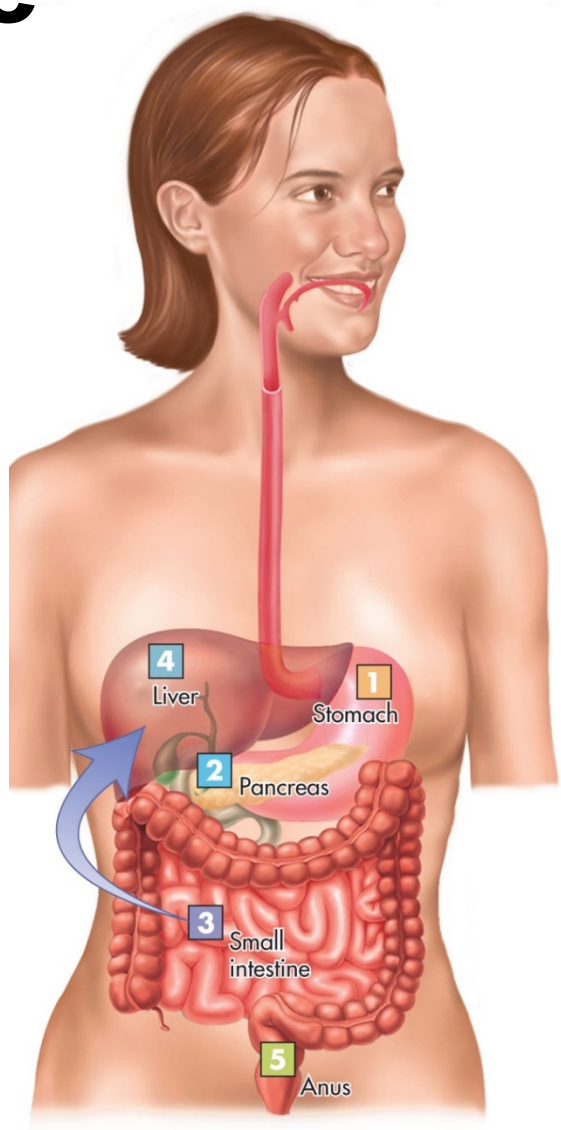
Digestion

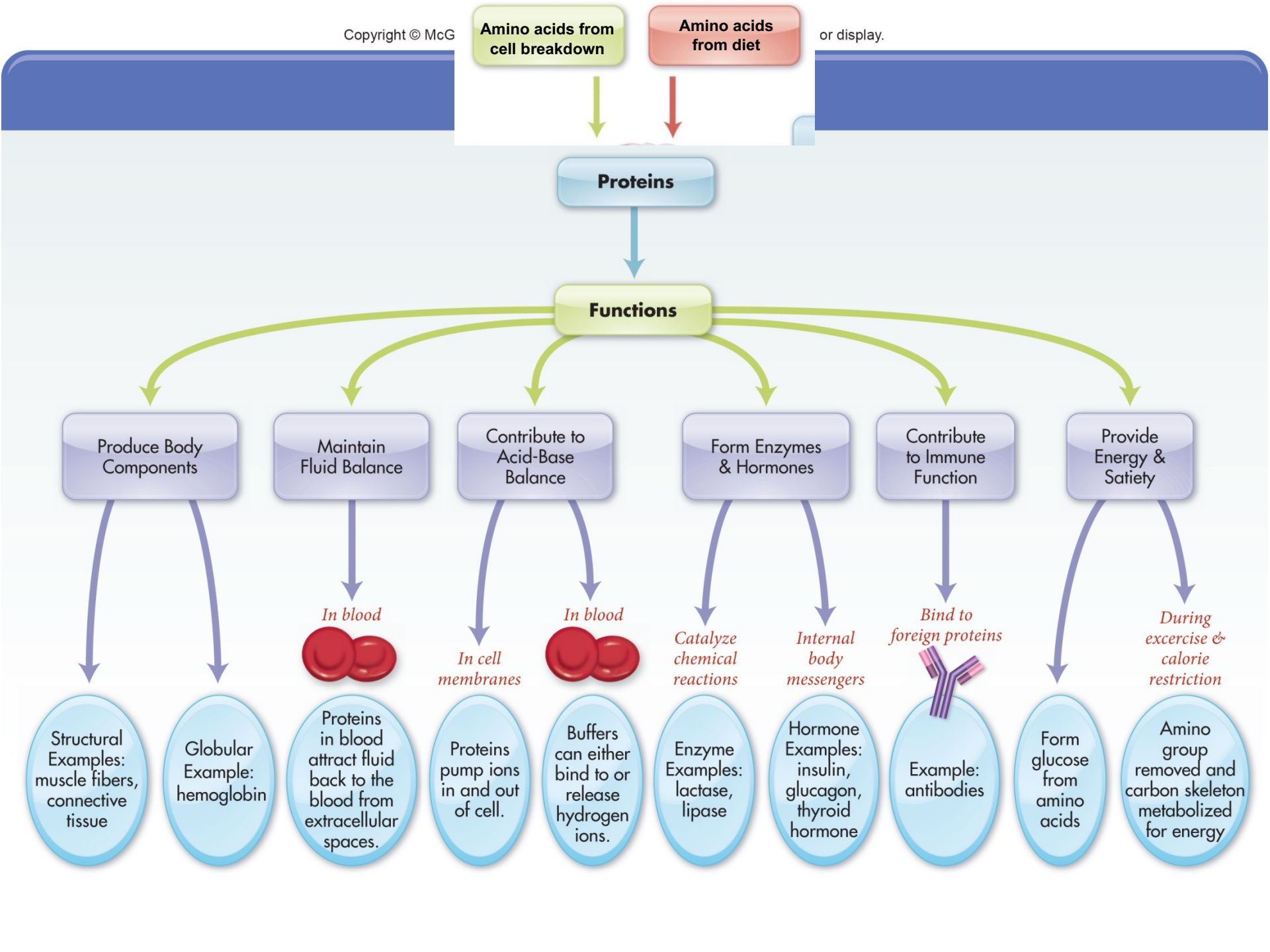
- Denatured
  - Alteration of a protein's three-dimensional structure, because of treatment by heat, enzymes, acid, alkaline solutions, agitation
- Hormone **Gastrin**
  - Thinking of and chewing food cause release into stomach
  - Stimulates the release of acid and pepsin
- **Pepsin**
  - Enzyme produced by the stomach
  - Breaks polypeptide into shorter chains of amino acids



Digestion & Absorption in the Small Intestine

- Release of hormone cholecystokinin (CCK)
- Pancreatic enzymes:
  - Trypsin, among others, into the duodenum
- Peptides are broken down into amino acids & absorbed
  - Microvilli surface and within absorptive cells lining small intestine
  - Many different amino acid transport mechanisms
    - Active absorption
- Amino acids are sent to the liver via portal vein

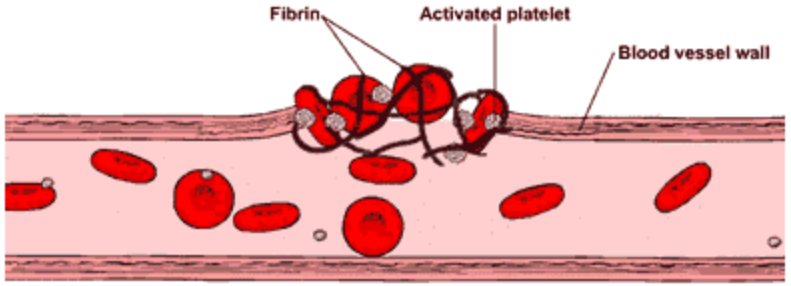




Producing Vital Body Structures

Amino-acid pool in a cell used to form body proteins and other products

- muscles
- connective tissue
- mucus
- blood-clotting factors
- transport proteins in bloodstream
- lipoproteins
- enzymes
- Immune antibodies
- hormones
- visual pigments
- support



Protein Turnover

- Amino acids can be recycled
- Most vital body protein are in a constant state of breakdown, rebuilding, and repair.
- During any day, an adult makes and degrades about **250 grams of protein**

Forming Glucose & Providing Energy

- Without enough carbohydrate, liver produces glucose from amino acids
  - In starvation, amino acids from muscle tissue are converted into glucose
  - Wastes muscle tissue and can produce edema
- Proteins supply little energy for a weight-stable person
  - Can provide energy during prolonged exercise and during weight loss efforts
  - Amino group from amino acid is removed, and remaining carbon skeleton is metabolized for energy needs
  - Increase in urea production
  - Protein is costly source of calories

Contributing to Satiety

- Provide the highest feeling of satiety after a meal
- **Satiety**
  - no longer a desire to eat; a feeling of satisfaction
- Higher protein diets are appropriate if nutritionally sound, being moderate in fat and having enough fiber

Protein Needs

- Promotes protein equilibrium/balance
- Estimating protein need:
- 0.8 gm of protein / kg of healthy body weight

$$\frac{154 \text{ lb.}}{2.2 \text{ kg/lb.}} = 70 \text{ kg}$$

70 kg x 0.8 g protein = 56 g protein

RDA for Protein

- About 10% of total calories, some experts recommend up to 20%
- Endurance athletes
  - *May* need up to 1.7 gm/kg
- Most of us eat more than the RDA for protein
- Excess protein cannot be stored as protein

Protein Intake Recommendations

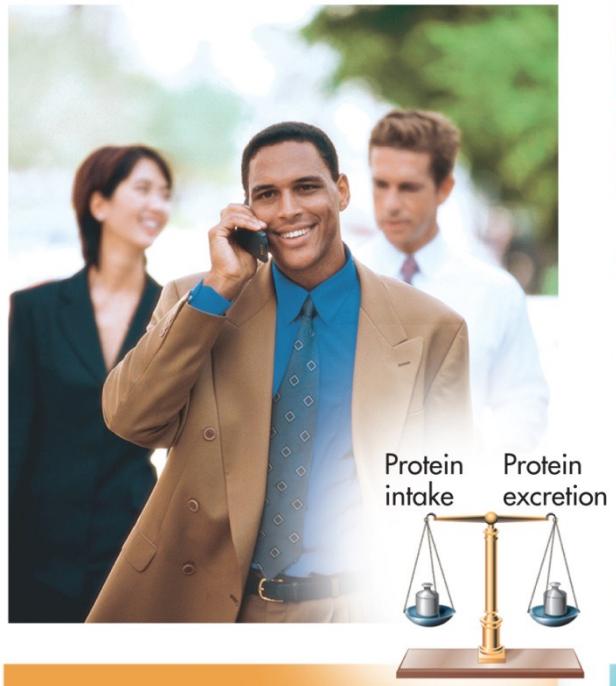
- *Dietary Guidelines for Americans*
  - Choose a variety of protein foods (seafood, lean meat and poultry, eggs, beans, soy, nuts)
  - Increase amount and variety of seafood consumed
  - Replace protein foods high in solid fats
  - Consume less animal protein

Protein Balance

Positive Protein Balance

- Growth
- Pregnancy
- Recovery stage after illness, injury
- Athletic training**

(a)



Protein Equilibrium

- Healthy adult meeting nutrient needs, notably protein and calorie needs

(b)

Negative Protein Balance

- Inadequate protein intake (e.g., fasting, intestinal tract diseases)
- Inadequate calorie intake
- Fevers, burns, infections
- Increased protein loss (e.g., kidney disease)

(c)

*Based on losses of urea and other nitrogen-containing compounds in the urine, as well as protein lost from feces, skin, hair, nails, and other minor routes.
**Only when additional lean body mass is being gained. Nevertheless, the athlete is probably already eating enough protein to support this extra protein synthesis; protein supplements are not needed.

Too much vs too little protein…

Does Eating a High-Protein Diet Harm You?

- If low in plant foods (fiber), vitamins, phytochemicals
- If high in saturated fat and cholesterol
- Cancer risk increases:
  - Red meat (colon)
  - Processed meat (colon)
  - Dairy (prostate)

- Burden on the kidney
- May increase calcium loss in the urine
- Increase urine production – increase risk for **dehydration**

Protein-Calorie Malnutrition

- Somewhat rare in developed countries
  - Seen in alcoholics
- In developing countries
  - Stunts growth and increase risk of infection
- **Protein-Energy Malnutrition**
  - **Marasmus**
    - Starvation and insufficient protein and calories
  - **Kwashiorkor**
    - Marginal amount of calories and insufficient protein

Protein-Calorie Malnutrition

Protein Calorie Malnutrition

Severe protein (with moderate energy) deficit; often accompanied by infections or other diseases

Severe energy and protein deficit

Characteristics of Kwashiorkor

- Edema
- Mild to moderate weight loss
- Maintenance of some muscle and subcutaneous fat
- Growth impairment (60%–80% of normal weight for age)
- Rapid onset
- Fatty liver

Characteristics of Marasmus

- Severe weight loss
- Wasting of muscle and body fat (skin and bones appearance)
- Severe growth impairment (less than 60% of normal weight for age)
- Develops gradually

(left): ©Kevin Fleming/Corbis; (right): ©Peter Turnley/Corbis

Food Protein Allergies

- Immune system mistakes food protein for harmful invader
- 8 foods account for 90% of food-related allergies; soy, peanuts, tree nuts, wheat, milk, eggs, fish, and shellfish
- Reactions range from mild intolerance to fatal allergic reactions
- Introducing allergenic foods early in life may prevent allergies

Most Common Food Allergens

Peanut/tree nuts

Milk products

Soy

Wheat

Eggs

Fish/shellfish

(all): Photos courtesy of Dennis Gottlieb

Gluten Sensitivity – Celiac Disease

- Protein found in certain grains, wheat, rye, barley
- Incomplete gluten breakdown in small intestine leaving small peptides and amino acids
- Celiac disease, inflammatory response to small peptides and amino acids
- Autoimmune response, genetic predisposition