

Chapter 6 Proteins

I. Introduction

II. Chemistry of Proteins

A. amino acids (AA)

1. Proteins are made of many AA connected together (polymers)
2. AA's have an identical structure with the exception of the side groups (R)
 - a. AA's contain the element nitrogen (N)
 - b. Differences in the side group are what make each AA unique
 - c. Around 20 different AA's
3. essentiality of amino acids (EAA)
 - a. Essential AA's
 1. AA's that cannot be made by the body and therefore must be supplied by the diet (table 6-1)
 - b. Nonessential AA's
 1. AA's that can be made by the body
 - c. Conditionally essential AA's
 1. AA's that are normally made providing the precursor is available

B. Proteins

1. Consist of the AA's linked together in different combinations
 - a. Sequence of AA's determines the conformation (3-D structure) which dictates the type and function of the protein
2. AA's are connected to each other through a peptide bond
 - a. condensation reaction

III. Digestion and Absorption of Proteins

A. Process of Digestion

taking the large protein molecule and breaking it down to smaller subunits (AA's)

1. Mouth
 - a. Mechanical
2. Stomach
 - a. Chemical breakdown (denaturation)
 1. Protein loses its 3-D structure in the low pH of the stomach caused by HCl
 - b. Enzymatic breakdown (proteases, peptidases)
 1. pepsinogen is converted to the enzyme pepsin at low pH

3. Small intestine
 - a. Pancreatic and intestinal proteases
 1. Enzymes are specific for certain peptide bonds connecting AA's
 - b. Proteins are broken down into oligo-, di- and tri-peptides

B. Process of Absorption

1. Intestinal cells absorb single AA's, di- and tri-peptides
 - a. Absorption occurs through transporters specific for certain AA's
 - b. Absorption requires energy

IV. Protein in the Body

A. Protein Synthesis

1. transcription: DNA → → RNA
 - a. Taking the information from DNA and transcribing it into RNA
2. translation: RNA → → Protein
 - a. Taking the information from RNA and translating it into AA's
 - b. AA pool
 1. dictates available AA's
 2. If an EAA is not present, perhaps due to a deficiency in the diet, protein synthesis will stop
 - a. Incomplete protein fragment is degraded back to constituent AA's
3. Errors in protein synthesis
 - a. Results in proteins that are dysfunctional
 1. Sickle cell anemia

B. Roles of Proteins

1. Building materials
 - a. growth and maintenance
 1. Muscle tissue
 2. Bone tissue
 3. Blood
 4. Skin
 5. Intestinal cells
 - b. repair
 1. Clotting factors
 - c. replacement
 1. Red blood cells
 - a. Life span of ~120 days
 2. Insulin
 - a. 6-10 minutes
 - d. protein turnover
 1. Proteins do not 'live' forever
 2. Continual breakdown and synthesis

2. enzymes
 - a. Enable reactions to occur without which life could not exist
 1. Synthesize (condensation) and breakdown (hydrolysis) compounds
 - b. Digestive enzymes
3. Hormones
 - a. Compounds made in one cell or organ that elicit effects upon other organs
 1. Insulin and glucagon
4. Regulate fluid balance
 - a. Proteins affect osmotic pressure
 1. Water moves into an area with a higher concentration of particles or solute (protein)
5. Regulates acid-base balance
 - a. Hemoglobin
6. Transporters and receptors
 - a. In blood
 1. Water insoluble compounds
 - a. Fat, steroids, hormones, vitamins
 - b. In cells
 1. Transport glucose
 2. Hormone receptor
 - a. Insulin, glucagon, estrogen
7. Antibodies
 - a. Specifically attack foreign bodies
8. Other roles
 - a. neurotransmitters
 - b. blood clotting
 - c. visual pigments

C. Preview of Protein Metabolism

1. Protein turnover
 - a. Continual synthesizing and breaking down of proteins (half-life)
2. Nitrogen balance
 - a. In balance: Intake = output
 - b. Negative balance: intake < output
 - c. Positive balance: intake > output
3. Using AA's to make protein and nonessential AA's
 - a. Some AA's can be made from other AA's to support protein synthesis
 - b. Deficiency
 1. Body protein will be broken down to obtain necessary AA's
4. Using AA's for energy
 - a. used to make glucose
 1. Deamination
 - a. Removal of the amino group (N)
 2. Carbon skeleton then used to make glucose (gluconeogenesis)
 - b. used for energy
 - c. xs used to make fat

V. Proteins in Food

A. Protein quality

1. Complete protein
 - a. contains all essential AA's in amounts we require
 1. support growth
 2. maintain adult's protein
 - b. Animal proteins; except soy
 - c. Egg protein is reference protein
 - d. In or positive nitrogen balance
2. partially complete protein
 - a. has limiting AA
 - (1) cereals → lysine
 - (2) legumes → methionine
 - b. support life not growth
 - c. In nitrogen balance in adult
 - d. Negative balance in child
 1. insufficient EAA
 - e. complimentary proteins
 1. combining incomplete protein sources in 24 hrs period
 2. black beans & rice
 3. peanut butter & bread
3. incomplete protein
 - a. won't support life or growth
 - b. Negative nitrogen balance
 1. Completely lacking EAA
4. measurement of protein quality (**EAA**)
 - a. chemical scoring
 1. AA profile compared to reference protein (egg)
 2. if valine is present at 70% of egg value then the score is 70
 - b. biological value (BV)
 1. requires living organism
 2. measure of nitrogen retained for growth/maintenance
 3. retained protein/absorbed protein
 - c. Protein efficiency ratio (PER)
 1. weight gain/protein intake

VI. Health Effects and Recommended Intakes of Protein

A. Protein-energy malnutrition (PEM)

1. Deprivation of protein, calories or both
2. most widespread form of malnutrition
 - a. poor growth in children
 - b. wasting in adults
3. children mostly afflicted

B. Types of PEM (table 6-5)

1. marasmus (chronic PEM) pg. 217
severe deprivation or malabsorption of protein and calories
 - a. age less than 2
 - b. severe muscle wasting
 - c. old looking face
 - d. growth failure
 - e. no edema
 - f. no fatty liver
 - g. good appetite
 - h. low temperature
 - i. no hair color changes but easily plucked
 - j. Develops slowly
(adaptation to starvation; adaptation fails; kwashiorkor)
2. kwashiorkor (acute PEM) pg. 218
inadequate protein intake or infections
 - a. ages 1-3
 - b. growth failure
 - c. edema
 - d. fatty liver
 1. Impaired lipid transport
 - e. anorexia
 - f. I.Q. decrease
 - g. hair changes
 1. loses pigmentation
 - h. increased infections - as a cause
 1. rainy tropical regions
 - a. mold (protein synthesis inhibitor)
 - i. death
 1. quicker onset than marasmus

C. Health Effects of Excess Protein

1. contributes to obesity
 - a. Excess protein → fat
 - b. high protein foods → high fat foods
2. promotes calcium loss from body
 - a. 2x increase in protein → 50% increase in urinary calcium loss
 - b. Sulfur containing AA's (cystine, methionine)

3. stresses kidney and liver
 - a. if health is good there is no risk
 - b. if there is disease there could be a severe risk

D. Recommended Intake of Protein

1. nitrogen balance studies
 - a. protein is 16% nitrogen
 - b. analyze nitrogen in feces and urine, sweat, hair to find losses per day
 - c. amount of protein needed to replace losses
2. RDA for protein
 - a. 0.8 g/kg body weight or 0.36 g/lb (~15% of caloric intake)
 - b. Safety factors, digestibility
 1. no defects in absorption
 2. variety of protein mixes
3. Consume sufficient CHO to prevent protein from being used for energy

E. Animal versus vegetable protein

1. Vegetable protein lowers blood cholesterol
2. Vegetables are low in fat, high in fiber
3. Animal protein is higher quality

F. Vegetarians and Protein Intake

1. Protein sources
 - a. whole grains
 - b. vegetables
 - c. tofu (soy)
 - d. legumes, nut
2. Types of vegetarians
 - a. Lacto-vegetarian
 1. Eat milk and plants
 - b. Lacto-ovo-vegetarian
 1. Eat milk, eggs and plants
 - c. Semi-vegetarians
 1. some eat meat and dairy products

G. Protein and Amino Acid Supplements

1. RDA for Protein

a. Example:

$$180 \text{ lb.} / 2.2 \times 0.8 = 65.5 \text{ g protein for the day}$$

b. Typical lunch meal

<u>Item</u>	<u>Protein</u>
cheeseburger	14 g
french fries	6 g
milk shake	17 g (homemade)
Total	37 g or 56% of RDA

c. Typical daily protein intakes are > 100 g

2. protein supplements not needed

a. heavy exercise 1.0-1.2 g/kg wt.

1. 81.8 g - 98.2 g/day

2. Easily obtained from diet

b. Weightlifting 2.0 g/kg wt.

1. 163.3 g/day

2. Possible to obtain from diet

3. amino acid supplements

a. little scientific evidence to support supplementation

b. can be toxic

c. have not been tested

d. Expensive