DIETARY PROTEIN

PHAR-432

LECTURE: 9

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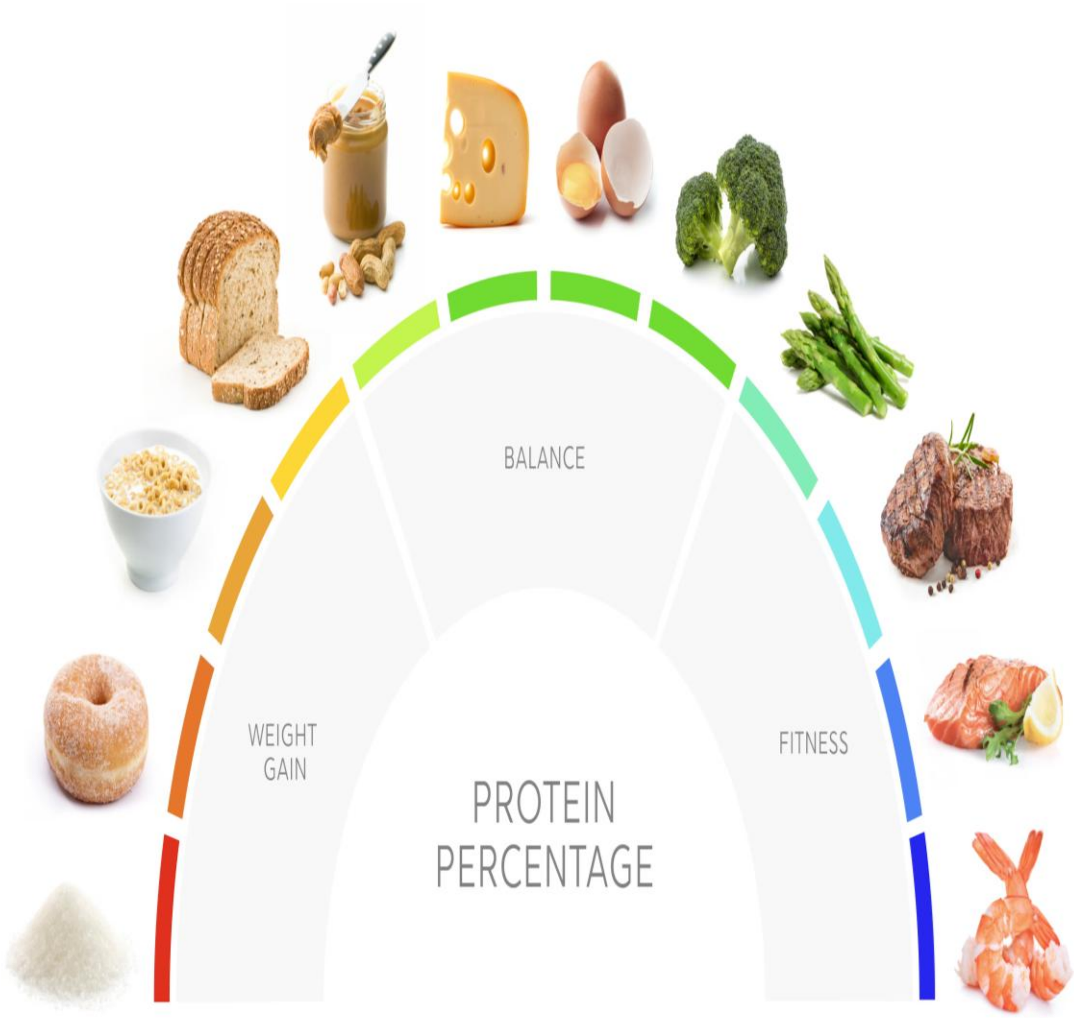
Spring Semester (2025-2026)

Outlines

- Protein
- Function
- Essential and non-essential amino acids
- Amino acid pool
- Protein turnover
- Nitrogen balance



Protein

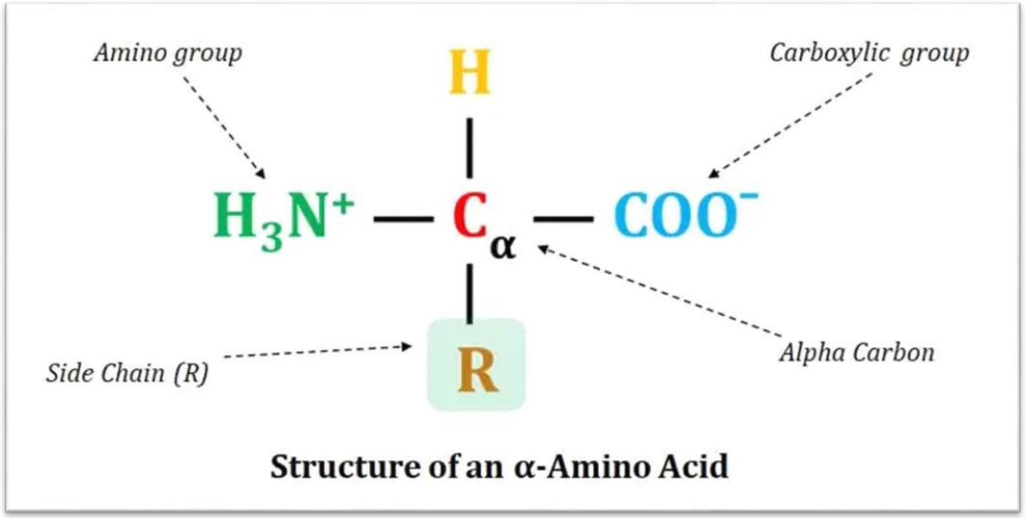
Proteins are the major components of the living cells.

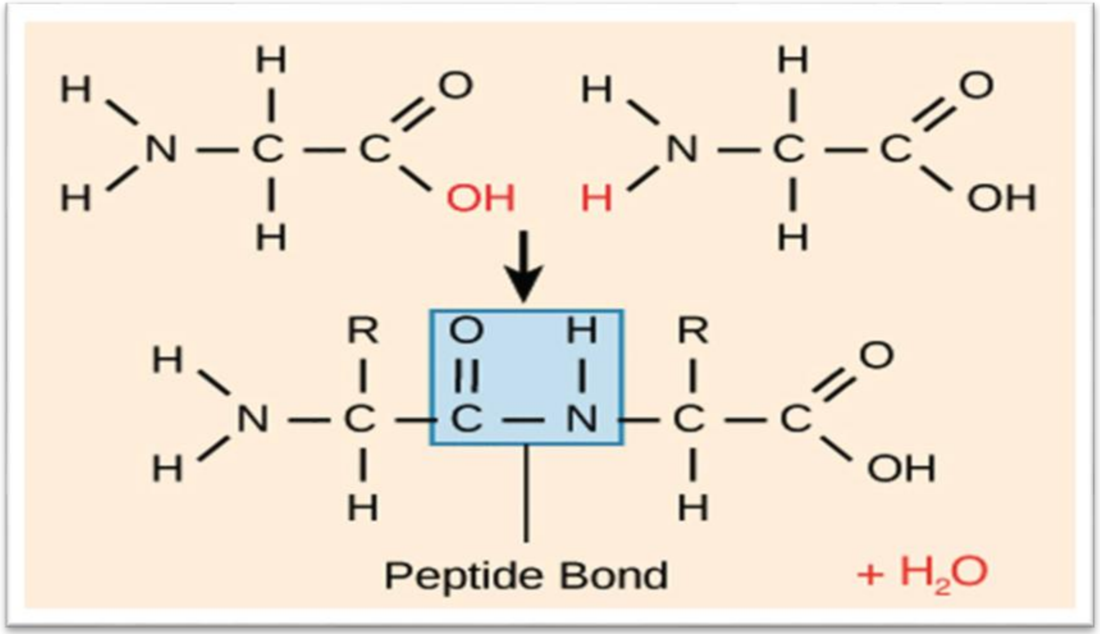
All contain *Carbon, Hydrogen, Oxygen and Nitrogen.* Most proteins contain *Sulfur* and certain proteins contain additional elements particularly *Phosphorous, Iron, Zinc and Copper.*

The molecular weight of proteins are very high (macromolecules), but on hydrolysis they all give a group of simple organic compounds of low molecular weight called alpha amino acids

Amino acids

- Alpha amino acids are building blocks of proteins.
- Amino acids are linked together to form peptides, polypeptides through an amide linkage called **peptide bond**





Amino Acids Classified on Basis of Nutritional Requirement

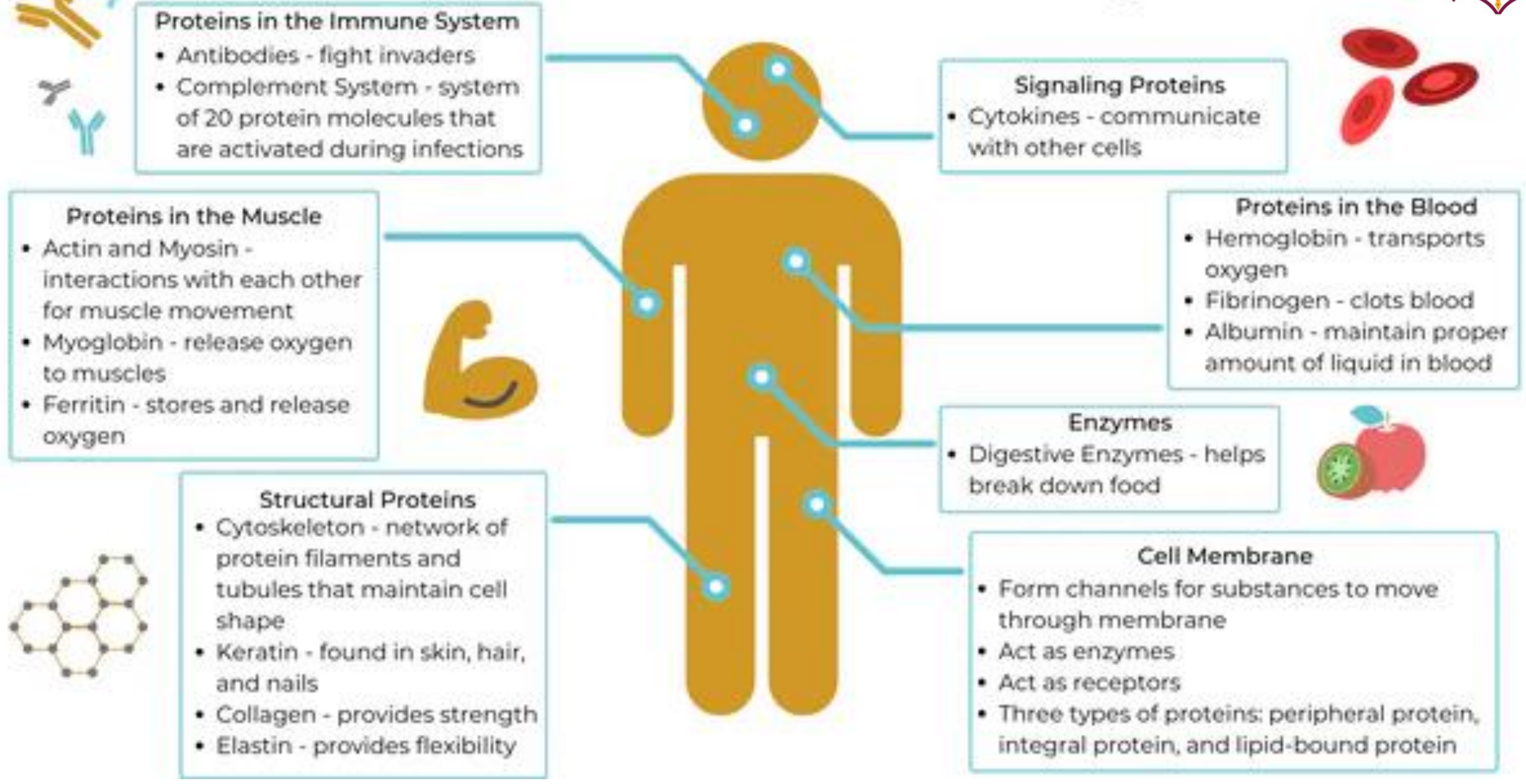
I. **Essential amino acids:** Not synthesized in the body and must be supplied in diet.

II. **Non-essential amino acids:** Synthesized in body and there is no diet dependency for them.

III. **Semi-essential amino acids:** Not synthesized in the body in adequate amounts and requires dietary supplementation, ex:- Arginine and Histidine.

ESSENTIAL AMINO ACIDS	NON ESSENTIAL AMINO ACIDS
Valine	Glycine
Leucine	Alanine
Isoleucine	Aspartic acid
Arginine	Aspargine
Histidine	Glutamic acid
Lycine	Glutamine
Threonine	Serine
Methionine	Cysteine
Tryptophan	Tyrosine
Phenyl alanine	Proline

Proteins in the Human Body



CLASSIFICATION OF PROTEINS

(Depending whether they contain all the essential amino acids or not)

A-Complete proteins : They contain all of the essential amino acids such as animal products : egg, milk, meat, fish, and poultry .

B-Incomplete proteins : They are deficient in one or more of the essential amino acids such as wheat, rice, corn , beans, peas, almond, soy.

Amino acid pool

Free amino acids are present throughout the body, for example, in cells, blood, and the extracellular fluids

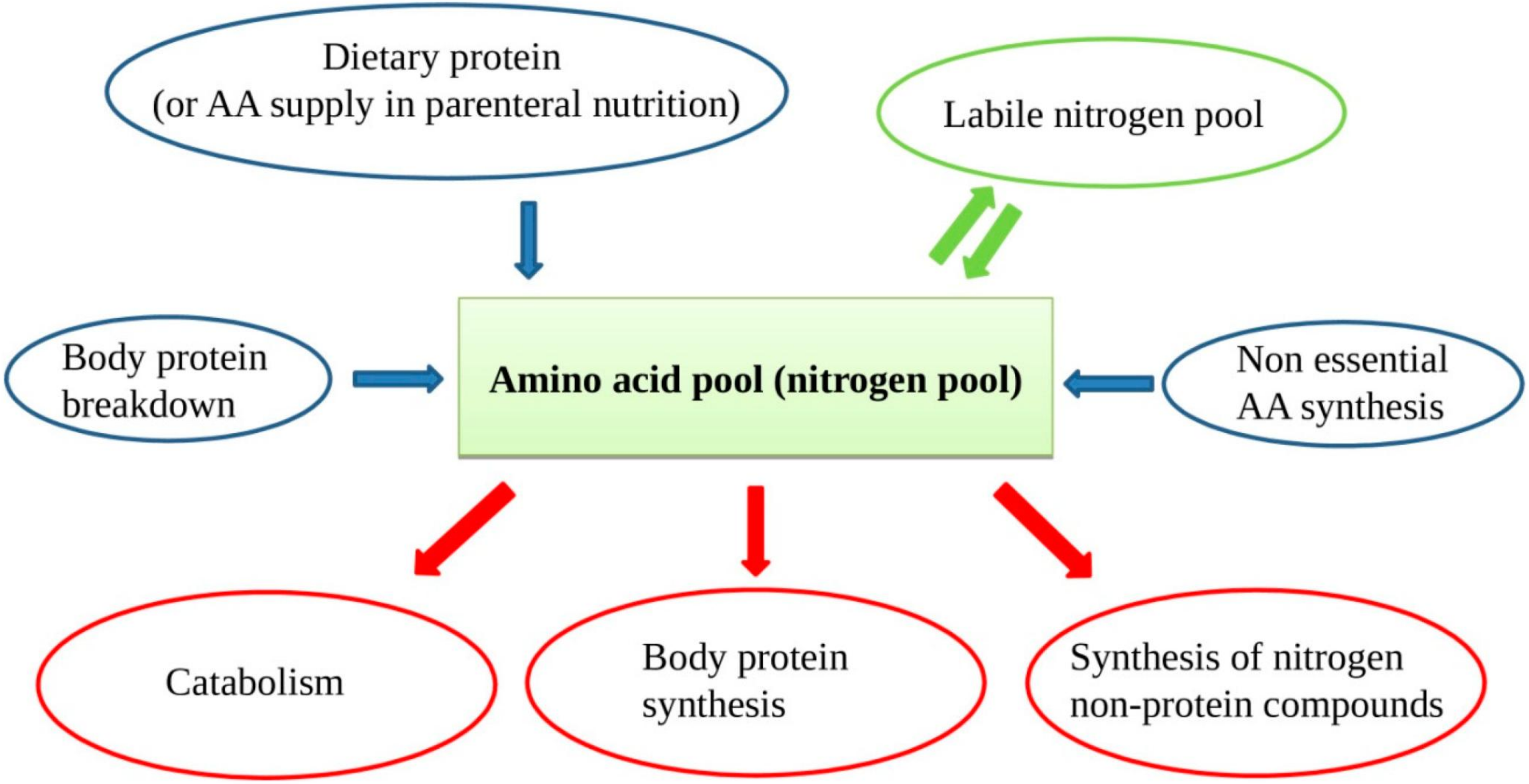
This pool is supplied by three sources:

1. Amino acids provided by the degradation of body proteins (300-400 g)
2. Amino acids derived from dietary protein, and
3. Synthesis of nonessential amino acids from simple intermediates of metabolism.

Amino acid pool

Conversely, the amino pool is depleted by three routes:

1. Synthesis of body protein (300-400 g)
2. Synthesis of nitrogen-containing small molecules like purine, pyrimidine and creatinine
3. Synthesis of glucose, glycogen, fatty acids, ketone bodies, or CO_2 + H_2O.


Dietary protein
(or AA supply in parenteral nutrition)
Labile nitrogen pool
Body protein
breakdown
Amino acid pool (nitrogen pool)
Non essential
AA synthesis
Catabolism
Body protein
synthesis
Synthesis of nitrogen
non-protein compounds

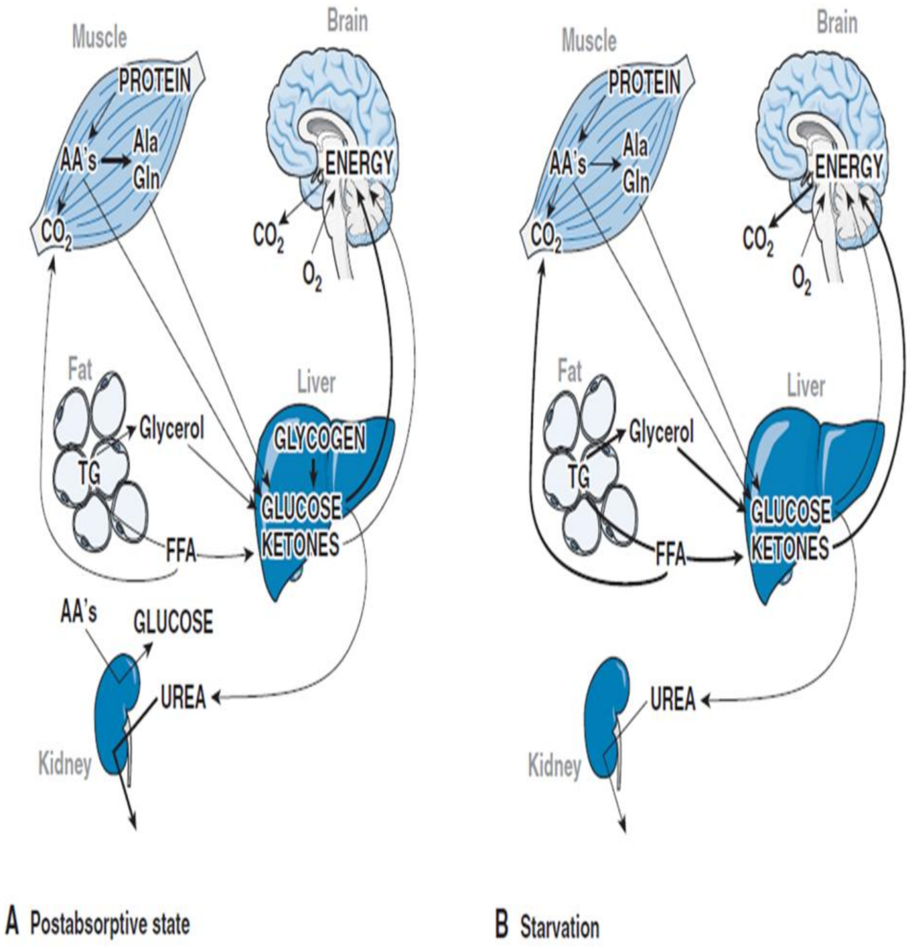
Metabolic Adaptation to Fasting and Starvation

POSTABSORPTIVE STATE (Between Meals)

- You are no longer absorbing nutrients from the intestine, so the body must maintain blood glucose using stored fuels.

STARVATION (Prolonged Fasting)

- Occurs after several days without food.



Postabsorptive vs Starvation

Feature	Postabsorptive	Starvation
Main glucose source	Liver glycogen	Gluconeogenesis
Liver glycogen	Present	Depleted
Ketone production	Low	Very high
Brain fuel	Glucose	Mostly ketones
Muscle breakdown	Moderate	Decreases over time
Urea excretion	Higher	Lower
Kidney gluconeogenesis	Minor	Important

The Fed State

During the fed portion of the day, three things occur to the dietary intake of amino acids and glucose:

1. They are used to replete protein and glycogen that were lost during the postabsorptive period.
2. If intake exceeds what is needed for replacement, then **Oxidation occur (Used for Immediate Energy)**
3. When energy intake is greater than immediate needs: **used for Growth or storage of Excess Calories**

Protein Turnover

Protein turnover is the ongoing process in which the body:

1. **Breaks down old or damaged proteins** (protein degradation)
2. **Builds new proteins** (protein synthesis)

- This process occurs every day in every tissue of the body.
- Approximately **300–400 g of body protein** is broken down and rebuilt each day.

Why Protein Turnover Is Important?

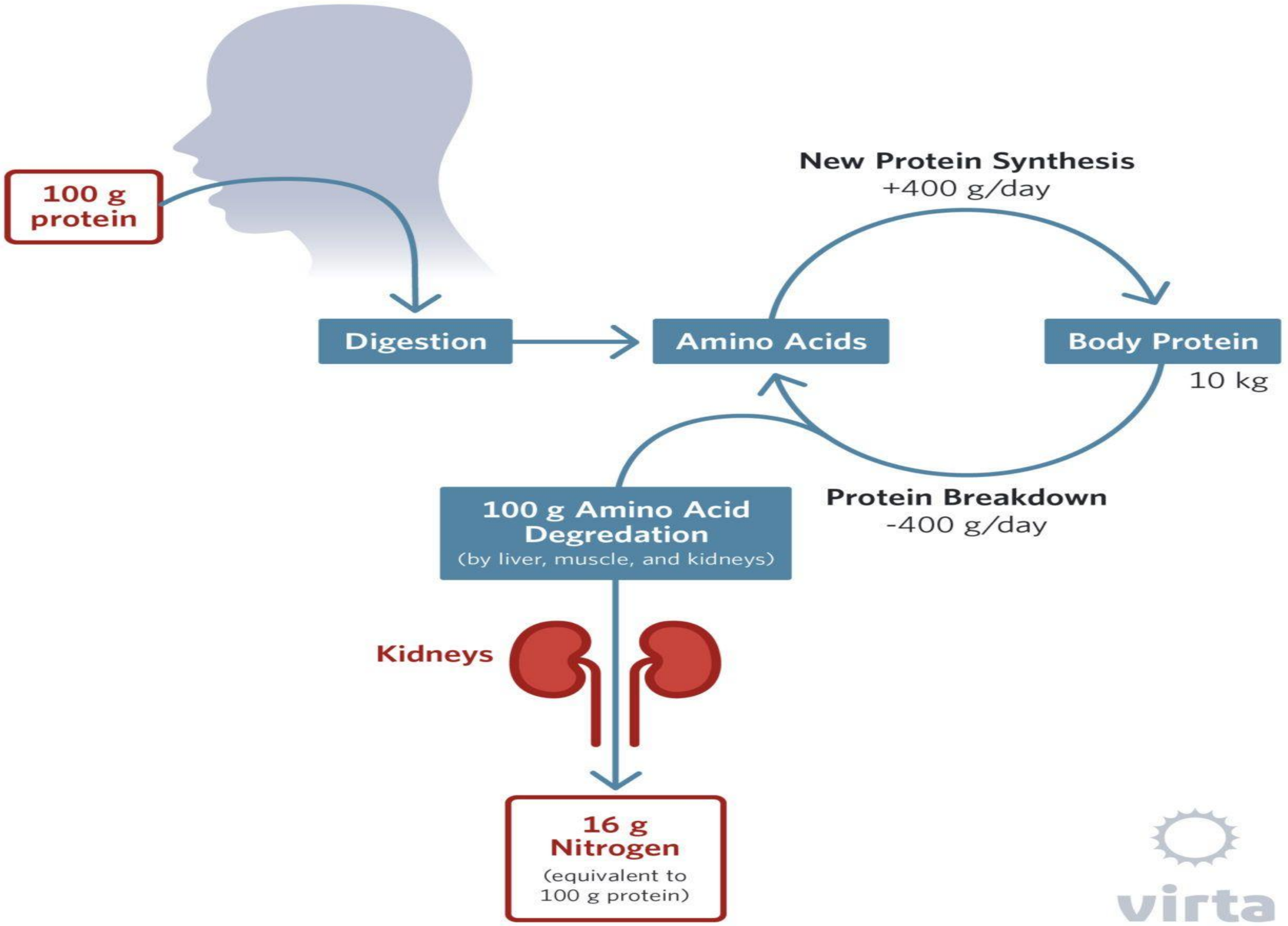
Protein turnover allows the body to:

- Remove abnormal or damaged proteins
- Replace worn-out proteins
- Adjust enzyme levels
- Produce hormones and antibodies
- Repair tissues
- Adapt to exercise and stress

Protein turnover

- The rate of turnover of individual proteins tends to follow their function in the body;
- That is, those proteins whose concentrations need to be regulated (e.g., Enzymes) or that act as signals (e.g., Peptide hormones) have relatively high rates of synthesis and degradation as a means of regulating concentrations.
- Conversely, structural proteins such as collagen and myofibrillar proteins or secreted plasma proteins have relatively long lifetimes.

Protein Intake and Turnover



Nitrogen Balance

- Since nitrogen is the most characteristic and constant product of protein and protein catabolism, its estimation is necessary to determine the overall process of protein metabolism and consequently nitrogen balance and there will be 3 possibilities:-

The 3 possibilities to determine nitrogen balance

1. If the nitrogen content of foods exceeds that excreted, this means that the body is taking nitrogen principally as tissue proteins and this condition is called **Positive Nitrogen Balance**, such as those occur in cases of **infants, children, pregnancy and athletes.**
2. If the nitrogen excreted is equal to that of the food taken, the condition is called **Nitrogen Balance** in which catabolism = anabolism, and this is usually **the case of adults** .
3. If the nitrogen excreted exceeds that of food eaten, the condition is called **Negative Nitrogen Balance** such as those occur in cases of **illness, starvation, protein deficiency, surgery, advanced cancer.**

Nitrogen removal from amino acids

Metabolism of amino acids requires two processes - Transamination reaction followed by Oxidative Deamination.

Removing the a-amino group is essential for producing energy from any amino acid and is an obligatory step in the catabolism of all amino acids.

Once removed, this nitrogen can be incorporated into other compounds or excreted as urea by urea cycle, with the carbon skeletons being metabolized to yield energy .

Protein Requirements

The recommended daily allowance (RDA) for dietary protein in most countries is 0.8 grams per kg of body weight per day. That amounts to 56 grams for a 70 kg adult.

Normal” protein intake range of 10% to 15% of energy, meals with an average of 20% to 30% of energy from protein are representative of high-protein diets when consumed in energy balance

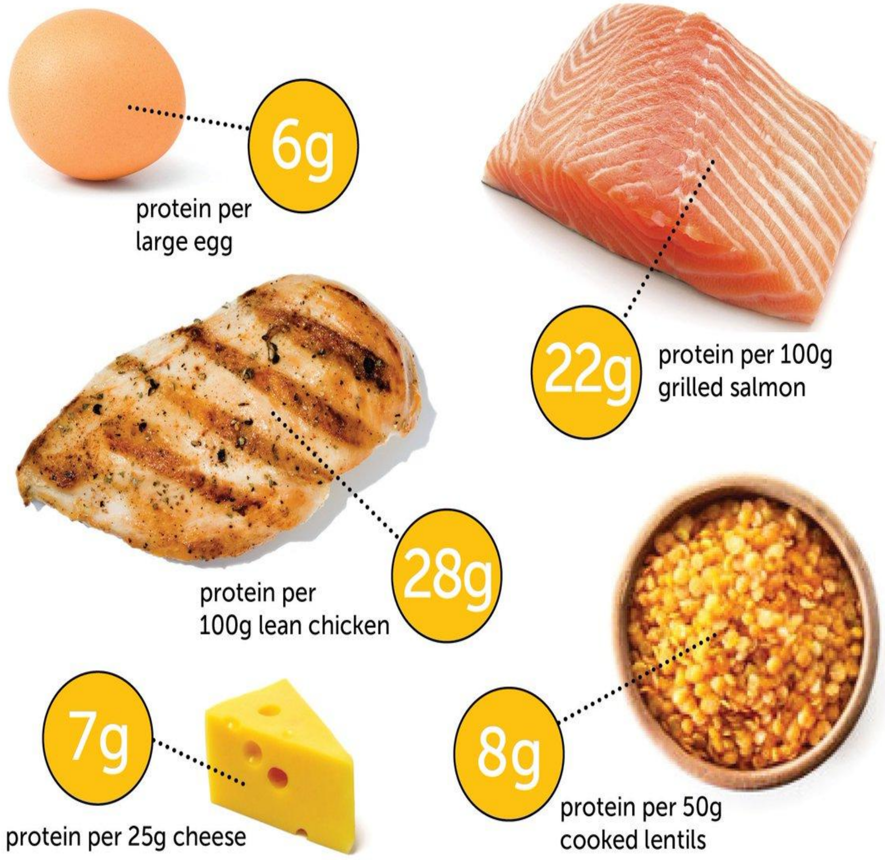


TABLE 1.11 RECOMMENDED INTAKES OF HIGH-QUALITY REFERENCE PROTEIN FOR NORMAL HUMANS

AGE (y)	WEIGHT (kg)		EAR[a] (g/kg/d)	RDA[b] (g/kg/d)
0–0.5	6			1.52[c]
0.5–1	9		1.10	1.50
1–3	13		0.88	1.10
4–8	20		0.76	0.95
9–13	36		0.76	0.95
	Male	Female		
14–18	61	54	0.72	0.85
>18	70	57	0.66	0.80

High protein diet

- After a high-protein lunch, satiety and energy expenditure is significantly Higher than after a normal-protein lunch, without differences in ghrelin and (PYY) responses.

Why a High-Protein Lunch Increases Satiety and Energy Expenditure?

1. Feel fuller (greater satiety)
2. Burn more calories after the meal (higher postprandial thermogenesis)
3. Do this even when key appetite hormones such as ghrelin and PYY do not change significantly and GLP1 that (Promote satiety) is reduced.

- This demonstrates that protein affects appetite and metabolism through multiple mechanisms, not just through changes in a single hormone.

Why GLP-1 Was Lower After the High-Protein Meal?

Carbohydrates are potent stimulators of GLP-1 release.

- Normal-protein, higher-carbohydrate meal → higher GLP-1
- High-protein meal → lower GLP-1 than the carbohydrate-rich meal

Despite this, satiety was greater with protein

Why Protein Increases Fullness Even Without Hormonal Differences?

A. Higher Thermogenesis

The body expends more energy processing protein, which is associated with stronger satiety signals.

B. Increased Amino Acid Availability

Circulating amino acids such as leucine can signal the hypothalamus and activate pathways such as mTOR, promoting satiety.

C. Greater Protein Synthesis

Building proteins consumes ATP and contributes to metabolic demand and fullness.

D. Slower Gastric Emptying

Protein can delay stomach emptying, prolonging gastric distension.

E. Improved Glycemic Stability

Protein tends to reduce large glucose swings, which can decrease rebound hunger.

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