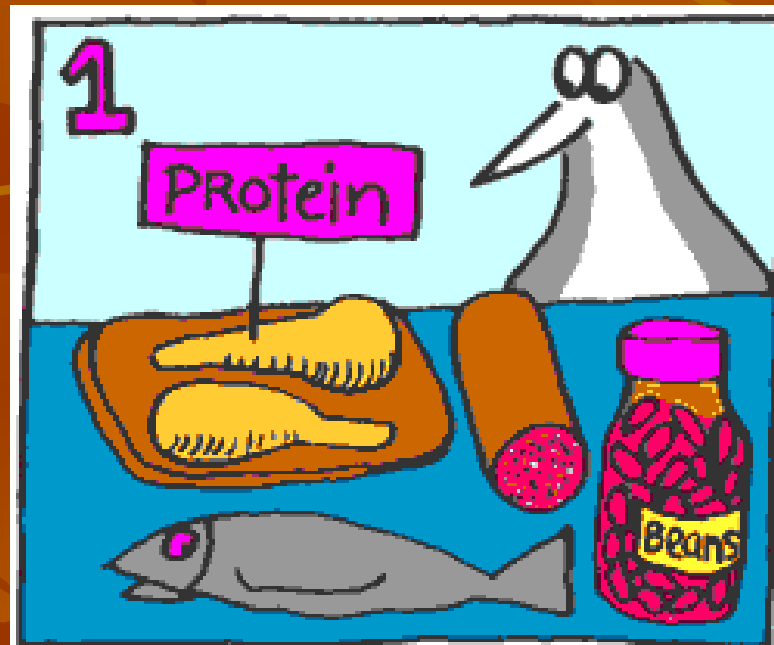


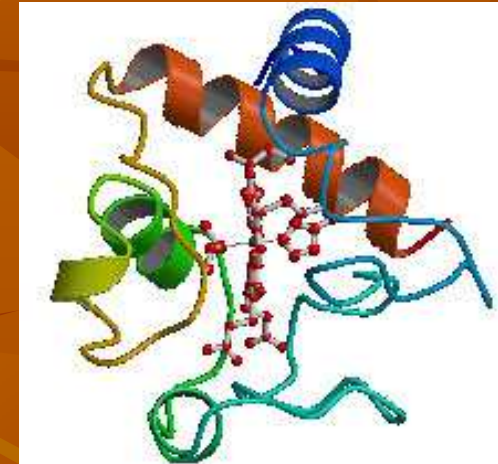
Proteins, amino acids and exercise



Proteins and amino acids

■ Proteins

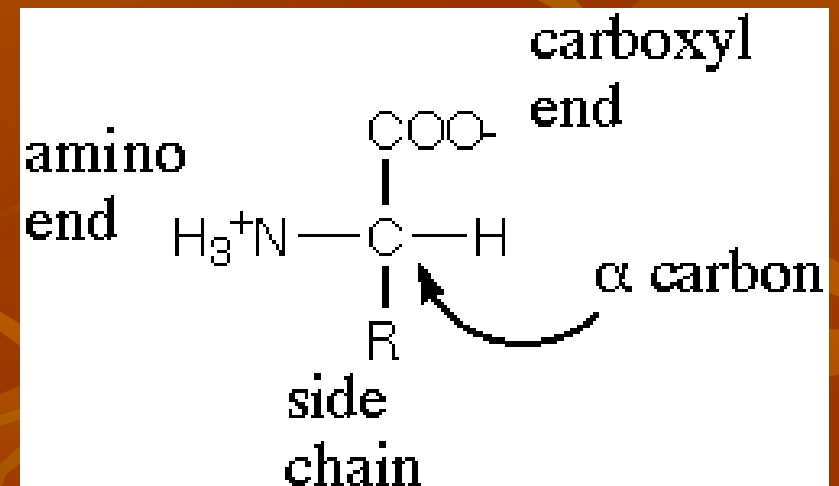
- the most important biological compounds needed for life
- act as the structural materials in humans
- Enzymes are proteins that catalyze the body's chemical reactions.
- make up muscles that aid in movement.



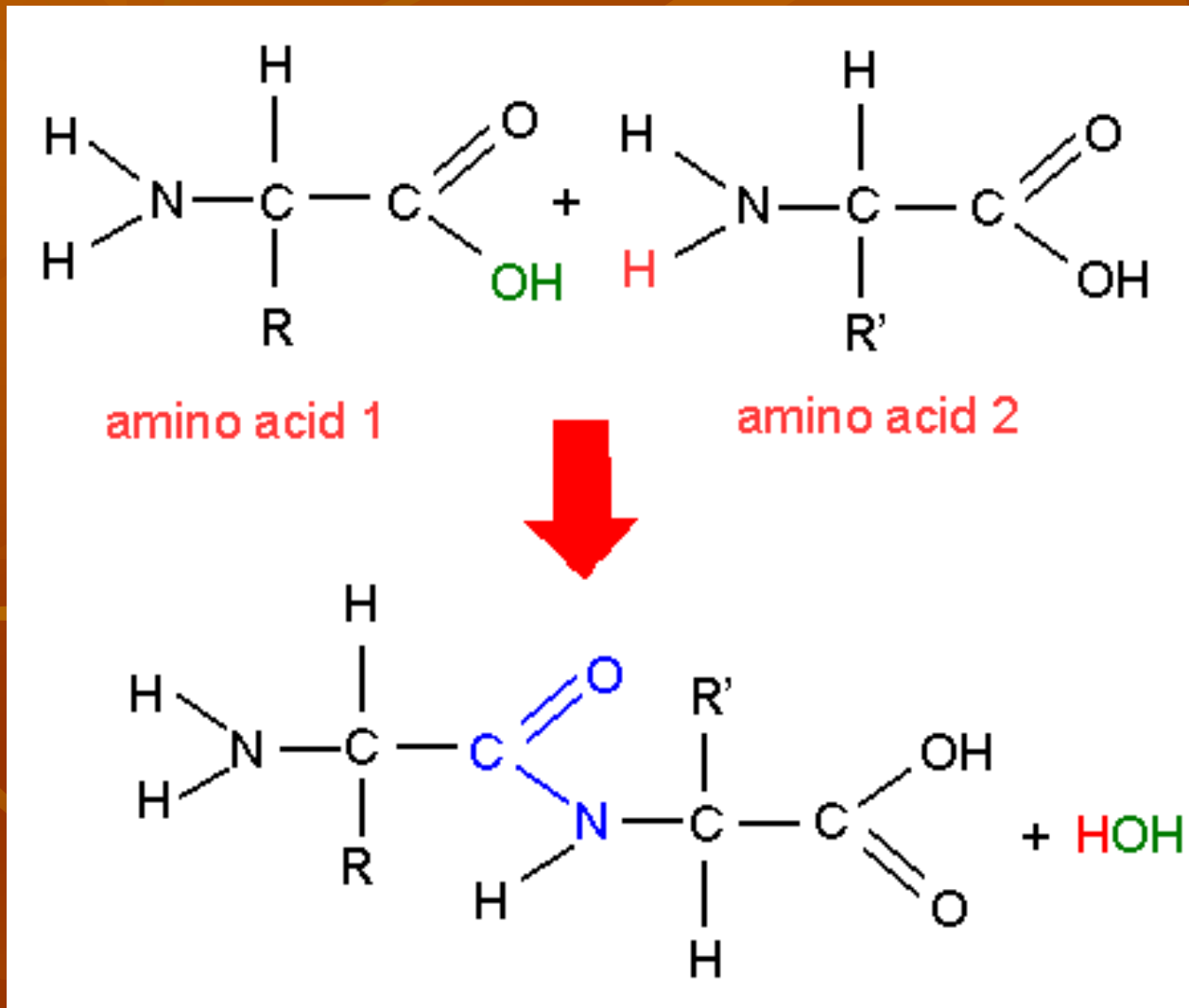
Source: Institute of Biological Sciences, UFMG

■ Amino acids

- Proteins are made up of chains of amino acids.
- an amine group ($-\text{NH}_2$) bonded to a carbon atom that is bonded to a carboxylic acid group ($-\text{COOH}$)



Amino acids can bond together by peptide bond



Amino acids (AA)

- 20 amino acids in the nature
- Classification of amino acids
 - **Essential AA** - methionine, leucine, isoleucine, lysine, phenylalanine, threonine, tryptophan, and valine
 - **Conditionally essential AA** - histidine, arginine (required for infants)
 - **Nonesential AA** – glycine, aspartic acid, asparagine, proline, glutamine, glutamic acid, cysteine, tyrosine, serine, alanine, hydroxyproline

Digestion and absorption of protein

■ Digestion

■ The stomach

- Hydrochloric acid, pepsine
 - Proteins => polypeptides, amino acids

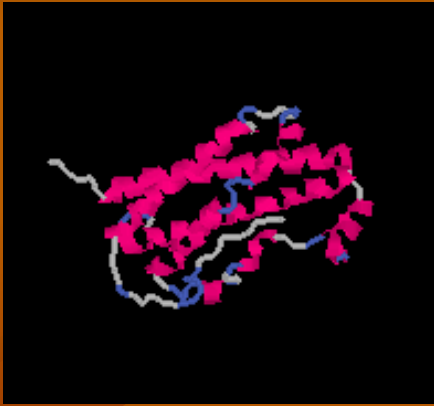
■ The small intestine

- pancreatic and intestinal proteases
 - Polypeptide => oligopeptides, tripeptides, dipeptides, amino acids
- Peptidase
 - Tripeptides and dipeptides => amino acids

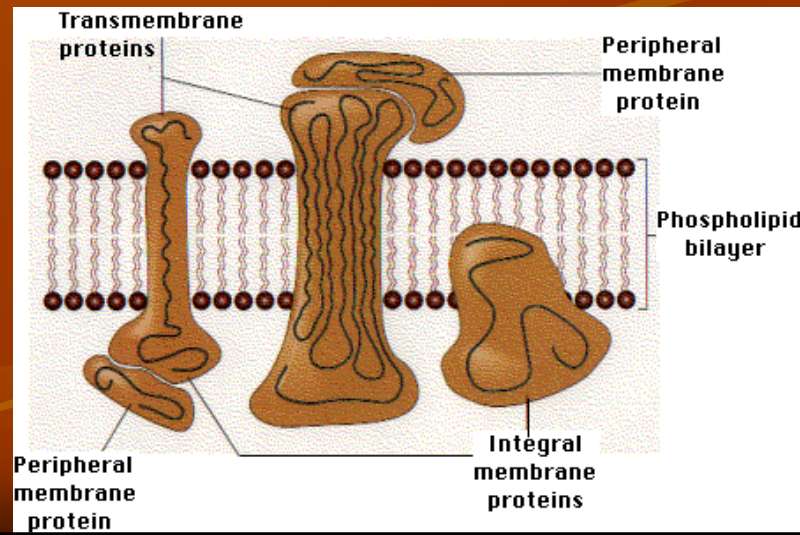
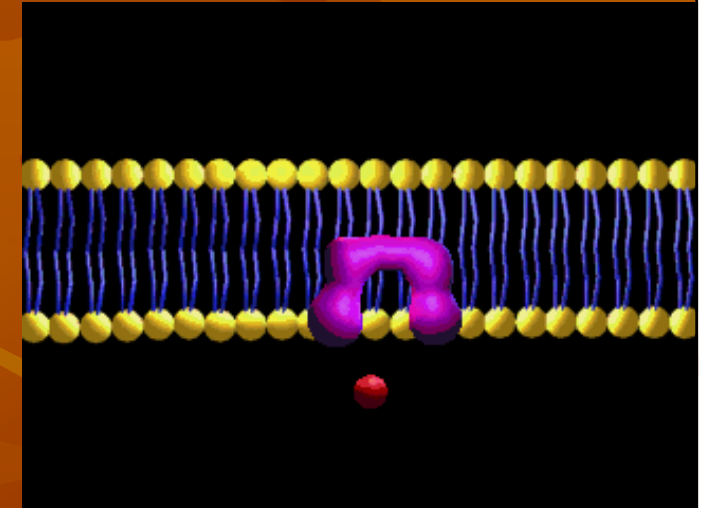
■ Absorption

- Specific carriers transport AA

Roles of proteins in the body

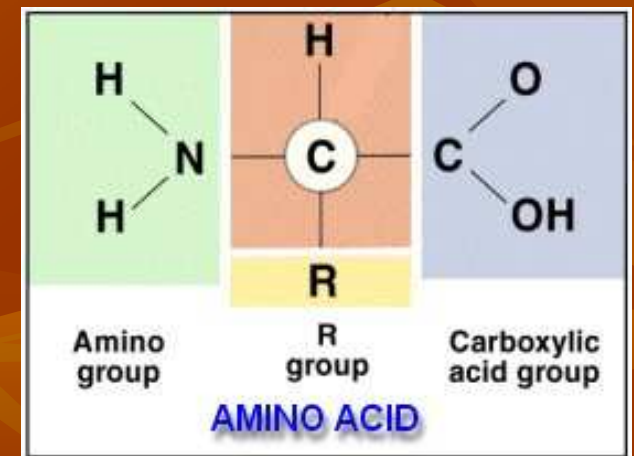


- As a building material
- As enzymes
- As hormones
- As regulator of fluid balance
- As acid-base regulators
- As transporters
- As antibodies
- As a source of energy and glucose



Protein metabolism

- **Protein turnover and the amino acid pool**
 - proteins are being made and broken down
 - Nitrogen balance
 - Positive – growing infants, children, pregnant women
 - Negative – people who are starving or suffering severe stress
- **Using AA to make proteins, nonessential AA**
- **Using AA to make other compounds**
 - Tyrosine → neurotransmitters - norepinephrine, pigment melanin, hormone thyroxin, precursor for the vitamin niacin
- **Using AA for energy**
 - Glucose, fatty acid is limited => amino acids are source of energy
- **Deamination AA**
 - Broken down AA (source of energy)
=> stripped of their nitrogen-containing amino groups (NH₂)
ammonia => urea
- **Using AA to make fat**
 - If a person eat a lot of protein => convert to fat and store



Proteins in food and their quality

- Source of protein
 - Animal source – meat, fish, milk and dairy products, egg
 - Plant source – lentils, legumes, nuts, whole grains, vegetables
- Limiting AA
 - e.g. lysine in grains, methionine in legumes
- Complete protein
 - = animal protein – contains all essential AA
- Biological value (BV)
 - A measure of protein quality
 - The amount of protein nitrogen that is retained from a given amount of protein nitrogen absorbed
 - BV egg 100, meat 92 – 92, fish 94-96, legumes 75-80, grains 70

RDA of protein

- 12 – 15 % energy
- Diet 2000 kcal = 300 kcal from protein = 75 g

Age	Protein RDA (g/kg)
11- 14	1,0
15 - 18	0,8 – 0,9
Adult	0,8
Endurance athlete	1,2 -1,4
Strength athlete	1,4 – 1,8
Children athlete	1,5

Approximate protein content of various foods

Food	Protein (g)
Beef 3 oz	28
Pork 3 oz	28
Cod 3 oz	21
Oysters 3 oz	17
Milk 1 c	8
Cheddar cheese 1 oz	7
Egg 1 large	6
Peanut butter (1 tbs)	8
Potato 1 med	3
Bread 1 slice	2
Banana	1
Carrots 2 c	1
Apple 1	2
Sugar, oil	0

Metabolism of amino acids and protein during exercise

- Amino acid x not source of energy
- **Hormones influence muscle protein turnover**
 - Influence synthesis, breakdown or both
 - Anabolic - synthesis
 - Catabolic – breakdown
- Single exercise bout modify the amount of circulating levels of hormones
 - Growth hormone, tyrosin ↑

Hormones influence muscle protein turnover

■ Insulin

- Release is stimulated by elevated blood glucose and less potently by elevation of AA
- Promote uptake of AA to cells (skeletal muscle)
- Promote a synthesis of protein, limiting break down
- During exercise is release of insulin blunted (greater glycogen and fat breakdown)
- Endurance exercise - more AA available for gluconeogenesis

Hormones influence muscle protein turnover

■ Cortisol

- Released by the adrenal gland during physiological or nutritional stress
- Stress hormone
- Increase energy nutrient availability – breakdown protein
- Vary in level during exercise (intensity, duration)

■ Growth hormone (GH)

- Increase during exercise, remain elevated for some time afterward
- Increase level of AA after protein rich meal => ↑ GH
- ↑ GH => ↑ AA uptake to muscle cells, protein synthesis

Hormones influence muscle protein turnover

■ Insuline-like growth factor 1 (IGF-1)

- Anabolic efect of GH is mediated with IGF-1
 - If IGF-1 is ↓ and GH is ↑ = inhibited protein synthesis

■ Testosterone

- Promoter of protein synthesis in muscle
- Enhance utilization of AA for protein synthesis
- Level of testosterone ↑ = resistance and endurance training

Resistance exercise (RE)

- **Protein synthesis**
 - unchanged or reduced during RE
 - Increase for several hours after RE
- **Protein breakdown**
 - Not occur during RE
 - May increase after RE
- **AA oxidation**
 - Not enhanced during RE
- Consumption of a carbohydrate and protein meal after RE
 - => minimize protein breakdown
 - => maximize protein synthesis

Endurance exercise (EE)

- **Protein synthesis**
 - unchanged or reduced during EE
- **Protein breakdown**
 - can occur during higher intensity, longer duration EE
- **AA oxidation**
 - Can occur during prolonged moderate to higher intensity submaximal EE
- **Consumption of carbohydrate and protein meal after EE**
 - => minimize protein breakdown
 - => maximize protein synthesis

Protein intake of athletes

- Endurance athlete 1,2 - 1,4 g/kg
- Strength athlete 1,4 – 1,8 g/kg
- Timing and composition of meal - **postexercise**
 - Carbohydrates – fuel and increase the uptake of AA
 - AA – allows for an influx into muscle cells, protein synthesis
 - After training
 - 0,5 g protein per kg + 1,5 g carbohydrates per kg
 - Weight training - at least 135 g of carb. and 45 g of protein for a 90 kg weight trainer
 - Endurance training – at least 105 g of carb. and 35 g of protein for a 73 kg endurance athlete
= 560 – 720 kcal (1/5 – 1/6 daily energy needs)
 - After 3-4hour eat again

⇒ Maximise positive effect of exercise on muscle protein turnover

Protein intake of athletes

- Timing and composition of meal – **during exercise**
 - Carbohydrate consumption (e.g. Sport drinks) – support better recovery and adaptation
- Number of meals
 - Numerous smaller meals over the waking hours
 - = more consistent influence on insulin level
 - = minimize catabolic periods between meals
 - = more consistent availability essential AA = more desirable influence on protein synthesis
 - 5 – 6 meal during a day
 - After exercise approximately 40 g protein
 - Each other meal 15 – 20 g of protein