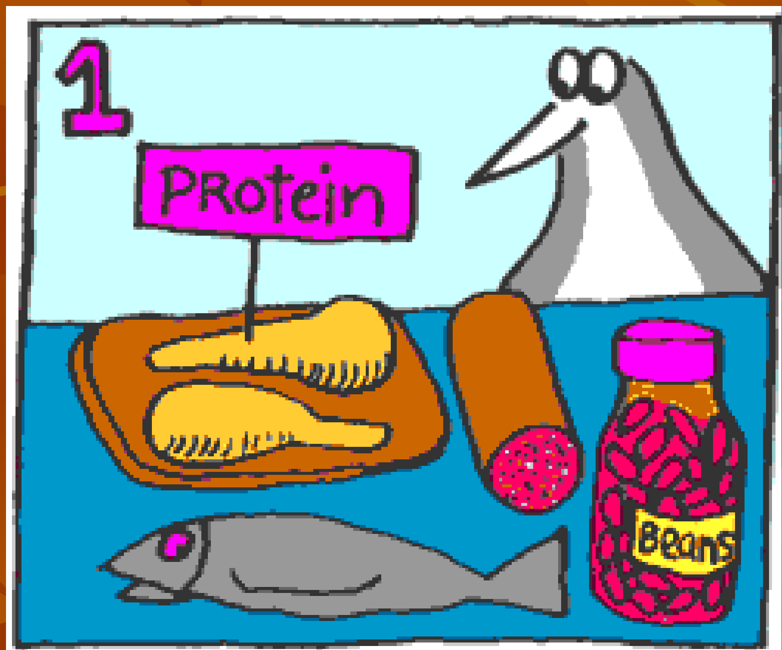
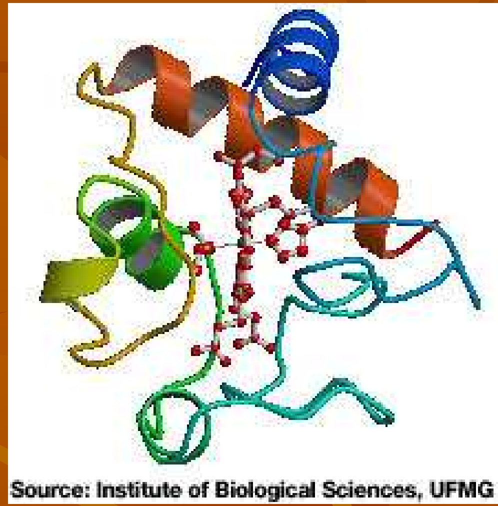
Proteins, amino acids and exercise

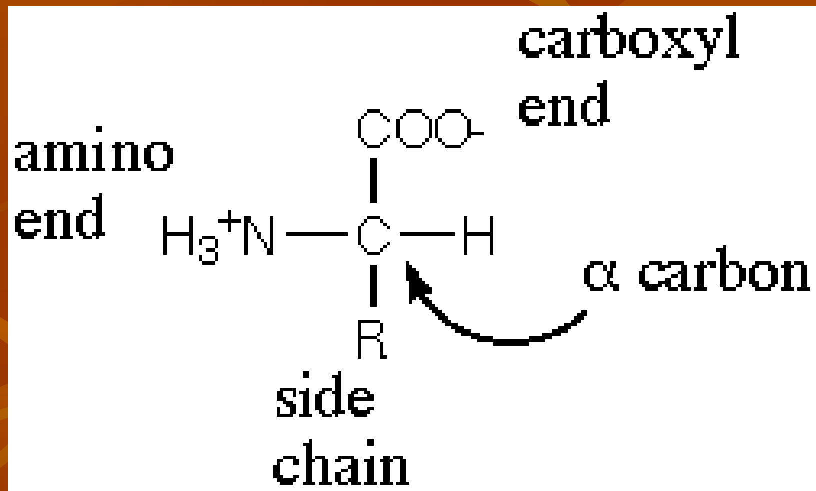


Proteins and amino acids

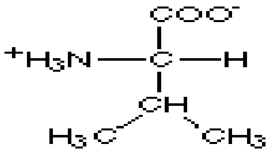
- **Proteins**
  - the most important biological compounds needed for life
  - act as the structural materials in humans
  - Enzymes are proteins that catalyze the body's chemical reactions.
  - make up muscles that aid in movement.



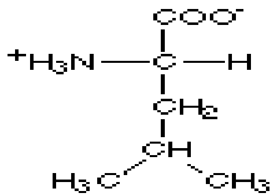
- **Amino acids**
  - Proteins are made up of chains of amino acids.
  - an amine group ($-NH_2$) bonded to a carbon atom that is bonded to a carboxylic acid group (-COOH)



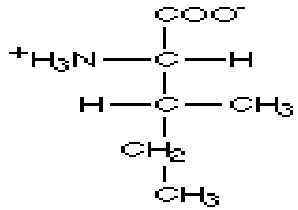
Amino acids with hydrophobic side groups



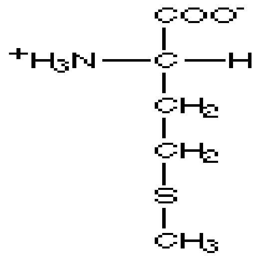
Valine
(val)



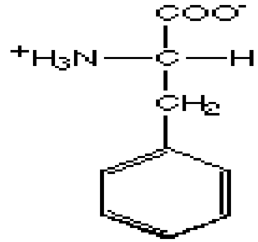
Leucine
(leu)



Isoleucine
(ile)

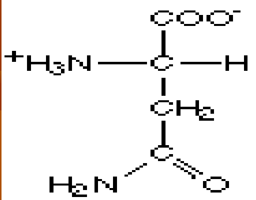


Methionine
(met)

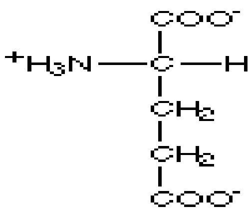


Phenylalanine
(phe)

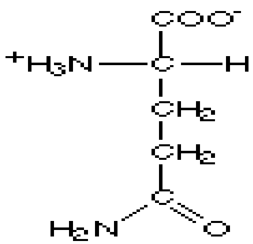
Amino acids with hydrophilic side groups



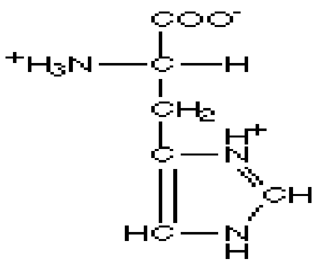
Asparagine
(asn)



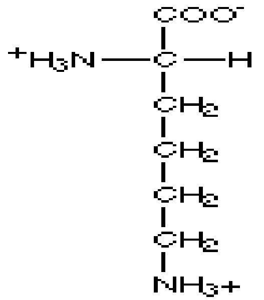
Glutamic acid
(glu)



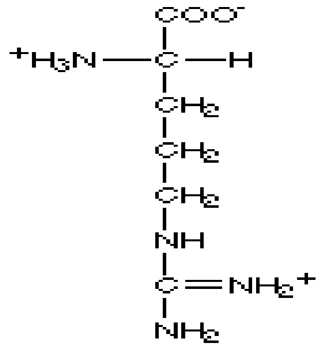
Glutamine
(gln)



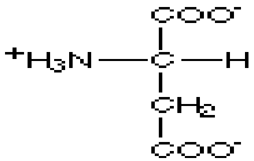
Histidine
(his)



Lysine
(lys)

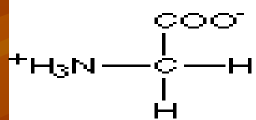


Arginine
(arg)

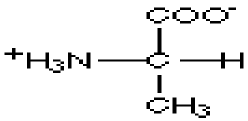


Aspartic acid
(asp)

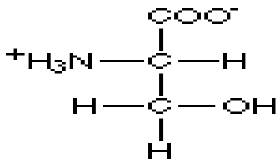
Amino acids that are in between



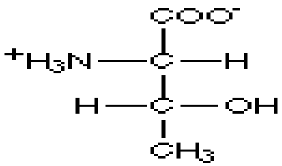
Glycine
(gly)



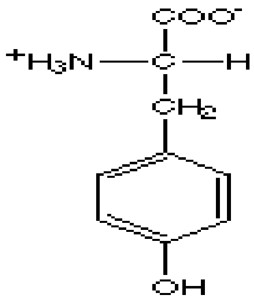
Alanine
(ala)



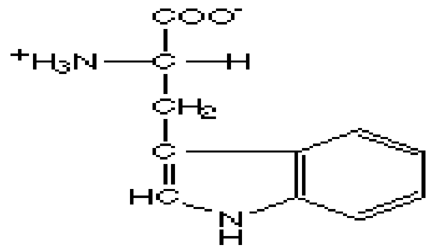
Serine
(ser)



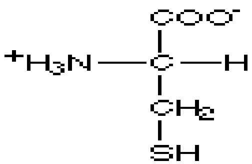
Threonine
(thr)



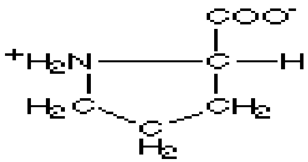
Tyrosine
(tyr)



Tryptophan
(trp)

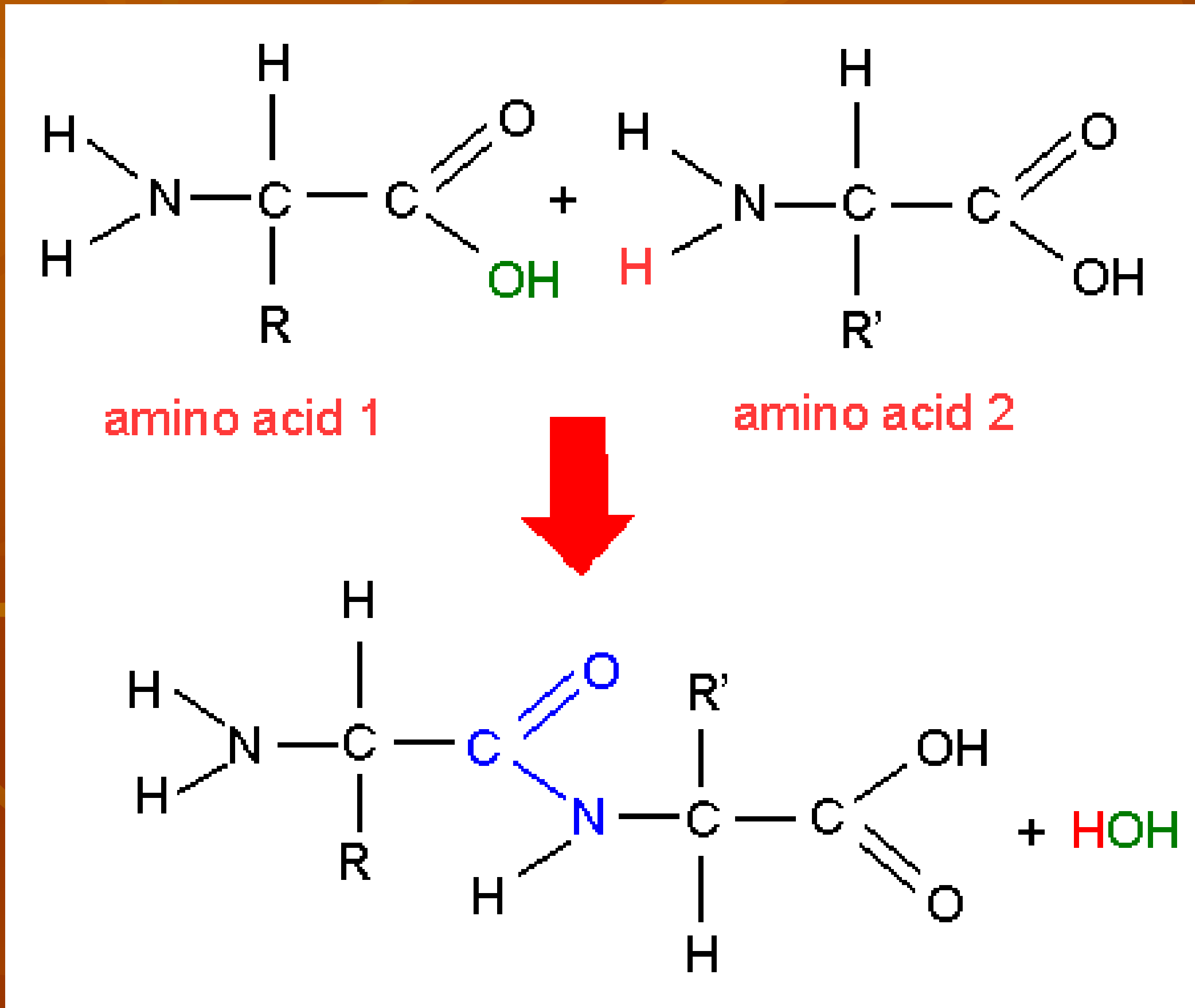


Cysteine
(cys)



Proline
(pro)

Amino acids can bond together by peptide bond



Amino acids (AA)

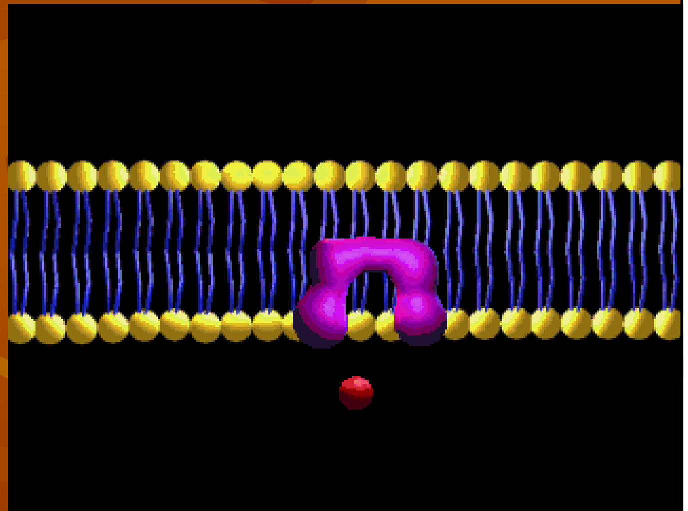
- 20 amino acids in the nature
- Classification of amino acids
  - Essential AA - methionine, leucine, isoleucine, lysine, phenylalanine, threonine, tryptophan, and valine
  - Conditionally essential AA - histidine, arginine (required for infants)
  - Nonesential AA – glycine, aspartic acid, asparagine,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

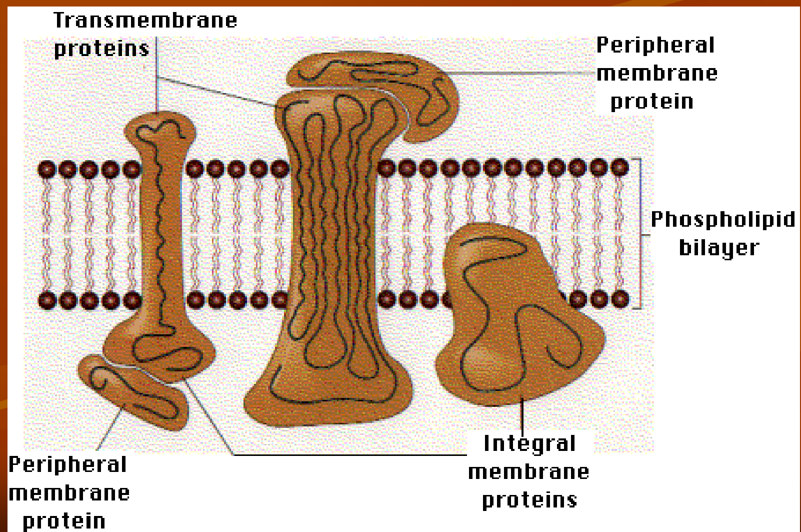
Digestion and absorption of protein

- **Digestion**
  - *The stomach*
    - Hydrochloric acid, pepsine
      - Proteins => polypetides, 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



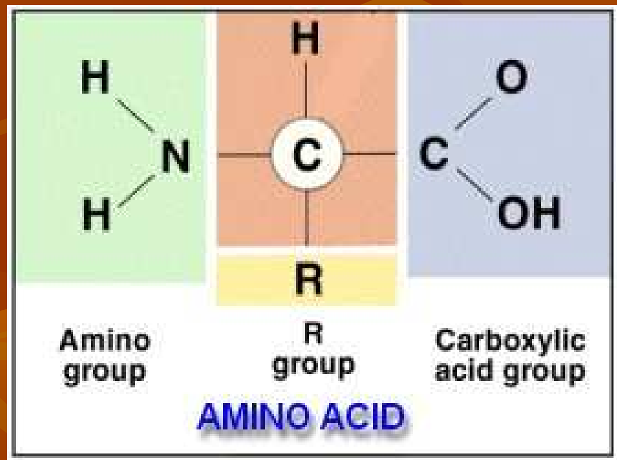


Protein metabolism

- **Protein turnover and the amino acid pool**
  - proteins are being made and broken down
  - Nitrogen balance
    - Positive – growing infants, childrens, 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, hormon 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 (NH_2)

    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 esential 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 cheese1 oz	7
Egg 1 large	6
Peanut butter (1 tbs)	8
Po1 medtato 1	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 blod 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 availaility – 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 lest 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 efect 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