

Chapter 6

Proteins

Proteins

- composed of long, folded chains of aa (amino acids)
 - 9 essential (complete vs. incomplete)
 - each aa contains an amino group, acid group and a unique side chain
- Animal sources = complete vs plants = incomplete

Structure

- have nitrogen
- linked together by **peptide bonds** to form **polypeptides**
 - all proteins are polypeptides, but not all polypeptides are proteins
 - to be a *functional protein*, it needs to fold into a specific structure w/ 3 or 4 levels of organization
- **the shape of a protein is essential to its function!**

The 4 levels of Protein Structure

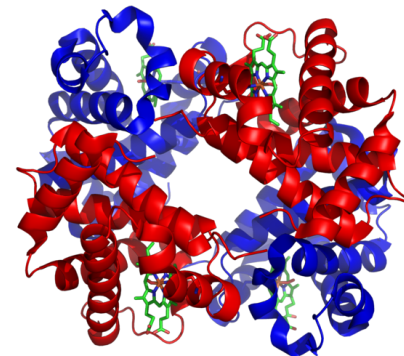
- polypeptide chain is the primary structure of the protein
- H bonds between side chains in the polypeptide help form alpha-helices and beta pleated sheets which form its secondary structure
- disulphide, H bonds etc. between side chains form the tertiary structure
- quaternary structure is the binding of 2+ polypeptide chains together

Denaturation

- alteration of a protein's 3D structure (heat, acid, agitation can denature a protein)
 - once it loses its 3D structure, it loses its original function

Protein Digestion and Absorption

- chemical digestion of protein begins in the stomach (HCl and pepsin begin chemical protein denaturation)
- small intestine, proteases secreted by our pancreas and the micivilli (brush border) finish the digestion of protein



a metalloprotein
quaternary structure
of hemoglobin

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- once we have single amino acids or double ones (dipeptides), these can be absorbed along the villi wall through **active transport**
- protein's 3D structure must be first denatured and the polypeptide must be broken down into individual aa's to be absorbed
- aa's are then absorbed into the SI by **active transport**
 - similar aa's use the same transporter

Protein synthesis

- our DNA contains the 'recipe' for making all our body proteins (genes turned on/off to drive/ halt protein synthesis)
- our body will and choose from the **amino acid pool** in order to make up specific body proteins
 - insulin, myosin (found in muscles)
- if we lack one of the 11 non-essential aa's required to make a protein, we can synthesize that aa from a similar one
 - through the process of **transamination**
- if we lack one of the essential 9 aa's that is needed to form a specific protein, that protein cannot be synthesized!
 - that mission aa = **the limiting acid**

basically, if our diet is lacking in non-essential acids, our body can make these aa's from other aa's through the process of transamination! However, if an essential amino acid is missing from the diet, *you cannot make that protein! protein synthesis is limited!!*

Protein Functions

- structure
 - building block of life: protein adds structure to many different body tissues
 - ex) protein: **collagen** which is found in connective tissue all around the body
 - it adds structure and strength to bones, ligaments, etc
- enzymes
 - most enzymes are proteins (sucrase, lipase, etc = they speed up the rate of reactions and are critical during digestion!)
- transport
 - proteins help us transport various thing around the body, around the cell and into and out of the cell
 - protein hemoglobin which oxygen binds to so we can transport oxygen around the blood and drop it off to the tissues
- protection from disease (**antibodies are proteins**)
- movement (actin and myosin are responsible for moving our whole muscles and bodies)

- fluid balance (**edema** may result with low blood protein levels)
- *producing ATP from amino acids*
 - we must first take off the N group by **deaminating** them —> this protein group will be excreted within urine and depending on which of the 20 amino acids we started with, the remaining structure can be used to synthesize pyruvate, acetyl coA or citric acid cycle intermediates = capturing of energy within ATP

Protein as a source of energy

- proteins provide 4kcal/gram
 - minor source of energy overall
 - when carbs, fats are insufficient to fuel cellular needs, will break down body proteins to form ATP
 - recall that proteins must first be deaminated in order to extract energy from them
 - when diet is excessive in calories, aa's can be converted into FA's and stored in adipose tissue

Protein in Health in Disease

Protein-Energy Malnutrition (rare in Canada)

- **Kwashiorkor**(protein deficiency leading to fluid accumulation in the abdomen, fat accumulation in the liver)
- **Marasmus**(protein *and energy* deficiency leading to depletion of fat stores and wasting of muscle)

High Protein Diets (HPD)

- popular with those looking to build muscle mass, as dietary protein is required to promote muscle gain
- beyond certain level of protein intake, no further protein synthesis occurs
- HPD = more protein waste products excreted in urine
 - requires more water excretion, can lead to dehydration
 - may increase progression of kidney failure in predisposed individuals
 - HPD may increase calcium loss, but does not necessarily cause bone loss
 - HPD may increase risk of kidney stones
 - proteins in foods may trigger intolerances or allergies
 - more waste products are excreted because of the deamination process which clips off the N group from amino acids
- increased consumption of red meats, esp. processed red meats, low fibre intake = increased risk of heart disease, diverticulosis, cancer

Meeting Protein Needs

- AMDR = 10-35% of Calories
- RDA = 0.8g/kg body weight
- pregnant women RDA =25g/d
- adults require more total protein than infant, infants and children have higher protein requirements as a proportion of their body weight b/c of their growing processes

Protein requirements Table 6.1	
Age	RDA (g/kg/day)
0-6 months	1.52
7-12 months	1.50
13 months-3 years	1.10
4-13 years	0.95
14-18 years	0.85
≥19 years	0.80

Branch-Chain Amino Acids

- **claim:** branch-chain amino acids, which are EAAs, have a unique ability to stimulate muscle protein growth
- **reality:** need all the EAAs and NEAAs to create muscle protein; claims that these 3 offer an added benefit beyond others are not currently supported by empirical evidence in humans
- **protein quality-** measure of how well a food provides all the essential aa's
 - assessed using the **protein digestibility corrected amino acid score (PDCAAS)**
 - takes into account digestibility of the protein
- animal proteins have a higher PDCAAS, and are more likely to be **complete** proteins, having all essential aa's
- plant proteins have lower PDCAAS and are more likely to be **incomplete** proteins

Protein Complementation

- important for many vegetarians
- a diet with different sources of plant proteins (rice and beans)

Vegetarian Diets

- vitamin and mineral deficiencies are more common
- vegans require V B12 supplements
- calcium, vit. D deficiencies may occur if milk products are not consumed
- iron, Zinc are poorly absorbed from plants
- omega-3 may be low in vegan diets