Module 3. Proteins, Amino Acids and Peptides

This section makes up about 13% of the test and is broken down into 3 subsections.

1. Metabolism
   1. Catabolic pathways (Protein synthesis, TA)
   2. Anabolic pathways (TA/OD/RA, Urea cycle)
2. Chemistry
   1. Structure
   2. Properties
   3. Function
3. Nutritional Concepts
   1. Food sources
   2. Digestion
4. METABOLISM
   1. PATHWAYS – Catabolic and anabolic are going to be combined in one section.
   2. Remember the purposes of your pathways
      1. You ate lots of protein – You are going to do transamination (that gets the “energy” part of the molecule made available), followed by oxidative deamination, followed by the urea cycle
      2. You need non-essential amino acids – You are going to do reductive amination (to make the glutamate to make the non-essential amino acid), then transamination to actually make the non-essential amino acid.
      3. Here is the link for the pathways: <https://youtu.be/LhoTl5FA0vA>
   3. Let’s talk a little more about the DEGRADATION OF AMINO ACIDS
      1. We said that, after we do transamination, we get the keto-acid or “carbon skeleton” – basically, the amino acid without the amino group- and that’s what goes to make energy or do whatever you needed to do with that amino acid. We need to talk a little more about where these molecules go. Based on where they go, they are grouped into one of two categories-
         1. GLUCOGENIC – Most amino acids fall into this category because they produce pyruvate or intermediates in the Krebs Cycle that can then go and produce glucose (gluconeogenesis)
         2. KETOGENIC – These amino acids produce ketone bodies (such as acetyl-CoA and acetoacetate) which can then be used as alternate fuels. Think starvation or diabetes mellitus. LYSINE AND THREONINE fall into this category.
         3. BOTH – Some amino acids fall into both categories – PHENYLALANINE, ISOLEUCINE, TRYPTOPHAN, and TYROSINE.
         4. DON’T FORGET – TRANSAMINATION OF
            1. GLUTAMATE forms ALPHA-KETOGLUTARATE
            2. ALANINE forms PYRUVATE
            3. ASPARTATE forms OXALOACETATE
            4. And vice versa
   4. AMINIO ACIDS THAT COME FROM GLYCOLYSIS:
      1. GLYCINE comes from SERINE
      2. CYSTEINE comes from SERINE
      3. SERINE comes from 3-PHOSPHOGLYCERATE (remember that in glycolysis)
      4. ALANINE comes from the transamination of PYRUVATE
   5. AMINO ACIDS THAT COME FROM THE KREBS CYCLE OF ITS INTERMEDIATES:
      1. ARGININE comes from GLUTAMINE
      2. GLUTAMINE comes from GLUTAMATE
      3. PROLINE comes from GLUTAMATE
      4. GLUTAMATE comes from ALPHA-KETOGLUTARATE
      5. ASPARGINE comes from ASPARTATE
      6. ASPARTATE comes from the transamination of OXALOACETATE
   6. ONE MORE GOOD ONE TO KNOW – TYROSINE comes from the essential amino acid, PHENYLALANINE, and is used in the manufacture of T4 (thyroid hormone).
5. CHEMISTRY

STRUCTURE

* 1. PROTEIN STRUCTURE – Proteins are made in the ribosome (remember, translation), based on the genetic code (remember mRNA). The shape of the protein is developed in stages or structures
     1. PRIMARY PROTEIN STRUCTURE – formed by peptide bonds, linear sequence of amino acids, forming polypeptide chain
     2. SECONDARY PROTEIN STRUCTURE –
        1. Formed by HYDROGEN BONDS between the carboxyl oxygen and amino hydrogens
        2. Remember alpha-helix, beta-pleated sheet, triple helix (e.g. collagen)
     3. TERTIARY STRUCTURE
        1. Spatial relationship of secondary structures to each other
        2. 3-dimensional shape of the protein
        3. SINGLE polypeptide chain (e.g. myoglobin)
     4. QUARTERNARY STRUCTURE
        1. Multiple polypeptide chains (e.g. hemoglobin)
  2. AMINO ACID STRUCTURE
     1. Proteins are chains of amino acids. There are 20 amino acids that make up over 100,000 different proteins in the body. 10 of those amino acids are essential (i.e. it’s “essential” that you eat them because you cannot make them) and 10 or them are non-essential (i.e. you can make them).
     2. ESSENTIAL AMINO ACIDS (PVT TIM HALL – first letter of all of them), but don’t forget that Private Tim Hall always ARGues (meaning that arginine is essential), but never TYRes (meaning that tyrosine is never essential) since you have both essentials and non-essentials that start with “A” and “T”.
        1. Phenylalanine
        2. Valine
        3. Threonine
        4. Tryptophan
        5. Isoleucine
        6. Methionine
        7. Histidine (essential only during pregnancy and periods of growth)
        8. Arginine (essential only during pregnancy and periods of growth)
        9. Leucine
        10. Lycine
     3. NON-ESSENTIAL AMINO ACIDS (GAS C GAGAPA T)
        1. Glycine
        2. Alanine
        3. Serine
        4. Cysteine
        5. Glutamate
        6. Aspartate
        7. Glutamine
        8. Asparagine
        9. Proline
        10. Arginine
        11. Tyrosine
     4. SOME MORE STRUCTURAL STUFF
        1. Amino acids can be categorized by other properties:
           1. AROMATIC (contain rings) amino acids are phenylalanine, tyrosine and tryptophan. PTT. These three AA make most of the neurotransmitters.
           2. SULFUR-CONTAINING amino acids are cystine, cysteine (2 cystines together) and methionine. Think of the skate and hockey gear brand, CCM. Cysteine contains a disulfide bridge. That’s how the 2 cystines are attached. It’s a component of insulin and glucagon.
           3. BRANCHED CHAIN (BCAA) amino acids are valine, leucine and isoleucine. Think about the actress, LIV Tyler. Maple syrup urine disease is BCAA problem.
           4. PURELY KETOGENIC (means just go to fats) amino acids are leucine and lysine (the L’s)
           5. ACIDIC AMINO ACIDS are aspartic acid (aspartate) and glutamic acid (glutamate) – AG
           6. BASIC AMINO ACIDS are Histidine, Arginine and Lysine (HAL)

SOME AMINO ACID DERIVATIVES

* Phenylalanine → Tyrosine (deficiency of phenylalanine hydroxylase causes phenylketonuria aka PKU, mental retardation in babies)
* Tyrosine → L-dopa → Dopamine → Norepinephrine → Epinephrine (Catecholamines)
* Tyrosine → L-dopa → Melanin (skin pigmentation) (also Tyrosine → thyroxine (T4))
* Tryptophan → Serotonin and Niacin and Melatonin
* Lysine → Carnitine (remember the carnitine shuttle in fat metabolism)

NUTRITIONAL CONCEPTS

* + - 1. Food sources – Seafood, meat, poultry, eggs, peas, beans, soy, lentils, nuts, seeds
      2. Absorption and Digestion
         1. Amino acids are absorbed via a sodium co-transporter, in a similar mechanism to monosaccharides. They are then transported across the basolateral membrane via facilitate diffusion. Di- and tripeptides are absorbed via separate H+-dependent co-transporters and, once inside the cell, are hydrolyzed to amino acids.
         2. Digestion video link: <https://youtu.be/VVuVDuPSxmY>. Also, see the “Read this first / Module 0” section where digestion is pulled together in one place.