CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 4:

- ## PROTEIN: AMINO ACIDS

Everybody knows that protein is important. It is advertised on every cereal box; it is said to “build strong bodies,” and to provide “super go power.” In fact, as you will see, protein has been so overemphasized that many people eat more than enough, sometimes at the expense of other nutrients that are equally important. An understanding of the quantity and quality of protein needed in the diet will help put it in its proper place as only one – although a very important one – of the nutrients needed in correct proportions to achieve a balanced diet.

A protein is a chemical compound that contains the same atoms as carbohydrate and lipid – carbon, hydrogen, and oxygen – but protein also contains nitrogen atoms.

The human body contains an estimated 10,000 to 50,000 different kinds of proteins. Of these thousands only about 1,000 have been identified, and only about 10 are described in this session.

Enzymes: A Function of Protein
Enzymes and what they do are so fundamental to all life processes that it seems worthwhile to introduce an analogy to clarify two important characteristics they all share. Enzymes are comparable to the ministers and judges who respectively make and dissolve human matrimonial bonds. When two individuals come to a minister to be married, the couple leaves with a new bond between them. They are joined together – but the minister is only momentarily involved in the process and remains unchanged. One minister can therefore perform thousands of marriage ceremonies. Similarly, a judge, who facilitates the separation of married couples, may decree many divorces before he dies or retires.

The minister represents enzymes that synthesize larger compounds from smaller ones – the synthesases, which build body structures. The judge represents enzymes that hydrolyze larger compounds to smaller ones – the proteases, lipases, carbohydrates, disaccharidases, and others. Maltase is a disaccharidase.

The first point to be learned is that some enzymes put compounds together and others take them apart. Since you yourself are a very put-together kind of organism, superbly organized out of billions of molecules designed to make muscle, bone, skin, eyes, and blood cells, you can imagine how numerous and active in your body are the enzymes that put things together. (Only a naïve student thinks of enzymes as being solely digestive enzymes – those that take things apart.)

The second point is that enzymes are not themselves affected in the process of facilitating chemical reactions. They are catalysts. Biologists and chemists define an enzyme as a protein catalyst.

What makes you unique and distinct from any other human being is minute differences in your body proteins (enzymes, antibodies, and others). These differences are determined by the amino acid sequences of your proteins, which are written into the genetic code of the DNA you inherited from your parents and ancestors. Each person receives at conception a unique combination of genes (DNA codes for protein sequences).

Perhaps you have realized by now that the protein story moves in a circle. All enzymes are proteins. All proteins are made of amino acids. Amino acids have to be put together to make proteins. Enzymes put together the amino acids. Only living systems work with such self-renewal. A broken toaster cannot be fixed by another toaster; a car cannot make another car. Only living creatures and the parts they are composed of – the cells – can duplicate themselves.

To follow the circle in nutrition, start with a person eating proteins. The proteins are broken down by proteins (enzymes) into amino acids. The amino acids enter the cells of the body, where proteins (enzymes) put them together in long chains with sequences specified by DNA. The chains fold and become enzymes themselves. These enzymes may then be used to break apart other compounds or to put other compounds together. Day by day, billion reactions by billion reactions, these processes repeat themselves and life goes on.

Protein Synthesis
The instructions for making every protein in a person’s body are transmitted in the genetic information he or she receives at conception. This body of knowledge is filed away in the nucleus of every cell. The master file is the DNA (deoxyribonucleic acid), which never leaves the nucleus. The DNA is identical in every cell and is specific for each individual. Each specialized cell has access to the total inherited information but calls on only the instructions needed for its own functions.

To inform the cell of the proper sequence of amino acids for a needed protein, a “photocopy” of the appropriate portion of DNA is made. This copy is messenger RNA (ribonucleic acid), which is able to escape through the nuclear membrane. In the cell fluid it seeks out and attaches itself to one of the ribosomes (a protein-making machine, itself composed of RNA and protein). Thus situated, the messenger RNA presents the sequence in which the amino acids should be linked into a protein strand.

Meanwhile, another form of RNA, called transfer RNA, collects amino acids from the cell fluid and brings them to the messenger. For each of the 22 amino acids there is a specific kind of transfer RNA. Thousands of these transfer RNAs, with their loads of amino acids, cluster around the ribosomes, like vegetable-laden trucks around a farmer's market awaiting their turn to unload. When an amino acid is called for by the messenger, the transfer RNA carrying it snaps into position. Then the next and the next and the next loaded transfer RNAs move into place. Thus the amino acids are lined up in the right sequence. Then an enzyme bonds them together.

Finally, the completed protein strand is released, the messenger is degraded, and the transfer RNAs are freed to return for another load. It takes many words to describe the events, but in the cell, 40 to 100 amino acids can be added to a growing protein strand in only a second.

1. DNA is in the nucleus of each cell.
2. DNA makes a copy of the portion of itself that has the instructions for the protein the cell needs.
3. RNA leaves the nucleus.
4. RNA attaches itself to the protein-making machinery of the cell.
5. Transfer RNAs carry their amino acids to the messenger RNA, where they are snapped into place.
6. The completed protein strand is released.

Protein Quality

The role of protein in food is not to provide body proteins directly but to supply the amino acids from which the body can make its own proteins. Sine the body can make glycine and serine for itself, the proteins in the diet need not contain these two amino acids. But there are some amino acids the body cannot make at all, and some it cannot make fast enough to meet its need. (This is because the body does not possess the genes for the enzymes that could synthesize these amino acids, or because the enzymes it does make work too slowly.) These are the essential amino acids. Either amino acids are essential for adults; histidine is also essential for infants.

To make body protein, a cell must have all the needed amino acids available simultaneously. The first important characteristic of dietary protein is, therefore, that it should supply at least the eight essential amino acids and enough nitrogen for the synthesis of the others.

A complete protein is a protein that contains all of the essential amino acids in amounts adequate for human use; it may or may not contain all the others. A high-quality protein is not merely complete, but contains the essential amino acids in amounts proportional to the body's need for them, and is digestible, so that these amino acids reach the body's cells in the needed amounts.

Ideally, dietary protein supplies each amino acid in the amount needed for protein synthesis in the body. If one amino acid is supplied in an amount smaller than is needed, the total amount of protein that can be synthesized from the others will be limited. By analogy, suppose that a signmaker plans to make 100 identical signs, each saying LEFT TURN ONLY. He needs 200 Ls, 200 Ns, 200 Ts, and 100 of each of the other letters. If he has only 20 Ls, he can make only 10 signs, even if all the other letters are available in unlimited quantities. The Ls limit the number of signs that can be made. Furthermore, the signmaker has no place to keep leftover letters (the body has no storage place for extra amino acids), so if he doesn't get some more Ls right away, he will have to throw away all his other letters.

When the body uses a protein of poor quality, it wastes many of the amino acids. Enzymes strip off their nitrogen-containing amino groups and fix them into the compound urea, which is excreted in the urine. The carbon skeletons that remain are used to make glucose or fat, or are oxidized for energy; the nitrogen is not stored in the body. The amount of urea excreted is thus a measure of the number of amino acids not retained in body proteins.

The quality of dietary protein, then, depends partly on whether the protein supplies all the essential amino acids and, more importantly, on the extent to which it supplies them in the needed proportions and in a digestible form. An excellent protein by these standards is egg protein, whose nitrogen tends to be retained in the body. Egg protein has been designated the reference protein and has been assigned a biological value of 100 by the Food and Agriculture Organization of the United Nations, which sets world standards.

In the world where food is scarce and where many people's diets contain marginal or inadequate amounts of protein, it is important to know which foods contain the highest-quality protein. It is possible to determine the amino acid composition of any protein relatively inexpensively, but unfortunately, chemical scoring does not always reflect accurately the way the body will use a protein. If a protein can't be digested to small fragments – amino acids, dipeptides, and tripeptides – then its amino acids will not pass across the intestinal wall into the blood, but will be lost in the feces.

Fluid Balances
Proteins help maintain the water balance. There are three principal compartments for fluids in the body: the space in the blood vessels, the spaces between the cells, and the spaces within the cells. In normal, healthy people, each of these compartments contains the proper amount of fluid. Fluid can flow back and forth across the boundaries between them, but whenever the volume of fluid deviates, it is rapidly brought back to normal. Protein (with certain minerals) helps to maintain water at the proper volume in each compartment.

Space in the Blood Vessels
The space in the blood vessels is the intravascular space; the space between the cells is the intercellular or interstitial space; the space inside the cells is the intracellular space.
Intra = inside
Inter = between
Interstice = space between

Edema (uh-DEEM-uh)
Edema is the accumulation of fluid in the interstitial spaces. Edema in the abdomen is ascites (uh-SITE-eez).

Diuretic (dye-yoo-RET-ic)
A diuretic is a drug that stimulates increased renal water excretion.
Renal = kidney

Acid-Base Balance
The acid-base balance is the balance maintained in the body between too much and too little acid. Blood pH, for example, is regulated normally between 7.38 and 7.42.

PH
pH is the concentration of H^+ ions. The lower the pH, the stronger the acid. Thus pH 2 is a strong acid; pH 6 a weak acid (pH 7 is neutral). A pH above 7 is alkaline, or basic (a solution in which acid-accepting ions such as OH^- predominate).

Antibodies and Hormones
Other major proteins found in the blood – the antibodies – act against disease agents. When a body is invaded by a virus – whether it is one that causes flu, smallpox, measles, or the common cold – the virus enters the cells and multiplies there. One virus may produce a hundred replicas of itself within an hour or so. These burst out and invade a hundred different cells, soon yielding ten thousand virus particles, which invade ten thousand cells. After several hours there may be a million viruses and then a hundred million and so on. If they were left free to do their worst, they would soon overwhelm the body with the disease they cause.

The antibodies, giant protein molecules circulating in the blood, present a defense against viruses, bacteria, and other "foreign agents." Each type of antibody molecule is different and specific, able to combine with and inactivate a specific foreign protein such as that in a virus coat or bacterial cell membrane. The antibodies work so efficiently that in a normal healthy individual the many disease agents that attempt to attack never have a chance to get started. If a million bacterial cells are injected into the skin of a healthy person, fever than ten are likely to survive for five hours.

Once the body has manufactured antibodies against a particular disease agent (such as the measles virus), the cells never forget how to produce them. The next time that virus invades the body, the antibodies will respond even more quickly. Thus the body acquires immunity against the diseases it is exposed to, by virtue of the molecular memory of the antibody-producing cells.

Hormones are also carried by the blood, and some are made of amino acids. Among them are the thyroid hormone and insulin. The thyroid hormone regulates the body's metabolic rate – the rate of the chemical reactions that yield energy. Insulin regulates the concentration of the blood glucose and its transportation into cells, upon which the functioning of the brain and the nervous system depend.

Development of Immunity

1. Body is challenged with foreign invaders.
2. Body makes code for manufacturing antibody.
3. Code makes antibody.
4. Antibody inactivates foreign invader.
5. Code remains to make antibodies faster the next time this foreign invader attacks.

Transport Proteins

A special group of the body's proteins specializes in moving nutrients and other molecules in and out of cells. Examples of well-known transport proteins are the glucose, potassium, and sodium pumps. The first two transport glucose and potassium into cells faster than they can leak out; the sodium pump transports sodium out of cells faster than it can leak in.

The mineral iron is a nutrient whose handling in the body illustrates especially well how precisely proteins operate. On moving into a cell of the intestinal wall, iron is captured by a protein residing in the cell, which will not let go of it unless the iron is needed in the body. Iron leaving the cell to enter the bloodstream is attached to a carrier protein. The carrier, in turn, can pass iron on to a storage protein in the bone marrow or other tissues, which will hold it until it is called for. Then, when it is needed, iron is incorporated into the structure of still another protein in the red blood cells, where it assists in oxygen transport, or into a muscle protein, which helps muscle cells oxidize their energy fuels. At least one protein is similarly involved in the body's handling of calcium. One of this proteins many roles is to relay to cells a sort of message conveyed from other parts of the body by calcium ions.

Acidosis

Acidosis is too much acid in the blood and body fluids.

Alkalosis

Alkalosis is too much base in the blood and body fluids.

Lethal

Lethal means, "causing death".

Sequester (see-KWESS-ter)

To hide away or take out of circulation.

Buffer

A buffer is a compound that can reversibly combine with H+ ions to help maintain a constant pH.

Antibody

An antibody is a large protein of the blood and body fluids, produced in response to invasion of the body by unfamiliar molecules (mostly proteins); it inactivates the invaders and so protects the body.

Helper Nutrients

The thyroid hormone contains iodine; insulin contains zinc; these minerals are helper nutrients.

Blood Clotting

Blood is unique and wonderful in its ability to remain a liquid tissue even though it carries so many large molecules and cells through the circulatory system. But blood can also turn solid within seconds when the integrity of that system is disturbed. (If it did not clot, a single pinprick could drain your entire body of all its blood, just as a tiny hole in a bucket makes the bucket forever useless for holding water.) When you cut yourself, a rapid chain of events leads to the production of fibrin, a stringy, insoluble mass of protein fibers that plugs the cut and stops the leak. Later, more slowly, a scar forms to replace the clot and permanently heal the cut.

Connective Tissue

Proteins help make scar tissue, bones, and teeth. When the construction of a bone or a tooth begins, bone-building cells first lay down a scaffolding made of a protein collagen. Later, they lay down crystals of calcium, phosphorus, fluoride, and other minerals on this matrix to form the hardened bone. When a bone breaks, the bone-building cells begin mending the break by molding a collagen matrix then lay down the bony material. Collagen is also the mending material in torn tissue, forming scars to hold the separated parts together. It is the material of ligaments and tendons and is a strengthening glue between the cells of the artery walls that helps enable them to withstand the pressure of surging heartbeats.

Visual Pigments
The light-sensitive pigments in the cells of the retina are molecules of the protein opsin. Opsin responds to light by changing its shape, thus initiating the nerve impulses that convey the sense of sight to the higher centers of the brain.

Ferritin
The protein residing in the intestinal wall cells is ferritin; the carrier protein, transferrin; the storage protein, ferritin again; the red-blood-cell protein, hemoglobin; and the muscle-cell protein, myoglobin.

Calmodulin
Calmodulin is the protein that relays calcium's messages.

The chain of events is as follows:

1. A phospholipid (thromboplastin) is released from blood platelets (small, cell-fragment-like structures in the blood).
2. Thromboplastin catalyzes the conversion of prothrombin (a precursor protein made in the liver that circulates in the blood) to thrombin.
3. Thrombin then catalyzes the conversion of fibrinogen (another circulating precursor protein) to fibrin.

Thrombo = clot
Fibr = fibers
Ogen = gives rise to

Vitamin K
Vitamin K is involved in the production of prothrombin and calcium, which is needed for the blood to clot and are helper nutrients.

Collagen
Collagen is the protein material of which scars, tendons, ligaments, and the foundations of bones and teeth are made.
Kolla = glue

Vitamin C
Vitamin C (needed to form collagen) and minerals (to calcify bones and teeth) are helper nutrients.

Opsin
Opsin is the protein of the visual pigments. Vitamin A is a helper nutrient, attached to opsin to form the pigment rhodopsin.

CERTIFIED HEALTH & NUTRITION COUNSELOR ONLINE COURSE - SESSION 4 **– QUESTION & ANSWERS**

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1. ______________________ is the protein that relays calcium's messages.

2. Acidosis is too much acid in the blood and body fluids. T/F

3. The human body contains an estimated 20,000 to 60,000 different kinds of proteins. T/F

4. A buffer is a compound that can reversibly combine with H^- ions to help maintain a constant pH. T/F

5. Interstice = ______________________________

6. Renal = ______________________________