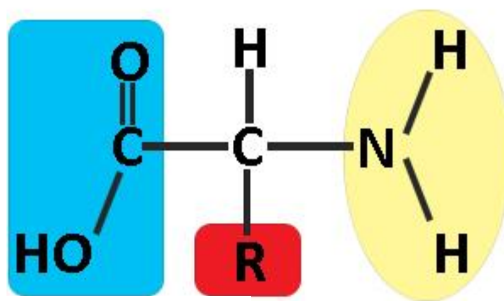
Proteins

Proteins are some of the most important and diverse biological molecules. Proteins have many functions. They serve as transport molecules, receptor molecules, hormones, energy storage molecules in some organisms, structural molecules and as biocatalysts (enzymes). The monomer unit of this class is the amino acid. The name amino acid literally describes the basic structure of the monomer. The amino acid is composed of an NH_2 functional group called an amine (yellow ellipse below) and a -COOH group which is an acid functional group (blue rounded rectangle). The carbon atom linking these two moieties is called the alpha carbon. The R-group is covalently bonded to the alpha carbon. The composition of the



Carboxyl functional group Amine functional group

R-group (R stands for radical) distinguishes each of the 20 common amino acids. For example, in the amino acid glycine, the R-group is simply a hydrogen atom. In the amino acid tryptophan, the R-group includes 2 large ring structures. You may have heard of tryptophan. It is purported to make you sleepy, think big turkey dinners. High levels of tryptophan are found in turkey, other poultry, fish, yogurt, meat, cheese and eggs. Tryptophan is necessary for the production of the B vitamin niacin (needed for digestion) and which is necessary for the production of the neuropeptide serotonin. Serotonin in turn is needed for the production of melatonin, a compound known to impact sleep and sleep cycles. While the scientific link between turkey and postprandial sleepiness has not been proven turkey and tryptophan are often credited. This presumption of relaxation and sleep has led to a robust over the counter market for tryptophan.

Individual amino acids covalently bond through dehydration or condensation synthesis. The covalent bond formed is called a peptide bond. The strand of amino acids is called a peptide. The smallest protein known is thought to be glutathione with only 3 amino acids in the protein. Glutathione is found in every cell. It acts as an antioxidant to detoxify harmful free radicals. Titin is the longest protein discovered so far with 34,350 amino acids. Titin, also called connectin is important to the elasticity of muscle tissue. As you can see, proteins have an incredible range of sizes and functions.

Protein	Number of amino acids	Function
albumin	~575	Egg white (nutrition), osmoticant and carrier molecule in blood plasma
insulin	51	Hormone important in glucose regulation
hemoglobin	574	Transports gases in the blood
RuBisCo	4,784	Fixes CO_2 from the atmosphere into sugars in photosynthetic organisms
titin	34,350	Important in the contraction and relaxation of muscle fibers
glutathione	3	Antioxidant; detoxifies free radicals

Protein structure is critical to protein function. Four different levels of protein structure can be described. The primary level of structure is simply a listing of the amino acids in the protein. The secondary level of protein structure occurs because of the formation of hydrogen bonds between different amino acids. These hydrogen bonds twist and turn the peptide in a three dimensional space. Hydrogen bonding can lead to a structure called alpha-helix where the peptide curls around a central axis, similar to a circular stairway. Another formation that can occur is the beta pleated sheet. In this case the peptide folds back on itself in a regular planar arrangement similar to the layers in a multi-layer cake. The amount of alpha helix and beta pleated sheet found in any protein is determined by the amino acids found in the protein and the order in which they occur. Some proteins have a lot of alpha helix and little beta pleated sheet. Others have more beta pleated sheet and less alpha helix. Every protein will have regions where there is neither alpha helix nor beta pleated sheet. The tertiary structure of proteins results from the interaction of R-groups. Some R-groups are hydrophilic and some are hydrophobic. The amino acids with these respective R-groups turn either toward a 'watery' environment or away from the water. Another interaction at this level of complexity is the formation of disulfide bonds. The amino acid cysteine contains a sulfide functional group (-SH) as part of its R-group. The R-groups of two cysteine amino acids can interact to produce a disulfide bond (-S-S-). The final level of structure is the quaternary level, or fourth level of structure. The quaternary level of structure involves the interaction of separate peptides. For example, the molecule hemoglobin is actually composed of 4 different peptide strands, 2 alpha chains and 2 beta chains.

If a protein's structure changes, its ability to function can also be impacted. Consider the outcome of boiling a fertilized chicken egg. Will the chicken hatch? Of course not, the enzymes and proteins have been destroyed by heat, and continued development is stopped. The destruction of protein function is called denaturation. Proteins can be denatured by heat, cold, changes in pH, and heavy metals.