**Tertiary Protein Structure and 3-Dimensional Shape**

Read the article carefully and then answer the questions which follow.

Proteins are the most complex and varied of the molecules that living organisms are made of and this allows them to have a huge variety of functions. They are **polymers** – long molecules made of repeated small molecules, but the reason they are so varied in structure, shape and function is that they are polymers made up from not just 1 repeated small molecule but any one of 20 **amino acids**, arranged in any order. In contrast, starch is polymer made of repeated glucose molecules and it has just 1 function, to act as an insoluble store of carbohydrate in plant cells.

Each of the 20 amino acids is slightly different, so whilst they are similar enough to join to any neighbouring amino acid in the protein, they have slightly different chemical properties and can make slightly different chemical bonds within the protein. So a long chain of amino acids (a protein) will have hundreds of these chemical bonds holding it in a precise 3 dimensional shape called its **tertiary structure**.

The order of amino acids in the protein is coded by the DNA sequence of a **gene** (the order of A, C, G and T) in the nucleus of the cell. So if a mutation occurs in a gene, a different amino acid will be coded for, a slightly different pattern of chemical bonds occurs in the protein, and the 3 dimensional shape of the protein is slightly different too.

In enzymes, this idea of tertiary structure and 3 dimensional shape is familiar to you. Each type of enzyme has an **active site** that is just the right shape to bind to its **substrate** and catalyse a reaction – the active site is a **complementary** shape to the substrate. This is why the enzyme maltase can digest the sugar called maltose but it can’t digest the sugar called lactose.

People with the condition **haemophilia** have problems with their blood clotting process. It is caused by a mutated gene for an enzyme called factor VIII. Factor VIII is involved in converting prothrombin to thrombin to cause blood clotting. The faulty factor VIII enzyme is not able to catalyse this reaction.

You should remember that in the immune response, **antibodies** can attach to just 1 type of **antigen** so antibodies that help give immunity against measles do not work against ‘flu. Antibodies are proteins with a particular order of amino acids and so a precise tertiary structure and 3-dimensional shape. Part of each antibody is called the **antigen binding site** and this has a 3 dimensional shape that is complementary to the shape of the antigen. Each type of antibody has a slightly different order of amino acids and so a slightly different shaped antigen binding site that is complementary in shape to a different antigen.

**Haemoglobin** is a large protein found in red blood cells that allows them to carry oxygen from the alveoli or gills to the other tissues of the body. These tissues use the oxygen for aerobic respiration. Some mammals need haemoglobin that binds very tightly to oxygen – if they live in places where there is not much oxygen in the environment; other mammals need haemoglobin that releases its oxygen more easily – if they have a very high rate of respiration. So the haemoglobin protein of each mammal is slightly different, having a slightly different order of amino acids and so a slightly different tertiary structure. This is what gives the different types of haemoglobin their different properties.

1. Give the names of 4 different proteins mentioned in the article and briefly explain their function.

i.

ii.

iii.

iv.

2. Explain why proteins are described as polymers.

3. Why is it significant that there are 20 different amino acids?

4. What is meant by the ‘tertiary structure’ of a protein?

5. Why does an enzyme bind to only one substrate and catalyse only one reaction?

6. Using this idea, why does a mutation to the gene for factor VIII cause non-functional factor VIII to be produced?

7. Explain in terms of protein structure, why antibodies against one type of ‘flu’ virus can’t give immunity to other strains of ‘flu’ virus.

8. Suggest 2 animals that might need haemoglobin that is especially good at binding to oxygen.

9. And 2 animals that might need haemoglobin that is better at releasing oxygen.

10. Why would the tertiary structure of a haemoglobin molecule be altered by a mutation to the haemoglobin gene?