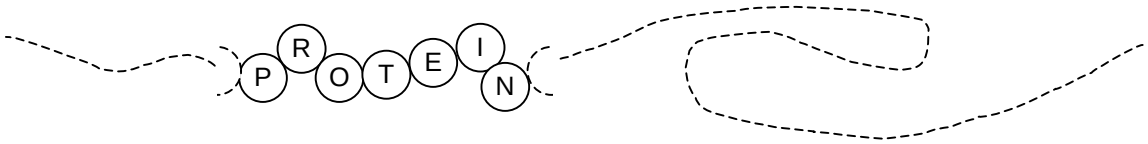
Teacher Information Regarding „Proteins in Food“ Experiments

In addition to fat and carbohydrates, proteins belong to the nutrients.
Proteins mainly provide nutrients and substitutes for the human organism and are of vital importance (the name protein is derived from the Greek “proteuo” = I take the first place). Fat and carbohydrates are mainly important as energy carriers. There are proteins of animal and vegetable origin, and in general proteins show an enormous variety. Proteins are formed through a complicated process that takes place in the cells and uses the genetic substance.

Chemical structure of proteins:

What is a protein?

Proteins consist of individual amino acids that are linked through a peptide bond into a large chain. Between a hundred and a thousand amino acids can be linked this way. Simply put, amino acids are organic nitrogen-containing acids. Similar to the characters of a language, we can compose amino acids into different chains. As proteins contain about 20 different amino acids, there is a large number of variations. For a protein consisting of 100 amino acids, this means that there are 20^{100} different structural combinations, i.e. a figure with 130 digits.



The amino acid chains either coil into a spiral (helix) or take on a structure that is similar to a folded sheet of paper (see the appendix for more detailed explanations)

The enormous variety of structural options explains why proteins can fulfil the most diverse tasks. They are necessary for the synthesis of cells; they carry out transport function; and as enzymes they control the metabolism.
Due to their variety we can also see why there are so many different manifestations and characteristics. There are fibrous proteins that serve as structural and supporting substances, such as collagen that occurs in connective tissue, and also keratin, the substance that hair, nails and feathers are made of. There are also rather spherical proteins, such as egg white protein, and many other representatives.

Correct nutrition: The importance of proteins for a balanced diet

A balanced diet is a prerequisite for a healthy and efficient organism. It is important to ingest the necessary energy with all vital nutrients. Energy in the food is provided by carbohydrates, fat and protein. Carbohydrates are recommended to supply 50-55% of the daily energy demand, fats 30% and proteins 10-15%. In addition to the nutrients that supply energy, i.e. fats, carbohydrates, and proteins, nutrients that do not supply any energy - such as vitamins, minerals, as well as trace elements, dietary fibres, and water - are also important.

Our body needs proteins of animal and vegetable origin to synthesise and continuously renew the cells. People are not able to produce all amino acids themselves. We have to ingest these essential amino acids with our food. Therefore, the content of essential amino acids determines the biological quality of a protein, e.g. its importance. This means that animal protein usually has a higher biological quality as its composition resembles the body's own protein more than that of a number of vegetable proteins. But also individual vegetable proteins such as potatoes, soya and rye have a similar or higher biological quality that animal ones. By combining different products (potato/egg, wheat/milk, beans/corn), we can even increase the overall biological quality.

Protein sources are, among others: cereal, rice, potatoes, soya, legumes (of vegetable origin) as well as meat, fish, eggs, milk and dairy products (of animal origin). According to recommendations of the German Nutrition Society, an adult should eat 0.8 g/kg body weight and a school pupil 1 g/kg body weight.

Only if there are not sufficient amounts of fat and carbohydrates available the body will decompose the body's own proteins in order to produce energy. That happens in areas where people suffer from hunger and it leads to lasting physical impairment of children and adults.

How can we learn more about the existence and characteristics of proteins and how do we know what food products contain proteins?
We have already mentioned that it is very important for our body to ingest the correct nutrients. As it is hard to see from the outside what substances certain food products contain we need methods to find that out. Only if we know the composition of food products we can create a balanced diet. With the following experiments we want to explain some of the detection methods.

Explanation regarding the experiment "Clotting of Protein"

Chemical properties of proteins:

Proteins can clot (coagulate, denaturate). Denaturating means a structural change of the protein. The special structure of the proteins, i.e. helix or folded-sheet structure, is destroyed, but the amino-acid chains remain intact.
Heat, acid or heavy metal salts can trigger a denaturation.
Thus proteins transit from an "organised" state as helix or folded-sheet structure into a state of a comparatively "unorganised" condition, i.e. amino-acid chains. These chains link up randomly forming larger clusters (conglomerates) that are not soluble any longer and can be perceived as flakes (deposit). This process is also called clotting or coagulation.

We can use the image of a tidy room vs. a messy room to illustrate the fact that a protein solution in an "organised" state is clear and in an "unorganised" state is "untransparent" or turbid due to flocculation after denaturation:

In a tidy room, the toys are organised in shelves and cupboards. The floor is empty and clearly visible (clear vision = clear protein solution). In a messy room, all things lie around helter skelter, the floor is covered with toys and hardly visible (the toys are "flocculated" lying around randomly and take up considerably more space than organised in a cupboard).

Explanation regarding the experiment “Evidence of Proteins” (Biuret Reaction)”

In a strongly alkaline environment, protein reacts with copper sulfate solution (see explanation below) and the solution turns violet (see appendix for the formula). The biuret reaction is characteristic for proteins.

The reaction occurs even without heating in a water bath. In this case, we have to wait at least 5 minutes, though.

Adding copper sulfate solution will create light-blue flakes; and only after sodium carbonate solution is added, the solutions with proteins will turn violet.

The alkaline environment is very important for the successful detection of proteins. Therefore we have to add sufficient sodium carbonate solution (ratio: 1 part copper sulfate and 5 parts sodium carbonate solution). The solutions containing proteins will turn violet blue, those without will remain turquoise and flaky. Solutions containing dairy products will only turn milky light-violet.

Alkaline environment:

A solution is called alkaline if it behaves like soap or buck. Alkaline is the opposite of acid.

Appendix

Chemical structure of proteins

We can make the following distinction when describing the structure of proteins:

Primary structure:

The primary structure refers to the sequence in which the amino-acid components are organised.

Secondary structure:

The spatial arrangement of the amino-acid chains is called secondary structure. The chains can either coil into a spiral (helix) or can adopt the structure of a folded sheet of paper (folded-sheet structure).

Tertiary structure:

The helix- or folded-sheet-structure chains are also organised in a specific spatial arrangement. This spatial arrangement of the helix and folded-sheet ranges is called tertiary structure.

Violet-coloured complex compound for a biuret reaction: