Enzymes:

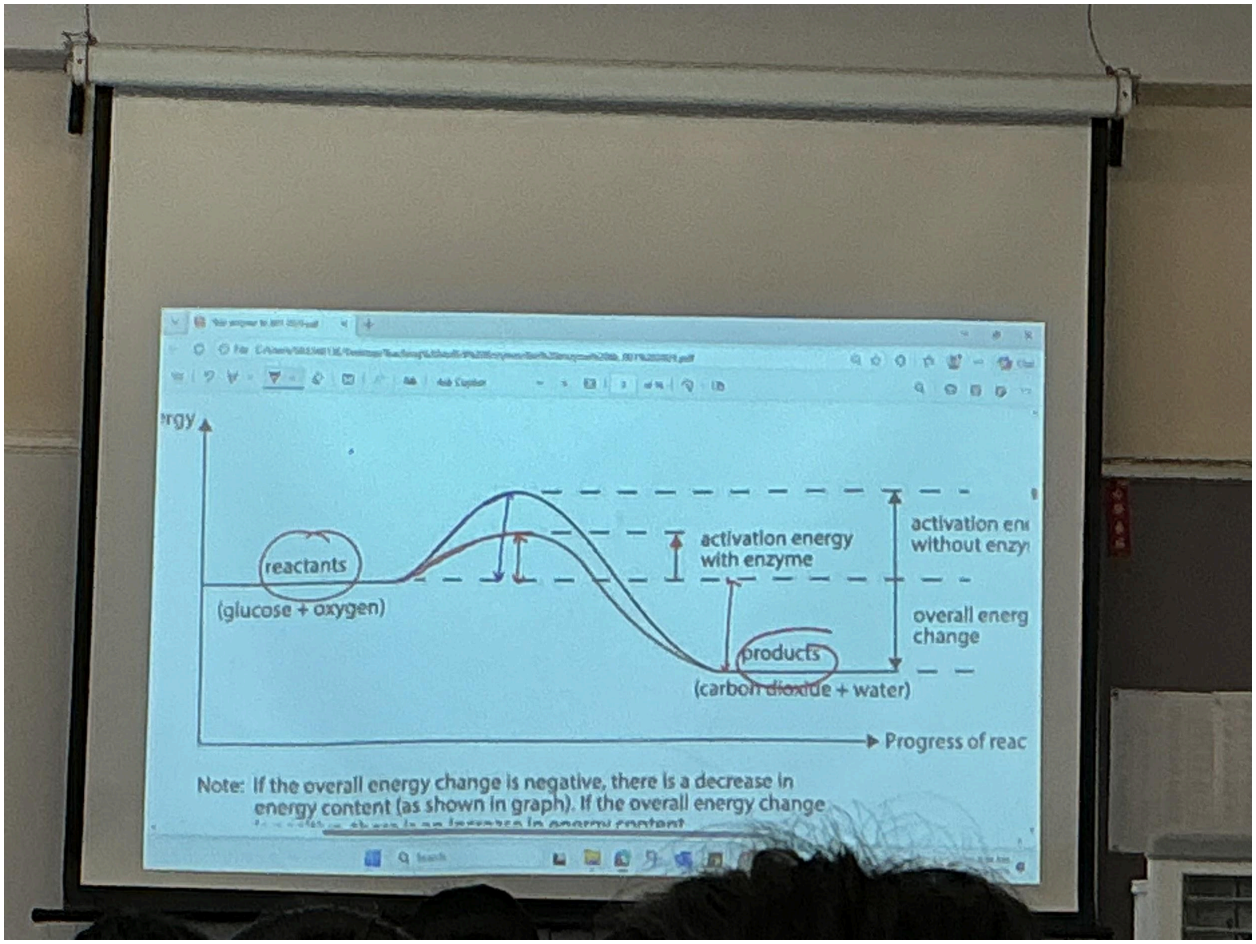
Definition: Enzymes are proteins that function as biological catalysts. They speed up the rate of reactions and remain chemically unchanged at the end of the reaction.

1. Used for chemical reactions like:
    a. digestion (breaking down)
    b. synthesis of protein, photosynthesis (building up)

    These reactions are called metabolic reactions.

    Enzymes also speed up chemical reactions, they are **catalysts** for it:

    a. Allows it to happen faster, like digestion to ensure that the human body obtains enough substances needed.
        i. **Activation energy** (an energy needed to START a reaction) is needed for a reaction to occur is decreased in the presence of enzymes. Molecules must collide with each other for reactions to happen.
        ii. Enzymes lower the activation energy required to break down large molecules into smaller molecules.
    b. At the end of a reaction, the enzyme **remains chemically unchanged.**



Amount of energy produced is the same, is just that enzymes lower the amount of activation energy required.

2. Application:
    a. Cleaning agents (detergents, lipase)
    b. Meat tenderiser (pineapple, proteases) (btw cooking breaks down biological molecules)
    c. They are usually used in small quantities because they can be reused.
3. Enzyme is **specific** in nature
    a. They have a shape that fits a specific substrate (The molecule being broken down/built up).
        i. The unique shape is the part called the active site. It is a unique 3D shape. Enzymes are large molecules, but they have a very specific spot, a small

groove with a very unique shape for the substrate to fit in. The shapes of enzymes are **complementary** to the substrates.

   ii. E.g. Amylase's active site is complementary to starch, hence it can only break down starch.

4. Enzymes are also affected by different conditions, such as:
    a. Temperature
    b. pH level
    c. Substrate concentration
    d. Enzyme concentration
5. Enzymes break down what?
    a. Catalase breaks down Hydrogen Peroxide
    b. Amylase breaks down starch

Nutrients revision: (26.3.26)

Benedict's test - comprised of copper (II) sulfate

Reducing sugars within a substance added to Benedict's solution turns Cu (II) sulfate into copper sulfate, which is brick red.

Sucrose is a non-reducing sugar and will be tested with a result that is negative.

Glycogen - complex carbohydrate like starch

Glycogen is found in mammals, within the liver and muscle while Starch is found in plants **only**. Both store energy within them.

Glucose produced in photosynthesis is either:

a. used to release energy via respiration
b. In excess glucose produced, it will be stored in the plant as starch.

The starch is consumed by animals, and is broken down and absorbed as glycogen in the liver and muscles of animals, as starch is a large molecule that we cannot absorb.

Peptide bonds are found between 2 amino acids. A polypeptide chain is what is a multitude of amino acids held together by peptide bonds. Then, it forms protein.

Long Chains of Amino Acids Fold to Give Proteins a Three-dimensional Shape

Many amino acid molecules are joined in a linear manner to form a polypeptide. Polypeptides in turn may be linked up to form an even longer chain of amino acids. A protein molecule is made up of one or more such chains folded together (Figure 3.23). In most proteins, the polypeptide chains are folded into a more complex, three-dimensional shape.

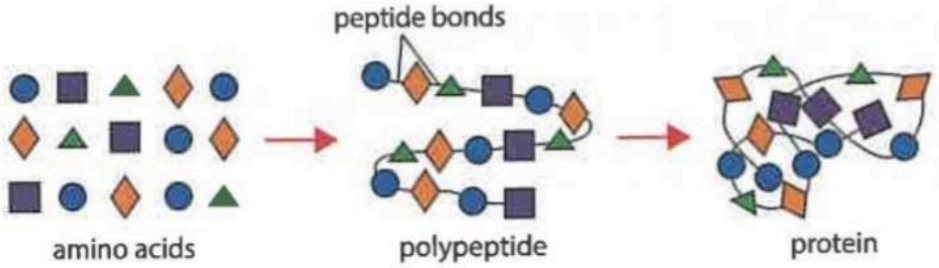
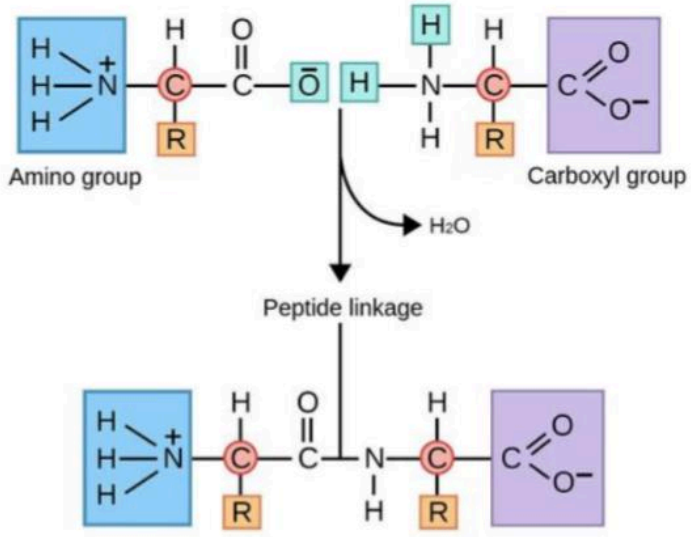
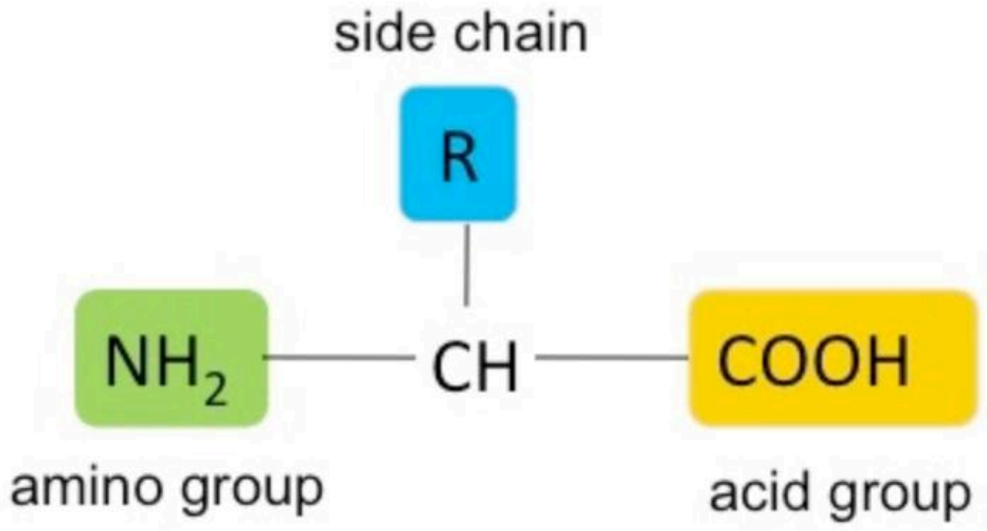
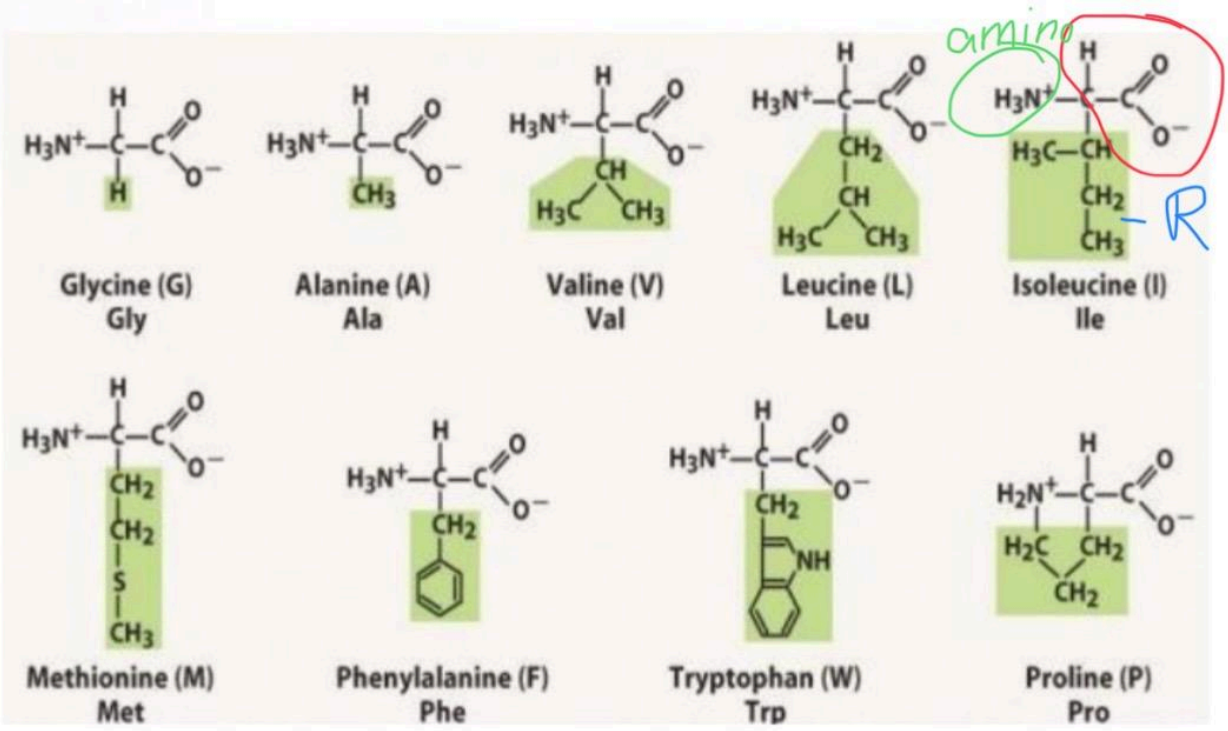


Figure 3.23 Amino acids are joined to form polypeptides, which link up to form even longer chains of amino acids.



Amino acids: H^3 and N+





20 different types of amino acids occur naturally, the difference in them in the R group, which forms the R chain (in green on the diagram)

CARBOHYDRATES AND FATS BOTH STORE ENERGY

Fats - long term storage and higher energy value
Carbohydrates - short term storage and lower energy value

Enzymes (continuation):

Activation energy: the energy needed for molecules to start a reaction
Enzymes lower the activation energy required for molecules to start a reaction, which increases the rate of a reaction.
Some molecules use the option of a higher activation energy, but overall there will be more product produced in a shorter period of time.

Observation of simulation:
The enzyme was specific to substrate A and and broke down substrate A into the products A and B without affecting substrate B.

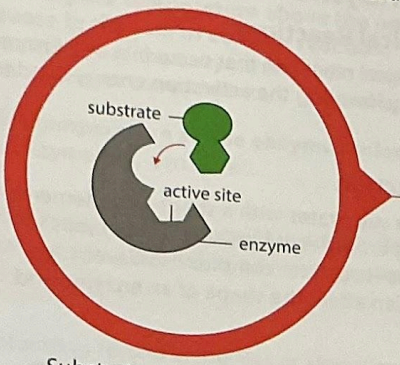
Enzymes also build up molecules:
Photosynthesis, glucose is synthesized using carbon and water and an enzyme boosts the reaction rate.

Why an enzyme remains unchanged after the reaction:

1. it's not a reactant, so the enzyme facilitates the breaking down of bonds and building up of bonds. It leaves no impact of itself.
2. It simply provides an environment for substrates to break down bonds or build up bonds much more easily, hence a faster rate of reaction.

Unique shapes & active sites are caused by the folding of polypeptide chains into proteins. The way it is folded differs, leading to different types of enzymes that are specific to the substrate.

The specific nature of an enzyme for its substrate is described in Figure 4.9.

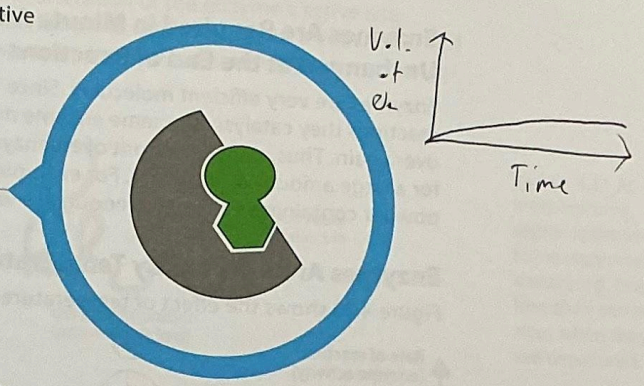


Substrate entering active site of enzyme

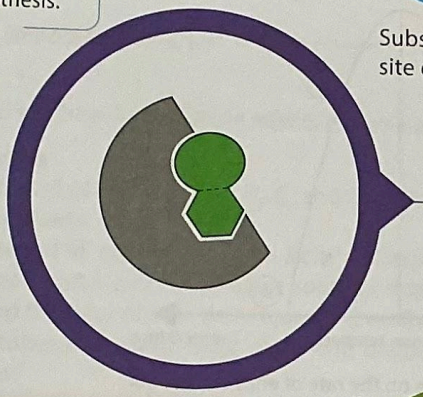
① An enzyme has a specific three-dimensional (3-D) shape. It has a depression called the active site.

The substance on which the enzyme acts is called the substrate.

② Only the substrate with a 3-D shape complementary to that of the active site can fit into the enzyme. This results in the formation of an enzyme–substrate complex. The enzyme is just like a lock and the substrate a key. The substrate fits into the enzyme just like a key fits into a lock. This is called the 'lock-and-key' hypothesis.

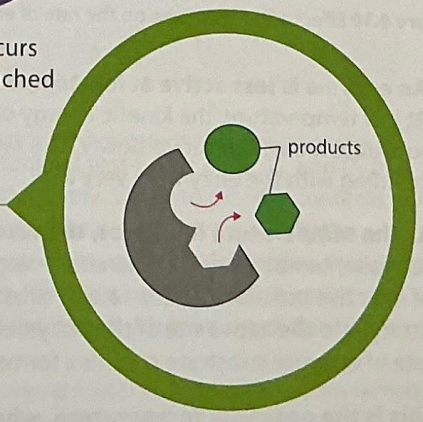


Substrate binds to active site of enzyme



③ While the substrate is attached to the active site, a chemical reaction occurs. The substrate is converted to the products.

Chemical reaction occurs while substrate is attached to the enzyme



④ Later, the products leave the active site. The enzyme remains unchanged. It can catalyse another reaction.

Products leaving active site of enzyme

Word Alert

Complementary: matching

Figure 4.9 The mode of action of an enzyme

Key words:

- active site
- specific 3 dimensional shape
- substrate (the substance that acts with the enzyme)
- shape is complementary to the enzyme/substrate
- formation of an enzyme-substrate complex
- enzyme is a lock, substrate is a key
- once the enzyme is attached, a chemical reaction occurs
- When the product is formed and leaves the active site, the enzyme remains unchanged
- the enzyme can catalyse another reaction

Extra: explain using the “lock and key hypothesis”:
The enzyme is a lock and the substrate is the key. The substrate fits into the enzyme just like a key fits into a specific lock.
This hypothesis also explains why enzymes are specific.

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Sometimes, the shape of an enzyme changes the shape of the active site during a reaction. However, after traction, the enzyme always reverts back to its original shape

Raw egg to cooked egg: structure of protein has changed, hence it can be concluded that proteins, which the egg is made out of, is affected by heat.

Protein denaturation
Structure determines the function of protein. 20 amino acids are essential, hence our body produces them naturally, even though there are 100s of amino acids possible.

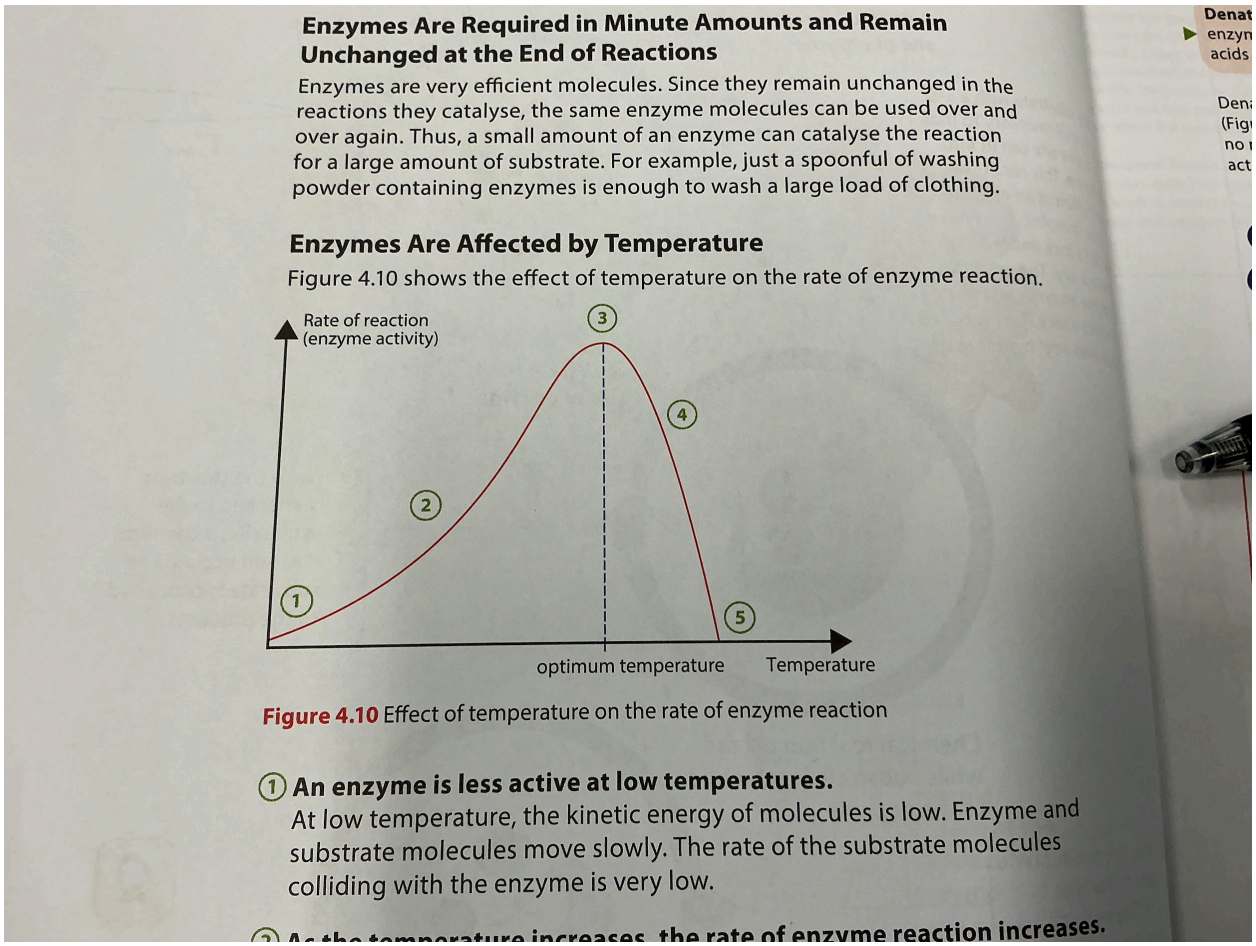
Proteins are affected by heat, acid and force. Enough heat applied leads to proteins being denatured as they gain enough energy to break bonds and revert to polypeptide changes. Water is forced out from between the chains.

Then, the polypeptide chains can be reformed into different proteins. Polypeptide chains do not have functions, hence it must be folded and form bonds to become a protein and have a function.

More heat > more movement (kinetic energy gain from thermal energy)

Too much movement causes bonds to break, which would lead to the protein unravelling itself and losing its function.

Enzymes need higher temperatures to function well.



Enzymes Are Required in Minute Amounts and Remain Unchanged at the End of Reactions

Enzymes are very efficient molecules. Since they remain unchanged in the reactions they catalyse, the same enzyme molecules can be used over and over again. Thus, a small amount of an enzyme can catalyse the reaction for a large amount of substrate. For example, just a spoonful of washing powder containing enzymes is enough to wash a large load of clothing.

Enzymes Are Affected by Temperature

Figure 4.10 shows the effect of temperature on the rate of enzyme reaction.

Figure 4.10 Effect of temperature on the rate of enzyme reaction

① **An enzyme is less active at low temperatures.**
At low temperature, the kinetic energy of molecules is low. Enzyme and substrate molecules move slowly. The rate of the substrate molecules colliding with the enzyme is very low.

② **As the temperature increases, the rate of enzyme reaction increases.**

(T.B pg 66), (temperature graphs are never symmetrical)

At low temperatures, the kinetic energy of the substance is low. The enzyme and substrate move slowly and the rate of effective colliding is low. This leads to a lower chance of the formation of an enzyme-substrate complex and a lower rate of reaction.

However, as the temperature increases, the rate of reaction increases and the enzyme and substrate move quickly and the rate of effective collision is high. Effective collision is basically the rate of substrate molecules colliding and fitting into the active site of the enzyme.

This is the optimum temperature where the enzyme is most active. However, any higher than that and the enzyme may undergo protein denaturation. The enzyme molecule begins to lose its original shape and is no longer complementary to the shape of substrate molecules.

Defnition of denaturation: Denaturation is the change in the three-dimensional structure of of an enzyme or any other soluble protein, caused by heat or chemicals such as acids or alkalis.