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PROTEINS

They're large biomolecules often called **macromolecules** or **polymers**, they take role in everything in our life

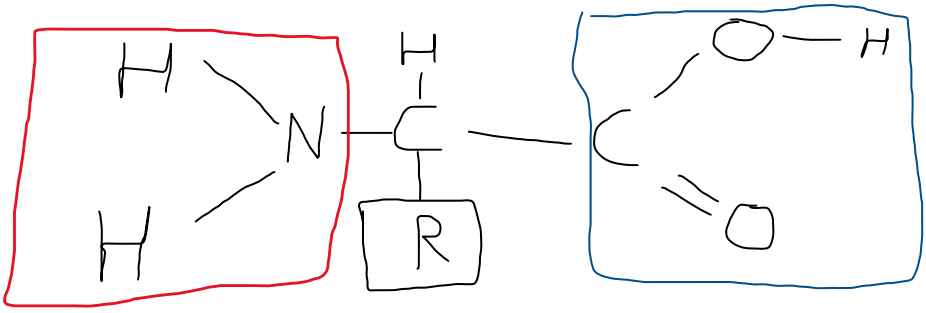
They consist of

amino acids

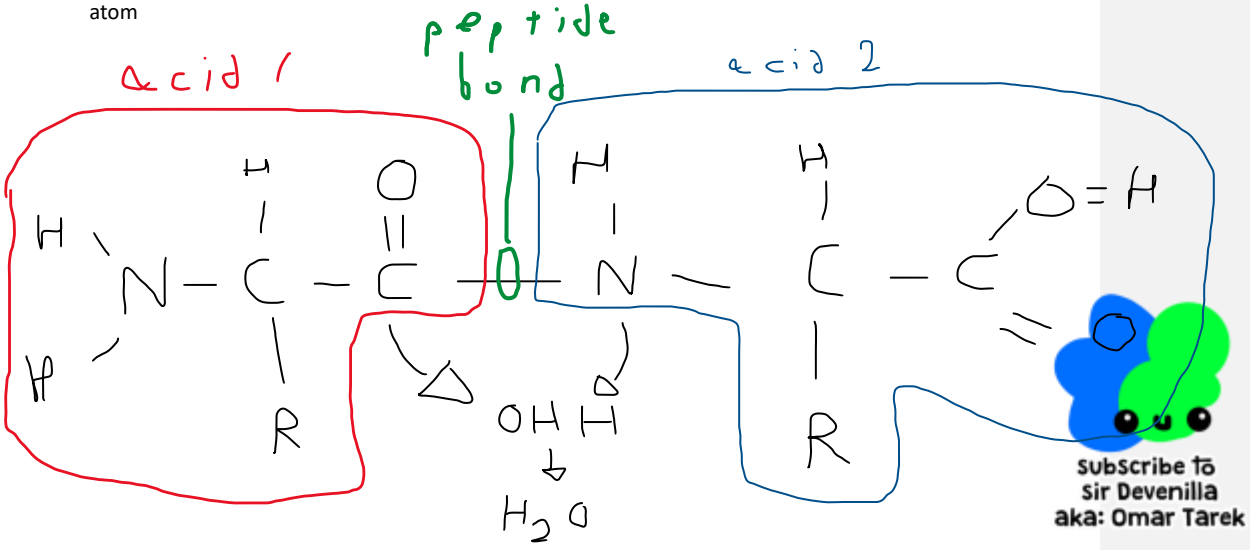
They are small biomolecules monomers that make up proteins, they all have 4 main elements, **C – H – O – N**

They consist of a central carbon atom that is bonded to 4 things

- **Hydrogen atom**
- **Amine group (NH2)** which is a basic group which turns sunflower to blue
- **Carboxyl group (COOH)** which is an acidic group which turns sunflower to red
- **Alkyl Group (R)** is a chain of carbon and hydrogen atoms that differentiate amino acids



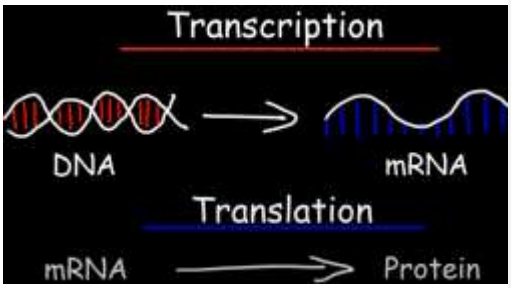
Amino acids form chains by forming **peptide bonds,** they are covalent bonds between the carboxyl group of an amino acid and the amine group of another, it happens when the carboxyl loses an **OH^-** group and the amine loses an **H^+ ion**, forming water in the process, and then the **nitrogen** is connected with the carbon atom



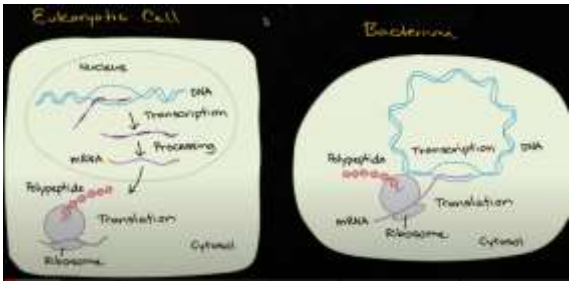
NOTES

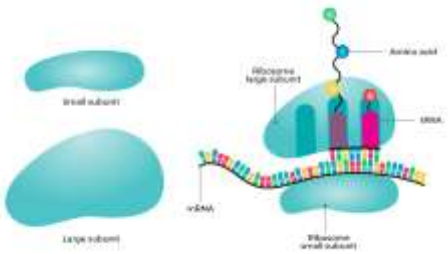
- To get the amount of peptide bonds **=** the amount of water molecules lost **= amount of amino acids – 1**
- When bonds two amino acids bond, they form a **polypeptide** which are basically proteins
- Proteins can react with **basic compounds** like it's acidic because of the **carboxyl group**
- Proteins can react with **acidic compounds** like it's basic because of the **amine group**
- The formation of peptide bonds is called **Polymerization**
- The breaking of peptide bonds is called **hydrolysis reaction**
- The thing differentiating amino acids from each other is the **alkyl group (R)**
- Proteins are different from one another because of the **type, count,** and **arrangement** of amino acids
- **Carboxyl** and **amine** are called **functional groups** because they do the bonding
- The amount of free functional groups is always **2**
- The amount of free **amine groups** = the amount of free **carboxyl groups** = always 1
- If we changed a single amino acid, the whole protein changes

Well, we learnt that proteins are generated using blueprints from the DNA, how does that happen exactly?



the organ used to make proteins is **ribosomes**



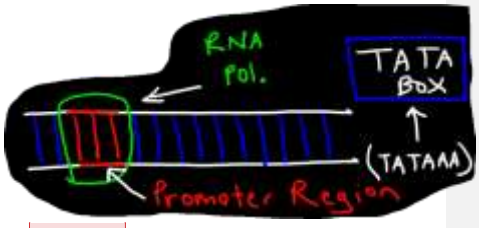


Transcription

is the process where DNA is converted into mRNA (Messenger RNA), it occurs in three steps

Initiation

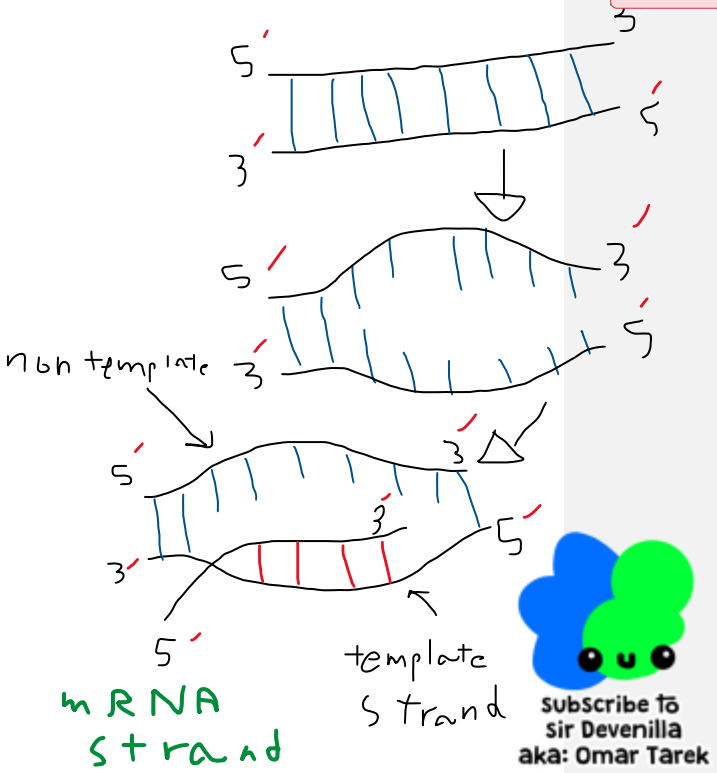
- **RNA Polymerase (RNA Pol)** is an enzyme responsible for the transcription of DNA, it has a types like RNA Pol I, RNA Pol II, RNA Pol III, each type responsible for transcription different types of RNA, in making **mRNA**, RNA Pol II will be used
- RNA polymerase II move along the DNA molecule from 5' to 3', and binds to it a specific starting point called the **promoter region**, it's a sequence of the nucleotides at the start of a gene, it reacts with RNA Pol to begin transcripting anything after it, acting like an instruction marker of the cell telling the enzyme where to start transcripting
    - In eukaryotic cells, it is known as **TATAAA** OR **TATA** box, because it's just made **Adenine and Thymine**
    - **"the promoter region is located 25 nucleotides upstream of the site where transcription begins"** means that the promoter sequence, which signals the start of transcription, is situated 25 nucleotides "before" the actual starting point where RNA polymerase binds and begins transcribing the DNA into RNA



Commented [SD1]: In molecular biology, "upstream" and "downstream" are terms used to describe the relative positions of DNA or RNA sequences. In this context:
- "Upstream" refers to the sequence in the DNA that precedes or comes before the transcription start site.
- "Downstream" refers to the sequence that follows or comes after the transcription start site.

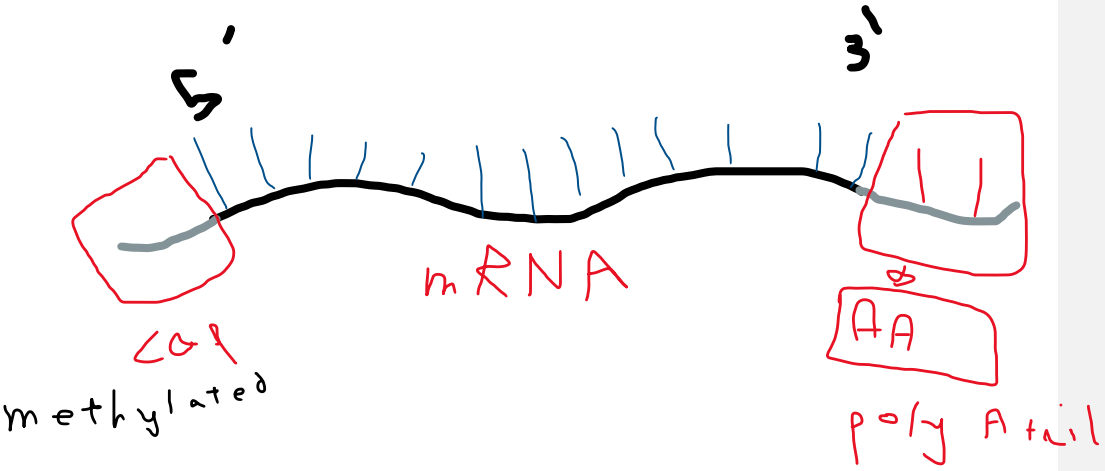
Elongation

- **RNA polymerase** causes the 2 DNA strands to separate, and begins to add nucleotides to the growing mRNA strand**,** thus **RNA polymerase** synthesizes **mRNA** starting from a 5 prime end to a 3 prime end, however, it reads the **DNA** strand in 3 -> 5 prime
- The strand that is used to synthizise RNA is called **Template Strand (antisense)**
- The other strand is called **Nontemplate Strand (sense)** or sometimes called **(coding)** strand because its sequence matches the one in the **RNA**

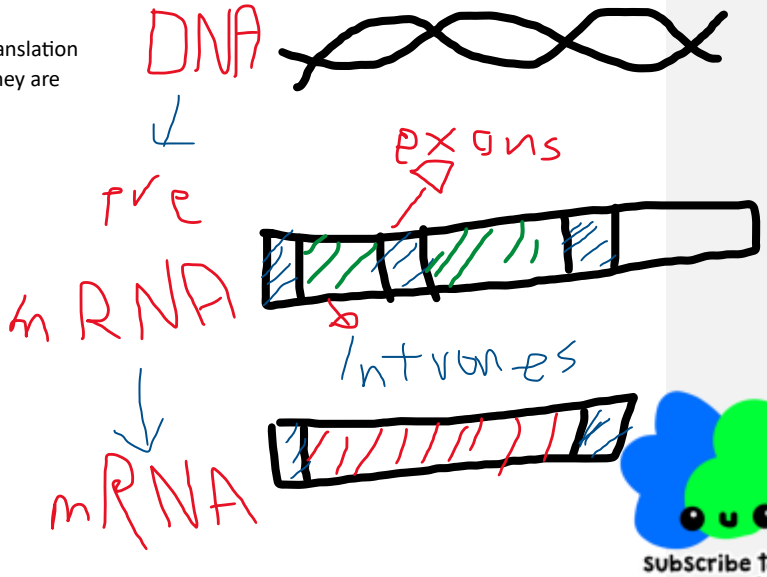


Termination

- The **RNA polymerase molecule** and the **mRNA strand** separate from the **template DNA strand**
- The **poly-A-polymerase** enzyme or **PAP,** begins adding a **polyadenine tail** or **poly-A-tail** to the 3 prime end of the mRNA strand
- **Poly-A-tail** is a stretch of adenine nucleotides that cap (covered) the 3' end of mRNA to stabilize it and help with nuclear export
- **At the beginning of the transcription process**, the 5' end of mRNA is also capped to protect the mRNA strand from being degraded



- at the end of the termination, DNA will be used to crea, pre mRNA, which has **introns** and **exons**,
- **introns** are long sequences of nuceleotides that serve no popurse and theirfore cute in DNA slicing
- **exons** they are used in the translation process to make protein so they are left unharmed



Practice problems

If you were given a sample of nucleotides on a DNA strand -> **3'-GCATAGTATACG-5'**

And you're asked to write the corresponding sequence on an mRNA strand

- replace each strand with its corresponding (T-A, C-G)
  this would give us
  3'-CGTATCATATGC-5'
- replace thymine (T) with Uracil (U)
  this would give us
  3'-CGUAUCAUAUGC-5'

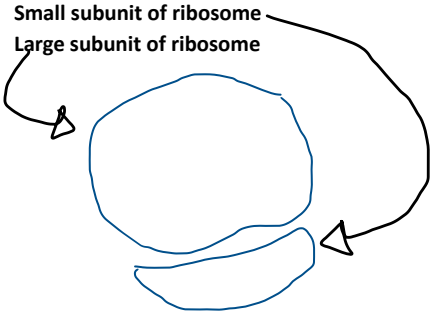
TRANSLATION

It's the process of taking the information from the mRNA and using it to create Proteins

When an mRNA strand gets synthetized, it leaves the nucleus through nuclear pores and in the cytosol it moves until reaching a free ribosome, or a one attached to the ER

Translation includes 4 key molecules

- **mRNA strand**
  - m**RNA** cotains codons that will encode for specifc amino acids.
  - mRNA will have a methylated cap at the 5' end, which will help with things
- **Small subunit of ribosome**
- **Large subunit of ribosome**



- **Transfer RNA (tRNA)** which is a small RNA molecule that serves as a interpreter or a **translator** for the mRNA, it contains anti-codons that are complementary to the codons of the mRNA, and it has an amino acid M**ethionine (Met) corresponding to the AUG codon**

- **The release factor** is a protein that recognizes stop codons and terminates the process, allowing the newly made protein to be free

Commented [SD2]: A strand of nucleotides that carries information

Initiation

- It begins when the small subunit of the ribosome attaches to the cap and moves to the **translation initiation site**
- **tRNA** contains anti codons that is complementary to the codons of the mRNA, causing it to attach to it, the first codon is typically AUG
- **the large subunit** inds with the small subunit to create the **peptidyl (P) site** and the **aminoacyl (A) site**
- the first tRNA occupies the P site, and then the second one occupies the A site
- the amino acid of the tRNA in site (B) gets transferred to site (A)'s amino acid, creating a peptide in the process, and then the tRNA in site(B) is removed and gets replaced with site (A)'s tRNA and the ribosome moves forward the mRNA chain, and the process repeats

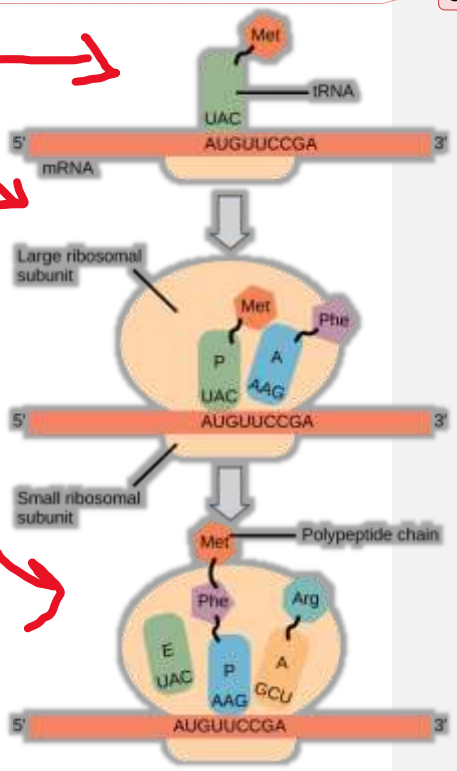
Elongation

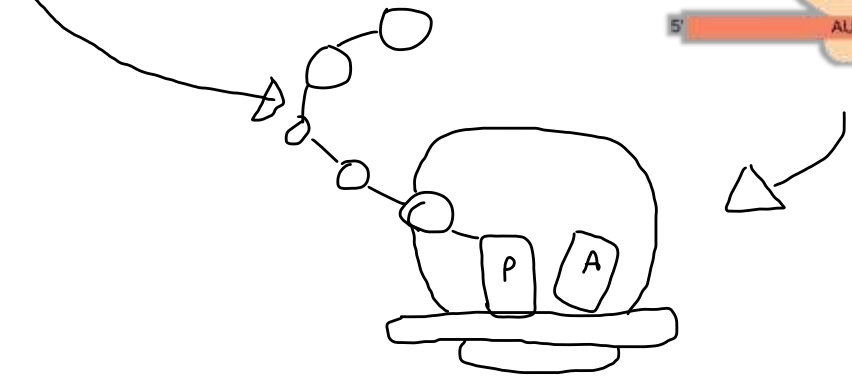
- after multiple repeats the peptide chain gets bigger forming a protein

Termination

- when the ribosome reaches the **stop codon** in the site A, it will trigger a reaction that will disassemble everything and set the DNA free

Commented [SD3]: Area where codons begin

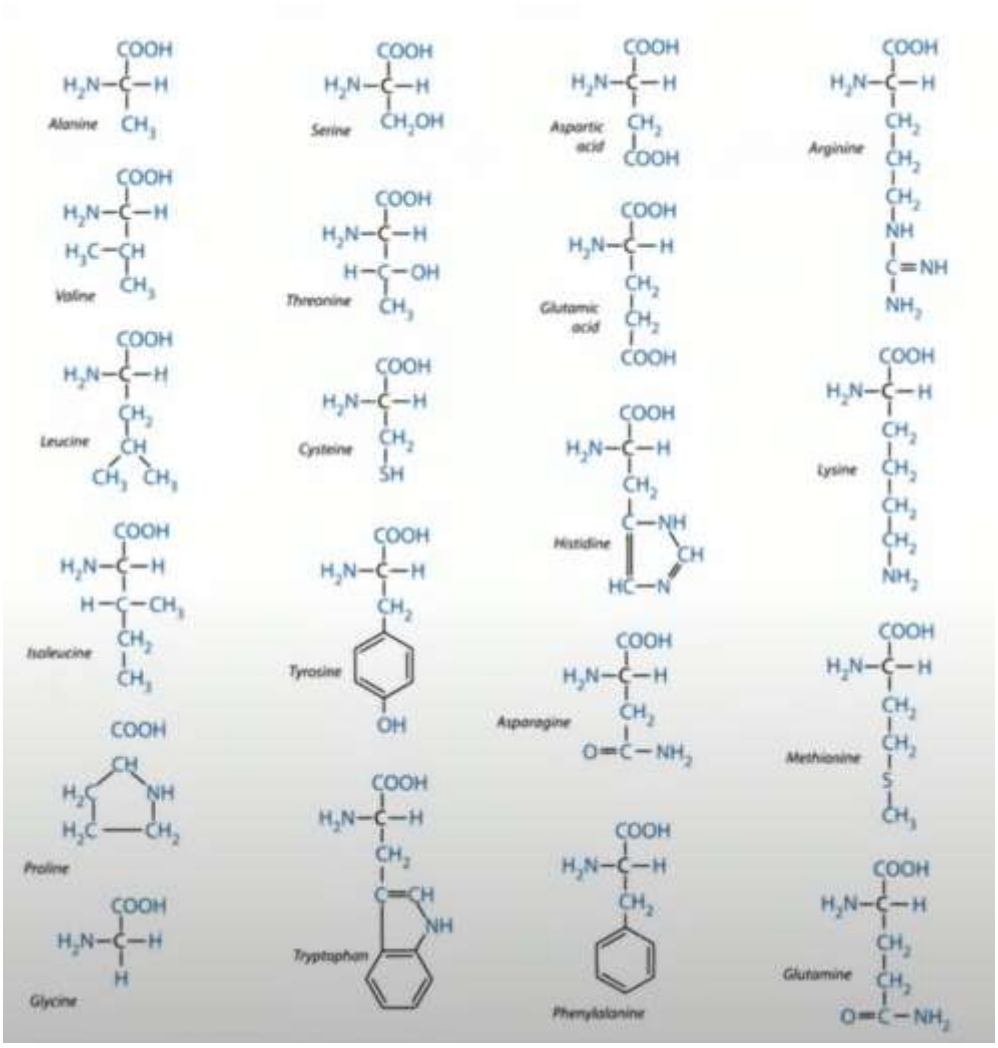




For visual description -> https://www.youtube.com/watch?v=5bLEDd-PSTQ

Back to amino acids!

TYPES OF AMINO ACIDS

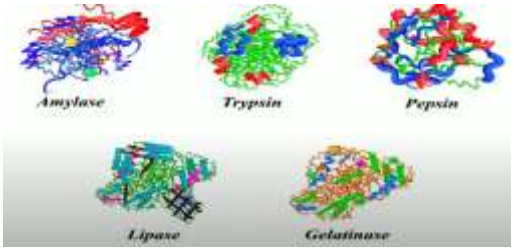


The simplest amino acid is **glycine**

FUNCTIONS OF PROTEINSin a nutshell

Messenger Proteins (Hormones) are proteins that help send messages between different parts of the body, for example, adrenaline is a hormone

Enzymetic Proteins are proteins that speed up chemical reactions like how we learnt in cell Transcription and digestion and breathing



Structural proteins are proteins essential to your body, this includes **collagen, keratin,** and **elastin**

Commented [SD4]: Froms the connective framework of your muscles, bones and cartlidge

Commented [SD5]: Main component in your hair, nails, and skin

Defensive proteins like antibiotics, are large Y shaped proteins used by the immune system to identify and attack bad bacteria, they are formed In white blood cells, they recognize a uniqe molecule in pathogens called an antigen

Transport Porteins

They carry vital materials to the cells, like how hemoglobin carries oxygen

Storage proteins

Are proteins that store molecules, **calbindin** helps with the absorption and storage of calcium from the intestinal walls

THE STRUCTURE OF PROTEINS

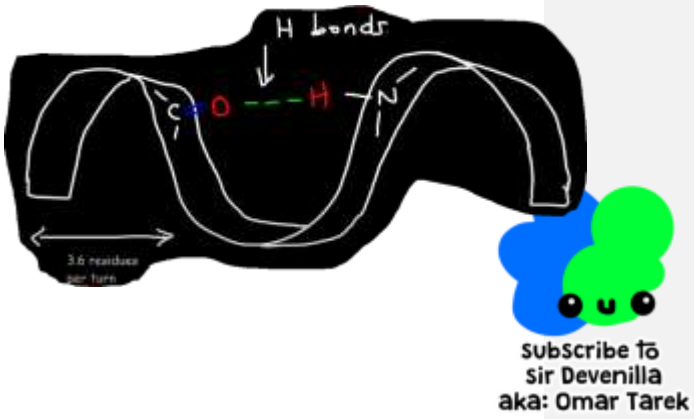
We already learnt how amino acids bond and what not, now time to talk about the structures they make

Primary Structure

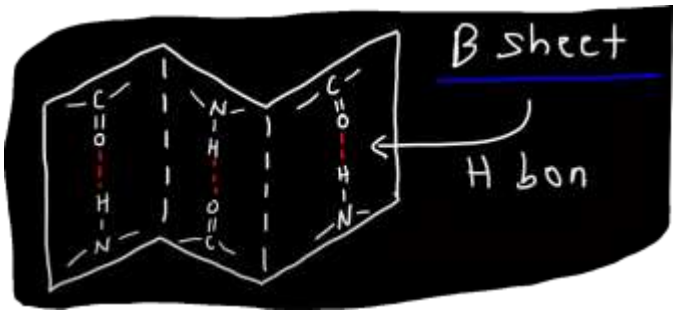
- It differentiates between proteins based on the sequence of amino acids
- So if we had the amino acids **Ala – Leu – Val - Met**, they aren't the same as **Ala – Leu – Met – Val**

Secondary Structure

- Describes the localized shape of a protein, meaning if you took DNA and looked at it, this is what you will see, it is separated into two key parts
  - α **(ALPHA) helix** which is stabilized by hydrogen bonds between the hydrogen atom on the **amine** group and the oxygen atom on the **carboxyl** group you would also see that it requires **3.6 amino acids** to complete a helix turn or that U shape

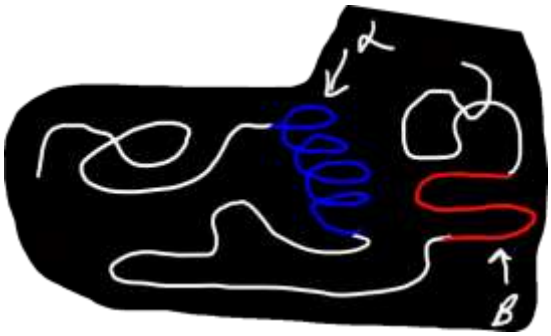


- **β (BETA) pleated sheets** which is like a sheet of amino acids s with stabilization between the H and O atoms



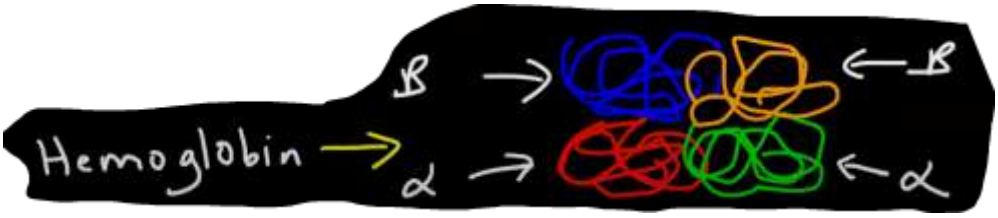
Tertiary Structure

- Represents complete 3D folding pattern, and it is called a **subunit**



Quaternary Structure

- Consists of multiple subunits



ENZYMES

They are proteins that speed up chemical reactions, or even help start them as “catalysts”, which is important in biochemical reactions as they happen everywhere every time

So let’s imagine the chemical reaction where water and CO2 turn into carbonic acid

Often called **soda**

WITHOUT CATALYST / ENZYME

When manufacturers make soda without the usage of enzymes or catalyst, the reactions happens slowly, as you can even see that the carbonic acid begins disassembling as you can see CO2 bubbles coming out of the soda, although it is **slow** because **no catalyst**

WITH CATALYST / ENZYME

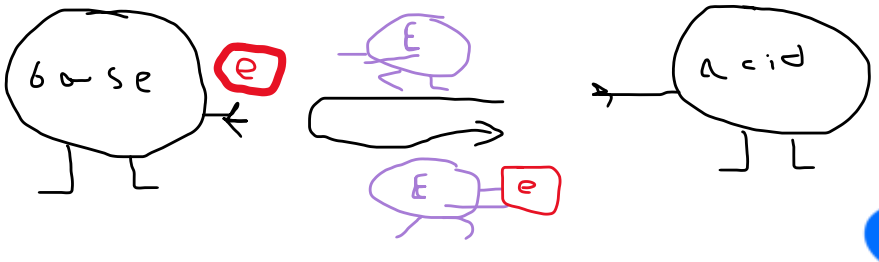
When you take a sip of the soda, you notice that it starts to fizz a lot more, that is because your saliva has an enzyme called **CARBONIC ANHYDRASE** that speeds up the reaction

ENZYME MECHANISM

Enzymes use a lot of catalytic strategies to push reactions, some of them are

ACID/BASE CATALYSIS

- This is when the enzyme acts as an ACID or BASE to trigger a reaction with another BASE/ACID, this is because ACIDS tend to be carriers for electrons so enzymes can just take an electron from a BASE and carry it to an ACID, causing a reaction



COVALENT CATALYSIS

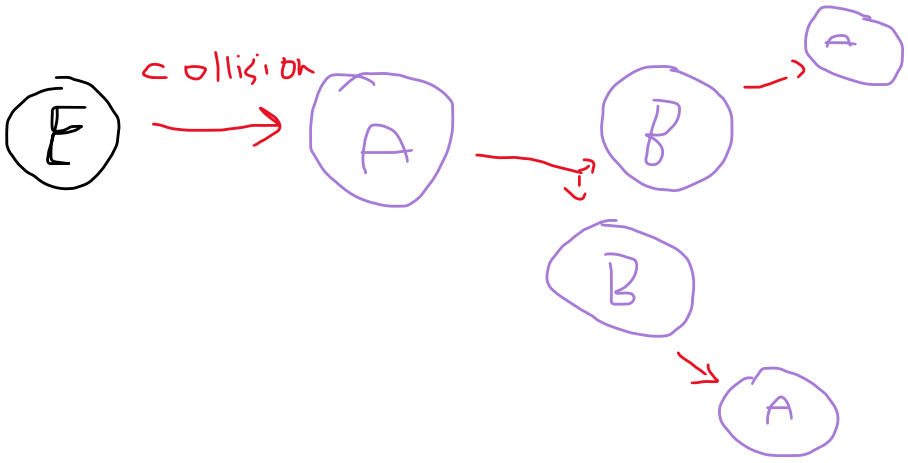
- When enzymes form a covalent bond with its target molecule

ELECTROSTATIC CATALYSIS

- DNA is a very negatively charged polymer because of the phosphate groups, so if an enzyme had a metallic cation on it like magnesium, it will cause it to react with the DNA causing it to stabilize, an example like **DNA Polymerase**

PROXIMITY & ORIENTATION EFFECTS

- Enzymes can physically collide with other atoms to push them into starting a reaction, and the more collisions that happen, the more likely a reaction is to start

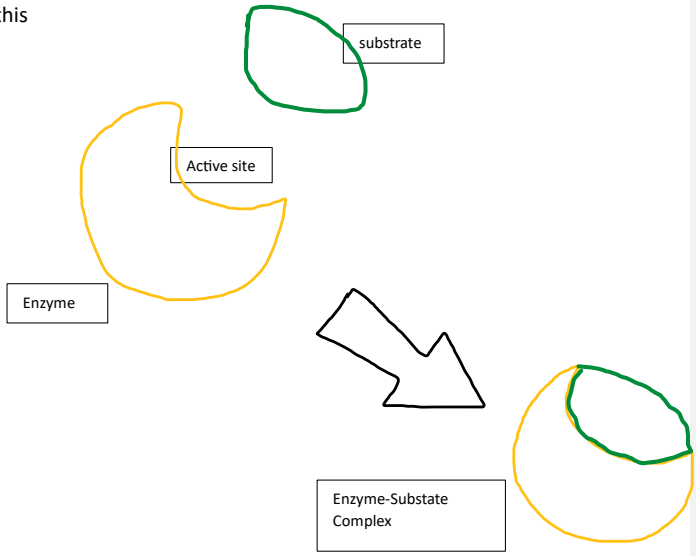


chain reaction

ENZYME STRUCTURE

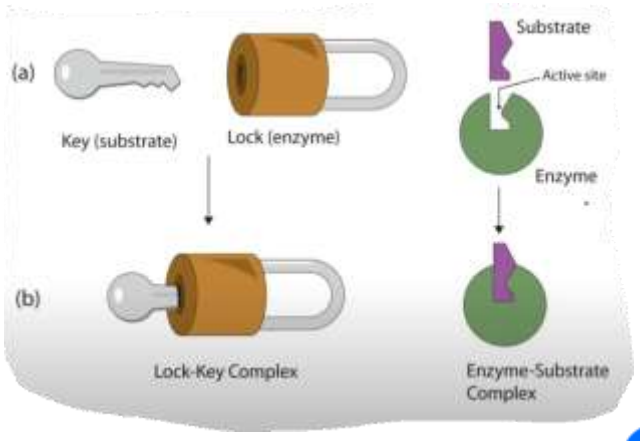
They are long chains of amino acids, and the sequence of these amino acids determines the 3 dimensional structure

Overall, it can be represented like this



Substrate -> the molecule or substance that the enzyme is designed to react with “target molecule”
Active Site -> a part of the enzyme that the substrate fits into, causing a reaction producing an **Enzyme-Substrate complex**

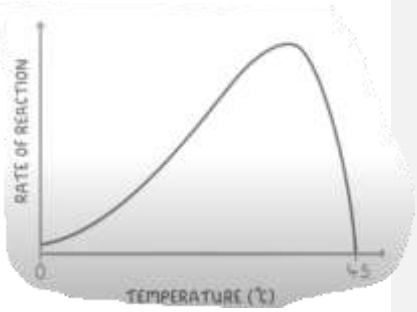
You can thing if it as a key-lock



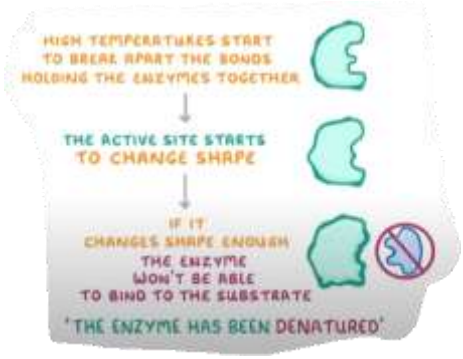
FACTORS OF ENZYMES

An Enzyme's reaction speed is determined by the

Temperature



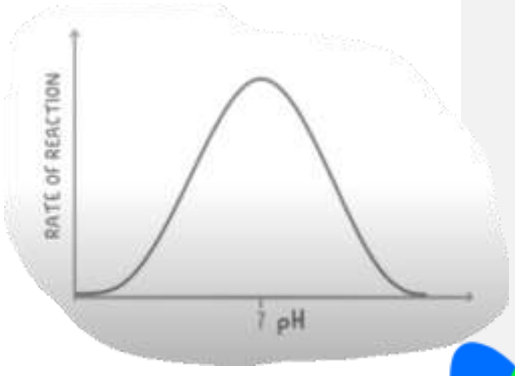
- **The first part**
  As the temperature increases, the rate of reaction increases because atoms gain speed which will lead to more collision which will lead to an increase in reaction
- **after 37°**
  the rate started to drop exponentially because the high temperature starts to break down the enzyme's bonds causing the active site to change until it's no longer able to do anything



-
- NOTE -> different enzymes have different optimal temperatures other than 37 degrees

pH levels

- you would see that the more acidic you became or more basic you become, the less the rate of the reaction, so the optimal reaction rate is at 7pH or distilled **water**
- This is because the high acidity or base will lead to the breaking of the bonds holding the enzyme apart, resulting in a change of shape in the active site leading it to be **denatured**



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STRUCTURE FUNCTION

POINTS TO KEEP IN MIND

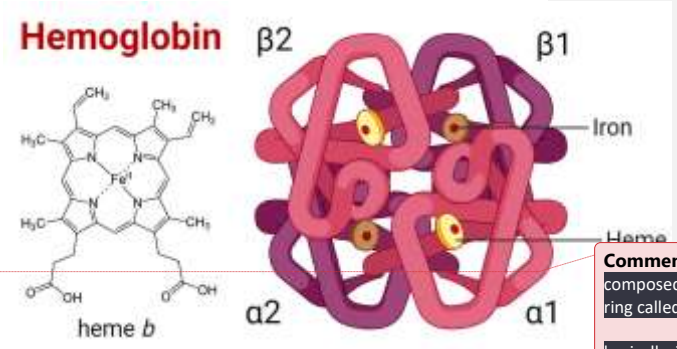
- The 3D structure of a protein is the reason for its function
- The hydrophilic part of a protein is on the outside while the hydrophobic is on the inside you can look up why in biology LO3
- The 3D structure is based on the primary structure "if a single amino acid changes, everything changes"

Let's understand the structure-function relationship of two proteins

Hemoglobin

Function -> oxygen transport

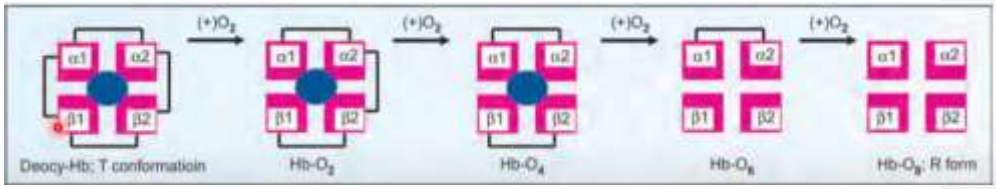
Structure



- It's a tetrameric protein, meaning it has 4 polypeptides or 4 chains connected to each other
- It consists of 2 alpha polypeptides, and 2 beta polypeptides
- Each polypeptide has a **HEME** group attached to the center
- It transports O_2 and CO_2 out and in the lungs because the iron attaches to the oxygen or carbon atom

Commented [SD6]: A heme group is a complex molecule composed of an iron atom contained within a large organic ring called a porphyrin

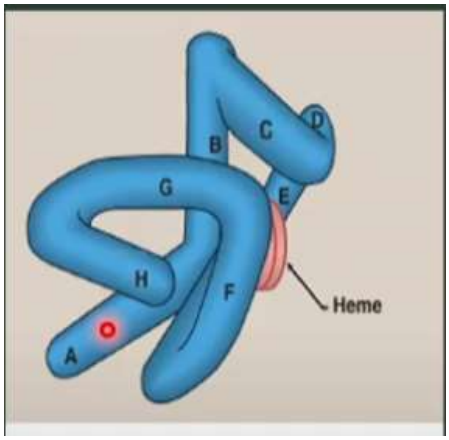
basically, it is iron with stuff around it



- **basically,** it saying that the more we add oxygen, the more salt bridges we break between the polypeptides

Myoglobin

Function -> oxygen storage



Structure

- It has a heme protein which is present in the heart and skeletal muscles, to store oxygen that can be used in emergency
- It conists of a single polypeptide chain and it is similar a single chain in hemoglobin
- It only binds with 1 oxygen molecule because it has 1 heme group