

BHUPAT AND JYOTI MEHTA SCHOOL OF BIOSCIENCES

**iGEM IIT Madras**

***THE LANGUAGE PROJECT  
PRESENTS***

# THE GENEY THEORY

A story  
introducing you to  
the fascinating  
realm of Molecular  
Biology brought  
to you by our two  
good friends –  
Wille and  
GeneY





# ACKNOWLEDGEMENTS

We'd like to thank iGEM for giving us this opportunity to get to know ourselves better. We realized that Popular Science is the best way to engage with the public and to spread the awareness and awesomeness of biology amongst the layman. The script is original and was written by the team members. The animations in the book are hand-drawn by the members of the Language Project Team.

We sincerely thank everyone who has helped us edit the script and its nuances for the better with their valuable suggestions. Special mention and gratitude to the Professors from the Department of Biotechnology, IIT Madras, for their constant support and encouragement.

We also believe that you, the readers of this book, will be able to help us even further with our goal of popularising simple bio-concepts. We request you to write to us at [languageproject@smail.iitm.ac.in](mailto:languageproject@smail.iitm.ac.in) in case of any further queries or suggestions and criticism.

Hope you enjoy your read! :)

With love,

Team Language Project

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The story is about a poor teenager 'Willie' who is suffering from sickle-cell anaemia. This takes a toll on his dirt-poor parents who struggle daily to put three square meals. In his adolescence, he became aware about his family's financial crisis on account of his illness and so he would often wander away from his home into the junkyard to spend some time alone.

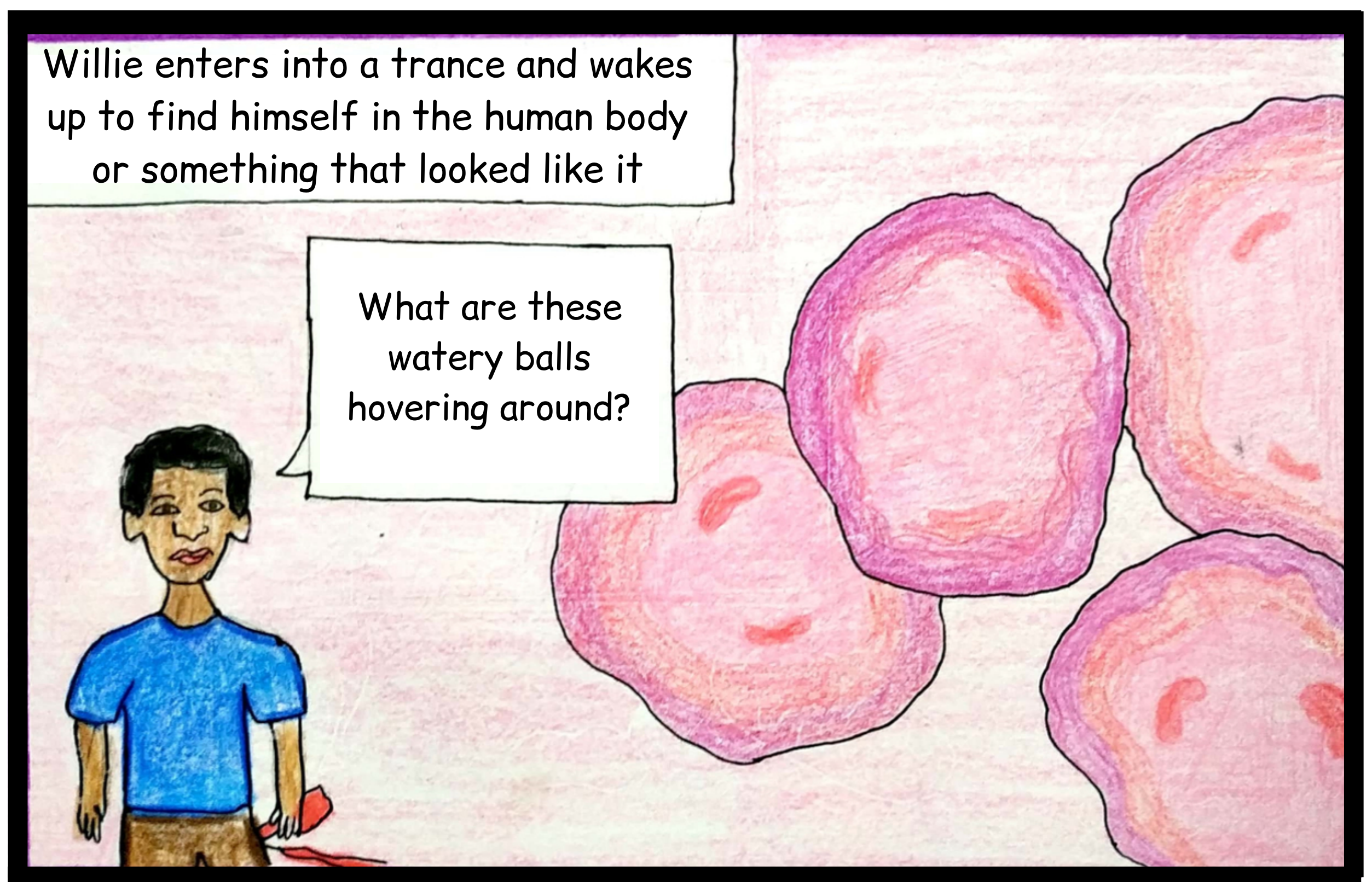


On one such day, he found a sealed champagne bottle in the junkyard. As it was very odd to find something so expensive in such a place, he uncorked the bottle out of curiosity. A pall of thick black smoke began to emanate from the bottle and in no time, he was standing in the presence of a huge GENIE!! The genie then offered him one wish.

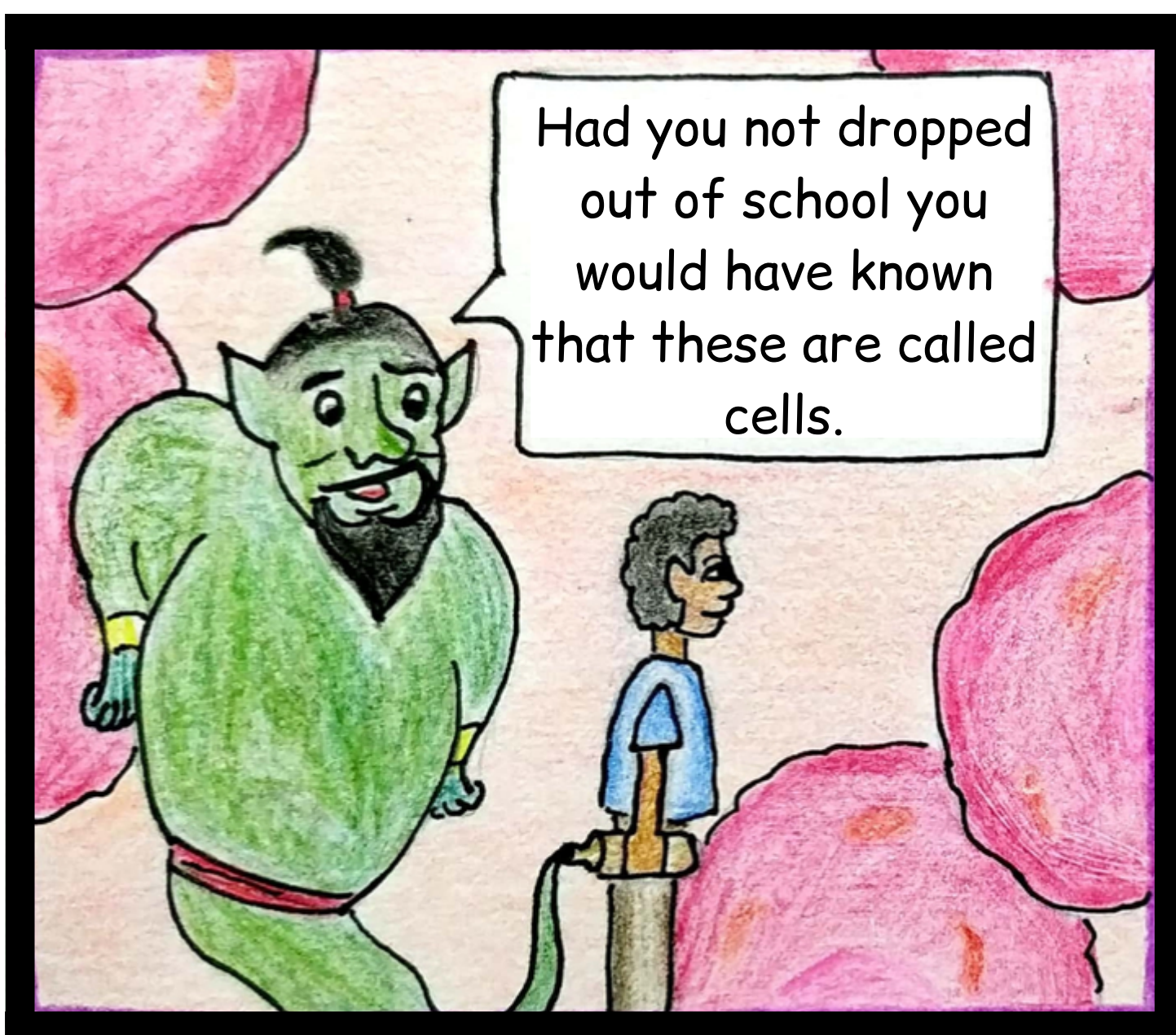
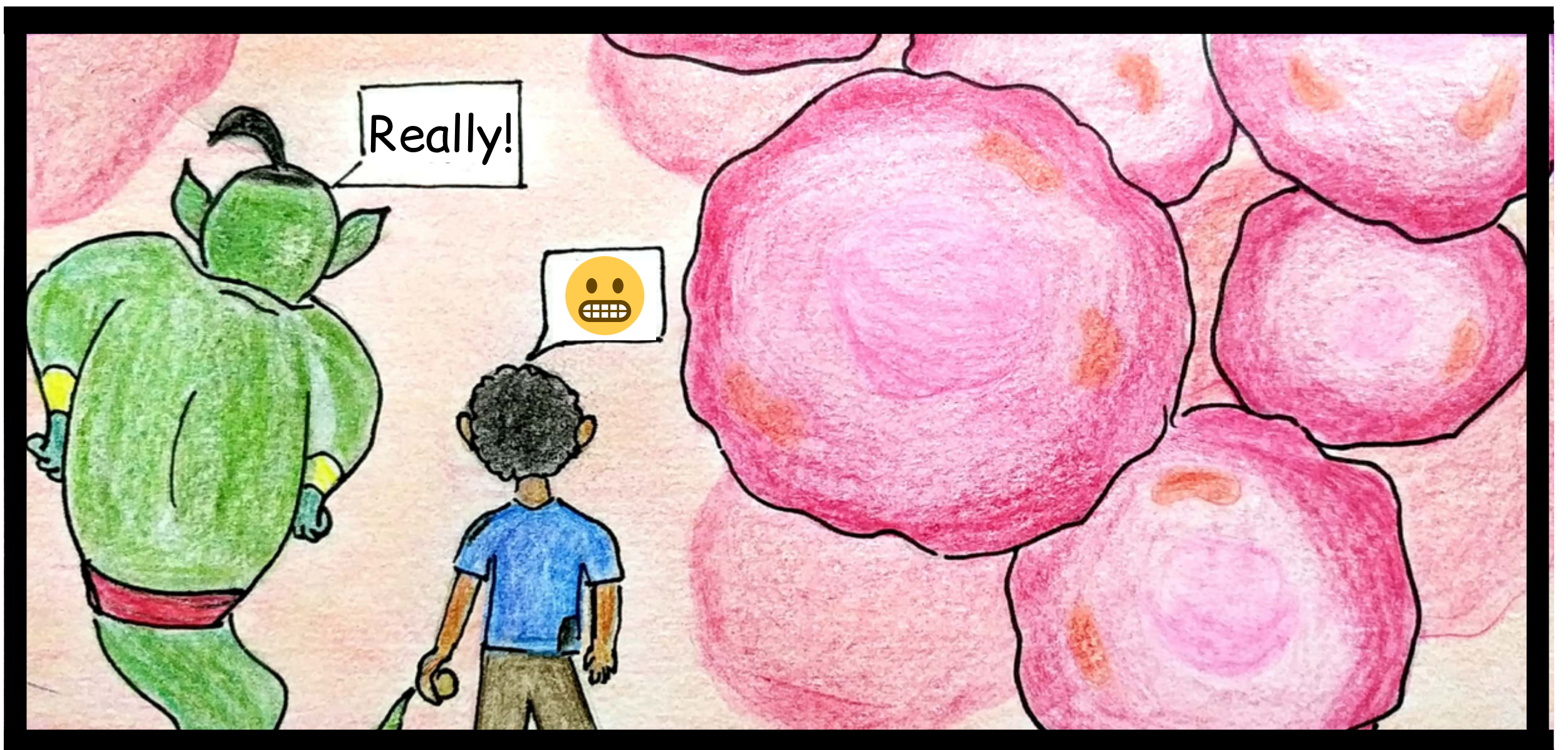
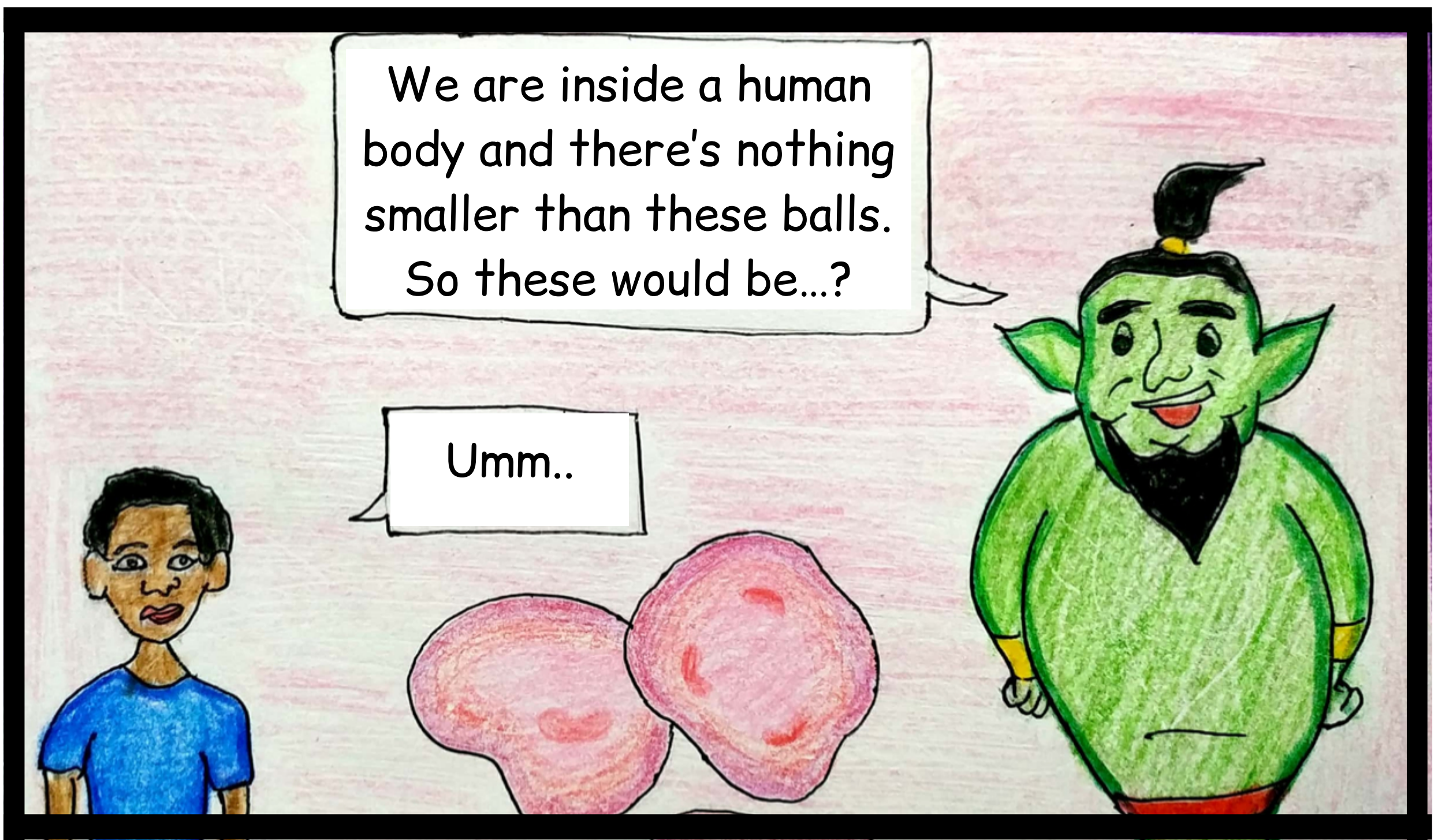










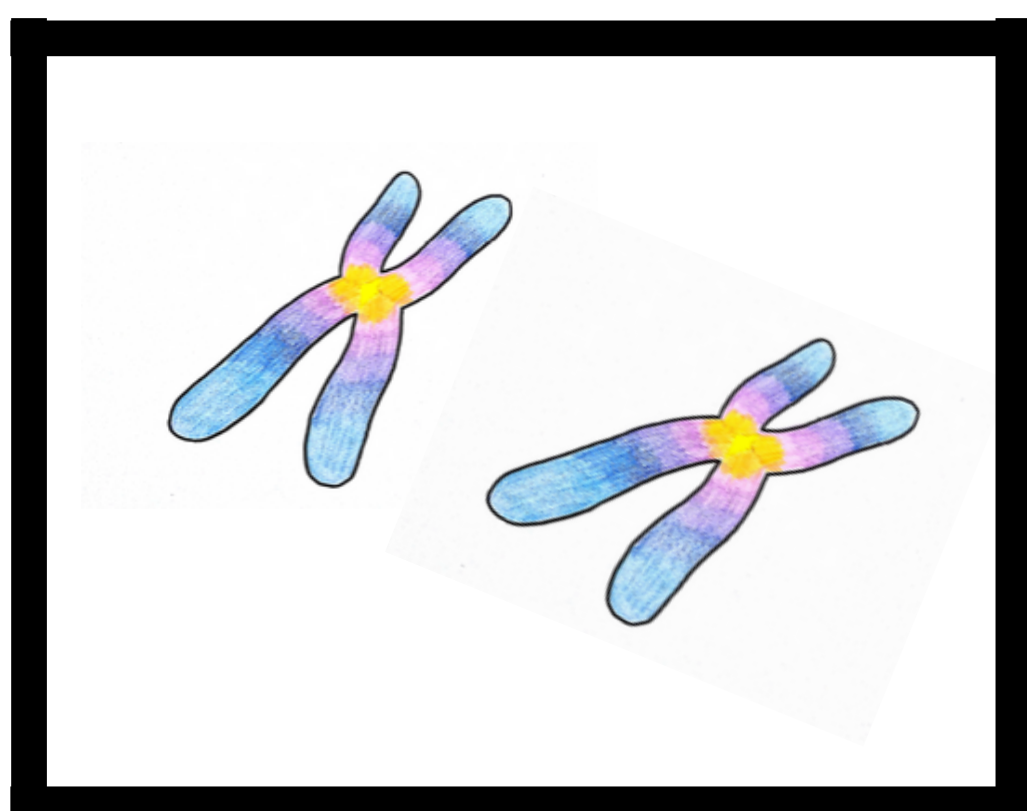
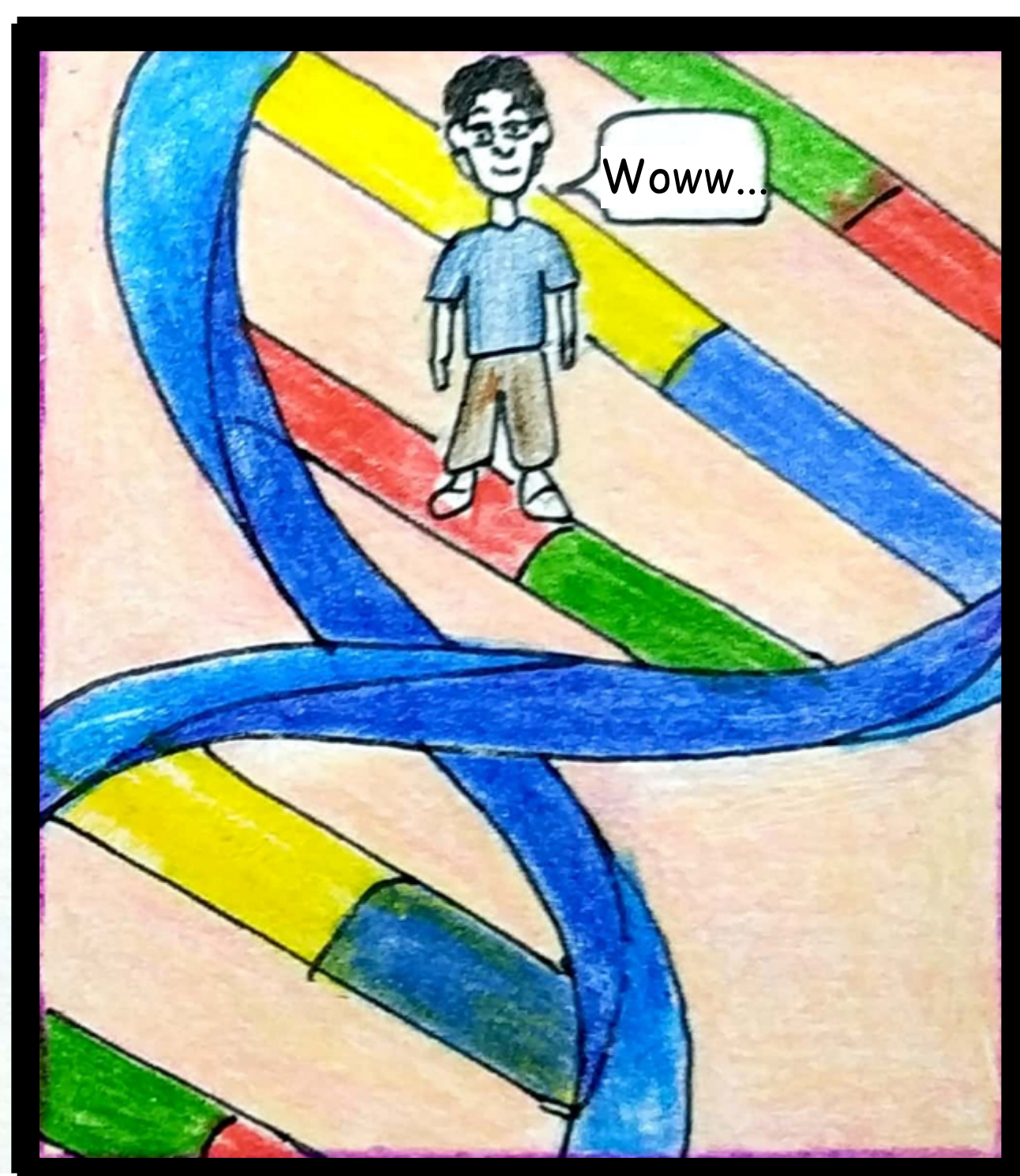
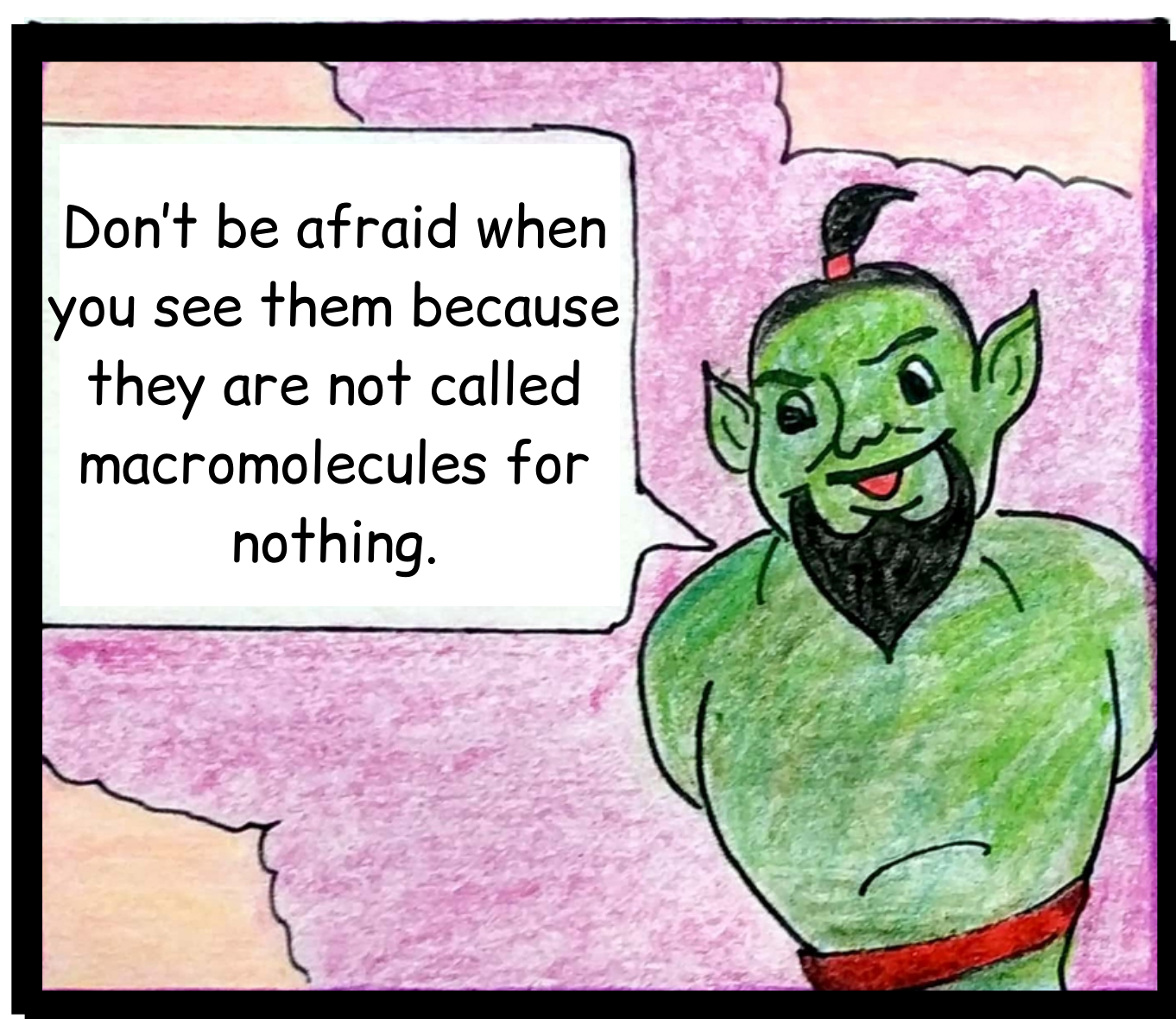
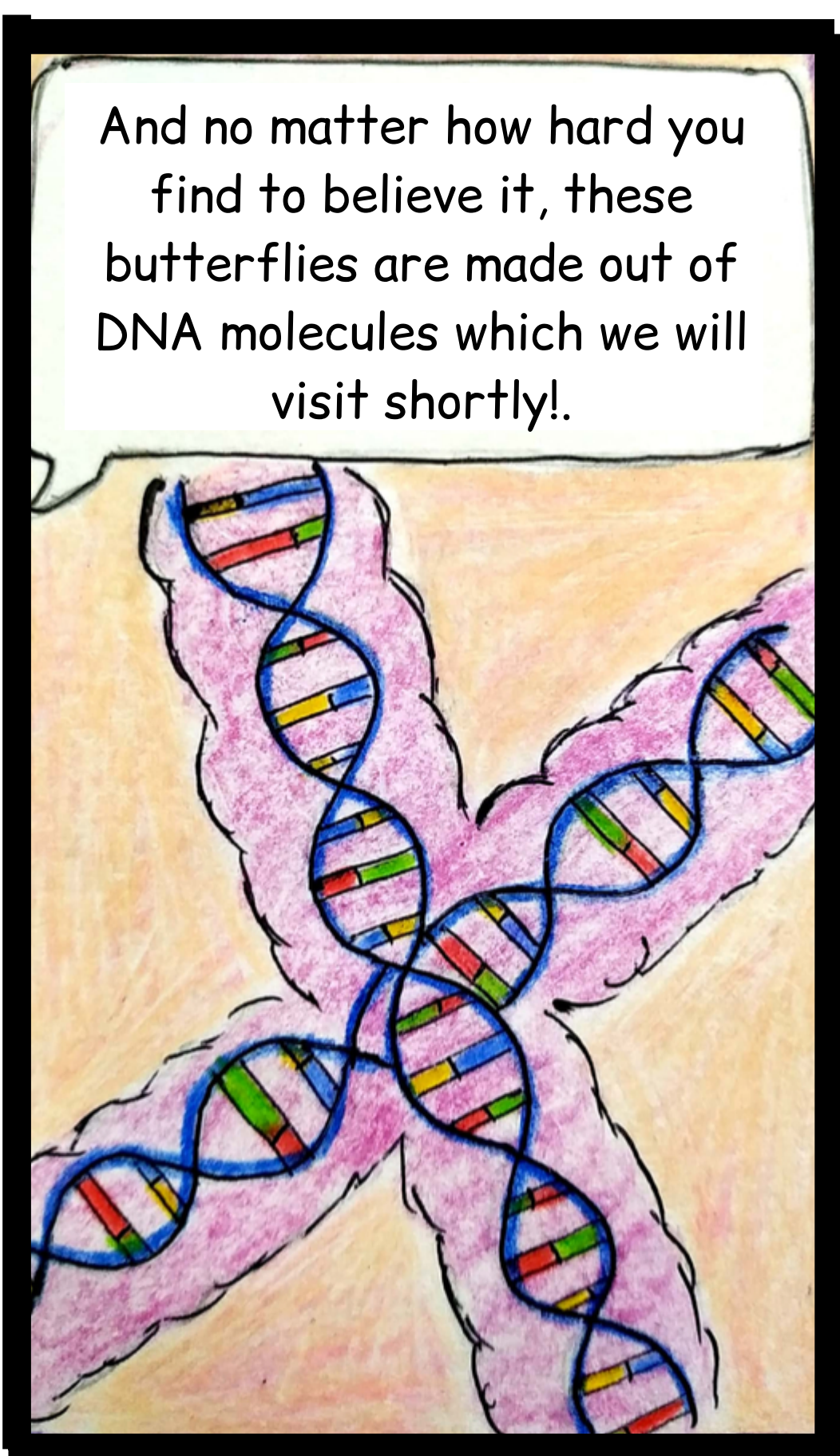
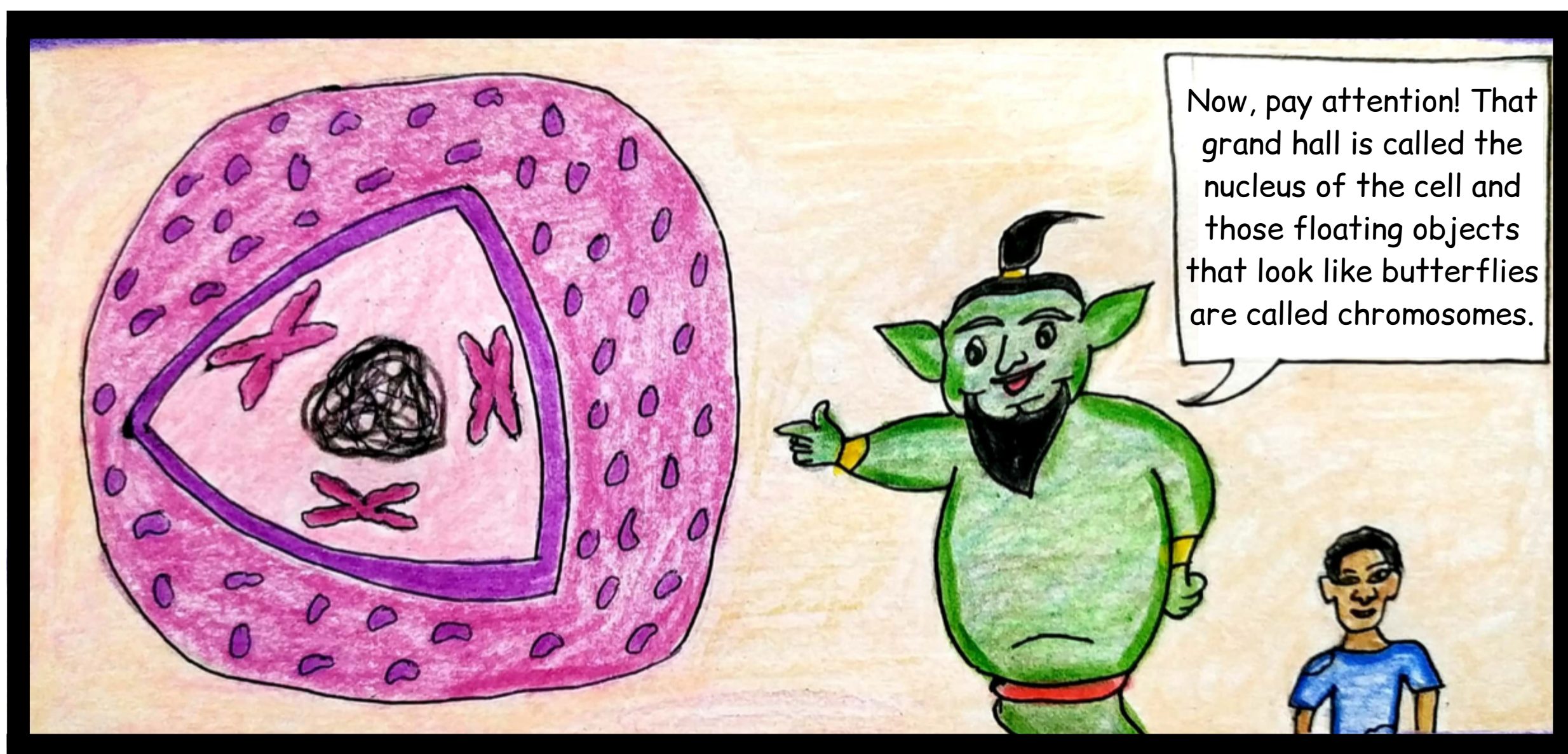




Let's get down to  
the fundamental molecules that  
constitute  
a cell.











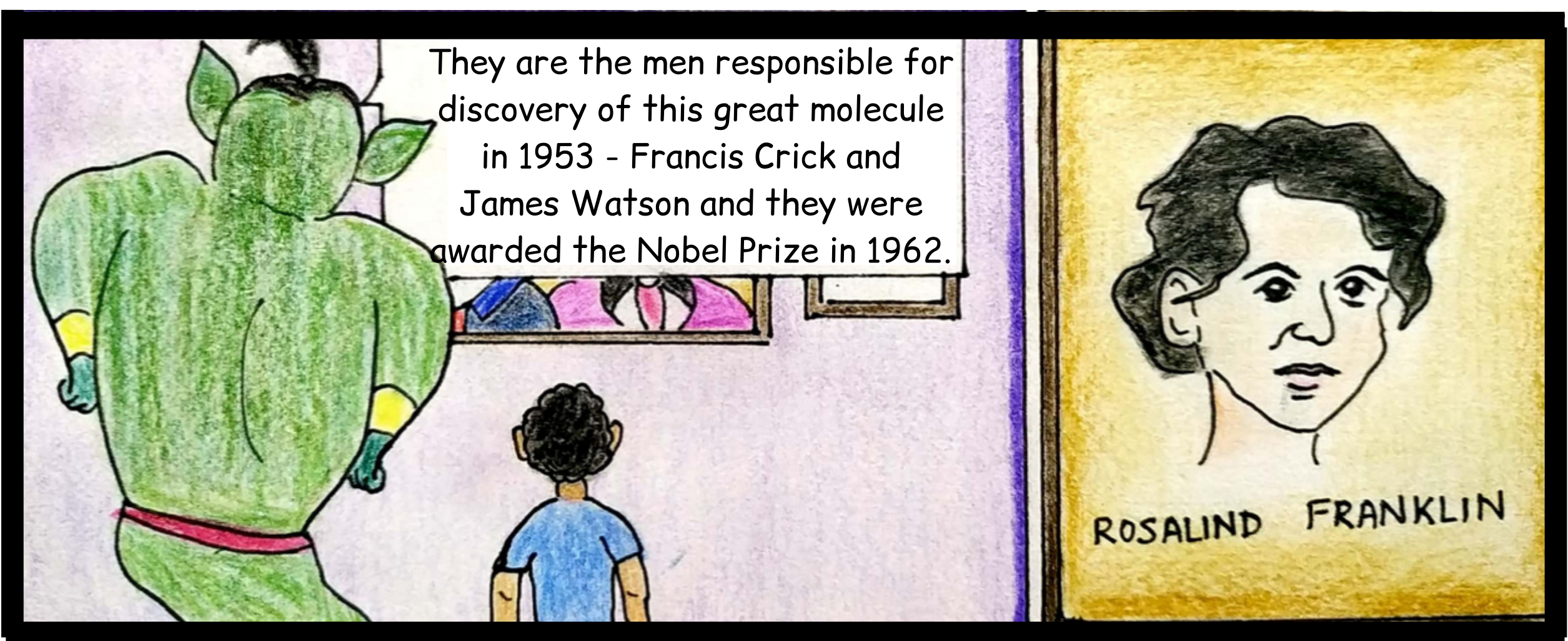


Down  
the  
staircase;  
through  
the  
history  
lane.

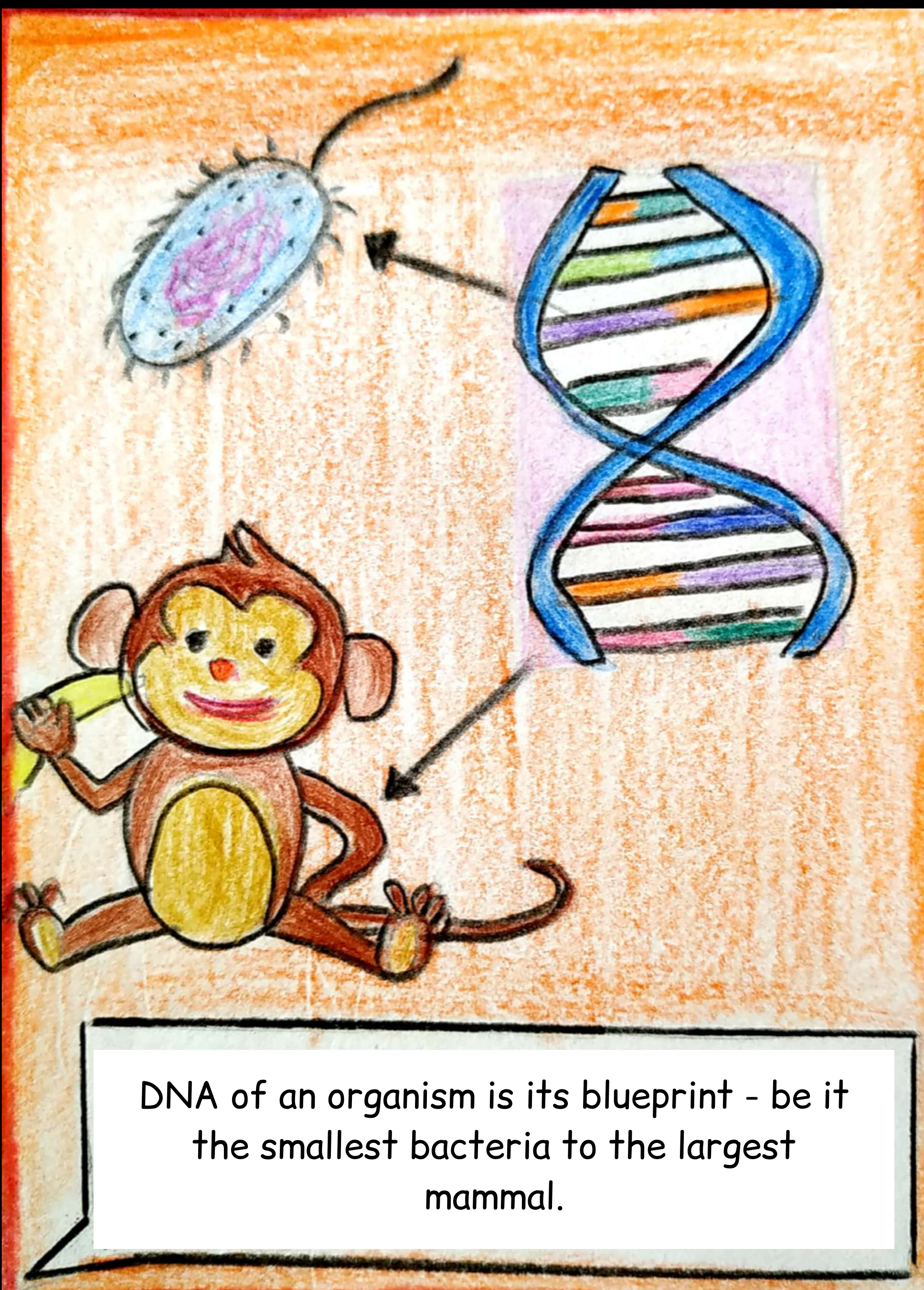
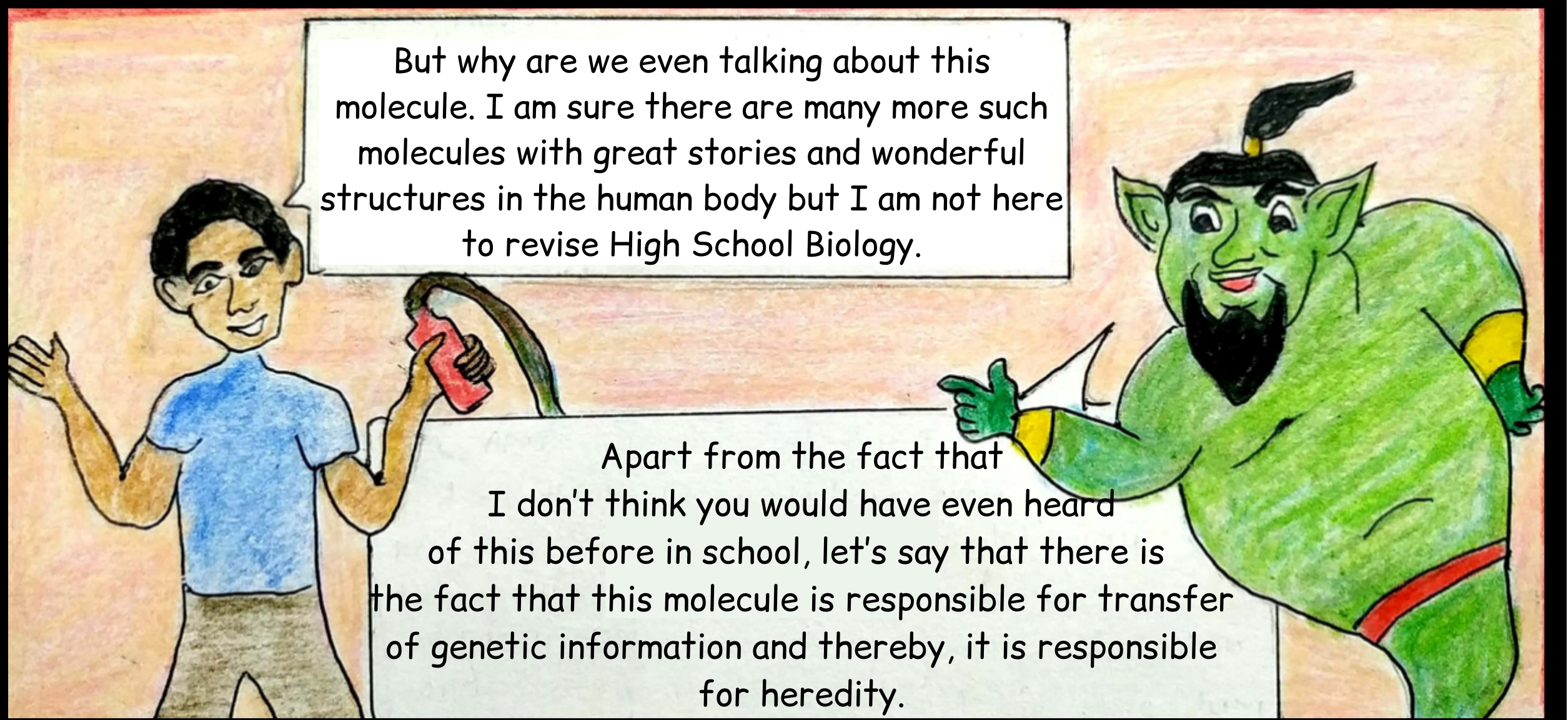
Where  
to?



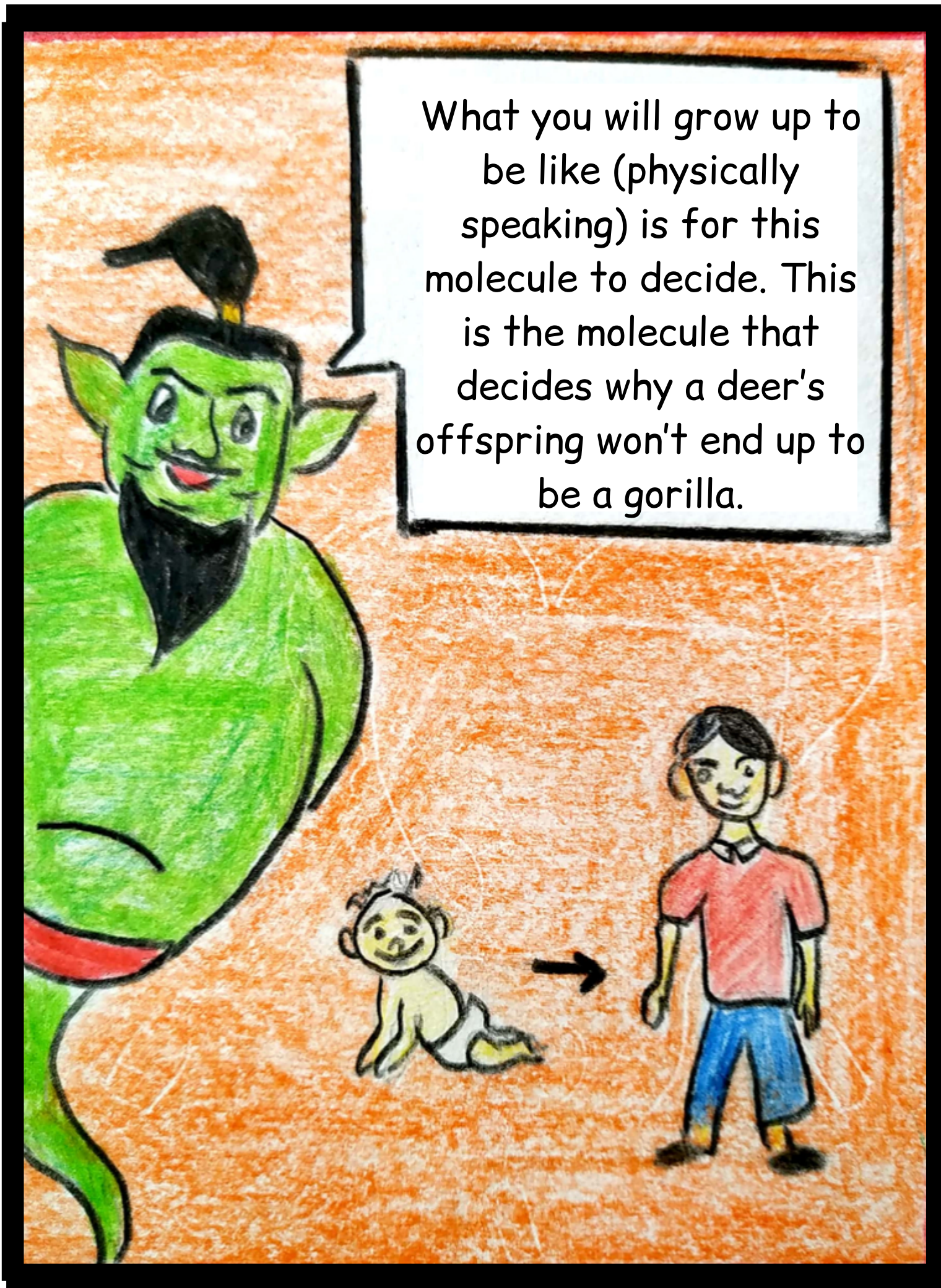




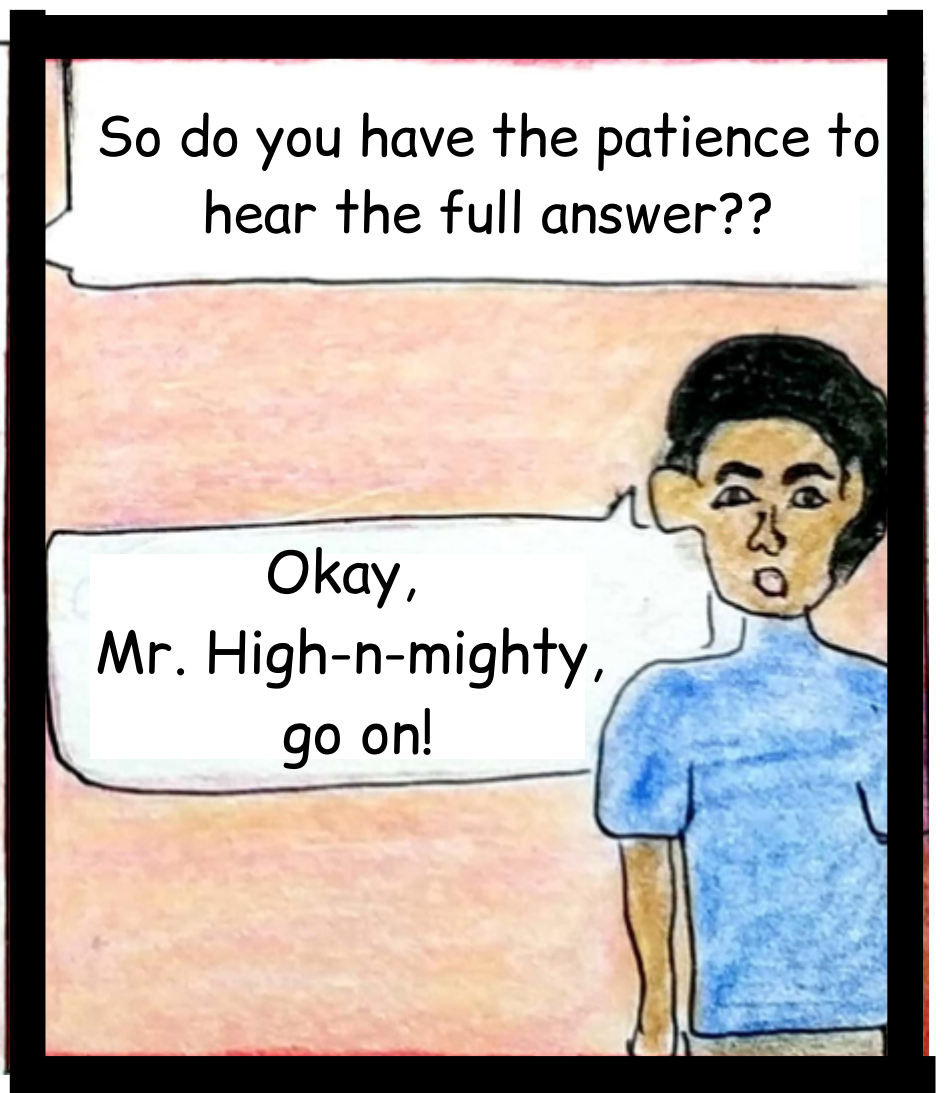
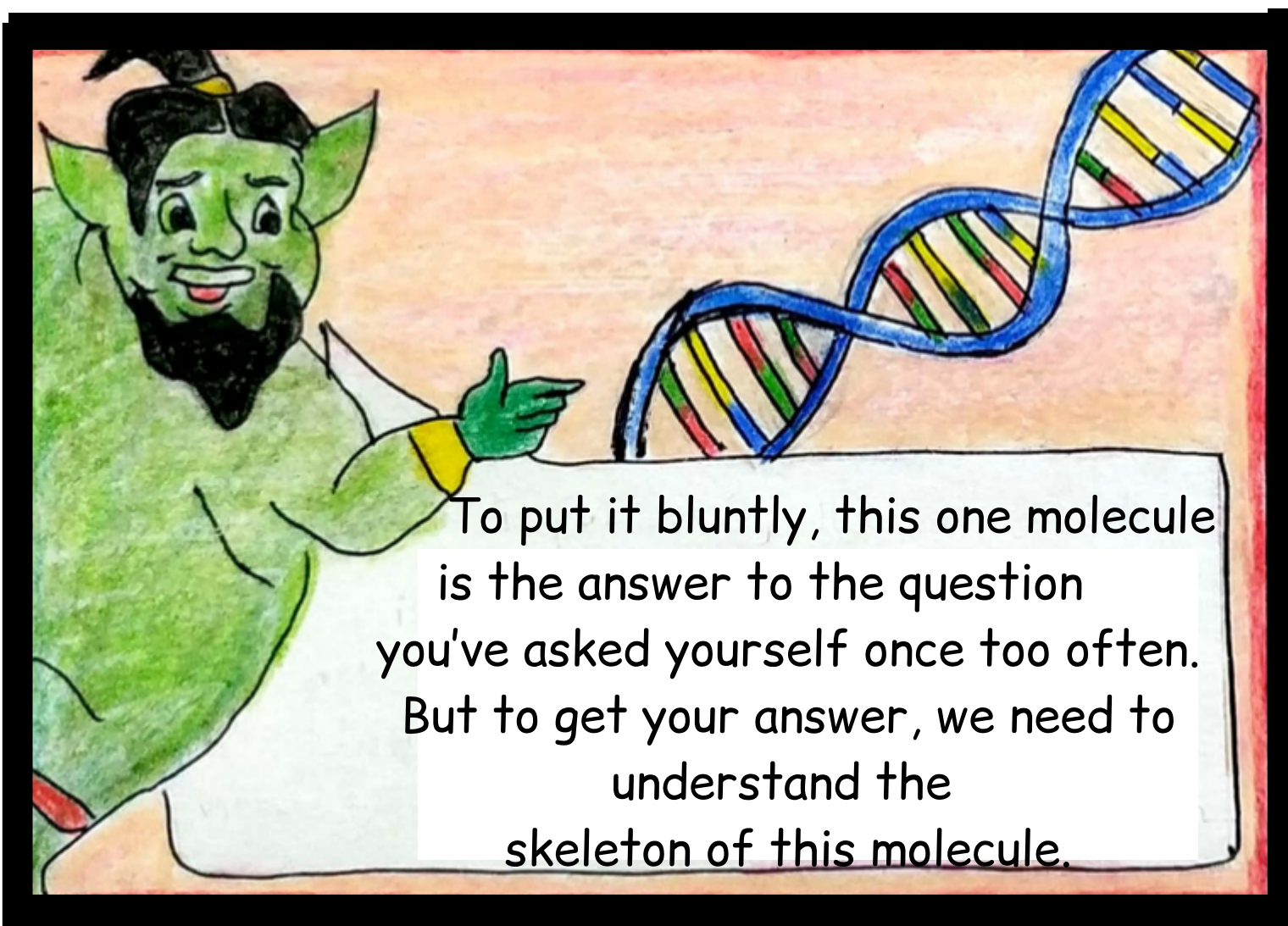




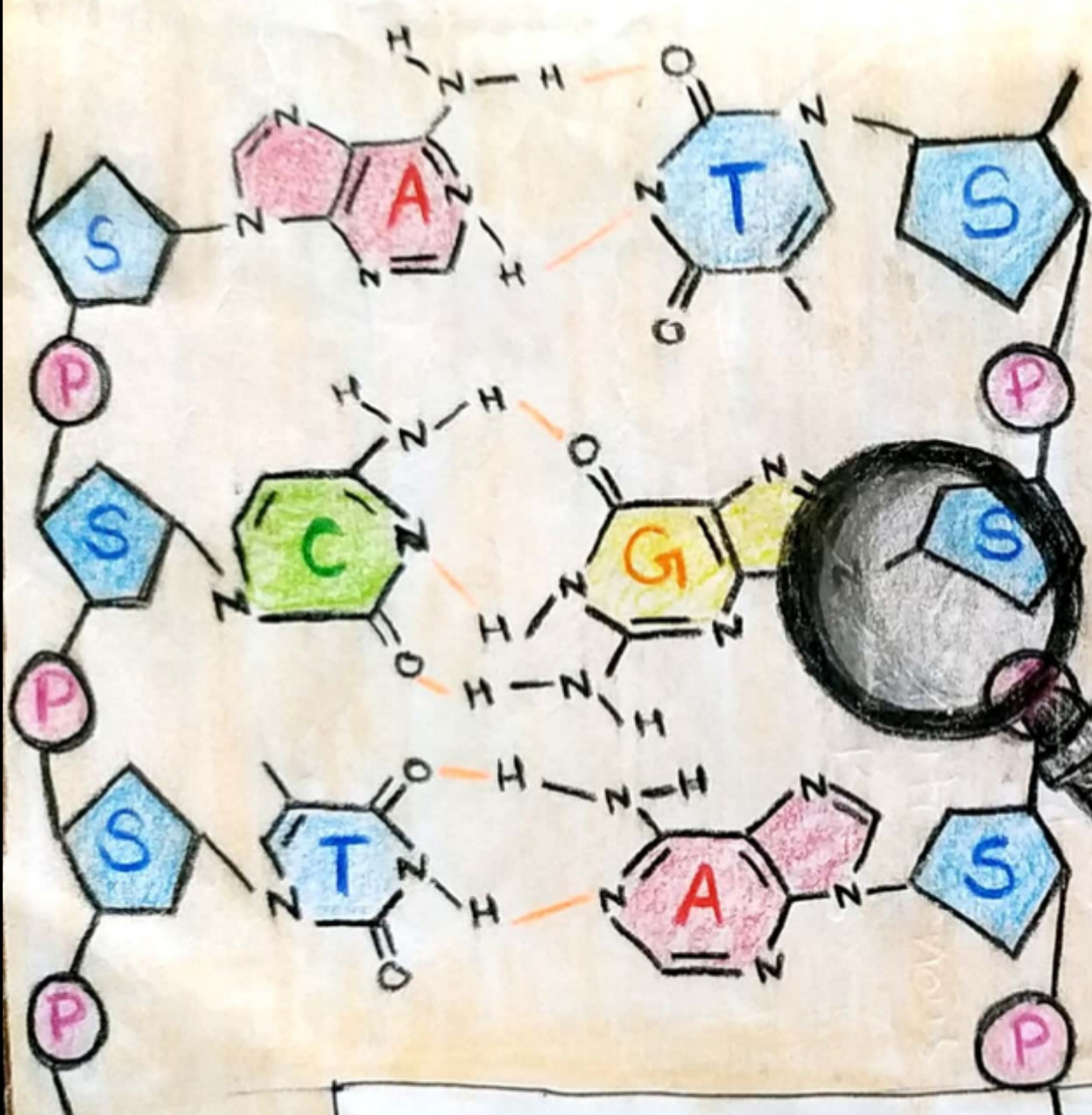
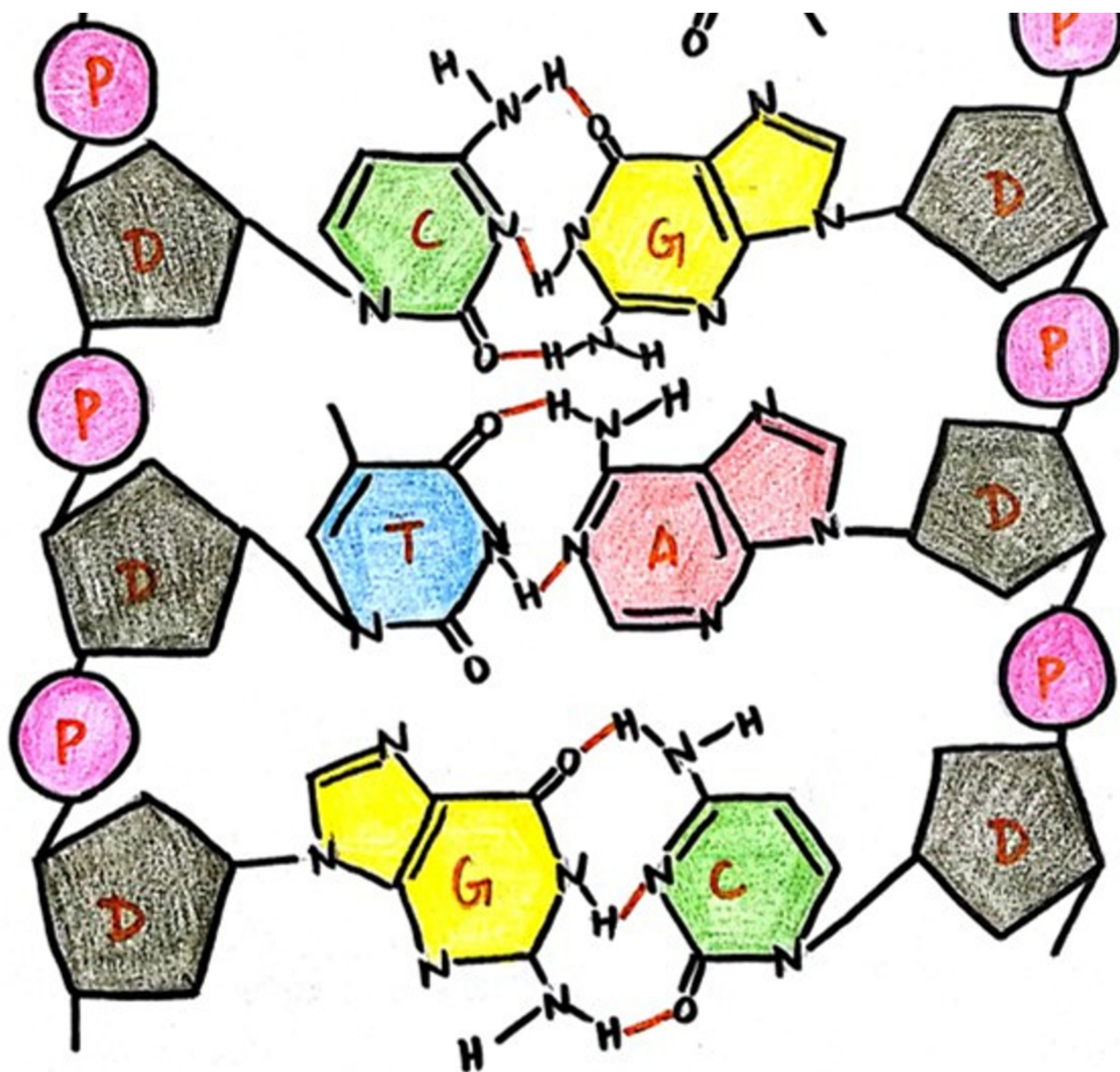




D  
N  
A





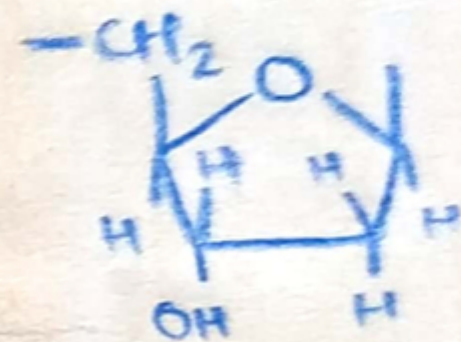
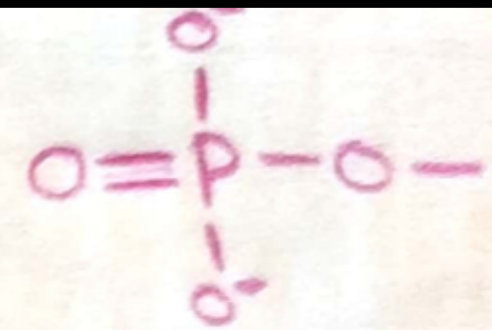
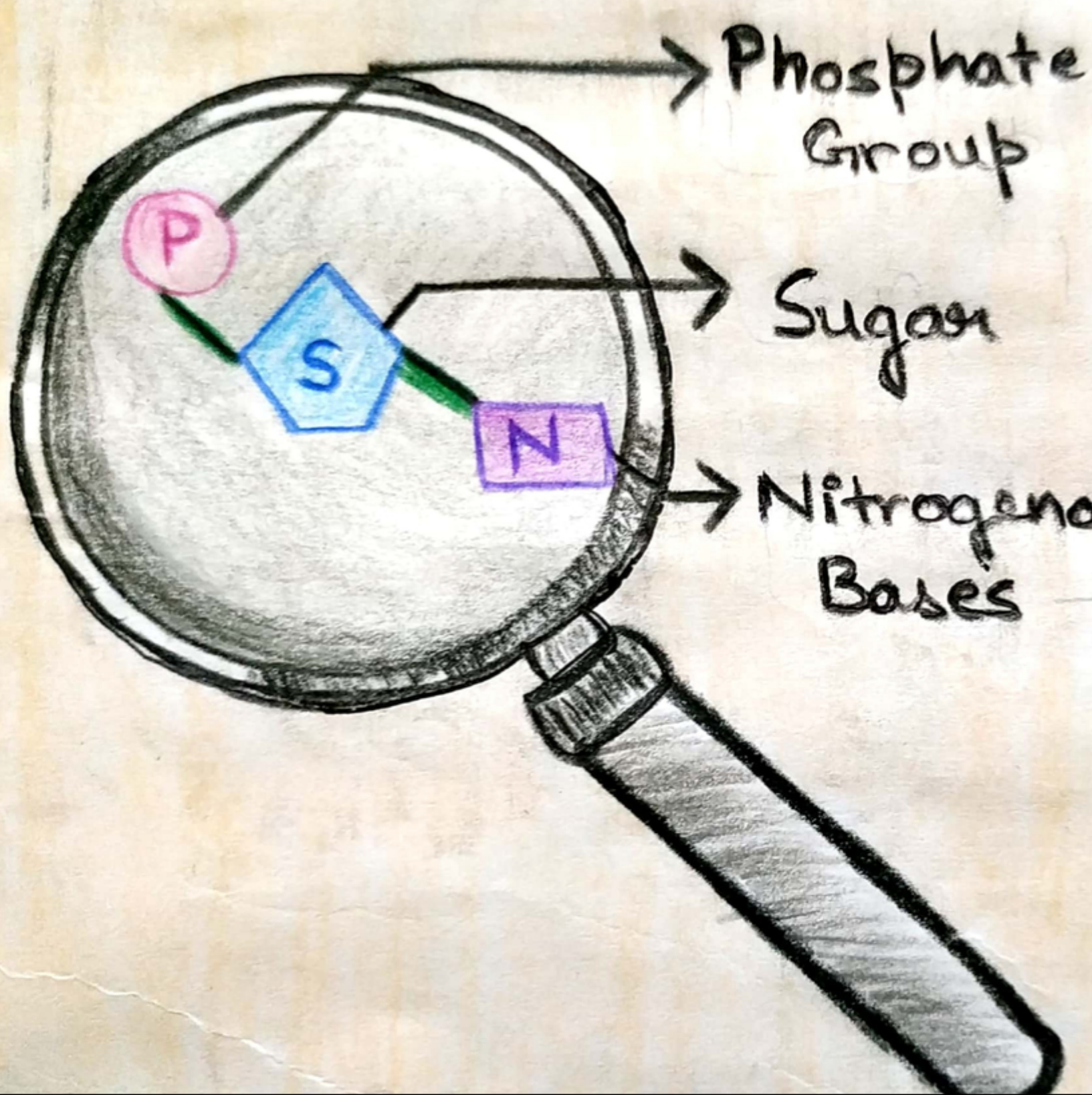


Okay, then listen! If we strip down this enormous molecule to its barebones, we will find this.





People call this a nucleotide and this has a sugar at its heart and a phosphate on one end and a nitrogenous base on the other. These nitrogenous bases come in 4 variants - adenine(A), thymine(T), guanine(G) and cytosine(C)



Nitrogenous Bases

Adenine (A)

Thymine (T)

Cytosine (C)

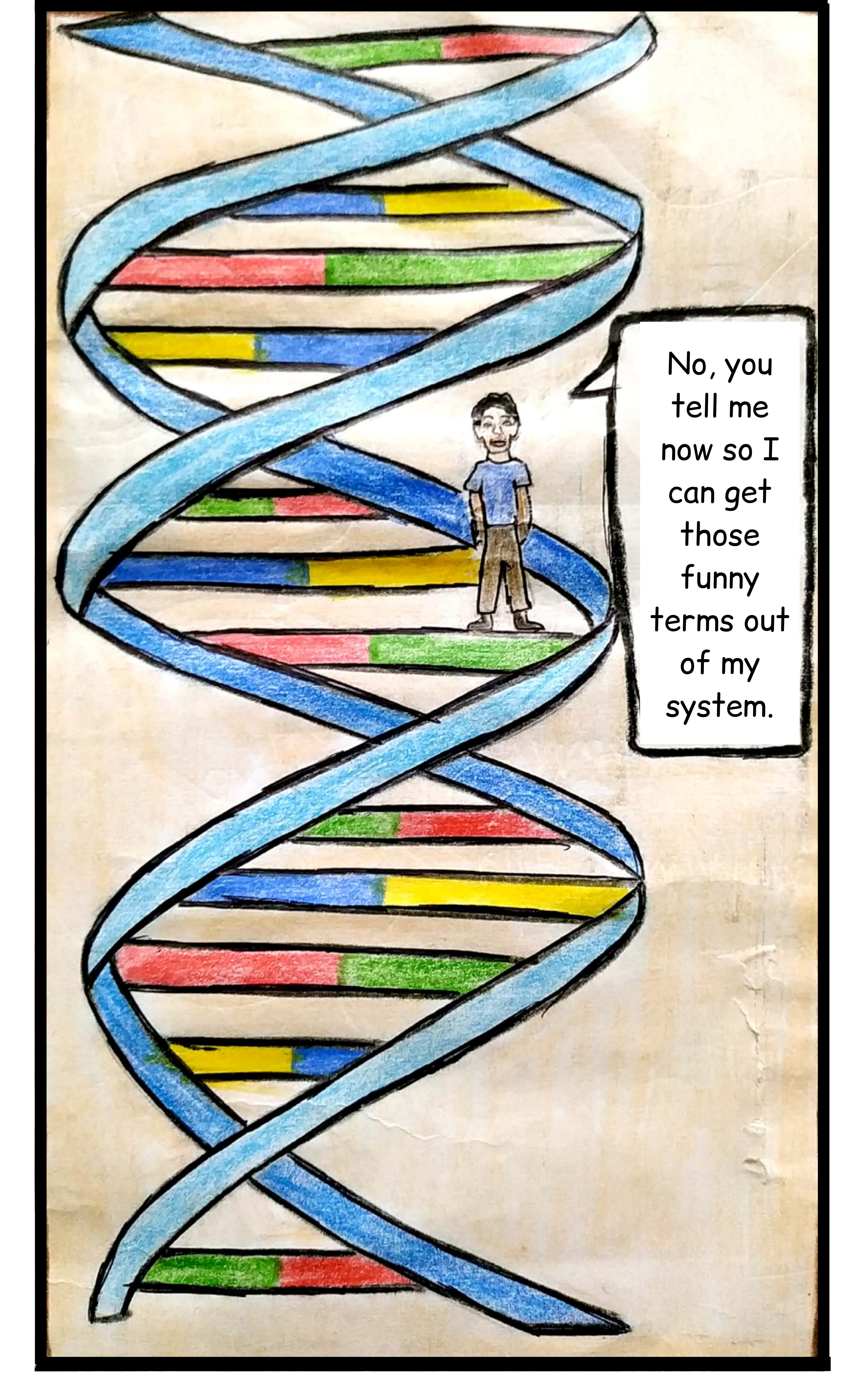
Guanine (G)



They form the steps on which we are standing at the moment while the sugar and phosphate molecules bond to form the banister of the staircase. Adenine and Guanine are called purines because of their fused ring structure while Thymine and Cytosine are called pyrimidines due to their single-ring structure. How exactly? We shall see.



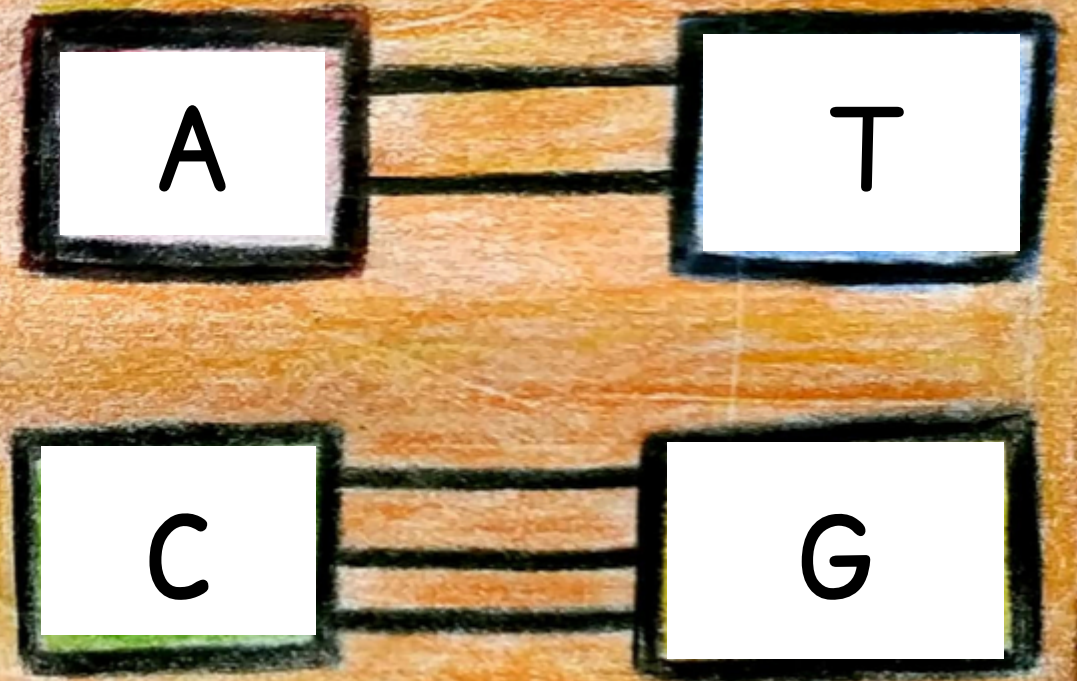


A hand-drawn illustration on a piece of aged, textured paper. It depicts a large DNA double helix structure. The two strands are drawn with thick blue lines, twisting around each other. Between the strands are horizontal bars representing base pairs, colored in red, green, and yellow. A small, simple drawing of a person with dark hair, wearing a blue t-shirt and brown pants, stands with their hands in their pockets inside the helix. To the right of the person, a speech bubble contains text.

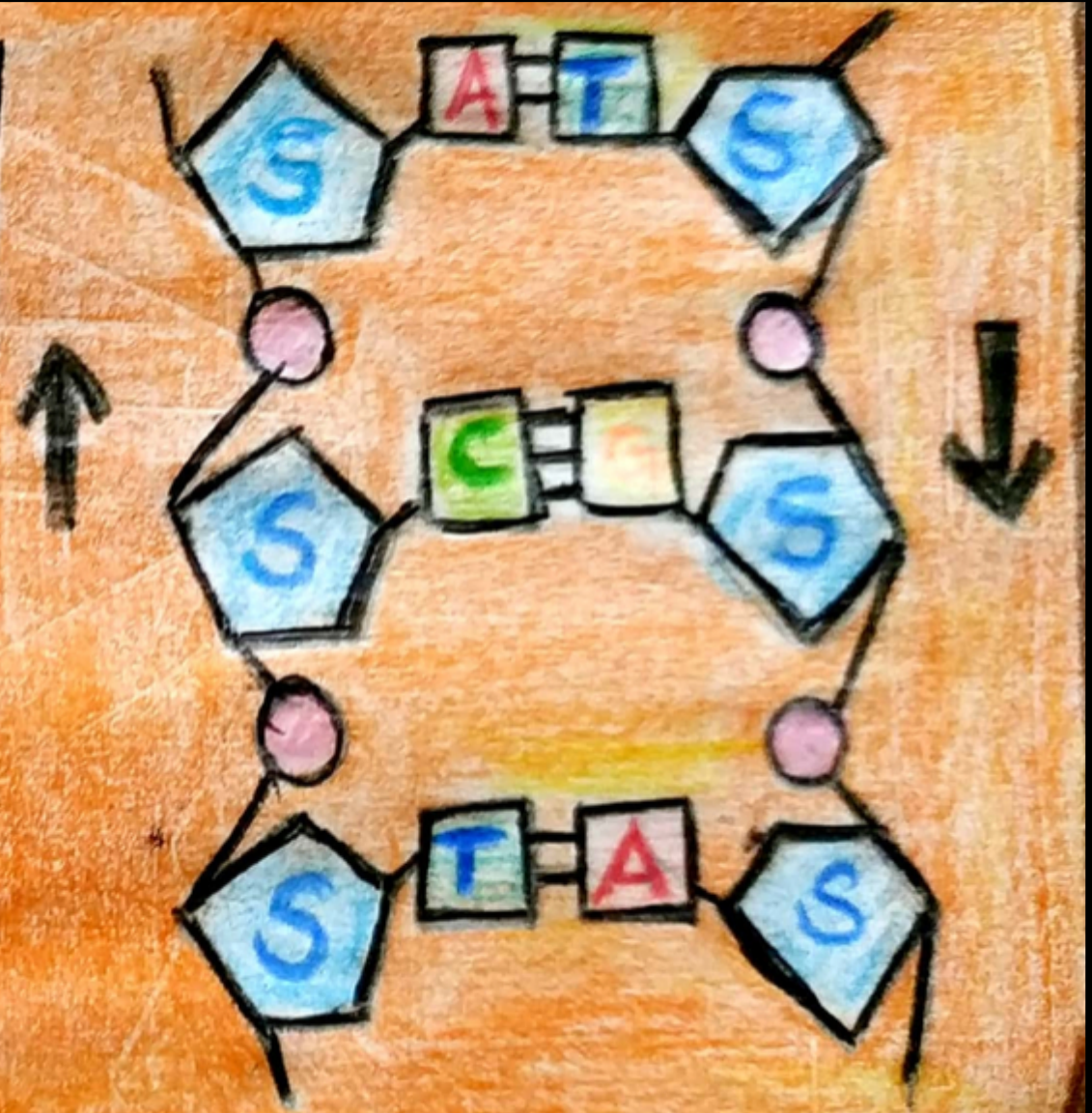
No, you  
tell me  
now so I  
can get  
those  
funny  
terms out  
of my  
system.



Okay, My Master. So here it is. The nitrogenous bases from the two strands bond with each other in a specific order: Adenine with Thymine (by double H-bonds) and Guanine with Cytosine (by triple H-bonds). This is not some random arrangement.



Only if you would have observed this my dear Willie, you would have seen that the strands run opposite to each other. This is called anti-parallelism which is important in DNA replication.



95001237986

The most interesting thing is that these sequences of nitrogenous bases can be read like a code which are unique, just how each phone number is.



Segments of this code are known as genes. These genes can control the structure and function of cells and eventually all the bodily features.

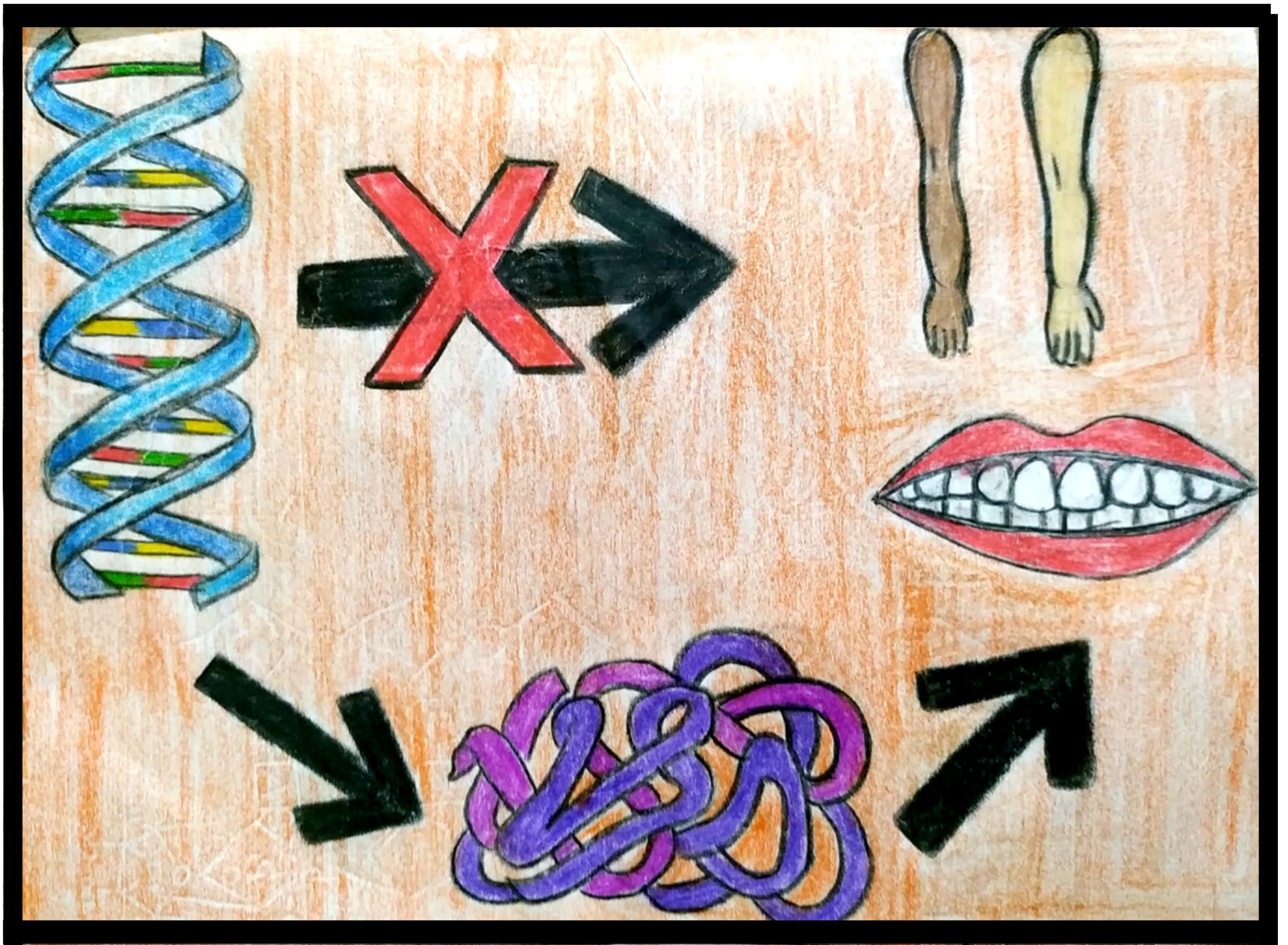
Okay, but how does this molecule, no matter how big or how important it is, affect everything from my teeth to my hair to the colour of my skin.



You are right! So, this molecule doesn't actually colour your skin or shape your teeth, it codes for proteins that do. To understand it better, imagine proteins as applications in a mobile phone and DNA as the programming language used to develop them.



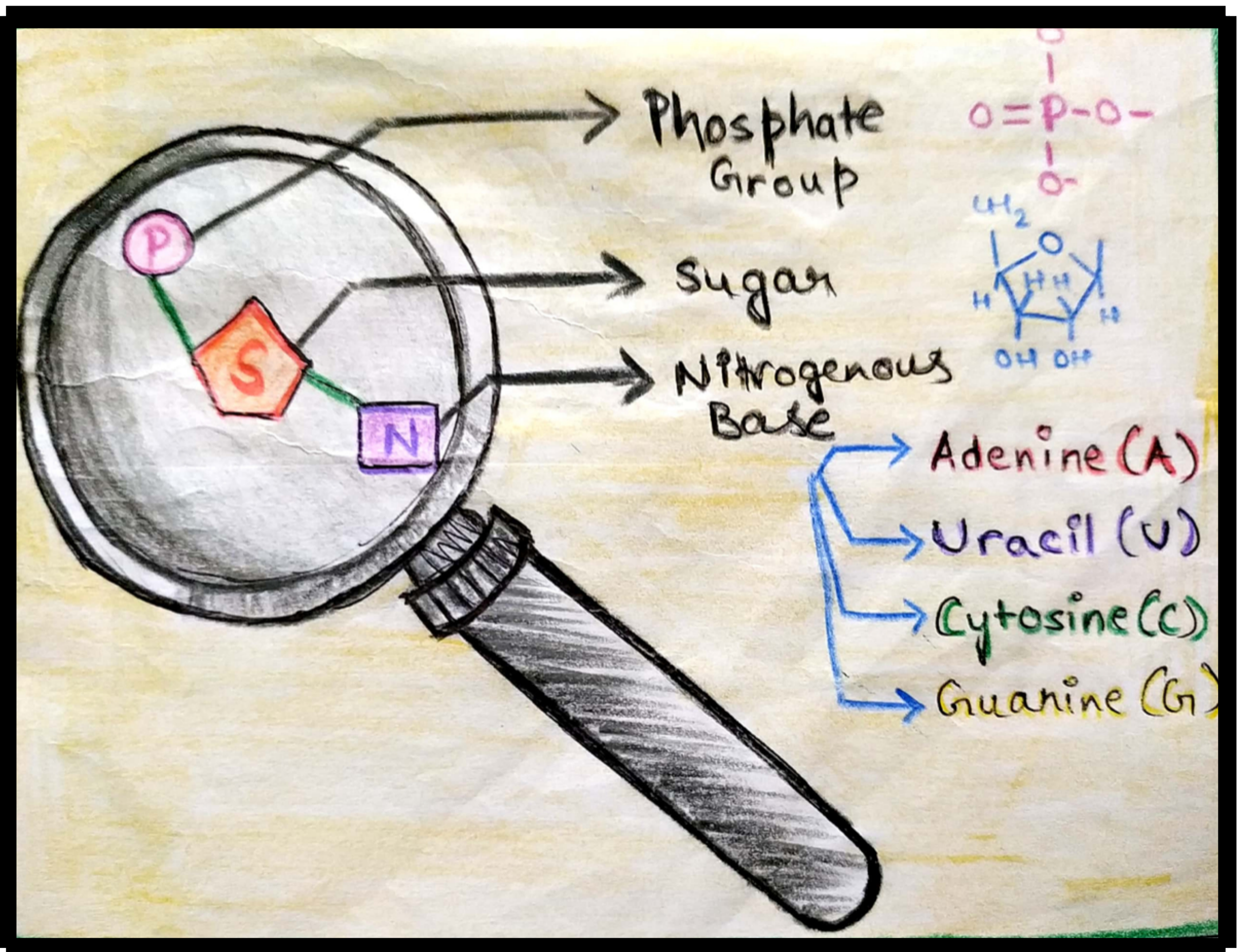
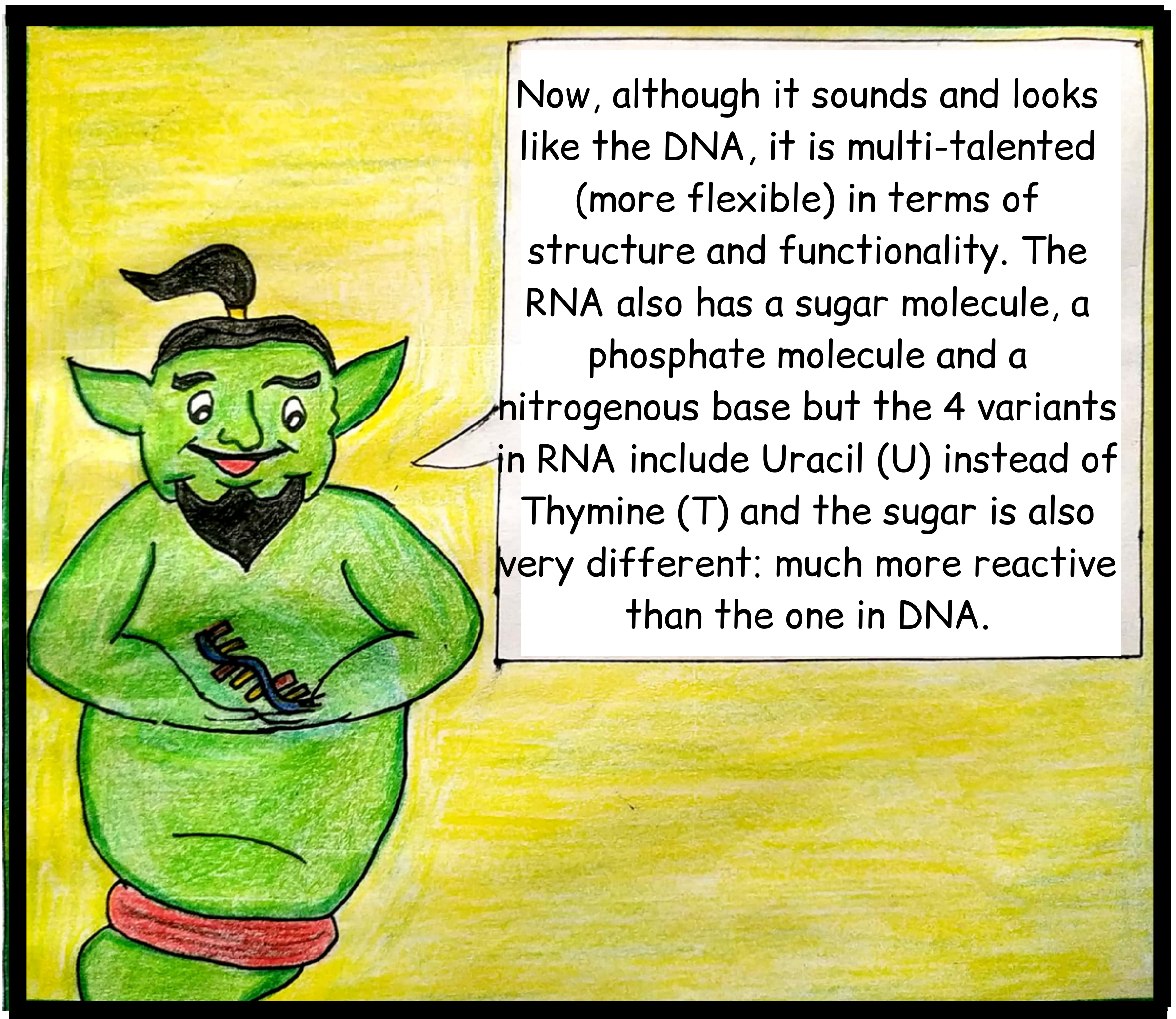




But, between the journey from DNA to proteins, we have the middleman - RNA.

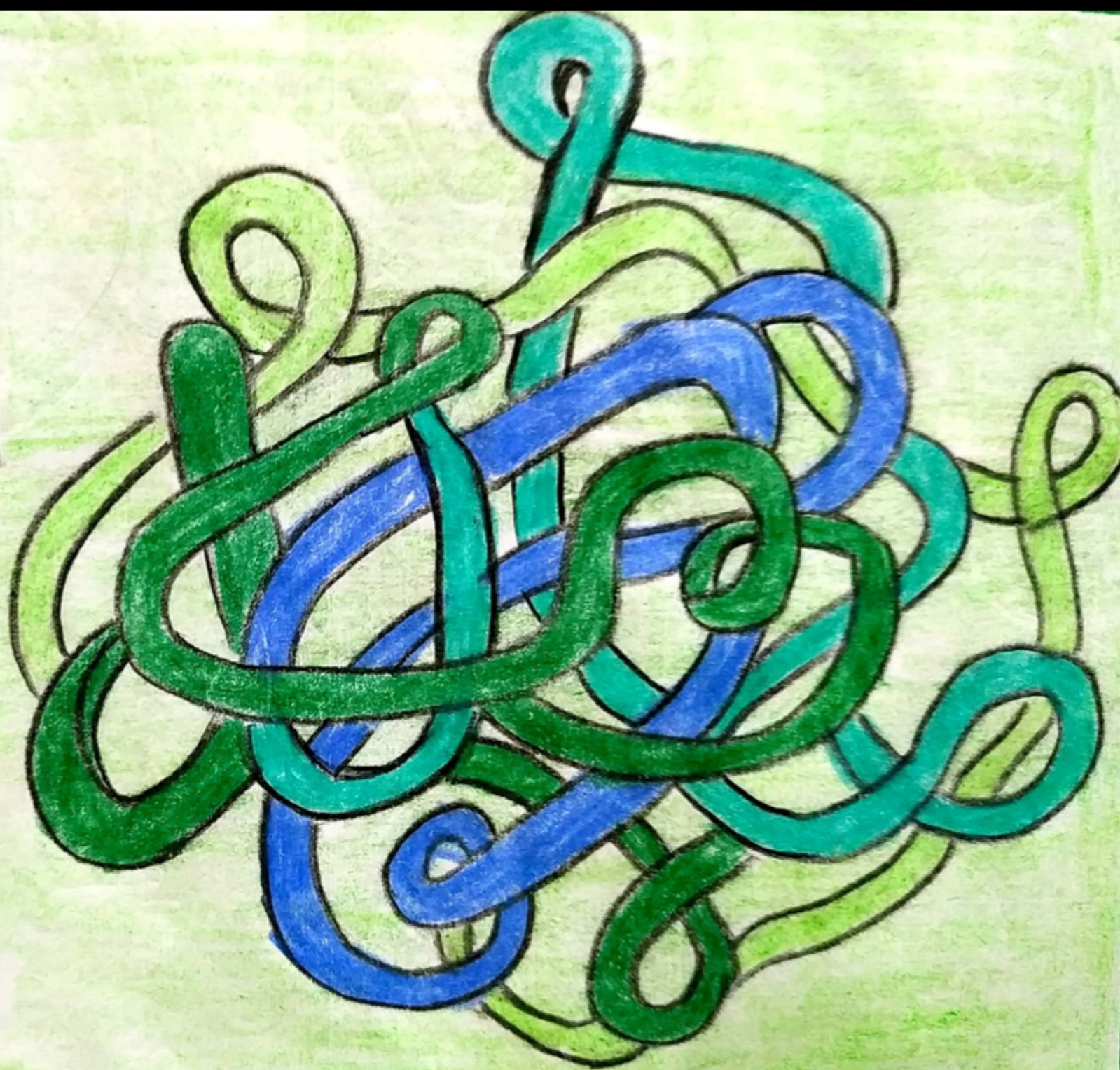








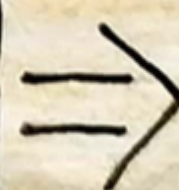
And what about these gigantic and distorted molecules: proteins?



These proteins are the most vital biomolecules inside the cell. They are found in many different forms carrying out countless functions. Right from enzymes that carry out bodily reactions, to hormones that transmit signals like messengers, all of these are proteins. In fact, their name comes from the Greek word 'Potas' which means 'primary importance'.



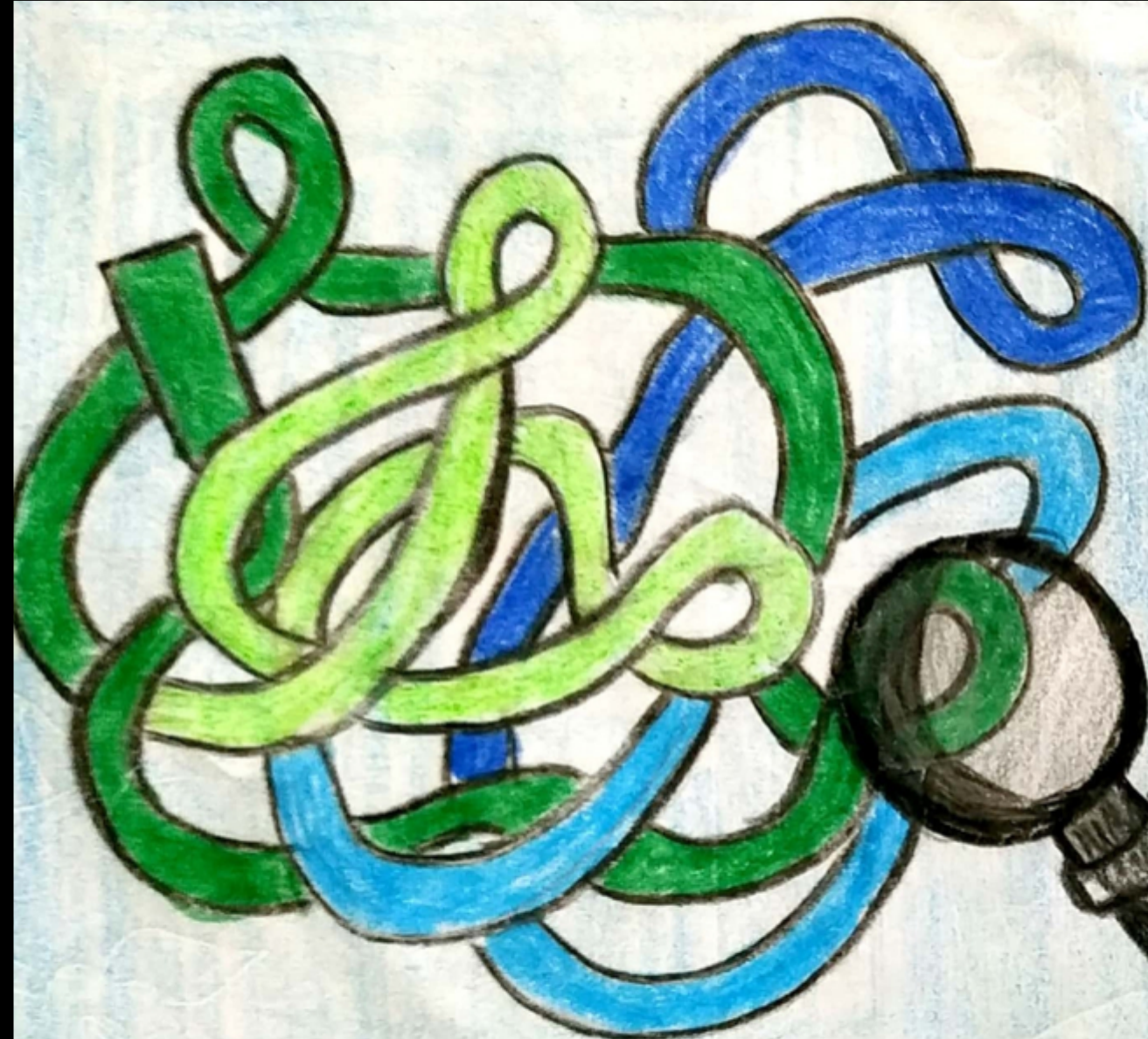
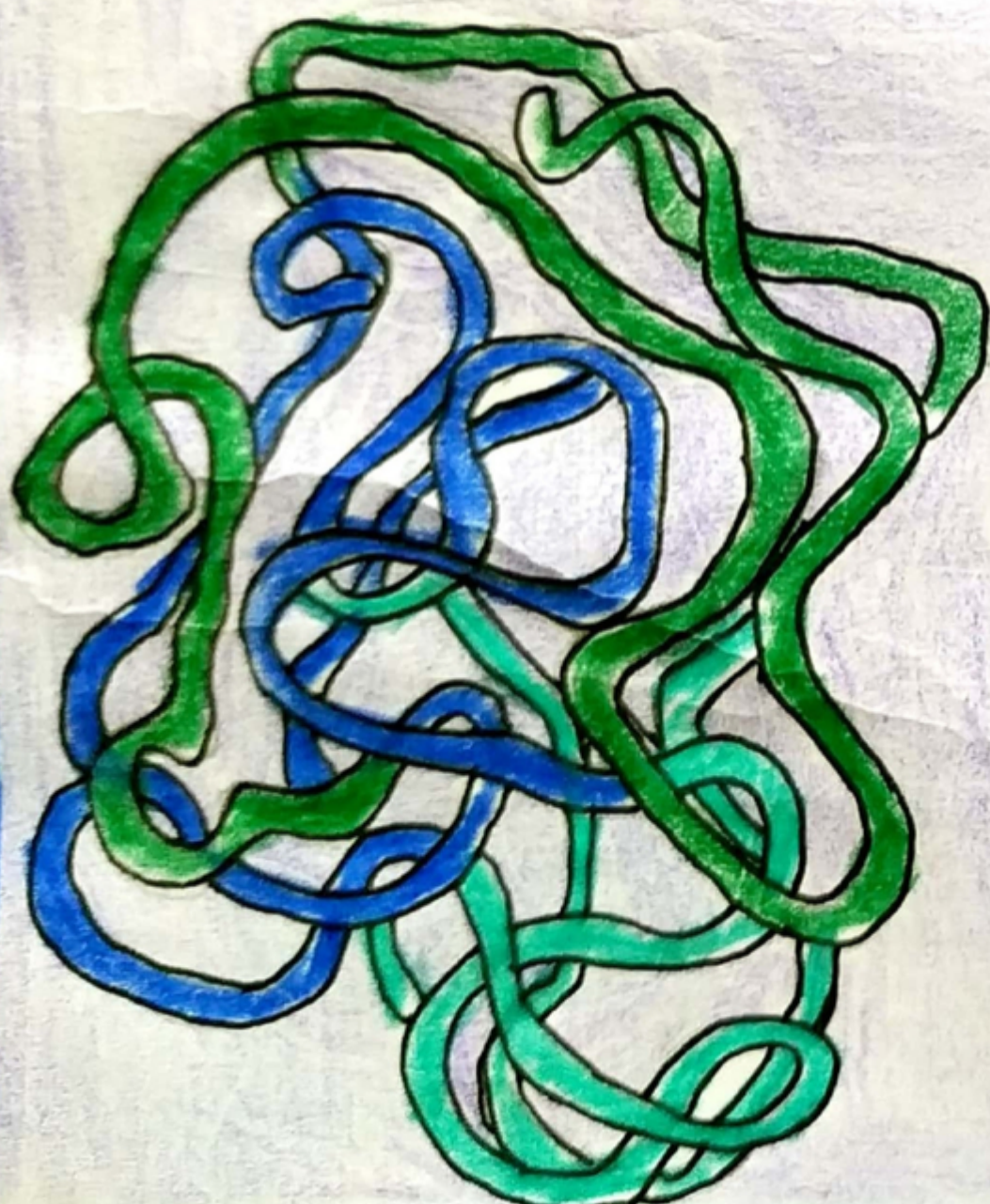
Potas



Primary Importance



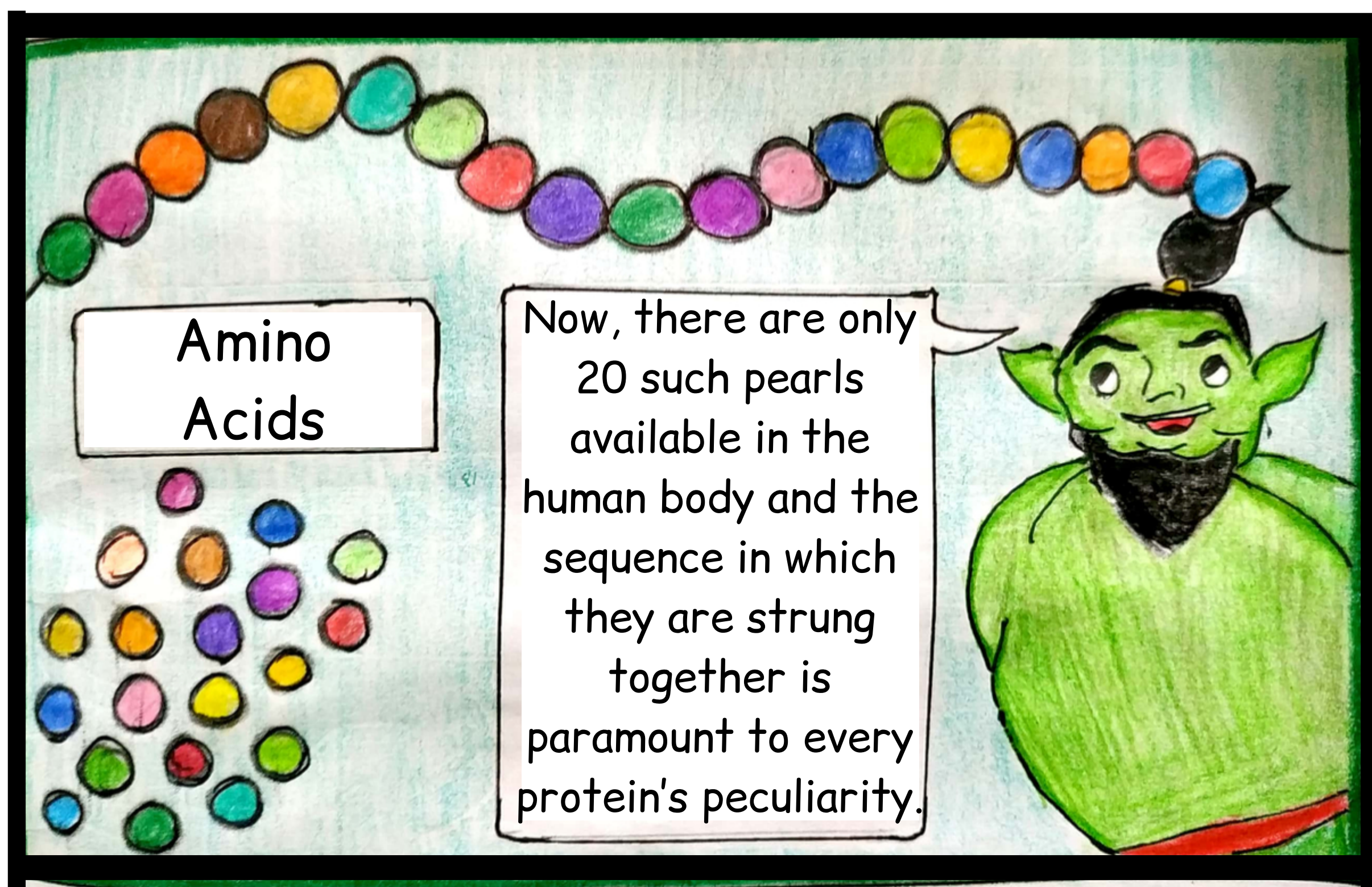
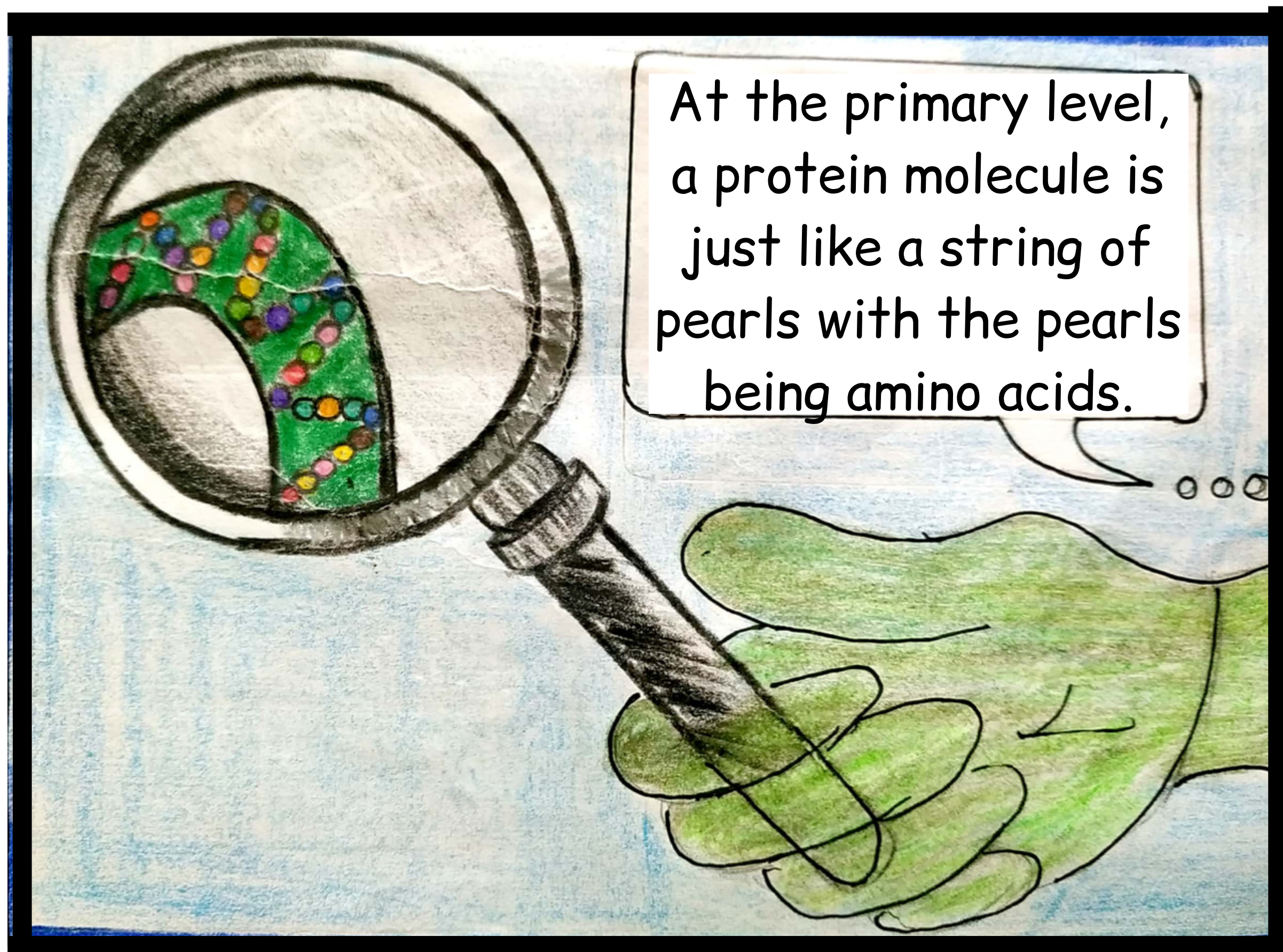
Can't we just skip the  
Greek and Latin part?



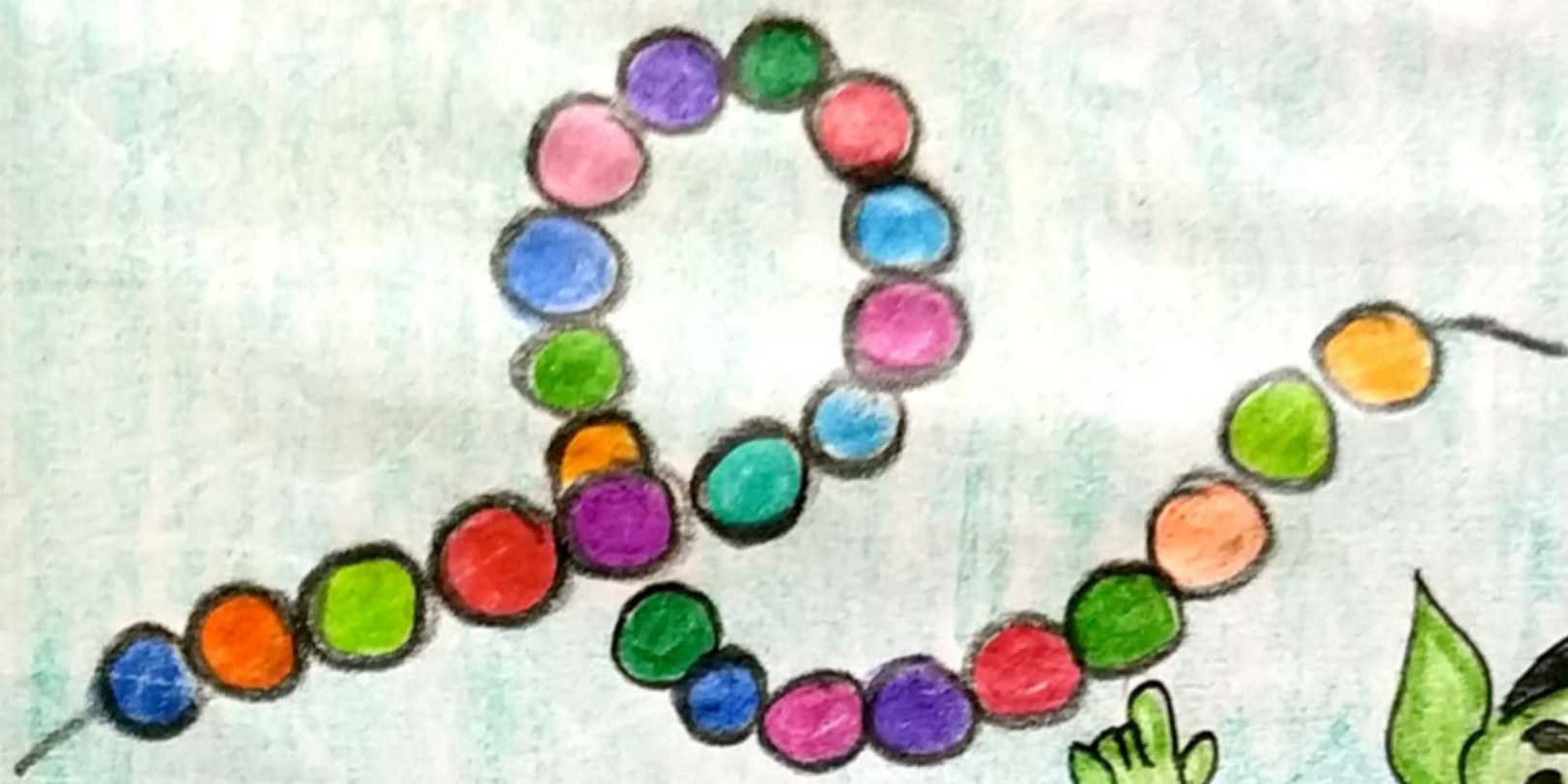
Sure. Let's just go down to  
the basic structure which is  
amazingly simpler than the  
macromolecular structure  
which is quite frightening  
(even for me).











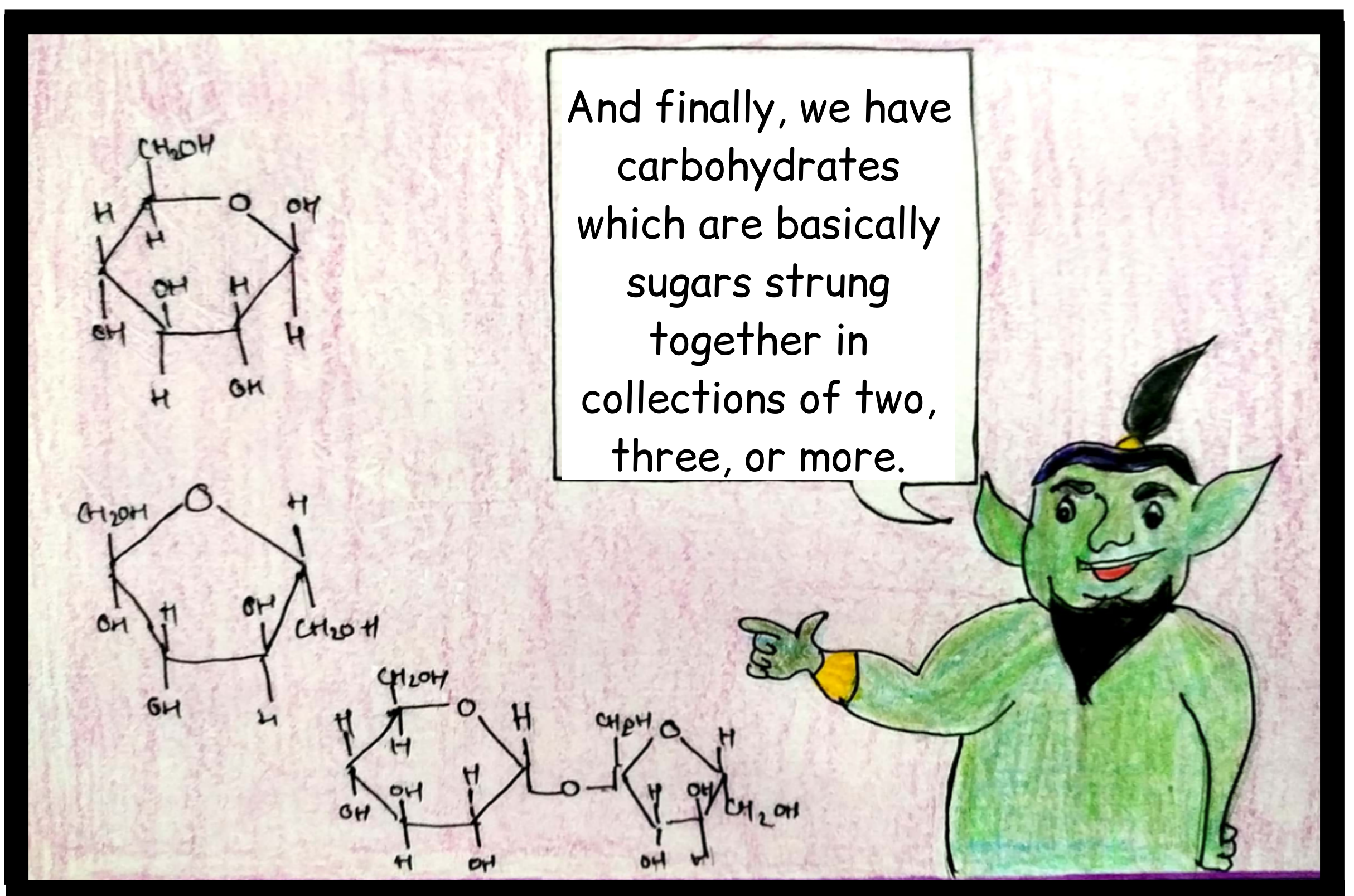
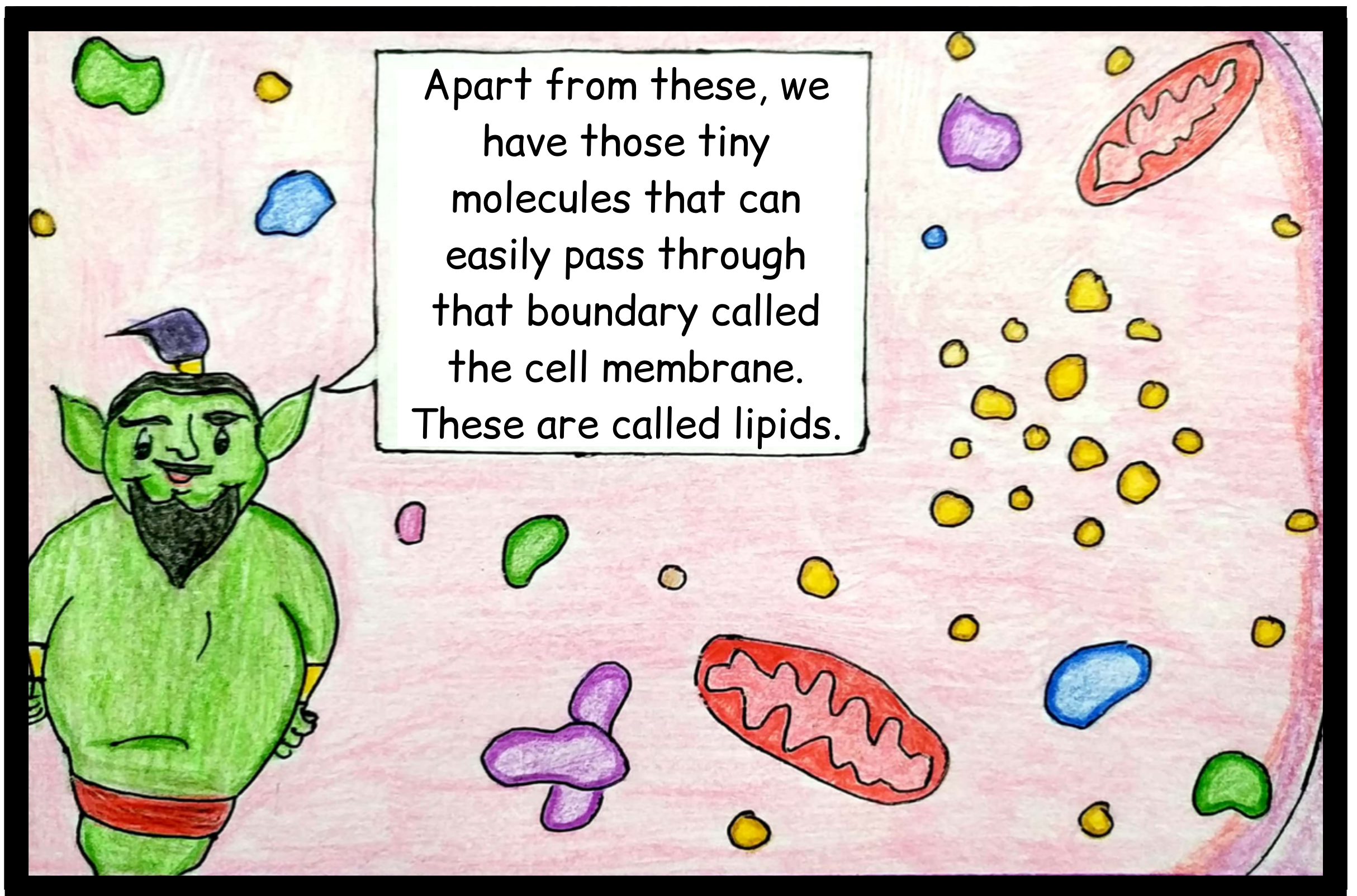
This is called the primary structure of a protein and it is unique for every kind of protein.



Now, when this structure is turned and twisted in more ways than you can imagine to form the final intimidating structure of a protein molecule, it is called the quaternary structure of a protein.

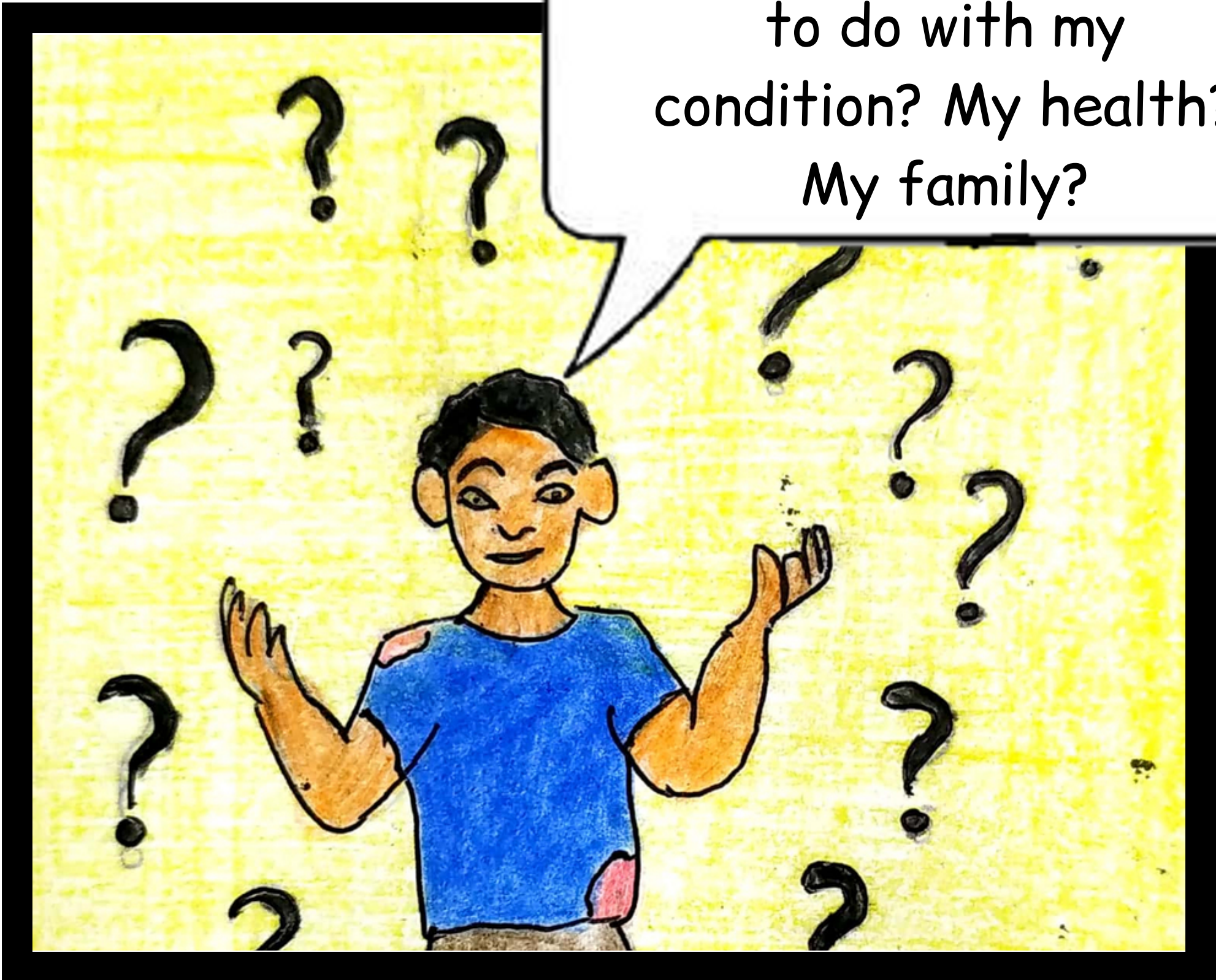








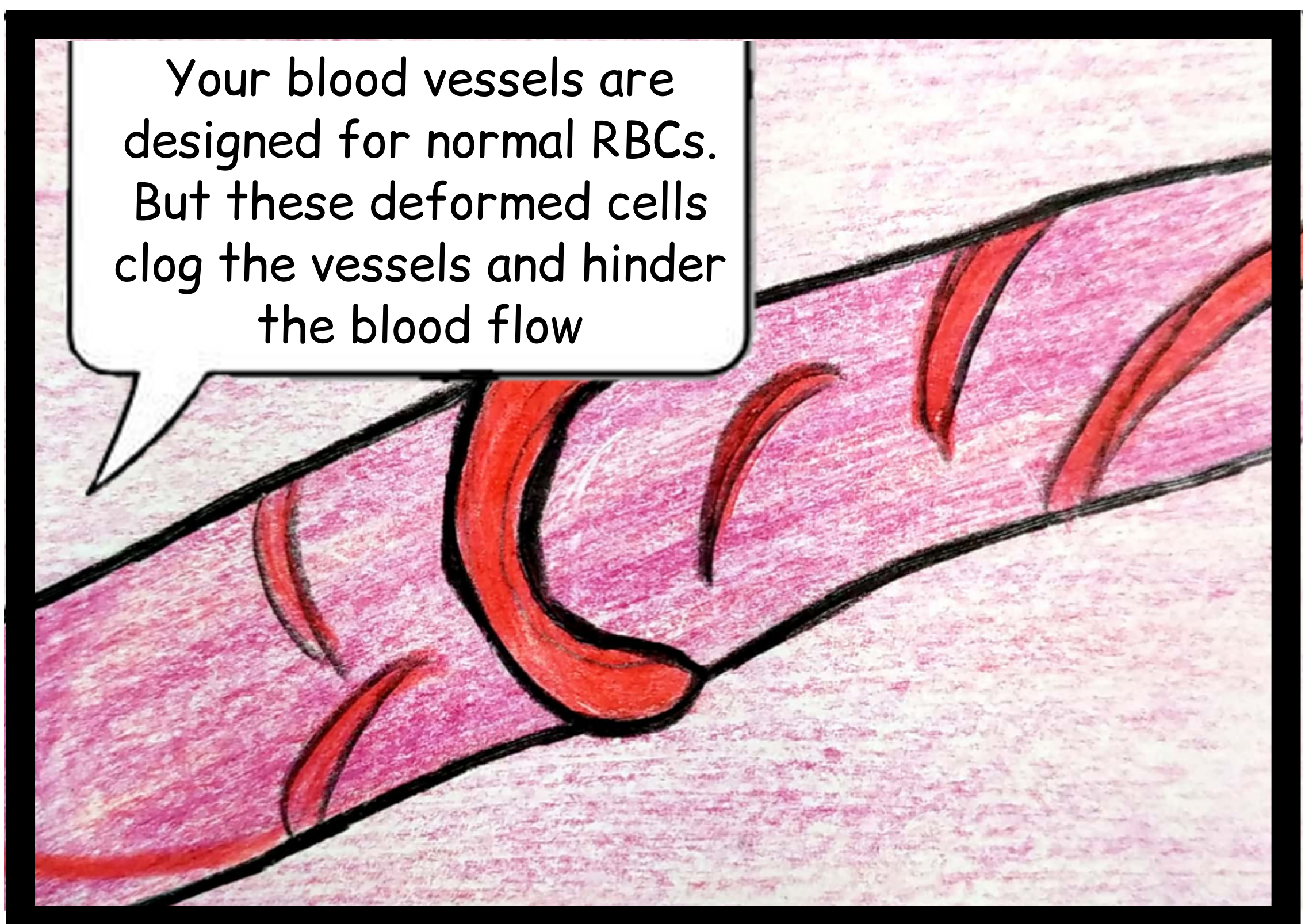
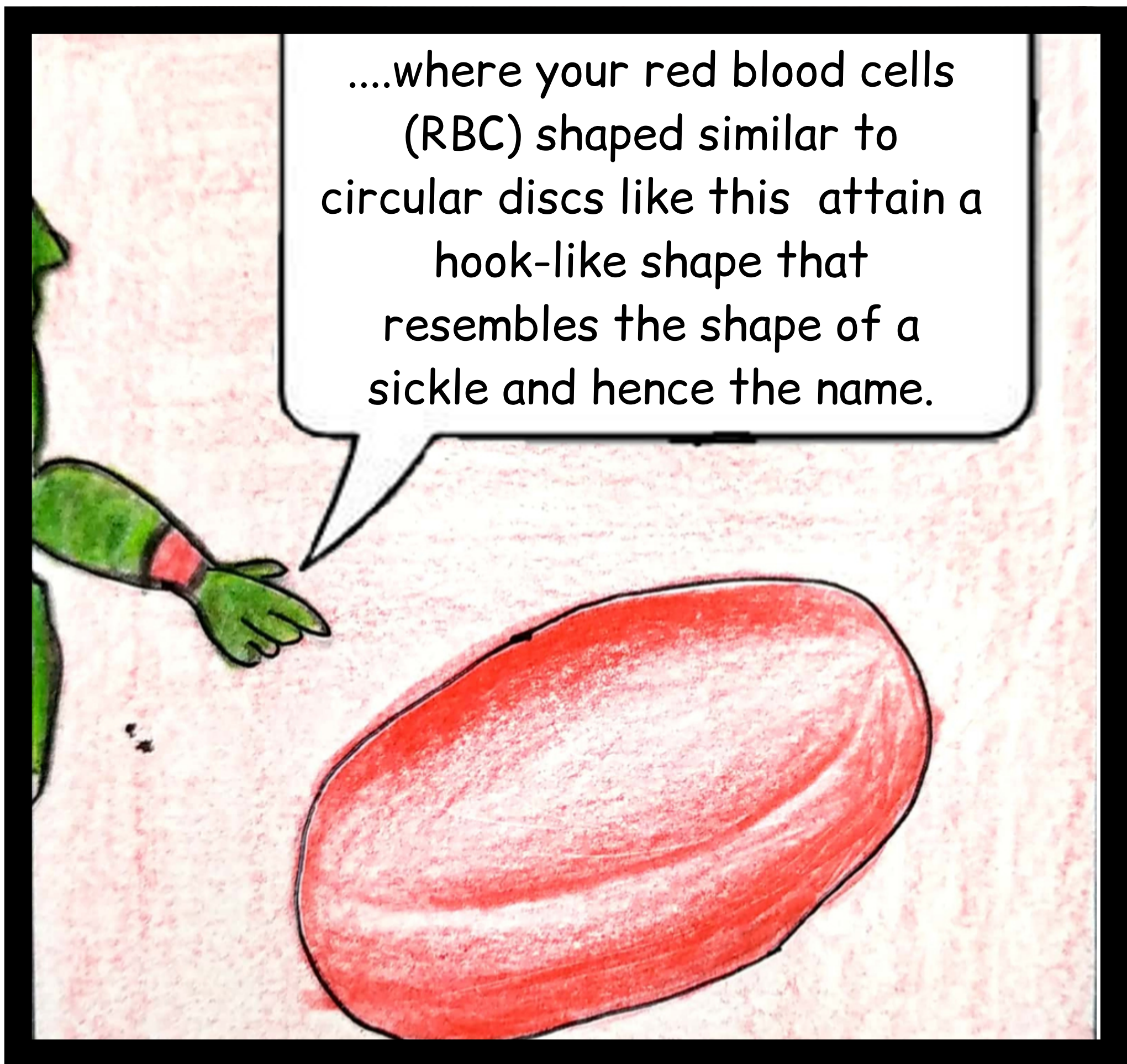
All this is just too much  
information to process.  
And what does it have  
to do with my  
condition? My health?  
My family?



Willie, you have a  
rare blood disorder  
called sickle cell  
anaemia...









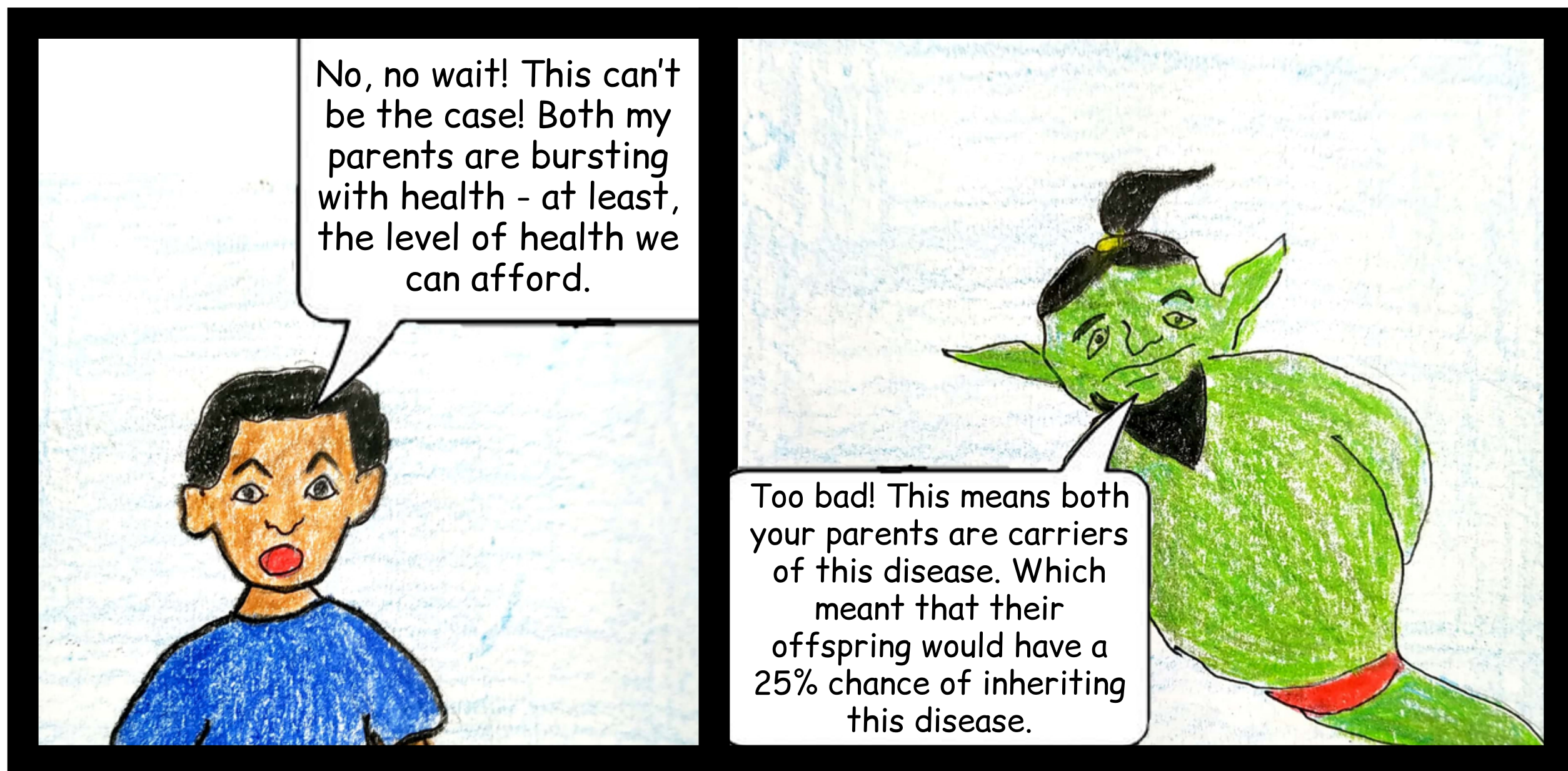
This is the root cause of most of your symptoms, from the swelling of your hands and feet to the frequent bouts of unconsciousness and shortness of breath



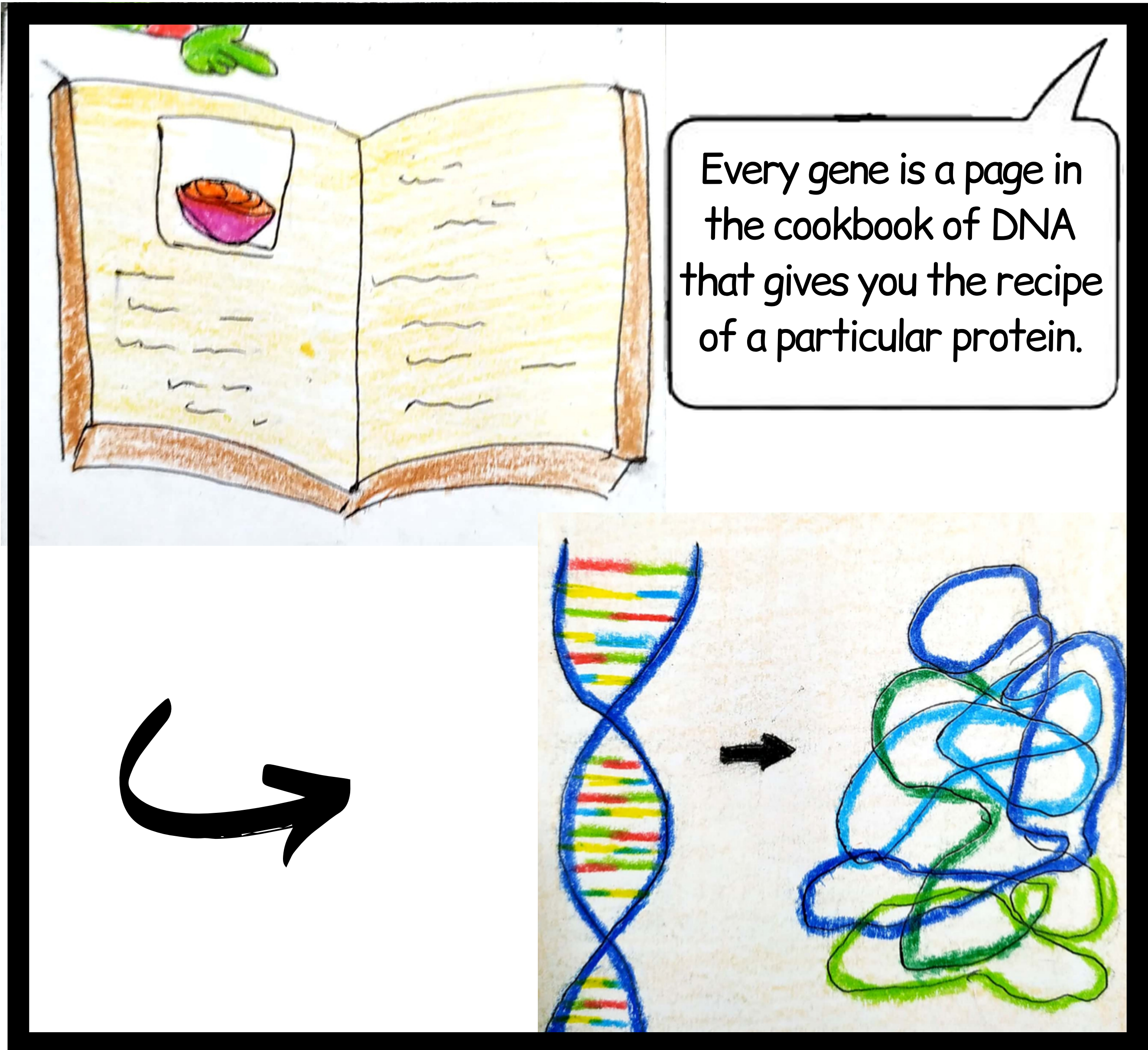
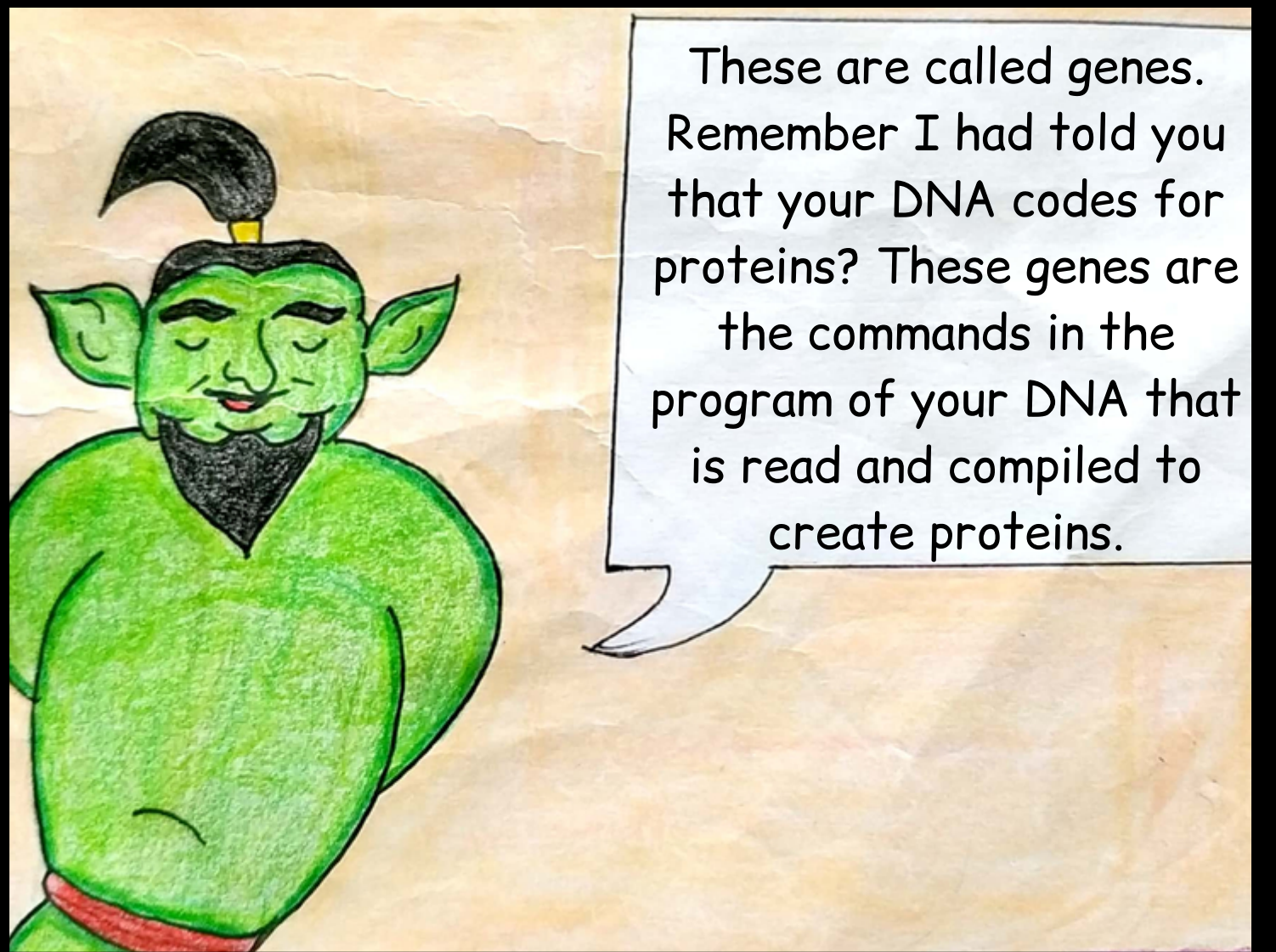
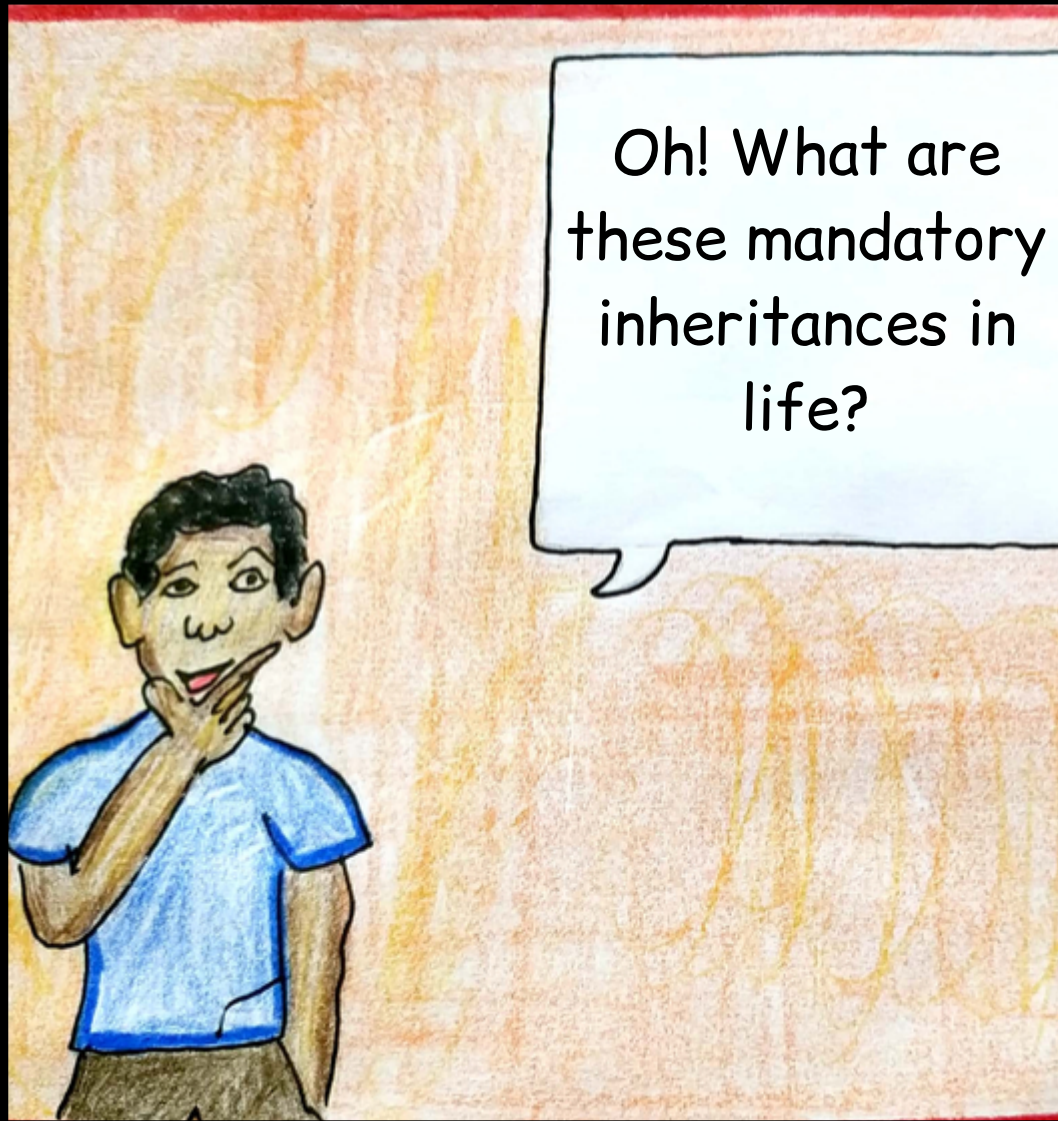
The worst part is that it has nothing to do with your actions or your lifestyle. It is a genetic disorder which means that it was passed down from your parents to you.



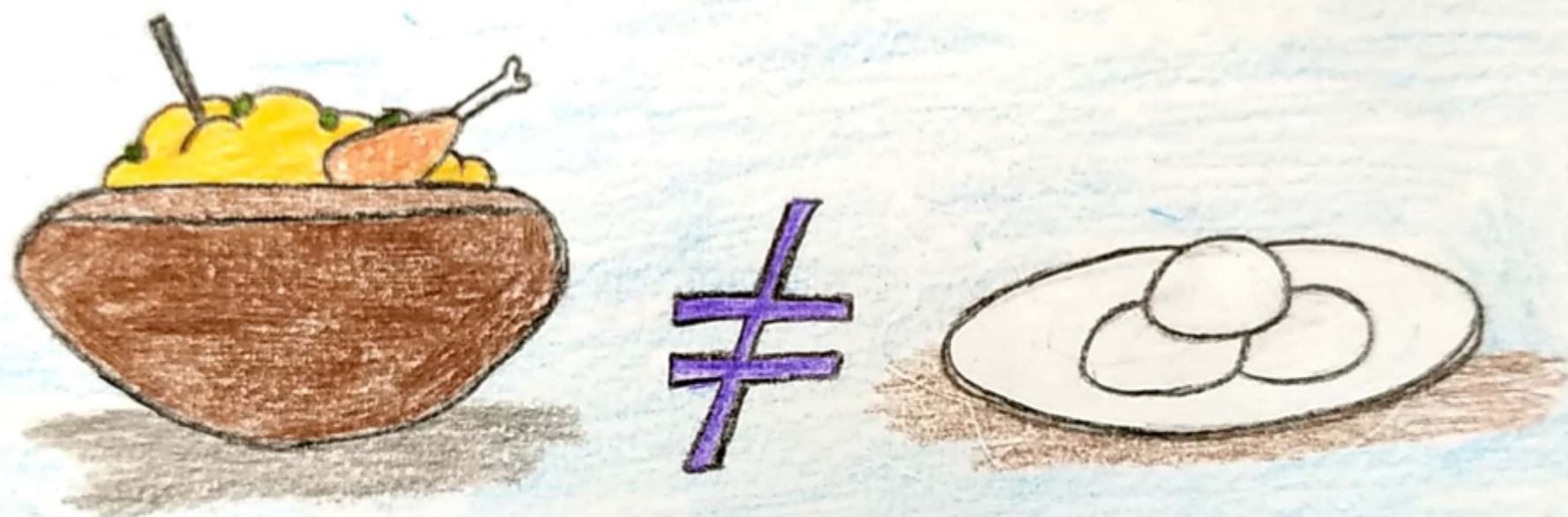










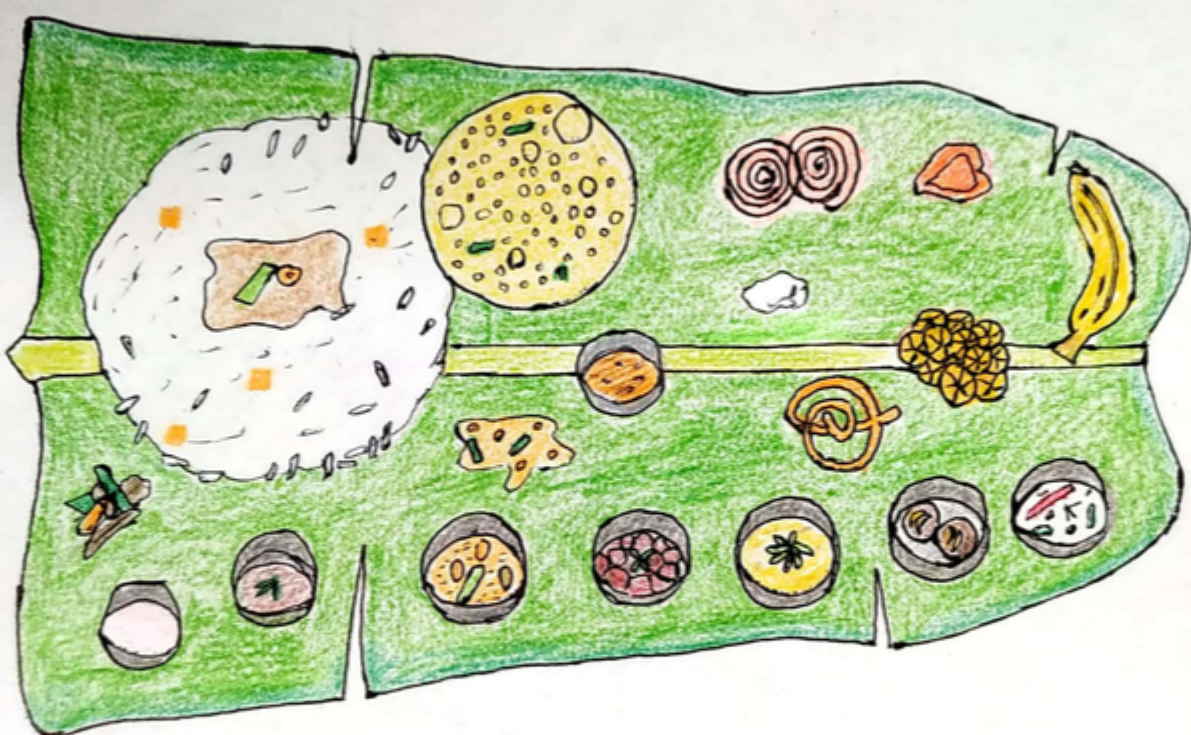


Now, the recipe for biryani will not be as long as the recipe for idli, will it? Similarly, genes in the DNA are of various sizes.

So, genes make up proteins? I thought proteins were made of amino acids?



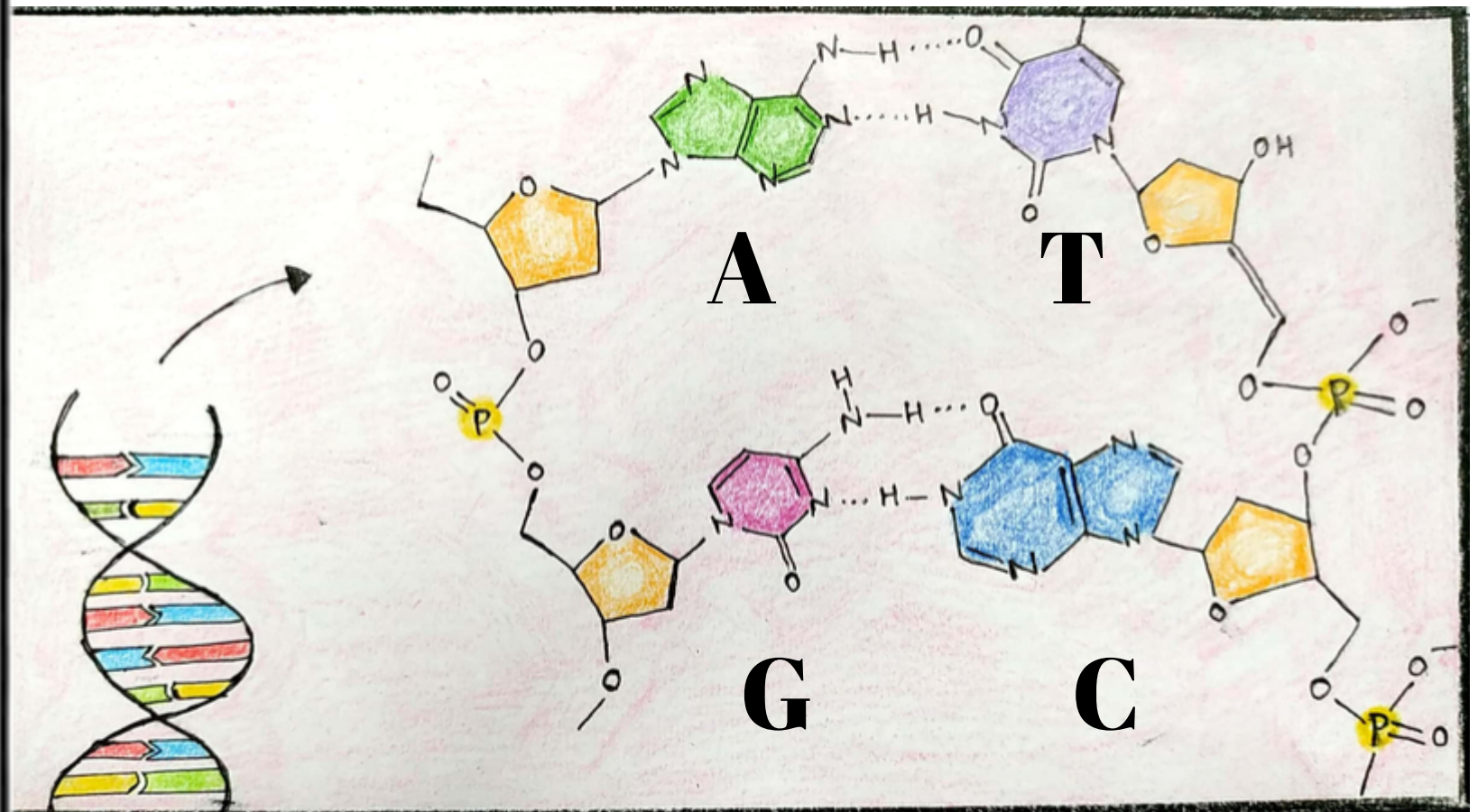
DNA molecules are present in the genes while amino acids are present in a protein. Basically, genes have the code for synthesizing various amino acids. It then strings them together to give a protein.



Think of a protein as a complete meal. From a cookbook that has all the Indian recipes, you can choose to make appam, puttu, egg roast, fish molee and kozhukatta to constitute a Keralite meal. Similarly, for every amino acid, we have codes in our genes.



These amino acids can be created and arranged together by reading the genes. A gene is a nucleotide sequence and what distinguishes adjacent nucleotides in a DNA molecule are their nitrogenous bases.



Nitrogenous bases A, T, G and C.

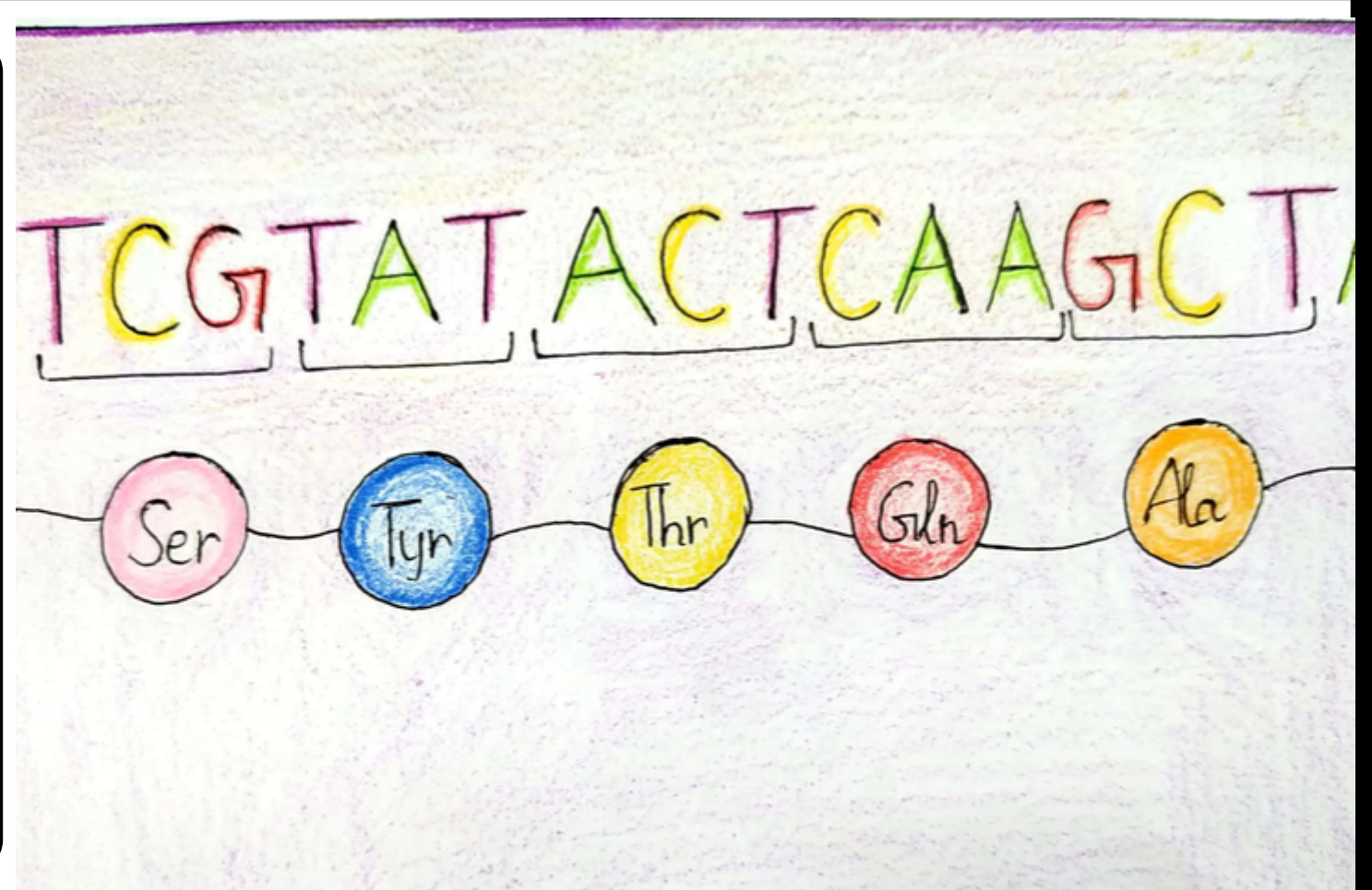


So we can represent a gene by the sequence of its bases. Say we have a gene:

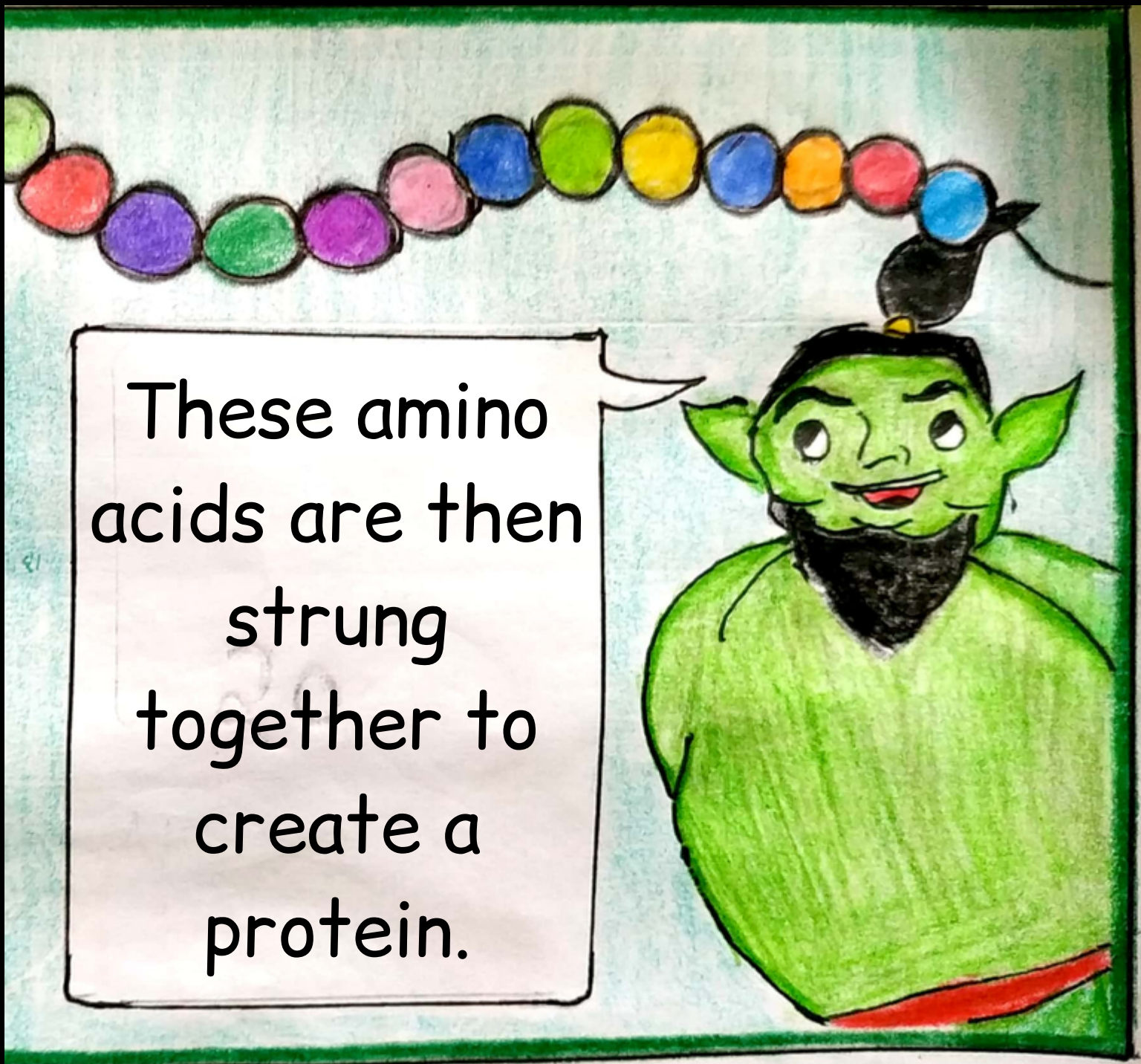
ATGGTGCACCTGACTCCTGAGGAGA  
AGTCTGCCGTTACT

This gene should give rise to a protein but what about the amino acids.

How does it create the relevant amino acids? A ribosome produces amino acids by reading this code in groups of three. So, ACT, GTT, GCC, etc. are all instructions to the ribosome to produce particular amino acids - Threonine, Valine and Alanine respectively in this case.







By the way, these packets of three are called codons. Every amino acid has multiple codons as we have 64 possible combinations but only 20 amino acids. So there is a surplus of codons.

## 20 AMINO ACIDS!!

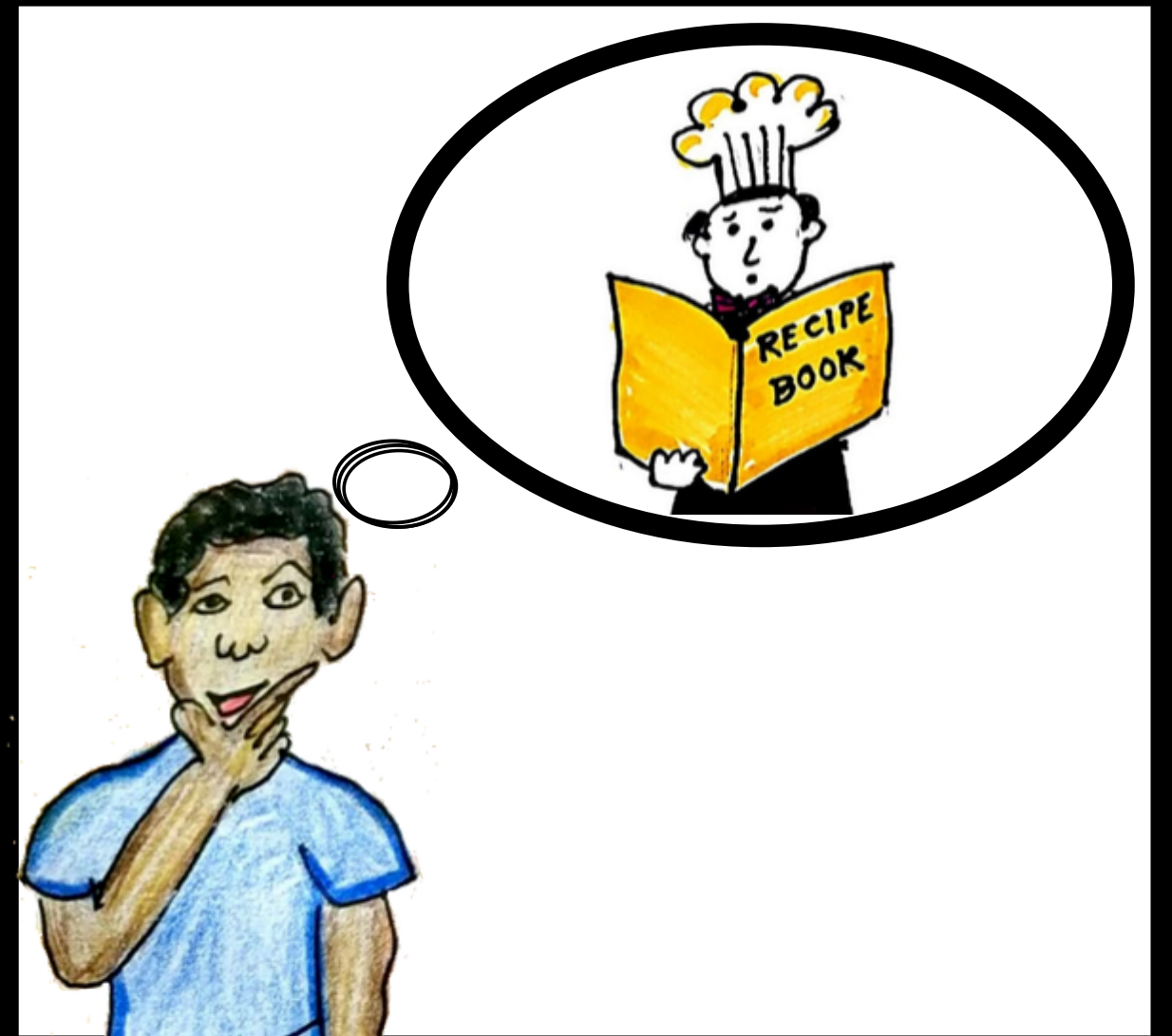
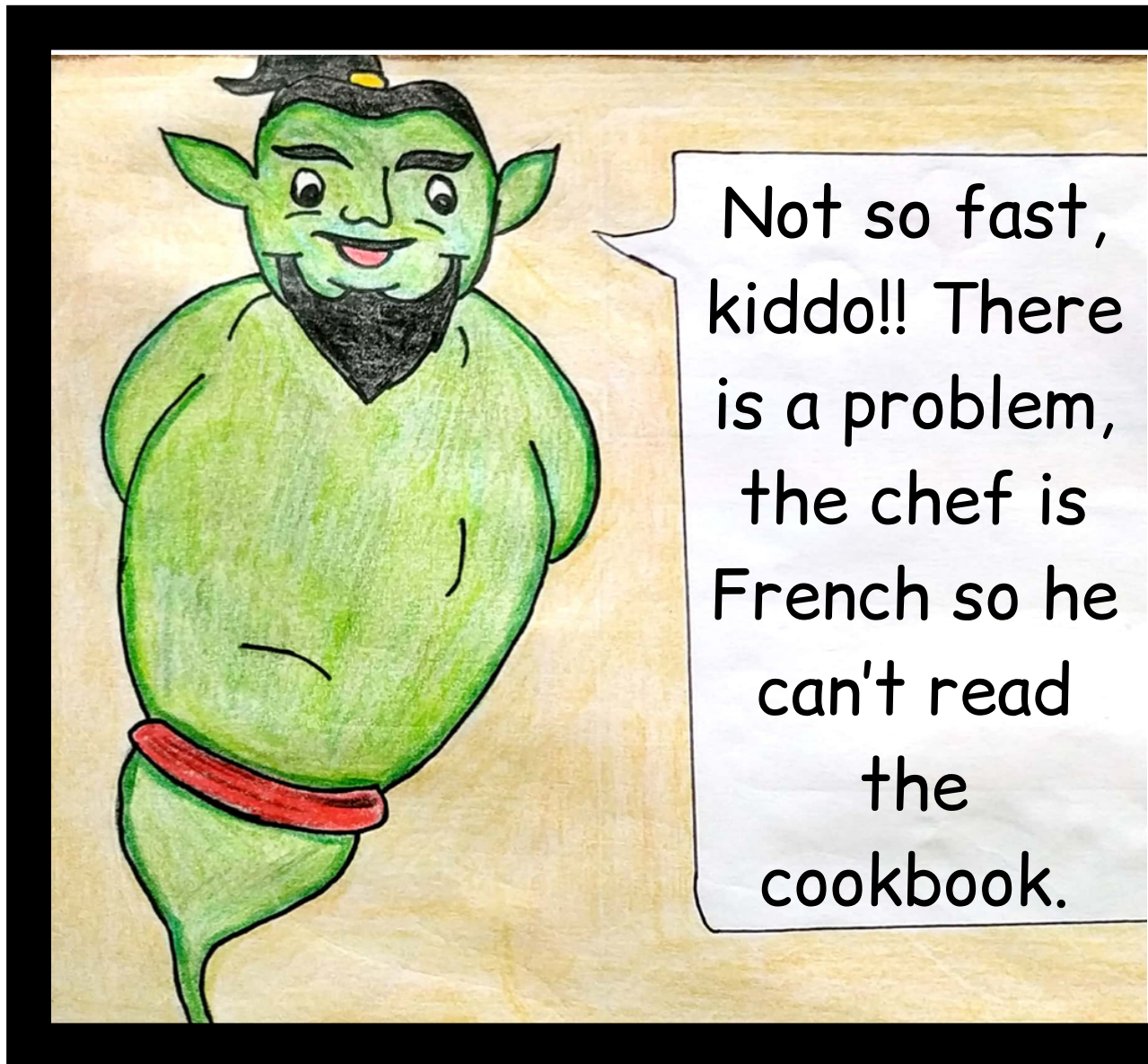
- |            |            |           |               |
|------------|------------|-----------|---------------|
| Glycine    | Serine     | Lysine    | Phenylalanine |
| Alanine    | Threonine  | Arginine  | Tyrosine      |
| Valine     | Cysteine   | Histidine | Tryptophan    |
| Leucine    | Proline    |           |               |
| Methionine | Asparagine | Aspartame |               |
| Isoleucine | Glutamine  | Glutamate |               |

		Second Letter				
		U	C	A	G	
First Letter	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA stop UAG stop	UGU } Cys UGC } UGA stop UGG Trp	U C A G
	C	CUU } Leu CUC } CUA } CUG }	CCU } Pro CCC } CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } Arg CGC } CGA } CGG }	U C A G
	A	AUU } Ile AUC } AUA } AUG Met	ACU } Thr ACC } ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } Val GUC } GUA } GUG }	GCU } Ala GCC } GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } Gly GGC } GGA } GGG }	U C A G

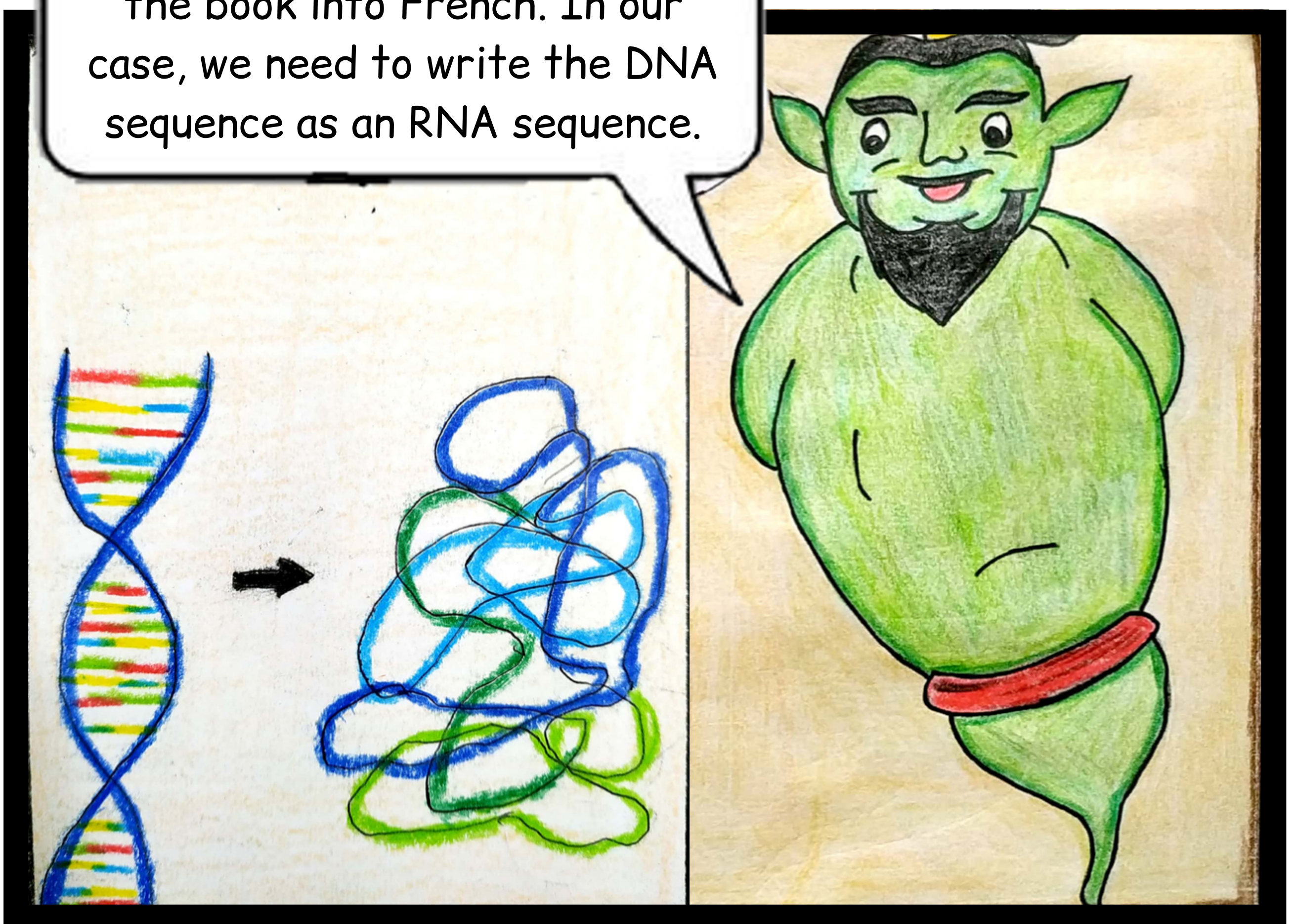
So, genes in the DNA are read by the ribosome to create strings of amino acids that make up a protein. Easy!!





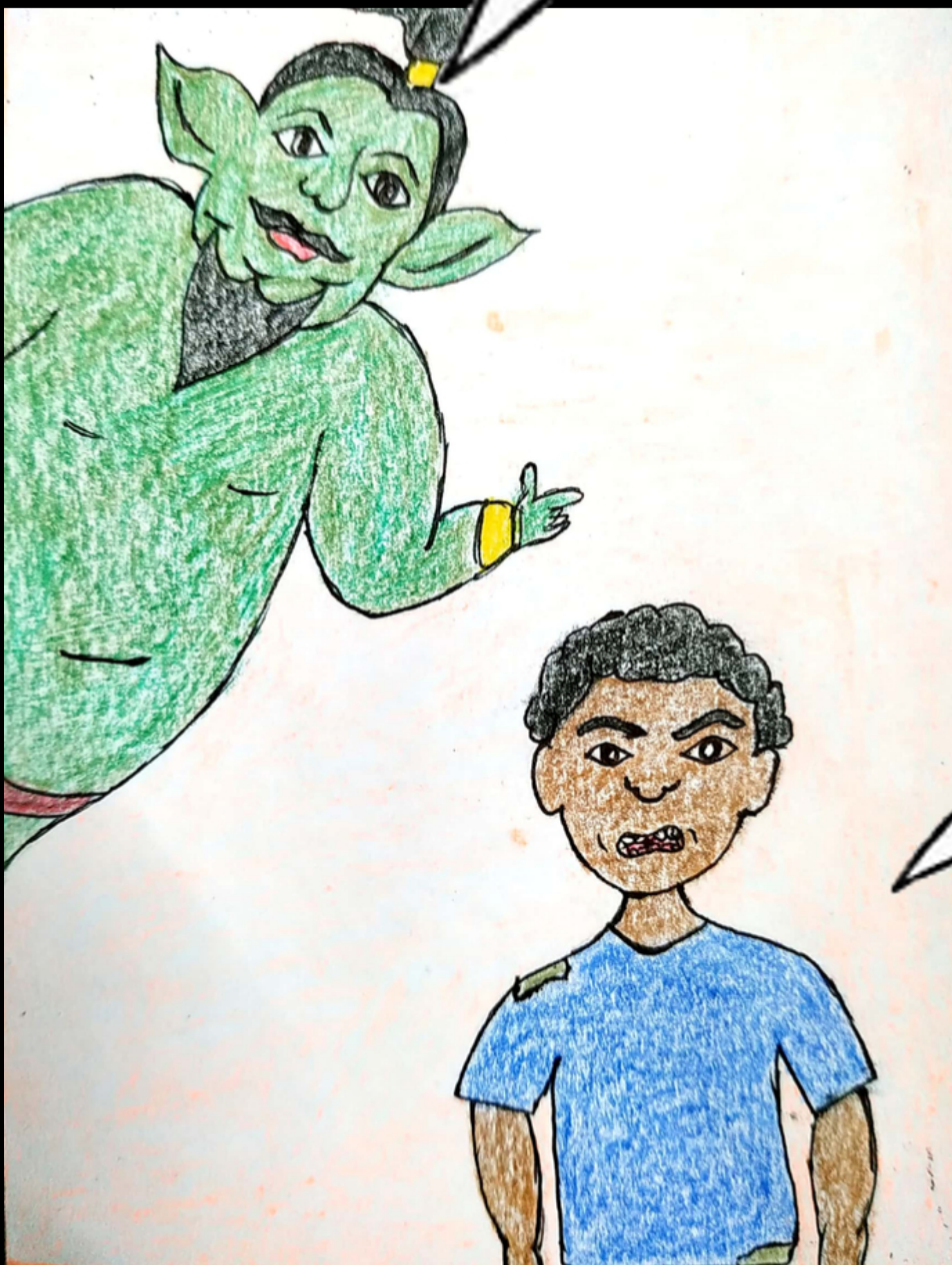


That, in our example, would refer to ribosomes that cannot directly read the DNA sequence. We need to translate the book into French. In our case, we need to write the DNA sequence as an RNA sequence.

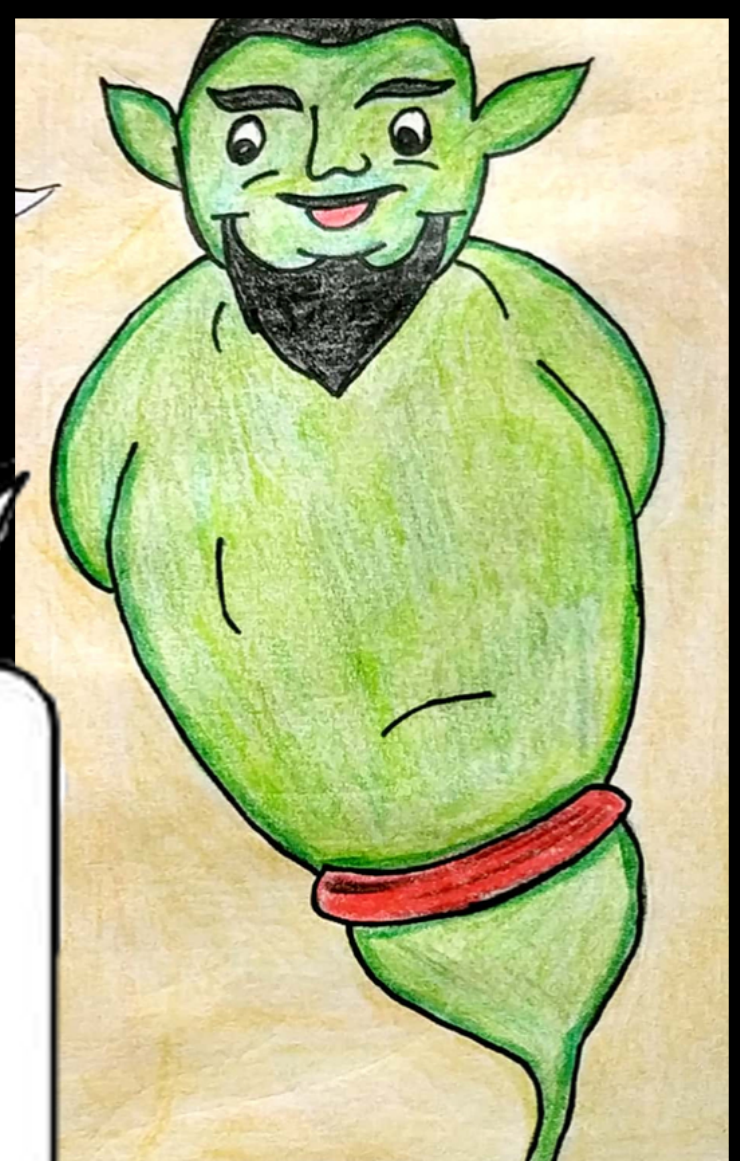




French has 26 alphabets like English but there are differences in pronunciation. Similarly, RNA and DNA are very similar but there are differences in nitrogenous bases. RNA has uracil instead of thymine. But, we also need a translator. This role is fulfilled by Mr. RNA polymerase in our bodies. He separates the two strands of a DNA and creates an RNA strand that can now be used by the ribosome to create amino acids. The former process is called Transcription and the latter is called Translation. At the end of translation we have a string of amino acids that folds to form a protein.

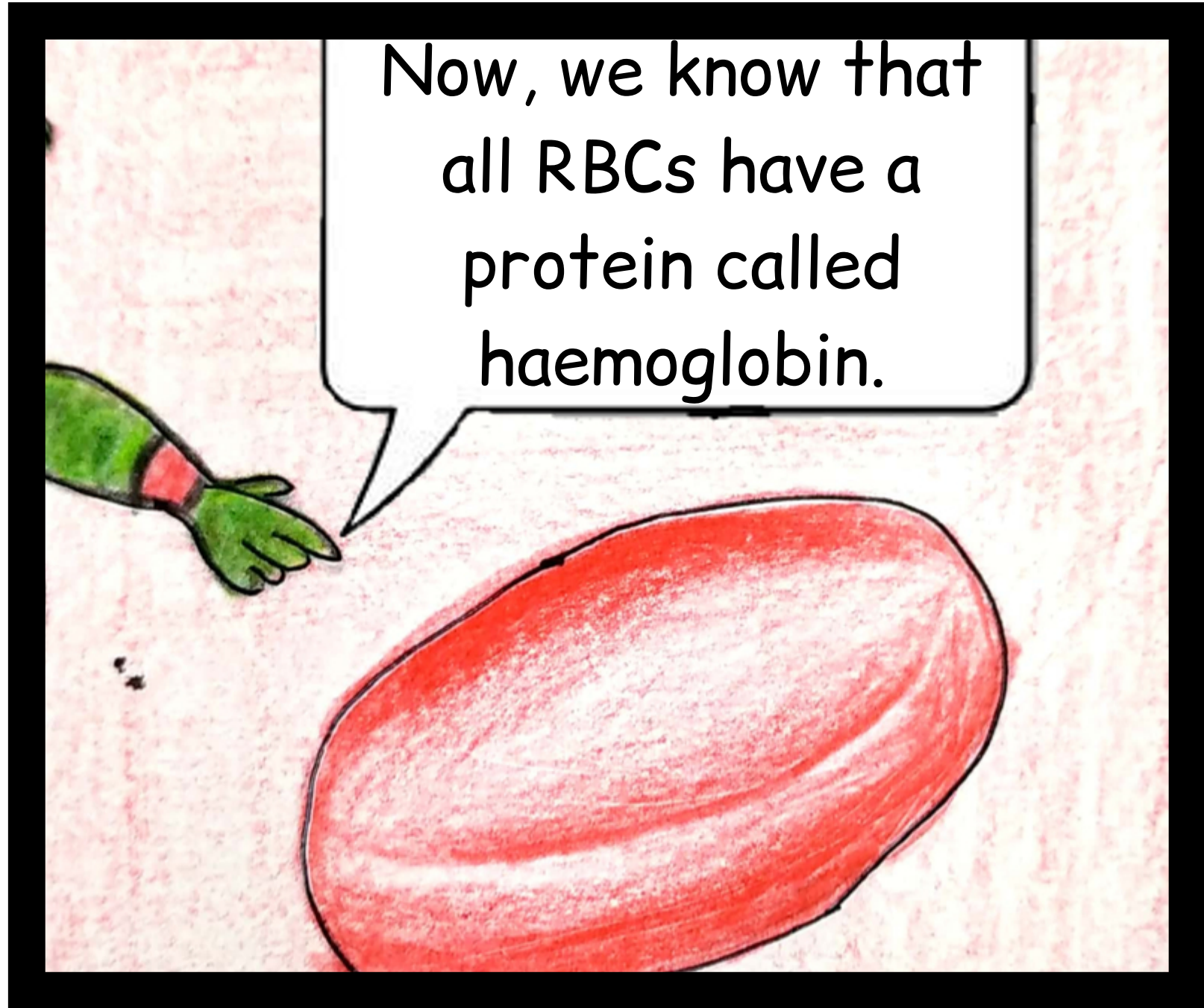




Do you just like to blabber? Because I don't see how any of this is connected to why my parents passed down a lethal gene?



Okay, I will cut to the chase. Your condition is due to a minor mutation. To understand that, it is necessary to know about these cellular processes.





NORMAL		SICKLE-CELL ANEMIA	
DNA sequence of Beta globin gene	.... CCT GAG GAG .....               .... GGA CTC CTC .....	.... CCT - GTG GAG .....               .... GGA - CAC CTC .....	
RNA sequence	... CCU - GAG - GAG ...	... CCU GUU GAG ...	
Protein sequence	— [Pro] — [Glu] — [Glu] —	— [Pro] — [Val] — [Glu] —	
Red Blood Cell			



In people afflicted with your condition, a particular codon, GAG is replaced by GTG i.e. there is a mutation and instead of glutamic acid, the protein incorporates valine. Such mutations are called point mutations.



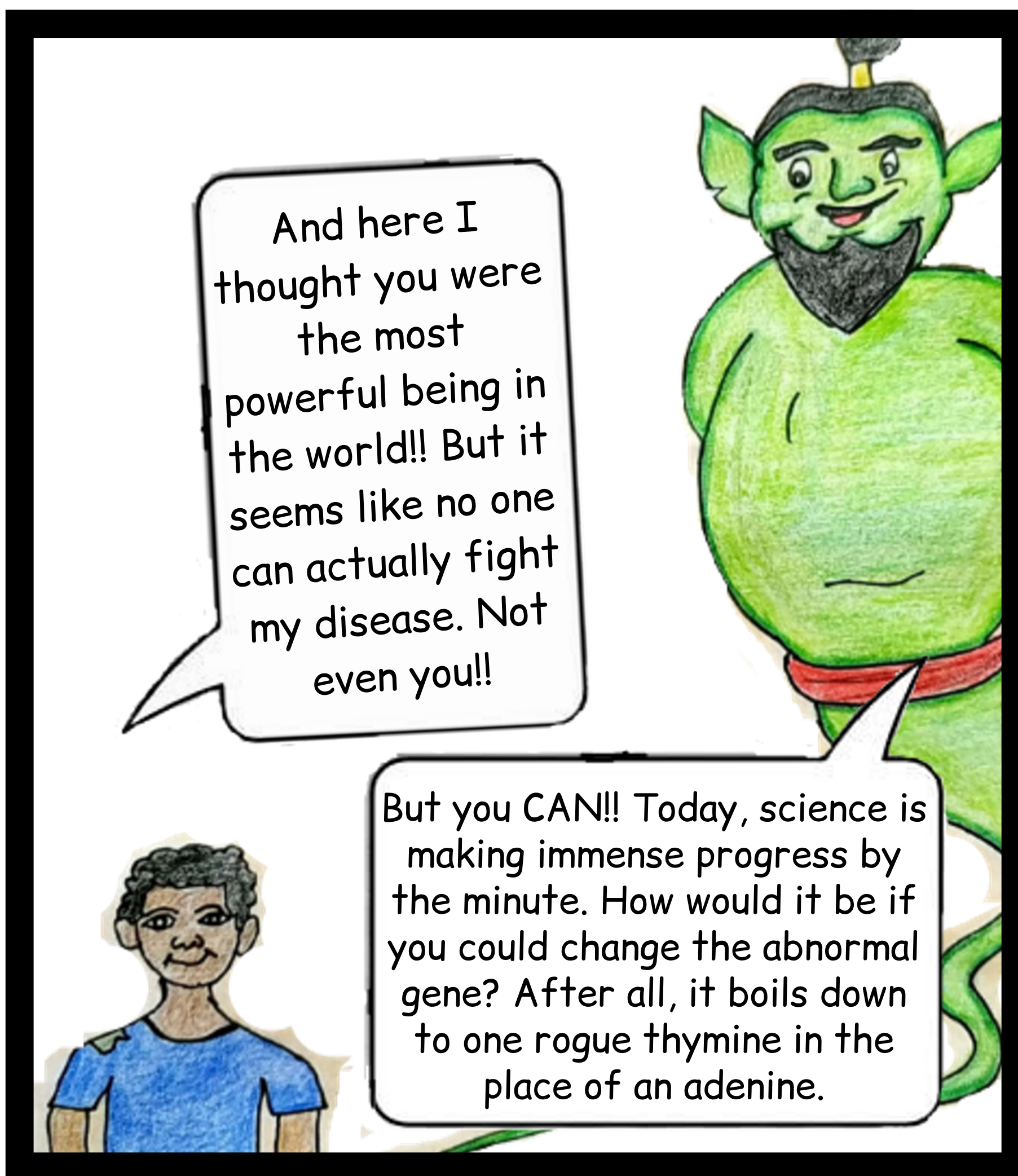
So, you see, one single change in your DNA can have a life-changing effect not only on you but also on your future generations. In fact, your parents also have this mutation but they must also be having the normal gene which compensates for the effects of the defective gene.



In your case, you inherited the abnormal genes from both your parents and therefore you could not keep this condition at bay. Sadly, this condition is treatable but incurable! Not even my magical powers can cure this ailment because it is actually incorporated in your DNA and in the matters of the DNA, the laws of genetics run supreme.







Scientists are working on ways to help people like you. But, for them to succeed as soon as possible, the research into the cure for this ailment has to be launched by hundreds and not ones or twos. They need you, Willie - people who know about transcription and translation. Go back to school and study! Not for the sake of your parents but for your sake. It is your crippling condition and you have borne the brunt of it for so long. Isn't it time to take matters into your own hands and effect the change you long for?

