Protein Synthesis

Part 1:

My name is Abdallah Najem Al-Fuhaid. I work as a biology teacher at Al-Imam Saud Al-Kabeer high school, Dhahran, Eastern Province, KSA. Our lesson for today is about how cells make the proteins required for our growth and daily activities. This is done by consuming nutrients rich in proteins, digesting, and converting them to amino acids which reach the cell through blood stream where they are combined again to form the proteins essential for our body structure & growth. But, first let's talk about the cell structure:
The cell is a fundamental unit of structure and function in living organisms, all living things are made of one or more cells, surrounded by a membrane contains the cytoplasm inside in which cell components and organelles swim. The most important ones are the nucleus of the cell which contains the chromosomes which carry the hereditary genes (genetic code), Golgi bodies, Mitochondria which produce the energy required for the cell activities, and ribosomes found in all parts of the cytoplasm. Ribosomes are composed of ribosomal proteins and ribosomal nucleic acid rRNA whose primary function is decoding messenger mRNA into peptide chains which are linked together later to form proteins. We can think of the ribosome as a factory that converts genetic information into proteins that play a major role in building body tissues or producing enzymes, hormones, antibodies, and others.

Activity # 1:

I have the following questions for you:

How does the cell make proteins?

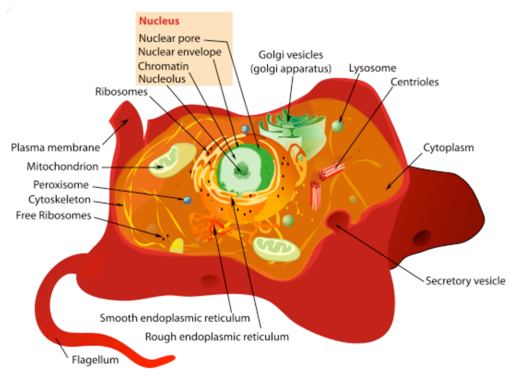
What is the role of the nucleic acid DNA in this process?

What does the messenger RNA (mRNA) do?

What does the ribosomal RNA (r RNA) do?

Work in groups to answer the previous questions.

I will see you after a few minutes



Part 2:

P.E. Teacher: Ahmed, Khalid… Come here, please.

Ahmed, Khalid: Yes, teacher.

Teacher: Your bodies look very thin. You need more proteins in your diet.

Ahmed, Khalid: Where can we find proteins?

Teacher: You can find them in meat & beans.

Ahmed is having a steak while Khalid is having some beans. My questions are: “What happens to the consumed food components when they reach the digestive system and then to the cell?”

How does this affect their growth?

Activity # 2:

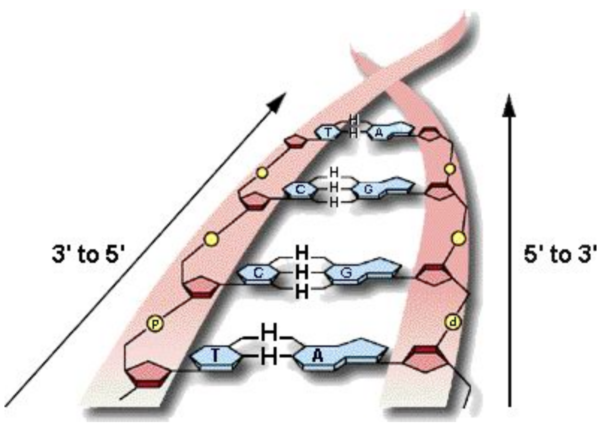
Work in groups to discuss and answer these questions.

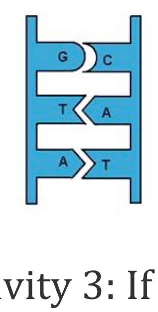
Part 3:

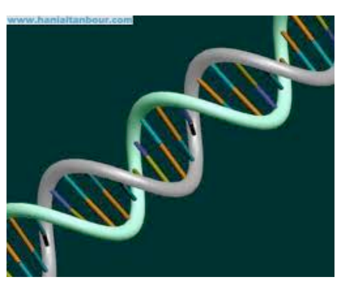
Here I am going to explain the answers.

When complex food components enter the digestive system, they are broken down into smaller components. As we all know, complex proteins such as meat and bean are broken down into simple molecules that are more easily absorbed into blood stream and from there to the cell. This is where the nucleic acid DNA starts working. The DNA is responsible for determining the characteristics of living things as a result of controlling a series of biochemical reactions inside living things. It consists of two wound strands of nucleotides to form a spiral ladder-shaped molecule .Each nucleotide consists of one of four nitrogen bases which are: (Adenine A or Guanine or Cytosine C or Thymine T), phosphate group (PO_4), and a deoxyribose sugar.

The small nucleotides are linked along the strand with each other so that each deoxyribose in one of the nucleotides is linked to a phosphate group in the next nucleotide on the same strand, and the nitrogen base molecule is linked to another nitrogen base present on the opposite strand by hydrogen bonding and therefore the DNA molecule can be thought of as wooden ladder in which the sides represent sugar molecules and phosphate group, while the stairs represent the nitrogen bases of the two strands which are wound around each other to form a spiral shape, and in order to link a nitrogen base in one strand to another nitrogen base in the other strand, the nitrogen base Adenine A must pair with the nitrogen base Thymine T, while the nitrogen base guanine G pairs with cytosine C. Whenever Adenine is found on one of the strands , Thymine is found on the other, while guanine is found paired to cytosine and so on.

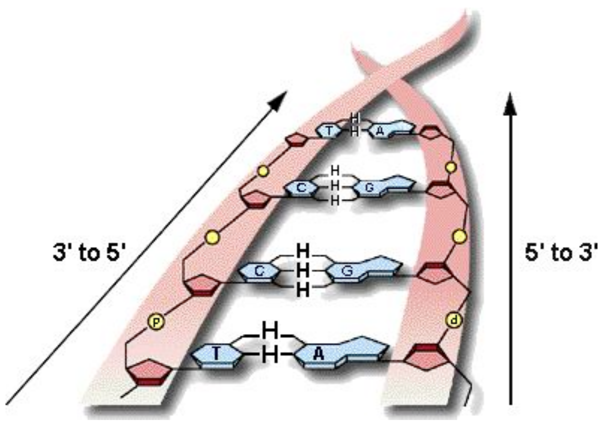


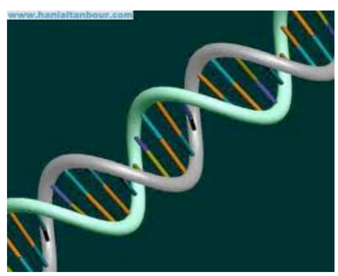




Activity 3: If we assume that strand (A) in the nucleic acid DNA has nitrogen bases sequenced as follows: TAC GGC ATA, what is the sequence of the nitrogen bases in the second strand of the DNA?

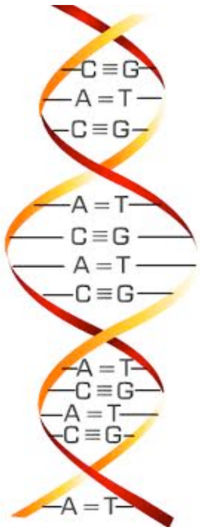
Work in groups to find the correct sequence of the nitrogen bases in the second strand (B) of the DNA. I will come back to you shortly.





The sequence of the nitrogen bases in the nucleic acid determines the type of protein produced, and-as we know-when the strand A in the DNA has the sequence:

(TAC GGC ATA), the sequence in the strand B will be as follows: (ATG CCG TAT). In this way, the genetic code is formed.



Activity # 4

Now, I have these questions for you:

What does the genetic code look like?

What transfers the genetic code from the nucleus to the ribosomes in the cytoplasm where protein is made? What does it look like when the sequence of the nitrogen bases in the DNA is (TAC GGC ATA)? What will the sequence be in the genetic code?

I will leave you to discuss these questions in groups and I will be back in a few minutes.

Part 5:

I am back again.

Before addressing nucleic acid that carries the genetic code from the nucleus to the cytoplasm, we need to know the structure of the nucleic acid RNA, which is composed of a single strand of nucleotide, found in the nucleus and cytoplasm, each nucleotide is composed of ribose sugar, and nitrogen base, a phosphate group. The nitrogen bases are adenine A, guanine G, cytosine C, and uracil U, and there are three types of nucleic acids RNA:

First: mRNA which carries DNA genetic code instructions, from the nucleus to the cytoplasm.

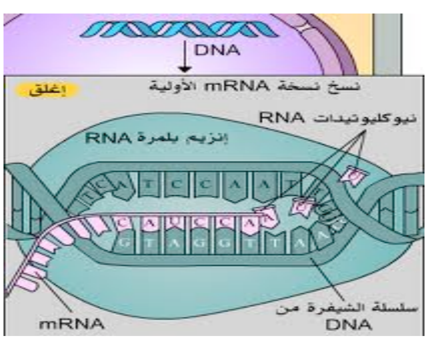
Second: tRNA that carries the amino acids in the cytoplasm resulting from protein digestion in the digestive tract, and attaches them to the genetic code on the nucleic acid mRNA bound to ribosomes.

Third: rRNA is one of the components of ribosomes which are the sites of protein synthesis by decoding the genetic code.

The messenger RNA (mRNA) is responsible for transferring the genetic code. It has the ability of replacing the nitrogen base-thymine T-which is found in the DNA strand with the nitrogen base; uracil U. When the nitrogen bases in the DNA has the sequence: (TAC GGC ATA)

The sequence of the genetic code on messenger RNA (mRNA) is:

(AUG CCG UAU), and the genetic code transfers from the nucleus to the ribosomes in the cytoplasm.



Activity # 5

Here is my question for you:

How are the amino acids in the cytoplasm linked to a strand of tRNA?

Part 6:

In order to answer the previous question, I should point out that for every amino acid there is a genetic code with three nitrogen bases. In nature, there are twenty amino acids which rearrange to form proteins in a way very similar to the formation of words from letters in a certain language.

There are 64 different genetic code combinations for the three nitrogen bases out four and the twenty amino acids which might have more than one cod, for example , serine has 6 genetic codes(UCU UCC UCG UCA AGU AGC), lysine and arginine have also 6 genetic codes, while methionine has only one (AGU),

And there are amino acids with 2, 3, 4, or 5 codes. So, there are 64 different genetic codes in living things and 20 amino acids.

Activity # 6

Now, I have this question for you:

How is the nucleic acid transfer RNA (t RNA) bound to the code on the messenger RNA (mRNA)?

I will leave you for a short time to discuss this question with your colleagues.

Part 7:

To answer this question, every amino acid is bound to a triplet code and carried by the tRNA starts moving in the cytoplasm and searching for nitrogen bases to pair up with the messenger RNA strand on the ribosomes.

The amino acids will be aligned next to each other with peptide bonds forming a chain of poly peptide to become eventually a new protein which might be structural for growth, an enzyme, hormone or antibodies.

Any change in the nitrogen bases in DNA could cause genetic mutation, since it changes the genetic code which in turn changes the amino acid composition and consequently changes the composition of the resulting protein which is called a genetic mutation. The cell needs one minute or a little more to synthesize a molecule of protein with the aid of enzymes, for example, making a molecule of hemoglobin from amino acids as previously described takes 90 seconds.

Through studying genetic code, protein synthesis and molecular genetics, many genetic disorders can be cured. In 1982, human insulin was produced in vast amounts for treating diabetes through inserting insulin gene to the DNA of the microorganisms and using cloning technology, other examples of proteins produced through genetic engineering and were approved by the US Food & Drug Administration (FDA) include:

- Growth hormone for growth deficiency in children.
- Thyrotropin for treating thyroid cancer.
- Alteplase for treating blood clots.

In addition to vaccines such as lever disease epidemic, flu, etc, this protein is the cause of growth for you and for Ahmed and Khalid.