LA IMMACULADA CONCEPCION SCHOOL
SENIOR HIGH SCHOOL
GRADE 11 – STEM: GENERAL BIOLOGY 2

TOPIC: Central Dogma of Molecular Biology
Sub- topic: Protein Synthesis

Overview

DNA is an essential component of life. This molecule contains the instructions for the growth and development of organisms. DNA determines the type of organism to which a cell belongs. In other words, a cell that belongs to a human being could further be determined as part of the human skin, for example. This could be inferred from the active participation of the cell's DNA in the production of melanin and keratin proteins which are commonly associated with the skin.

DNA carries the codes for various polypeptides or protein. Previously, it was hypothesized that a gene (a portion of the long DNA) specifically codes for one specific type of enzyme. It was called one-gene-one-enzyme hypothesis. It was taken that traits appear as produce of enzymatic reactions. Later on, discoveries of other polypeptides that do not have enzymatic roles prompted revision of the one-gene-one-enzyme hypothesis to one-gene-one-polypeptide hypothesis. This is to include polypeptides that have other functions such as structural and regulatory proteins.

The following processes are involved in protein synthesis.

1. Transcription

Transcription is the first of the three steps in protein synthesis. RNA polymerase will look for a promoter region to attach to and initiate unzipping. The promoter region is the part of the DNA that has thymine-adenine-thymine-adenine (TATA) sequence. This is called the TATA box.

After attachment and initiation, elongation of the RNA strand follows. The RNA polymerase uses only one strand of DNA in the 3' to 5' direction as template, thus mRNA grows in the direction of 5' to 3'.

The synthesis will terminate when the polymerase reaches the termination point that has a continuous adenine base DNA sequence in eukaryotes. At this point the polymerase detaches itself from the DNA template and the DNA will rewind into its helical structure.

Transcription also makes two more RNA, the tRNA and rRNA. The mRNA contains codons made up of 3 consecutive nucleotide bases that code for specific amino acids. There are 64 codons but there are only 20 amino acids. This implies that a specific amino acid maybe coded by more than one codon such as the amino acid alanin which is coded for by 4 codons GCU, GCC, GCA, and GCG.

Transfer RNA is also coded from the DNA in the eukaryotic nucleus. It is made up of 80 nucleotide bases that eventually end up in the cytoplasm. tRNA also has 3' end and 5' end. The 3' end of the tRNA has the sequence CCA which attaches to the amino acid. On the other hand, the 5' end of the tRNA contains the anticodon which serves as the complementary bases of the mRNA codon. It must be noted that the third nucleotide base of the tRNA and mRNA does not require strict complementarity making it possible for the anticodon of some tRNA to pair with more than one kind of codon. This makes it possible to have 45 different tRNAs base-pair with 64 different codons. The two-dimensional appearance of the tRNA makes the molecule appear to have three leaflets of a clover leaf.

Ribosomal RNA assembly happens in the nucleolus where various proteins from the cytoplasm are assembled with rRNA to form the small and large ribosome units. The subunits will exit the nucleus and enter the

cytoplasm where they will be assemled into ribosomes - the sites of protein synthesis. The ribosome will have three binding sites, mRNA bindingsite, P "polypeptide" site and A "amino acid" site. Also, rRNA has an exit site for the detachment of
the tRNA.

2. *RNA processing*

Following transcription, the mRNA will still undergo further processing. This step is essential for two reasons: stability is provided to the mRNA strand when it transfers from the nucleus to the cytoplasm and alternation alteration of mRNA is allowed.

Stability is achieved by adding nucleotide sequences to the ends of the mRNA. For the 5' end of the mRNA, GTP (guanosine triphosphate) is added forming a 5'cap. Aside from giving it stability, 5' cap also offers a binding site for the smaller ribosomal unit. The 3' end of the mRNA will have an addition of 150 to 200 adenine nucleotides called poly-A tail. Poly-A tail controls the movement of the mRNA across the nuclear pore.

Alteration of the mRNA is made by the removal of some segments of the strand that are noncoding. After the transcription of DNA to mRNA, the mRNA would contain two types of sequences of nucleotide. One type codes for specific polypeptides while the other types are made up of intervening sequences to the coding bases. These two types are referred to as exons and introns, respectively. The small nuclear ribonucleoprotein (snRNPs) functions in the removal of the introns from the heterogeneous nuclear RNA (unprocessed mRNA).

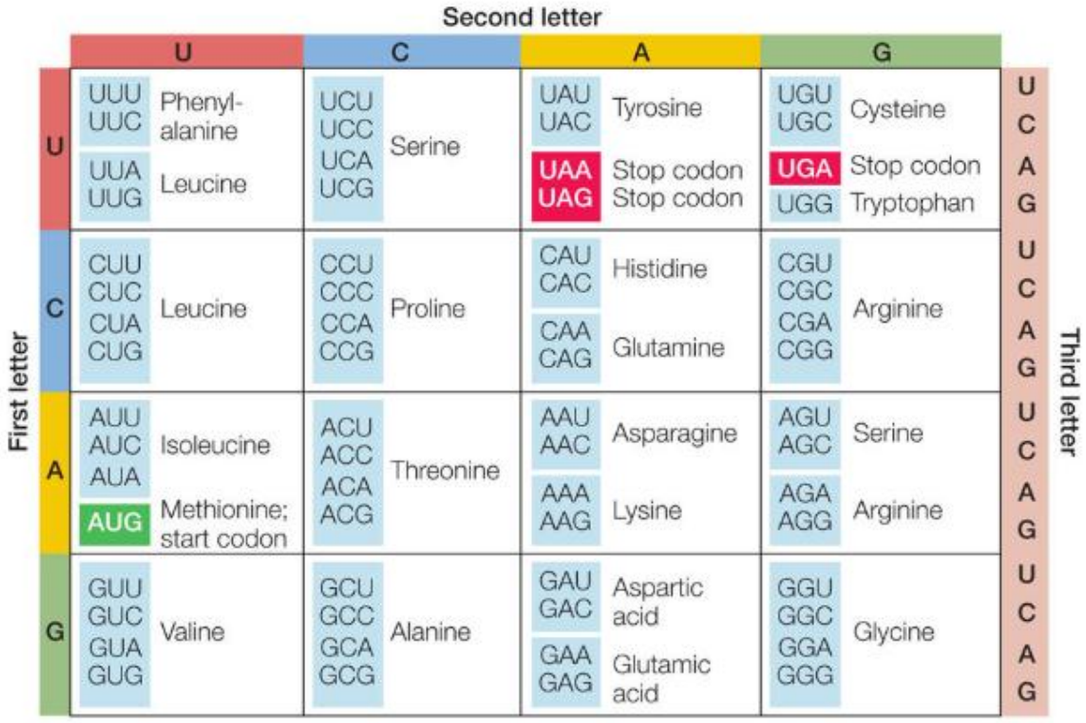
3. *Translation*

After the processing of the mRNA, the strand passes through the nuclear pore and into up in the cytoplasm. The translation of mRNA codons to amino acids forms polypeptides.

The first step in translation is the attachment of the small ribosome subunit to the 5' end of the mRNA. This is followed by the attachment of a transfer RNA that carries an anticodon UAC and methionine to the segment of an mRNA with the start codon AUG. This hydrogen bonding between complementary bases initiates the attachment of the large ribosome subunit. The large sub-unit has the P site where the first tRNA will be situated.

Elongation starts when another tRNA attaches to the A site of the ribosome carrying the anticdon that is complementary to the next codon after AUG and its corresponding amino acid. The second ammo and will form peptide bonds with methionine. The first tRNA then proceeds to the E site and detaches from the ribosome while the second tRNA transfers from the A site to the F site. This leaves the A site vacant for the third tRNA. The ribosome moves to present another codon to tRNAs. A third tRNA that carries the anticodon for the given codon attaches to the A site. The amino acid it carries then bonds to the existing peptide chain. At this point, there will be three amino acids in the growing chain. The second tRNA moves to the exit site and detaches while the third tRNA transfers from the A site to the P site. As the A site becomes vacant, tRNAs come in to check if the anticodons are complementary to the codons. The peptide chain will continue to grow longer as the mRNA keeps on presenting codons to be translated to amino acids.

Termination happens when the ribosome reaches the stop codons (UAG, UGA, UAA). At this units that came together to perform translation will detach from each other including the polypeptlde output of the process, the last tRNA, as well as the ribosomal subunits. The ribosornal subunit may attach to the same mRNA for another round of translation or to another mRNA to translate a different protein.



Reference: General Biology 2 pages 181-182

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ACTIVITY 1
CHAPTER TEST

Directions: Use your codon chart to determine the amino sequence. Remember to read through the strand and ONLY start on AUG and STOP when it tells you to stop.

Example:

DNA AGA CGG TAC CTC CGG TGG GTG CTT GTC TGT ATC CTT CTC AGT ATC
mRNA UCU GCC AUG GAG GCC ACC CAC GAA CAG ACA UAG GAA GAG UCA UAG
protein start - glu – ala –thre – hist – asp –glu – threo - stop

1. DNA CCT CTT TAC ACA CGG AGG GTA CGC TAT TCT ATG ATT ACA CGG TTG CGA TCC ATA ATC
mRNA
protein

2. DNA AGA ACA TAA TAC CTC TTA ACA CTC TAA AGA CCA GCA CTC CGA TGA ACT GGA GCA
mRNA
protein

3. DNA TAC CTT GGG GAA TAT ACA CGC TGG CTT CGA TGA ATC CGT ACG GTA CTC GCC ATC
mRNA
protein

4. DNA TAA ACT CGG TAC CTA GCT TAG ATC TAA TTA CCC ATC
mRNA
protein

5. DNA CTA TTA CGA TAC TAG AGC GAA TAG AAA CTT ATC ATC
mRNA
protein

6. DNA TAC CTT AGT TAT CCA TTG ACT CGA ATT GTG CGC TTG CTG ATC
mRNA
protein

7. DNA ACC CGA TAC CTC TCT TAT AGC ATT ACA AAC CTC CGA GCG
mRNA
protein

8. DNA TAC AGA CGG CAA CTC TGG GTG CTT TGT TCT CTT CTC AGT ATC
mRNA
protein

Directions: Encircle the correct answer.

1. (DNA/RNA) can leave the nucleus.

2. mRNA is made during (transcription/translation).

3. mRNA is made in the (cytoplasm/nucleus).

4. DNA is located in the (nucleus/cytoplasm)

5. (Translation/Transcription) converts DNA into mRNA.

6. (mRNA/rRNA) is used to carry the genetic code from DNA to the ribosomes.

7. (tRNA/rRNA) makes up the ribosome. Look in the book for this.

8. (DNA/RNA) uses uracil instead of thymine.

9. (RNA/amino) acids make up a protein.

11. Transcription takes place in the (nucleus/cytoplasm).

12. tRNA is used in (translation/transcription).

13. tRNA uses (anticodons/codons) to match to the mRNA.

14. Proteins are made at the (nucleus/ribosome).

15. (tRNA/mRNA) attaches the amino acids into a chain.

16. tRNA is found in the (nucleus/cytoplasm).

17. (Translation/Transcription) converts mRNA into a protein.

18. Translation takes place in the (cytoplasm/nucleus).

Directions: Answer the following:

1. Draw a DNA nucleotide & an RNA nucleotide. Label each of the 3 major parts.

3. What is the point of DNA replication? _____

4. When & where does replication occur? _____

5. What is the point of transcription? _____where does it occur? _____

6. What are three nucleotides together called on mRNA? (i.e.: ACA)_____

7. The mRNA codons can be used in a chart to find: _____

8. What molecule contains an anti-codon? _____ during what process is it used? _____

10. Translation takes place in a _____.

11. _____ and _____ make up ribosomes.

12. What is the point of translation?

13. Transcription and translation together is the process of _____ _____.

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TOPIC: Earth and Early Life Forms

Overview

The universe is hypothesized to be at least 14 billion years old. The Milky Way Galaxy to which our solar system belonged was formed 10 billion years ago by the collapse of a cloud of "dust". Our Solar System is 4.6 billion years old which is also estimated age of Earth. The early conditions of the young earth were harsh which made life impossible to start.

The toxic environment has to change first before it could harbour life. Several theories were presented to explain the origin of life, but the most accepted theory was the one proposed by Stanley Miller and other scientist. This will serve as a springboard for discussion on the existence of different organisms through geologic time.

The life history of Erath showcases a multitude of organisms that populated Earth at different eras and periods covering millions of year. It also presents possible explanation as to why some organisms do not exist anymore today.

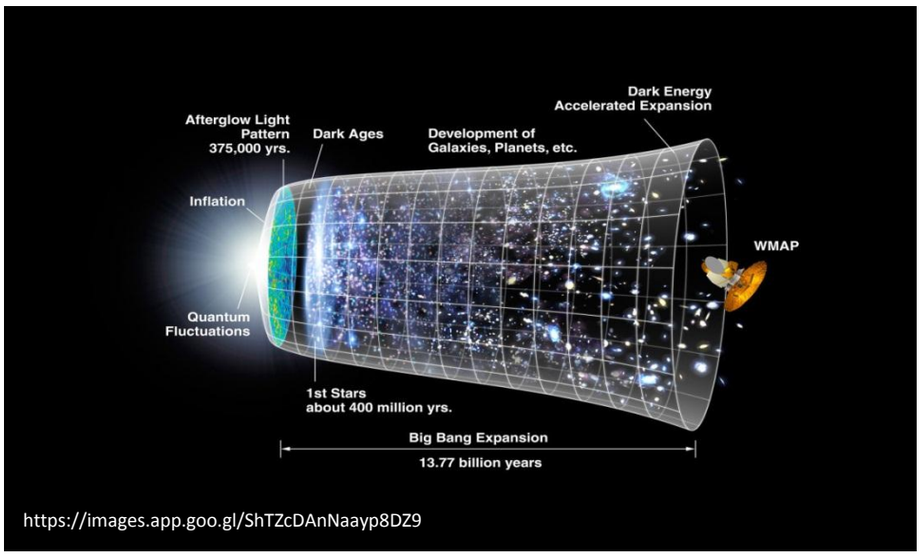


Figure1. A representation of the universe over 13.7 years starting from the bigbang to it different galaxies with stars and different interplanetary system (NASA)

Earth was bombarded with celestial body 4.2 to 3.9 billion years ago figure 1. This made the environment less chaotic but still lifeless. The atmosphere was filled with poisonous gas as the by-product of the impact of celestial body that hit the earth. But even if there were no sign of life yet, the geology of Earth continuously changed. The appearance of ocean waters changed, as well as the aggregations of small protocontinents approximately 4 billion years ago.

Singled- Celled Organisms Changed Earth's Environment

- Stromatolites were the first fossil evidence of life which were thought to have live on Earth 3.5 billion years ago.
- Stromatolites are layered sedimentary rocks formed by ancient cyanobacteria.
- Cyanobacteria are the ancestor of photosynthetic prokaryotes like the present cyanobacteria.
- Cyanobacteria have the ability to processed water liberating oxygen that reacted from the iron that comes in the ocean floors.

The Endosymbiotic Theory

It was first proposed by former Boston University Biologist Lynn Margulis in the 1960's and officially in her 1981 book "Symbiosis in Cell Evolution". Although now accepted as a well-supported theory, both she and the theory were mocked by mainstream biologists for a number of years. Thanks to her persistence, and the large volumes of data that support this hypothesis gathered by her and many other scientists over the last 30 years, biology can now offer a credible explanation for the evolution of eukaryotes.

Dr. Margulis was doing research on the origin of eukaryotic cells. She looked at all the data about prokaryotes, eukaryotes, and organelles. She proposed that the similarities between prokaryotes and organelles, together with their appearance in the fossil record, could best be explained by "endo-symbiosis".

[Endo = "within"

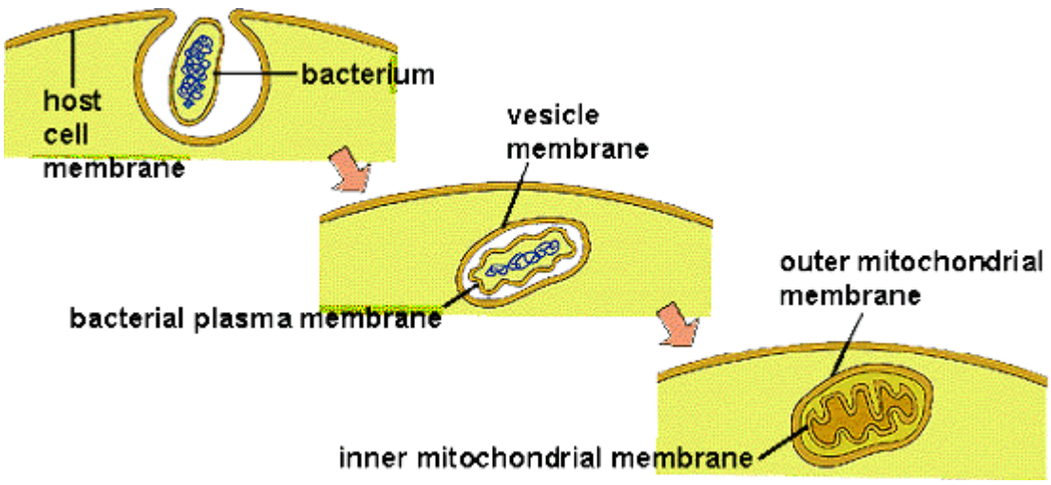
[cyto = cell) a process of 'cell eating' - cells are engulfed, but then usually digested as food

[Endosymbiosis = cells are engulfed, but not digested...cells live together is a mutually benefitting relationship, or symbiosis

Her hypothesis originally proposed that:

- mitochondria are the result of endocytosis of aerobic bacteria
- chloroplasts are the result of endocytosis of photosynthetic bacteria
- in both cases by large anaerobic bacteria who would not otherwise be able to exist in an aerobic environment.
- this arrangement became a mutually beneficial relationship for both cells (symbiotic).

Margulis' original hypothesis proposed that aerobic bacteria (that require oxygen) were ingested by anaerobic bacteria (poisoned by oxygen), and may each have had a survival advantage as long as they continued their partnership.



Each would have performed mutually benefiting functions from their symbiotic relationship. The aerobic bacteria would have handled the toxic oxygen for the anaerobic bacteria, and the anaerobic bacteria would ingested food and protected the aerobic "symbiote"..

The result = a cell with a double-membrane bound organelle. The inner lipid bilayer would have been the bacterial cell's plasma membrane, and the outer lipid bilayer came from the cell that engulfed it.

Reference: https://www.cliffsnotes.com/study-guides/geology/geologic-time/a-summary-of-earths-history

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ACTIVITY 1

LIFE IN STRIPS

Make a comic strip about how life biologically originates base on the theory discuss. Scientific basis should be considered in the making of the comic strips.

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ACTIVITY 2
Q&P

1. Look up for the Miller-Urey experiment online. Briefly discuss any new updates or discoveries about the experiment.

2. Describe the early conditions of earth and its first life forms.