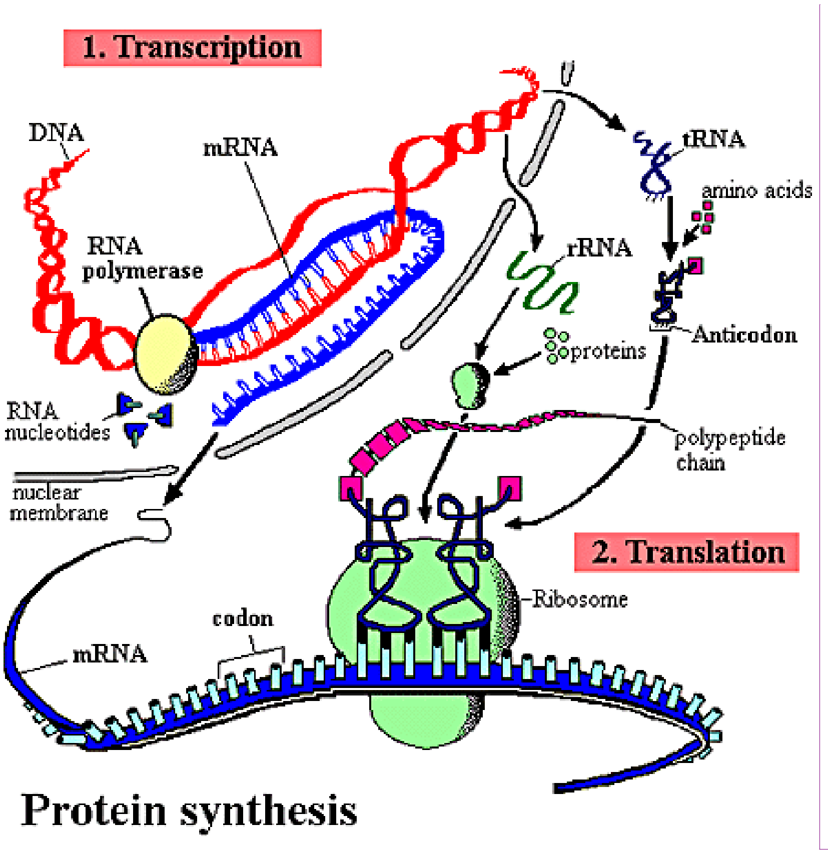
Gene Expression

Gene expression involves coded information on the DNA strand (gene) being synthesised into a functional gene product, usually protein. It involves the process of protein synthesis in which DNA → mRNA → polypeptide or protein. A specific gene on the DNA codes for a specific protein. Gene expression is used by all living organisms (eukaryotes, prokaryotes and possibly induced by viruses) to produce the macromolecules used for life!



http://www.accessexcellence.org/RC/VL/GG/protein_synthesis.php

1. Transcription- copies DNA to make mRNA
Eukaryote

Basic
In the nucleus the DNA molecule is unwind by an enzyme, exposing the nucleotides on the DNA strand. Another enzyme binds to the promotor region on the template strand. Transcription factors which are attached to an enhancer sequence upstream from the gene being transcribed join to the enzyme on the promotor sequence. This starts transcription of the gene. Free nucleotides match with their corresponding nucleotide on the template strand and the mRNA molecule is formed. The free nucleotides follow the base pairing rule of G-C and A-T however, on the mRNA strand T is replaced with U. RNA polymerase transcribes the gene until the termination sequence.

The following information relates to;

Achievement Objective

Evolution LW 7-3: Understand that DNA and the environment interact in gene expression.

and

Achievement Standard 901159: Level 2 Demonstrate understanding of gene expression

Comment [s1]: Have a diagram of protein synthesis and people can click on heading for explanations of the different stages.

Extension
In the nucleus the DNA molecule is unwind by the enzyme helicase, exposing the nucleotides on the DNA strand. The enzyme RNA polymerase binds to the promotor region on the template strand. However, RNA polymerase alone cannot start transcription of the gene. Transcription factors must also bind to the promotor region. Transcription factors are attached to an enhancer sequence which is upstream from the gene being transcribed. Transcription is activated when the transcription factors bind to the RNA polymerase. This is achieved by the enhancer sequence looping (hairpin loop) round so the transcription factors can join to the RNA polymerase. The RNA polymerase and transcription factors are now called the transcription initiation complex. The formation of a mRNA molecule starts. Free nucleotides are complementary and match with their corresponding nucleotide on the template strand and as the transcription initiation complex moves down the template strand it joins the bonds of the mRNA backbone. The free nucleotides follow the base pairing rule of G-C and A-T however, on the mRNA strand T is replaced with U. This enables the mRNA strand (copy of gene) to leave the nucleus while the 'master' DNA remains within the nucleus. RNA polymerase transcribes the gene until the termination sequence.
It is thought a range of transcription factors and enhancer sequences selectively express specific genes at different stages of the cells development. (example here of research)

Prokaryote – add picture
Prokaryotes do not have a nucleus therefore the DNA is found in the cytoplasm and all stages of protein synthesis occur in the cytoplasm. As in Eukaryotes the DNA molecule is unwind by an enzyme exposing the nucleotide bases. For transcription to begin RNA polymerase must also bind to a promotor region on the DNA. However, an active repressor molecule binds to an operator region preventing the RNA polymerase transcribing the gene. This active repressor is created by a regulatory gene which is upstream from the structural genes (operon). Genes are 'switched on' by an inducer. This inducer molecule binds to the active repressor changing its shape and making it no longer viable to bind to the operator region and prevent the RNA polymerase from transcribing the gene. With no active repressor in the way the RNA polymerase can now start adding free nucleotides constructing a mRNA molecule as in eukaryotes.

(Extension – Spicing/ mRNA processing)
The mRNA has sections that do not code for functional proteins. These sections are called introns and are removed through the process of splicing before the mRNA leaves the nucleus.

Eukaryote & Prokaryotes
2. Translation- mRNA molecule is made into a polypeptide chain.
The mRNA molecule leaves the nucleus via a nuclear pore and attaches to a ribosome in the cytoplasm. The ribosome is the site of translation. The mRNA moves through the ribosome and codons on the mRNA are translated via tRNA into a chain of amino acids. tRNA is made up of an anticodon and amino acid. Codon/anti codons are specific to amino

acids. The anticodon on the tRNA matchs up with the complementary codon on the mRNA in the ribosome. The amino acid is ‘dropped off’ and a peptide bond forms between amino acids. The anticondon then goes back into the cytoplasm to attach to a specific amino acid and match up with another complementary codon. This process continues until the mRNA molecule is translated. The final order of amino acids (primary protein structure) is not random but determined by the genetic code on the original DNA sequence. A specific gene codes for a specific protein.

3. Formation of a protein

The final order of the amino acid sequence affects the folding of the final protein. Amino acids interact together forming bonds between amino acids and causing the polypepetide chain to coil and fold. A folded amino acid chain may join with another amino acid chain to form the final functional protein.

Extension

The final order of the amino acid sequence affects the folding of the final protein. Amino acids interact together forming bonds (such as hydrogen bonds, disulphide bridges and ionic bonds) and causing folding. Hydrophobic and hydrophilic regions within the protein also cause coiling and folding.

References

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