Biology 3/4 (1)

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UNIT 3

Area of Study 1

💡 **The relationship between nucleic acids and proteins**

Gene - a section of DNA (nucleotide sequence) that codes for a specific protein

- types of genes:
  - structural → code for protein products that become part of the structure and functioning of the organism
  - regulatory → code for proteins that control the action of other genes. Determines whether gene is active or not and if active the rate of protein synthesis. Prevent the over or under expression of a particular protein.

Allele - variation of a gene due to differences in the sequence of bases

Genome - full set of genes within a cell (same for all cells within an organism)

Proteome - complete set of proteins found in a cell/organism

Nucleic Acids → PONCH

- contain the elements carbon, hydrogen & oxygen, nitrogen, phosphorous

STRUCTURE: pentose sugar, phosphate group, nitrogenous base

DNA:

- Definition → a double-stranded nucleic acid chain made up of nucleotides. DNA carries the instructions for proteins which are required for cell and organism survival

Is wound in a 3D double helix held in place by large proteins - histones

hydrogen bonds = joins the nitrogenous bases → WEAK BONDS

*phosphodiester bond*s = strong bonds formed by the phosphate group joining the 3′ carbon sugar of one nucleotide to the 5′ carbon of the next. Forms the backbone of DNA → STRONG BONDS

DNA is negative because.... phosphate isn't bound on the 5′ ends

RNA:

- Definition → a single-stranded nucleic acid chain made up of nucleotides. Includes mRNA, rRNA, and tRNA
  - While RNA serves many different functions within cells, it is primarily involved in the synthesis of proteins. There are several different types of RNA, including...`

Is a single stranded molecule (no base pairing)

Types of RNA (3 main types exist in cells of eukaryotic organisms)...

Messenger RNA (mRNA) - produced in the nucleus in the transcription of DNA and a single linear chain moves out to the cytosol through the nuclear membrane pores, carrying genetic information from the nucleus to the ribosomes for protein synthesis (formation of a polypeptide chain).

Transfer RNA (tRNA) - a folded chain of nucleotides (clover shape), located in the cytosol, involved in transferring specific amino acids to the ribosome after recognising specific nucleotide sequences on the mRNA, complementary to its own anticodon.

Ribosomal RNA (rRNA) - main structural component of the ribosome within cells.

Comparing differences of DNA and RNA

	DNA	RNA
structure	double stranded, double helix	single stranded
5C sugar	deoxyribose	ribose
nitrogenous bases	A,G,T,C	A,G,U,C

SIMILARITIES: they both have a negatively charged phosphate group

The genetic code

- the DNA gene code needs to be transported from the nucleus to the ribosomes for decoding to form the specific protein → messenger RNA (mRNA) and transfer RNA (tRNA) are involved

The triplet code of DNA:

-the conversion of a gene into a protein is based on a 3 base triplet code in the DNA.

-each amino acid is coded for by a 3 base sequence / 3 nucleotides

The universal nature of DNA:

-a particular triplet/codon codes for the same amino acid in nearly ALL living ORGANISMS

- eg; TTT codes for lysine

Unambiguous nature of DNA:

-each triplet/codon is only capable of coding for one specific amino acid

-eg; UUA only codes for 'leucine'

Redundancy (degeneracy) of the genetic code:

-there are 64 different triplet combinations (4×4×4) but only 20 amino acids meaning for some amino acids there is more than one triplet code

-for most amino acids there is more than one triplet code

***tryptophan has only one triplet code (ACC)

- this allows for mutations (mistakes) in transcription without necessarily altering the amino acid - unless the first base is altered

Codon table:

trp and met are the only 2 amino acids which are not redundant/degenerate and are coded for by only 1 codon sequence.

Gene expression - protein synthesis:

Start triplet = TAC → codon = AUG

Gene sequence (DNA triplet code) —transcription(3'to5')→ pre-mRNA (codons) —RNA processing→ mRNA —translation→ protein (amino acid sequence)

Transcription: *occurs in the nucleus of eukaryotic cells*

- the gene unwinds and unzips and weak hydrogen bonds break between the bases
- RNA polymerase binds to the promotor region of the gene
- the template strand of the DNA gene is copied into a single stand of complementary nucleotide codons forming pre-mRNA
- the copying/reading of the strand occurs from the 3′ to 5′ end of the template strand as pre-mRNA is formed from the 5′ to 3′ direction
- copying continues until a stop triplet is reached at the terminator end of the gene

RNA processing in eukaryotic cells / post-transcriptional modifications: occurs in nucleus

pre-mRNA to mRNA

-pre-mRNA must be modified before the mRNA (mature) molecule leaves the nucleus

1. introns (non-coding regions of mRNA) undergo transcription but not translation so are removed by enzymes called spliceosomes. This is called digestion of the pre-mRNA.
2. exons (coding regions or mRNA) are both transcribed and translated (coding for amino acids). They are therefore joined/spliced together using the enzyme RNA ligase. This forms mature mRNA.
3. a methylated cap is added to the 5′ end (AUG) and a poly-A tail (AAAAA) is added to the 3′ end of the mature mRNA.

***these additions....

→ protect/stabilise the mRNA from damage

→ enable the ribosome to recognise the head and tail of the mRNA so it will read it from the correct end.

ALTERNATIVE SPLICING...

- the process where different exons may be spliced together in a different order resulting in a single gene producing multiple different mRNA strands - hence different proteins
  - introns may be retained
  - order of joining exons / introns may differ

Translation by ribosomes

involves the decoding of the mRNA molecules to form the specific protein

→ the correct amino acids must be attached in the correct order

- after the mRNA has been modified it moves out of the nucleus via the nuclear membrane pores
- the mRNA attaches to a ribosome which reads each codon (starting 5′ / methyl cap end)
- transfer RNA (tRNA) with the correct anticodon, carries the specific amino acid to the ribosome
- an anticodon (3 bases) on the end of the tRNA is specific for the amino acid it carries and attaches to the corresponding codon of mRNA and the amino acid is released.
- the released amino acid is joined to the previous ones by peptide bonds, forming the specific polypeptide chain (primary structure) coded for by the original DNA gene sequence
- when the ribosome reaches the stop codon, the mRNA and the completed polypeptide chain are released
- the protein will then be folded into its functional form in the ER and golgi

Structure of genes

Sections of a gene...

- promoter / upstream region
- coding region (structural section of gene that codes for protein and is copied into complementary mRNA in transcription
- terminator / downstream region

Introns: sections within the coding region that DO NOT code for amino acids

- they are copied in transcription
- they are removed from the mRNA and NOT translated by ribosomes

Exons: sections within the coding region that code for amino acids (polypeptide formation)

- they are copied in transcription
- they are translated into the polypeptide

Promoter region:

-binding site for RNA polymerase **for transcription**

-promoter sequences control start of protein synthesis

-if sequence altered, may cause change in gene activity