NOTES: DNA REPLICATION & PROTEIN SYNTHESIS

<u>Genetic information (DNA) determines structure of proteins</u>

DNA → RNA → proteins → cell structure
→ enzymes control cell chemistry (metabolism)

Proteins - made of monomers called amino acids
- polypeptide chain - many different proteins
- each with unique shape and unique function
- 20 different amino acids

Proteins have many functions – proteins determine structure and function of organisms :
-enzymes
- regulate and speed up chemical reactions
- very specific (one enzyme for each reaction)
- structural proteins
- contractile proteins
- antibodies, hormones
- transport proteins
- plasma membrane proteins (receptors, channels, markers, attachment)
- transcription factors (regulate gene expression)

Protein Synthesis

The genetic code (DNA) is a code to build proteins; DNA determines the amino acid sequence in a protein.

Chromosome - one very long DNA molecule with supporting (histone) proteins
Gene - a section of the DNA molecule that **codes for one polypeptide chain**.
A single chromosome contains thousands of genes.
Locus - the particular location on a chromosome where a gene is located
Allele – different forms of a gene due to mutations

Nucleic Acids

2 types of nucleic acids : Ribonucleic Acid (**RNA**) and Deoxyribonucleic Acid (**DNA**)

DNA and RNA are polymers made of nucleotides

Each nucleotide is made of:

- a **sugar** (ribose in RNA, deoxyribose in DNA)
- a **phosphate** (same in RNA and DNA)
- a **nitrogen base**:
    - adenine, guanine, cytosine and *thymine* in **DNA**
    - adenine, guanine, cytosine and *uracil* in **RNA**

(adenine and guanine are *double* Carbon-Nitrogen ring molecules; **purines**)

(cytosine, thymine and uracil are *single* C-N rings; **pyrimidines**)

DNA is a polymer of a long chain of sugars & phosphates "the backbone" with nitrogen bases "the rungs" of the DNA structure.

- nucleotides can link in any sequence
- sequence of nitrogen basis is information, **"the code"**
- sequence of nucleotides has a 3' and a 5' end
- nucleotides can only be added at the 3' (" 3 prime")

RNA is a *single* chain of nucleotides

DNA is a *double* chain of nucleotides cross-linked by nitrogen bases ("**double helix**" or "twisted ladder")

-nitrogen bases always link a certain way: -

DNA Base Pairing	**RNA Base Pairing**
adenine to thymine and	adenine to uracil
guanine to cytosine	guanine to cytosine

- *nitrogen bases link by weak hydrogen bonds.*

- each sugar-phosphate has 3' and 5' ends – the two stands of nucleotides are antiparallel (opposite ends). The strands of nucleotides run in opposite directions to each other.

DNA Replication: forming duplicate copies of DNA

- complex series of reactions directed by enzymes to uncoil helix, break hydrogen bonds between base pairs, join new nucleotides
- possible because nitrogen bases are complementary

Guanine ↔ Cytosine Adenine ↔ Thymine

Questions to consider:

*Why is DNA important to living organisms?

*Why is DNA replication important?

- new polymer 5' → 3' (new nucleotides added at 3' end)
- "bubbles" form as DNA is replicated

STEPS of DNA Replication:

1. DNA helix unwinds into "ladder" shape.
2. DNA unzips between bases and forms two complimentary strands.
3. Free nucleotides attach to appropriate base pairs of original strands
4. Two new identical strands are formed.

The genetic code (DNA):

Translation converts the chemical language of DNA into chemical language of proteins

- a plan to describe amino acid sequence in proteins
- 4 nucleotide types (nitrogen bases) in DNA - therefore 4 letter alphabet
- 20 different amino acids make up all proteins - therefore 20 things for DNA to describe

If 1 nitrogen base coded for 1 amino acid – 4 possible (4 different nucleotides possible)

If 2 nitrogen bases coded for 1 amino acid – 16 possible (4 x 4 = 16)

If 3 nitrogen bases coded for 1 amino acid – 64 possible (4 x 4 x 4 = 64)

- 3 nucleotides in sequence code for 1 amino acid (= codon or triplet code)
- 64 possible codons - 20 amino acids, therefore several codons code for the same amino acid.
- DNA code is redundant but not ambiguous
- no punctuation between codons – depends on starting point

  A T C G C C T A G C A A C T G C T T

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Start and stop codons on mRNA:

Start Codon	**AUG = "start here" Adenine Uracil Guanine**
Stop Codons	**UAG, UAA, UGA = "stop" (5' → 3')**

- DNA and RNA constructed and translated 5'→3'
- **codons are universal; they code for the same amino acid in all living organisms;**
- Because the code is the same in all organisms scientists can make "Recombinant DNA", which is an artificially made DNA strand that is formed by the combination of genes from two or more organisms.

DNA → mRNA → Protein

↑ ↑

transcription translation

(note: the transcription process comes before translation process; transcription has a "C" in it and "C" comes before "L" in the alphabet)

Transcription

DNA → mRNA

- messenger RNA (mRNA) is created from DNA
- mRNA is formed/transcribed in the nucleus
- translation occurs in ribosomes out in the cytoplasm
- complementary RNA nucleotides are assembled along DNA by RNA polymerase
- RNA polymerase attaches at promoter and releases at terminator
- the mRNA is modified (portions mRNA are deleted, introns) before it (mRNA with exons) leaves the nucleus

STEPS of Transcription:

1. Inside the nucleus a small portion of the DNA separates.
2. Free RNA nucleotides attach to appropriate base pairs on the DNA template.
3. mRNA is formed
4. mRNA detaches from the DNA
5. mRNA leaves the nucleus to go out into the cytoplasm

Translation (Translating mRNA into the language of amino acids)

- The translation process in protein synthesis occurs in ribosomes (rRNA) in the cytoplasm of the cell using mRNA as a template
- Transfer RNA (tRNA) carries amino acid molecules to the ribosomes (rRNA) to be assembled into protein by matching to the code on the mRNA.

Steps in protein synthesis:

- begins at the 5' end of mRNA
- translation begins at first "start" codon (AUG) on mRNA
- the tRNA molecule, in the cytoplasm, carries an amino acid with the anticodon code to the active site in the ribosome which matches to the codon code of mRNA. Once matched, the amino acid is bonded to an amino acid chain and released from tRNA
- translation proceeds one codon at a time until a "stop" codon (UAA, UAG, or UGA) is reached on the mRNA

STEPS of Translation (forming a protein)**:**

1. Once in the cytoplasm mRNA travels to a ribosome (rRNA).
2. At the ribosome the codon of mRNA pairs with the anti-codon of tRNA
3. tRNA translates each anti-codon into one amino acid
4. Once amino acids are combined the codon and anti-codon are released from the amino acid chain.
5. A chain of amino acids will then form a protein.

Compare & Contrast DNA & RNA

DNA Only	Both DNA & RNA	RNA Only
Contains Thymine	Is called a nucleic acid	Has more than one type
Contains two strands of nucleotides	Contains a genetic code	Found outside of the nucleus
Pairs A-T, T-A, G-C & C-G	Found in the nucleus	Contains Uracil
	Contains Adenine, Guanine and Cytosine.	Contains one strand of nucleotides
		Pairs A – U, T – A, G – C & C-G