Name: _____ Circle Hour: 1 2 3 4

Chapter 16 & 17: The Molecular Basis of Inheritance: DNA

Ch 16 Sect 1

I. **History of DNA** – Once Mendel discovered the basic laws of heredity and T.H. Morgan's work with fruit flies showed that genes were on chromosomes….scientists were determined to discover what a chromosome was made of…what actually HELD the genetic information?

A. 1928 – Frederick Griffith experiments with MICE and pneumonia causing bacteria

1. Discovered **transformation** –

2. 1944 – Oswald Avery determined that the "transforming factor" was _____

B. 1952 – Alfred Hershey and Martha Chase "blender" experiments with bacteriophages

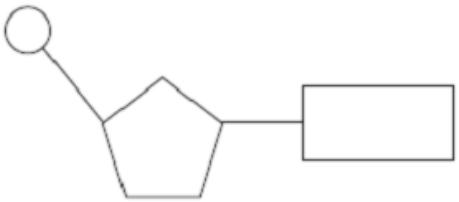
1. What material was injected by viruses into bacteria? _____

C. Erwin Chargaff's base pairing rules are:

D. Rosalind Franklin (X-ray diffraction) picture led Watson and Crick to discover DNA was a **double helix**.

II. (3.3.1) **DNA** is a polymer of **nucleotide** monomers

A. Label the nucleotide including numbered carbons:

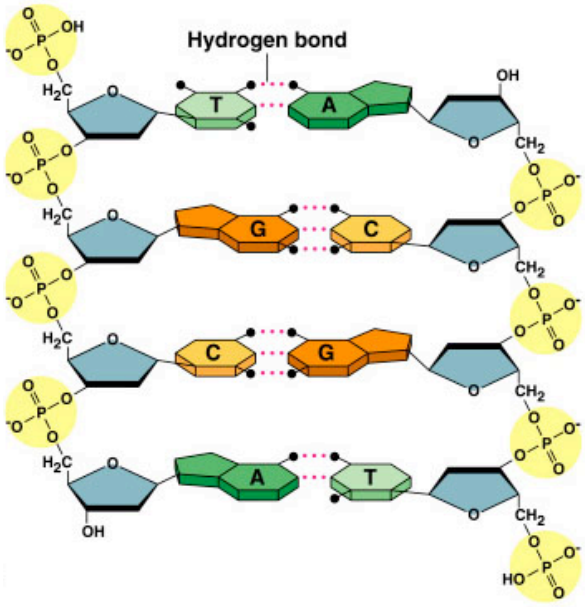


B. (3.3.2) Four nitrogenous bases:

Purines:

Pyrimidines:

C. (3.3.4) **Rules** of base pairing:



D. (3.3.3 & 3.3.5) Outline how DNA nucleotides are linked by covalent bonds (sugar/phosphate backbone) and by base pairing with hydrogen bonds

(7.1.1) Identify 3' to 5' linkages

NEED TO BE ABLE TO DRAW SIMPLE DNA

Ch 16 Sect 2

III. **DNA Replication** – when does this occur?

A. (3.4.3) DNA replication is **semi-conservative**

B. (7.2.3) DNA replication of eukaryotic chromosome occurs in **many** sites at once…each called **origins of replication**

C. At each end of the replication bubble there is a **replication fork** (Y-shaped region where DNA is being unwound). (3.4.1 & 7.2.2) Explain the role of the following enzymes:

1. **Helicase -**

2. **RNA primase -**

3. **DNA polymerases –**

1. Use **deoxynucleoside triphosphates**

2. 7.2.1 Adds nucleotides to the 3' end ONLY so the NEW strand elongates only in the **5' to 3' direction** and uses **complimentary base pairing** (3.4.2)

3. Leading strand

4. Lagging strand

Okazaki fragments

4. **DNA ligase -**

Ch 16 Sect 3

IV. **Chromosome Structure**

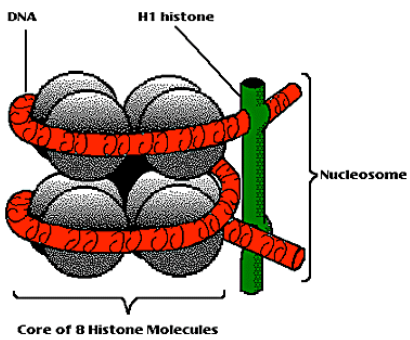
A. (4.1.1) Eukaryotic chromosomes are made up of DNA with protein

B. (7.1.2) What is a **nucleosome**?

(7.1.3) Functions of nucleosomes:

a. Help to supercoil the DNA to form chromosomes during cell division

b. Help regulate transcription (more to come later)



Nucleosome

Ch 17 Sect 1

V. (3.5.1) **RNA vs. DNA**

A. Sugar:

B. # of strands:

C. Nitrogenous bases:

VI. **Transcription & Translation Basics** – occurs in ALL organisms all the time!

A. **Transcription** -

1. Where does transcription occur?

2. Messenger RNA (mRNA)

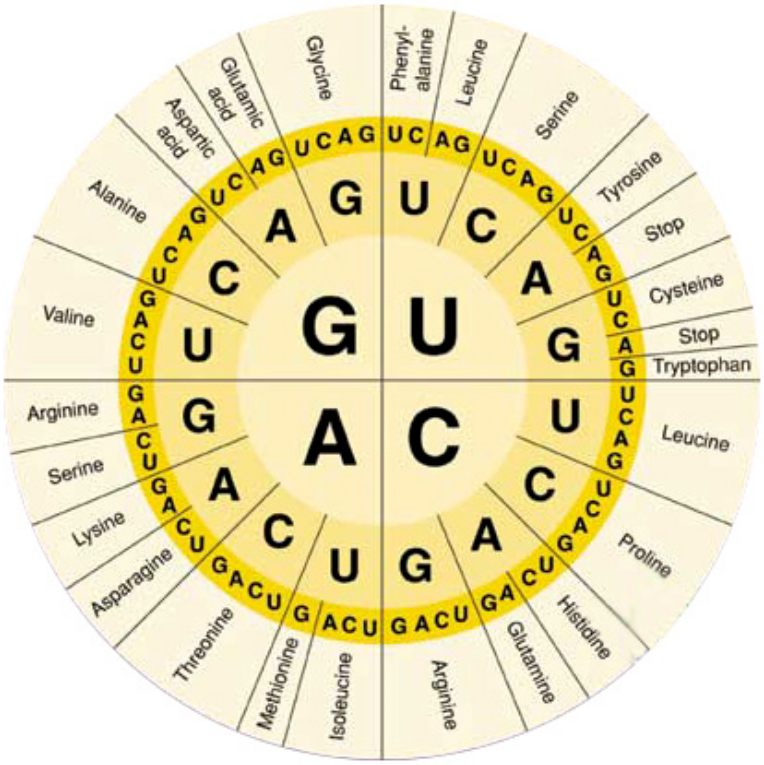
B. **Translation** –

1. Where does translation occur?

C. **Genetic Code**

(3.5.3) What are **codons**?

(7.3.2) **Sense strand** (nontemplate strand) of DNA has the SAME sequence as mRNA (except Us are in mRNA vs. Ts). The **nonsense** (template strand) is used to transcribe the mRNA.



Ch 17 Sect. 2

VII. **Transcription** – a closer look

(3.5.2 & 7.3.3) What is the role of the following:

1. **Promoter region** (TATA box) –

2. **RNA polymerase** –

   (7.3.1) Adds RNA nucleotides to the 3' end ONLY so the RNA elongates only in the **5' to 3' direction** and uses **complimentary base pairing**…C with G, A with U

3. **Terminator** -

VIII. **RNA Processing**

A. What is added to the 5' end?

B. What is added to the 3' end?

C. (7.1.5 & 7.3.4) Eukaryotic genes contain Introns & Exons

Ch 17 Sect. 4

IV. **Translation** – a closer look (3.5.4)

A. (3.5.4 & 7.4.1) **Transfer RNA (tRNA)** structure and function

1. What is tRNA's function?

2. What is the nucleotide triplet held on tRNA called? _____

3. **Aminoacyl-tRNA syntetases** –

4. What is the purpose of the CCA sequence at the 3' end of tRNA?

C. (7.4.2) Structure of the ribosome:

1. 2 subunits made up of **ribosomal RNA (rRNA)** and proteins

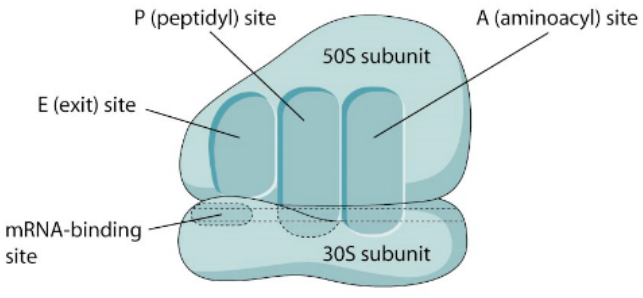
2. Binding sites for tRNA:

   a. P site –

   b. A site –

   c. E site –

   d. Also has binding site for mRNA



3. (7.4.3) Three stages of transcription

   a. **Initiation** –

   b. **Elongation** –

   c. **Termination** –

4. (7.4.4) Translation occurs in the **5' to 3' direction**

5. (7.4.6) What is a **polyribosome**?

6. (7.4.7) Ribosomes that are FREE typically produce proteins for use IN the cell. Ribosomes attached to Rough ER typically produce proteins for export from the cell.

7. (7.4.5) **Do you remember how to draw 2 amino acids LINKED by a peptide bond?**

Ch 17 Sect 5

X. (4.1.2) Define the following:

A. **Gene**

B. **Allele**

C. **Genome**

(7.1.4) 5-45% of the genome is "satellite DNA" highly repetitive sequences that have no apparent function…used for DNA fingerprinting

XII. (4.1.3) Define **gene mutation**

A. Substitution mutations

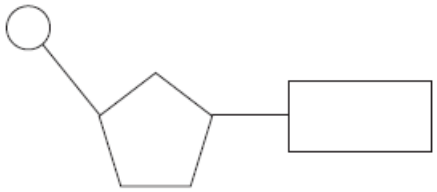
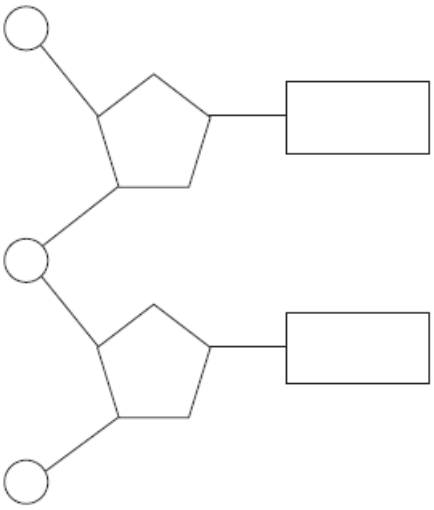
(4.1.4) Sickle Cell Disease Mutation

B. Frameshift mutations

XIII. (3.5.5) "One Gene One Polypeptide"

3.3 DNA structure

1 hour

	Assessment statement	Obj	Teacher's notes
3.3.1	Outline DNA nucleotide structure in terms of sugar (deoxyribose), base and phosphate.	2	Chemical formulas and the purine/pyrimidine subdivision are not required. Simple shapes can be used to represent the component parts. Only the relative positions are required. 
3.3.2	State the names of the four bases in DNA.	1	
3.3.3	Outline how DNA nucleotides are linked together by covalent bonds into a single strand.	2	Only the relative positions are required. 

	Assessment statement	Obj	Teacher's notes
3.3.4	Explain how a DNA double helix is formed using complementary base pairing and hydrogen bonds.	3	
3.3.5	Draw and label a simple diagram of the molecular structure of DNA.	1	An extension of the diagram in 3.3.3 is sufficient to show the complementary base pairs of A–T and G–C, held together by hydrogen bonds and the sugar–phosphate backbones. The number of hydrogen bonds between pairs and details of purine/pyrimidines are not required. **TOK:** The story of the elucidation of the structure of DNA illustrates that cooperation and collaboration among scientists exists alongside competition between research groups. To what extent was Watson and Crick's "discovery" of the three-dimensional structure of DNA dependent on the use of data generated by Rosalind Franklin, which was shared without her knowledge or consent?

3.4 DNA replication

1 hour

	Assessment statement	Obj	Teacher's notes
3.4.1	Explain DNA replication in terms of unwinding the double helix and separation of the strands by helicase, followed by formation of the new complementary strands by DNA polymerase.	3	It is not necessary to mention that there is more than one DNA polymerase.
3.4.2	Explain the significance of complementary base pairing in the conservation of the base sequence of DNA.	3	
3.4.3	State that DNA replication is semi-conservative.	1	

3.5 Transcription and translation

2 hours

	Assessment statement	Obj	Teacher's notes
3.5.1	Compare the structure of RNA and DNA.	3	Limit this to the names of sugars, bases and the number of strands.
3.5.2	Outline DNA transcription in terms of the formation of an RNA strand complementary to the DNA strand by RNA polymerase.	2	
3.5.3	Describe the genetic code in terms of codons composed of triplets of bases.	2	
3.5.4	Explain the process of translation, leading to polypeptide formation.	3	Include the roles of messenger RNA (mRNA), transfer RNA (tRNA), codons, anticodons, ribosomes and amino acids.

	Assessment statement	Obj	Teacher's notes
3.5.5	Discuss the relationship between one gene and one polypeptide.	3	Originally, it was assumed that one gene would invariably code for one polypeptide, but many exceptions have been discovered. **TOK:** The way in which theories are modified as related evidence accumulates could be discussed, and whether contrary evidence should cause a theory to be discarded immediately if there are exceptions to it. Where a theory is suddenly and totally abandoned, to be replaced by a different theory, this is known as a paradigm shift.

4.1 Chromosomes, genes, alleles and mutations

2 hours

	Assessment statement	Obj	Teacher's notes
4.1.1	State that eukaryote chromosomes are made of DNA and proteins.	1	The names of the proteins (histones) are not required, nor is the structural relationship between DNA and the proteins.
4.1.2	Define *gene*, *allele* and *genome*.	1	Gene: a heritable factor that controls a specific characteristic. (The differences between structural genes, regulator genes and genes coding for tRNA and rRNA are not expected at SL). Allele: one specific form of a gene, differing from other alleles by one or a few bases only and occupying the same gene locus as other alleles of the gene. Genome: the whole of the genetic information of an organism.
4.1.3	Define *gene mutation*.	1	The terms point mutation or frameshift mutation will not be used.

	Assessment statement	Obj	Teacher's notes
4.1.4	Explain the consequence of a base substitution mutation in relation to the processes of transcription and translation, using the example of sickle-cell anemia.	3	GAG has mutated to GTG causing glutamic acid to be replaced by valine, and hence sickle-cell anemia. **Aim 8:** There is a variety of social issues associated with sickle-cell anemia, including the suffering due to anemia, personal feelings if one has either inherited or passed on the sickle-cell allele, questions relating to the desirability of genetic screening for the sickle-cell allele before having children, and the genetic counselling of carriers of the allele. There are also ethical issues relating to screening of fetuses and abortion of those found to have a genetic disease. **TOK:** Where a correlation is found, a causal link may or may not be present. The frequency of the sickle-cell allele is correlated with the prevalence of malaria in many parts of the world. In this case, there is a clear causal link. Other cases where there is no causal link could be described as a contrast. There has clearly been natural selection in favour of the sickle-cell allele in malarial areas, despite it causing severe anemia in the homozygous condition. Natural selection has led to particular frequencies of the sickle-cell and the normal hemoglobin alleles, to balance the twin risks of anemia and malaria.

7.1 DNA structure

2 hours

	Assessment statement	Obj	Teacher's notes
7.1.1	Describe the structure of DNA, including the antiparallel strands, 3′–5′ linkages and hydrogen bonding between purines and pyrimidines.	2	Major and minor grooves, direction of the "twist", alternative B and Z forms, and details of the dimensions are not required.
7.1.2	Outline the structure of nucleosomes.	2	Limit this to the fact that a nucleosome consists of DNA wrapped around eight histone proteins and held together by another histone protein.
7.1.3	State that nucleosomes help to supercoil chromosomes and help to regulate transcription.	1	
7.1.4	Distinguish between *unique or single-copy genes* and *highly repetitive sequences* in nuclear DNA.	2	Highly repetitive sequences (satellite DNA) constitutes 5–45% of the genome. The sequences are typically between 5 and 300 base pairs per repeat, and may be duplicated as many as 10^5 times per genome. **TOK:** Highly repetitive sequences were once classified as "junk DNA", showing a degree of confidence that it had no role. This addresses the question: To what extent do the labels and categories used in the pursuit of knowledge affect the knowledge we obtain?
7.1.5	State that eukaryotic genes can contain exons and introns.	1	

7.2 DNA replication

2 hours

	Assessment statement	Obj	Teacher's notes
7.2.1	State that DNA replication occurs in a 5′ → 3′ direction.	1	The 5′ end of the free DNA nucleotide is added to the 3′ end of the chain of nucleotides that is already synthesized.
7.2.2	Explain the process of DNA replication in prokaryotes, including the role of enzymes (helicase, DNA polymerase, RNA primase and DNA ligase), Okazaki fragments and deoxynucleoside triphosphates.	3	The explanation of Okazaki fragments in relation to the direction of DNA polymerase III action is required. DNA polymerase III adds nucleotides in the 5′ → 3′ direction. DNA polymerase I excises the RNA primers and replaces them with DNA.
7.2.3	State that DNA replication is initiated at many points in eukaryotic chromosomes.	1	

7.3 Transcription

2 hours

	Assessment statement	Obj	Teacher's notes
7.3.1	State that transcription is carried out in a 5′→ 3′ direction.	1	The 5′ end of the free RNA nucleotide is added to the 3′ end of the RNA molecule that is already synthesized.
7.3.2	Distinguish between the *sense* and *antisense* strands of DNA.	2	The sense strand (coding strand) has the same base sequence as mRNA with uracil instead of thymine. The antisense (template) strand is transcribed.
7.3.3	Explain the process of transcription in prokaryotes, including the role of the promoter region, RNA polymerase, nucleoside triphosphates and the terminator.	3	The following details are not required: there is more than one type of RNA polymerase; features of the promoter region; the need for transcription protein factors for RNA polymerase binding; TATA boxes (and other repetitive sequences); and the exact sequence of the bases that act as terminators.
7.3.4	State that eukaryotic RNA needs the removal of introns to form mature mRNA.	1	Further details of the process of post-transcriptional modification of RNA are not required.

7.4 Translation

2 hours

	Assessment statement	Obj	Teacher's notes
7.4.1	Explain that each tRNA molecule is recognized by a tRNA-activating enzyme that binds a specific amino acid to the tRNA, using ATP for energy.	3	Each amino acid has a specific tRNA-activating enzyme (the name aminoacyl-tRNA synthetase is not required). The shape of tRNA and CCA at the 3′ end should be included.
7.4.2	Outline the structure of ribosomes, including protein and RNA composition, large and small subunits, three tRNA binding sites and mRNA binding sites.	2	
7.4.3	State that translation consists of initiation, elongation, translocation and termination.	1	
7.4.4	State that translation occurs in a 5′→ 3′ direction.	1	During translation, the ribosome moves along the mRNA towards the 3′ end. The start codon is nearer to the 5′ end.
7.4.5	Draw and label a diagram showing the structure of a peptide bond between two amino acids.	1	
7.4.6	Explain the process of translation, including ribosomes, polysomes, start codons and stop codons.	3	Use of methionine for initiation, details of the T factor and recall of actual stop codons are not required.
7.4.7	State that free ribosomes synthesize proteins for use primarily within the cell, and that bound ribosomes synthesize proteins primarily for secretion or for lysosomes.	1	