

Ib bio objectives 7.1- 7.4

[Science](#), [Genetics](#)



7. 1. 1 Describe the structure of DNA, including the antiparallel strands, 3'-5' linkages and hydrogen bonding between purines and pyrimidines. DNA is made up of two strands. At one end of each strand there is a phosphate group attached to the carbon atom number 5 of the deoxyribose (this indicates the 5' terminal) and at the other end of each strand is a hydroxyl group attached to the carbon atom number 3 of the deoxyribose (this indicates the 3' terminal). The strands run in opposite directions and so we say that they are antiparallel. One strand runs in a 5'-3' direction and the other runs in a 3'-5' direction. Adjacent nucleotides are attached together via a bond between the phosphate group of one nucleotide and the carbon atom number 3 of the deoxyribose of the other nucleotide. The bases of each strand link together via hydrogen bonds. Adenine and Guanine are purines as they have two rings in their molecular structure. Thymine and Cytosine are pyrimidines as they only have one ring in their molecular structure. A purine will link with a pyrimidine. Adenine and thymine link together by forming two hydrogen bonds while Guanine and cytosine link together by forming 3 hydrogen bonds.

7. 1. 2 Outline the structure of nucleosomes. Nucleosomes consist 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. Nucleosomes help to supercoil chromosomes and help regulate transcription.

7. 1. 4 Distinguish between unique or single-copy genes and highly repetitive sequences in nuclear DNA. Not all of the base sequences in DNA are translated. Highly repetitive base sequences are not translated. They consist of sequences of between 5 and 300 bases that may

be repeated up to 10 000 times. They constitute 5-45% of eukaryotic DNA. Single-copy genes or unique genes are translated and constitute a surprisingly small proportion of eukaryotic DNA.

7. 1. 5 State that eukaryotic genes can contain exons and introns. Eukaryotic genes can contain exons and introns.

7. 2. 1 State that DNA replication occurs in a 5'→3' direction. DNA replication occurs in a 5'→3' direction.

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 triphosphate. The first stage of DNA replication in prokaryotes is the uncoiling of the DNA double helix by the enzyme helicase. Helicase separates the DNA into two template strands. RNA primase then adds a short sequence of RNA to the template strands. This short sequence of RNA is a primer which allows DNA polymerase III to bind to the strands and start the replication process. Once this is done, DNA polymerase III adds nucleotides to each template strand in a 5'→3' direction. The nucleotides have 3 phosphate groups and are called deoxyribonucleoside triphosphates. Two of these phosphate groups break off during the replication process to release energy. Since the strands are anti-parallel (the two strands have their 5' end and 3' end in opposite sides) and replication can only occur in a 5'→3' direction, one of the strands will be replicated in the same direction as the replication fork and the other will be replicated in the opposite direction of the replication fork. This means that one of the strands is synthesised in a continuous manner (named the leading strand) while the other one is synthesised in fragments (named the lagging strand). The leading strand only needs one primer while the lagging strand needs quite a

few as it is formed in fragments. These fragments are called Okazaki fragments. DNA polymerase I will remove the RNA primers and replace these with DNA. The enzyme DNA ligase then joins the Okazaki fragments together to form a continuous strand.

7. 2. 3 State that DNA replication is initiated at many points in eukaryotic chromosomes. DNA replication is initiated at many points in eukaryotic chromosomes. Replication summary: 1. Helicase uncoils the DNA 2. RNA primase adds short sequences of RNA to both strands (the primer) 3. The primer allows DNA polymerase III to bind and start replication 4. DNA polymerase III adds nucleotides to each template strand in a 5'→3' direction 5. These nucleotides are initially deoxyribonucleoside triphosphates but they lose two phosphate groups during the replication process to release energy 6. One strand is replicated in a continuous manner in the same direction as the replication fork (leading strand) 7. The other strand is replicated in fragments (Okazaki fragments) in the opposite direction (lagging strand) 8. DNA polymerase I removes the RNA primers and replaces them with DNA 9. DNA ligase then joins the Okazaki fragments together to form a continuous strand

7. 3. 1 State that transcription is carried out in a 5'→3' direction. Transcription is carried out in a 5'→3' direction. 7. 3. 2 Distinguish between the sense and antisense strands of DNA. The antisense strand is the template DNA strand which is transcribed. The sense strand on the other hand is the DNA strand which has the same base sequence as the mRNA with thymine instead of uracil. 7. 3. 3 Explain the process of transcription in prokaryotes, including the role of the promoter region, RNA polymerase, nucleoside triphosphates and the terminator. mRNA is produced during transcription. In prokaryotes, RNA

polymerase recognises a specific sequence of DNA called the promoter. The promoter basically "tells" the RNA polymerase where to start the transcription process. Transcription is initiated with the binding of RNA polymerase to the promoter site. The RNA polymerase then uncoils the DNA and separates the two strands. One of the strands is used as the template strand for transcription. The RNA polymerase will then use free nucleoside triphosphates to build the mRNA in a 5' to 3' direction. These nucleoside triphosphates bond to their complementary base pairs on the template strand. As they bind they become nucleotides by losing two phosphate groups to release energy. Since RNA does not contain thymine, uracil pairs up with adenine instead. RNA polymerase forms covalent bonds between these nucleotides. It moves along the DNA to keep elongating the sequence of mRNA until it reaches a sequence of DNA called the terminator. This sequence of DNA "tells" the RNA polymerase to stop transcription. The RNA polymerase is then released from the DNA and the newly created mRNA separates from the template DNA strand. Finally, the DNA rewinds back to its original double helical structure.

7. 3. 4 State that eukaryotic RNA needs the removal of introns to form mature mRNA Eukaryotic RNA needs the removal of introns to form mature mRNA. | 7. 4. 1 Explain that each tRNA molecule is recognised by a tRNA-activating enzyme that binds a specific amino acid to the tRNA, using ATP for energy. There are many different types of tRNA and each tRNA is recognised by a tRNA-activating enzyme. This enzyme binds a specific amino acid to the tRNA by using ATP as an energy source. The tRNA molecule has a specific structure. It contains double stranded sections (due to base pairing via hydrogen bonds) and loops. It has an anticodon loop

which contains the anticodon and two other loops. The nucleotide sequence CCA is found at the 3' end of the tRNA and allows attachment for an amino acid. Each type of tRNA has slightly different chemical properties and three dimensional structure which allows the tRNA-activating enzyme to attach the correct amino acid to the 3' end of the tRNA. There are 20 different tRNA-activating enzymes as there are 20 different amino acids. Each enzyme will attach a specific amino acid to the tRNA which has the matching anticodon for that amino acid. When the amino acid binds to the tRNA molecule a high energy bond is created. The energy from this bond is used later on to bind the amino acids to the growing polypeptide chain during translation.

Summary: * Each tRNA activating enzyme recognises a specific tRNA molecule * The tRNA molecule is made up of double stranded sections and loops * At the 3' end of the tRNA there is the nucleotide sequence CCA to which the amino acid attaches to * The different chemical properties and three dimensional structure of each tRNA allows the tRNA-activating enzymes to recognise their specific tRNA * Each tRNA enzyme binds a specific amino acid to the tRNA molecule * The tRNA-activating enzyme will bind the amino acid to the tRNA with the matching anticodon * Energy from ATP is needed during this process

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. Ribosomes have a particular structure. They are made up of proteins and ribosomal RNA. They have two subunits, one large the other small. On the surface of the ribosome there are three sites to which tRNA can bind to. However not more than two tRNA molecules can bind to the ribosome at one time. Also there is a site on the

surface of the ribosome to which mRNA can bind to. 7. 4. 3 State that translation consists of initiation, elongation, translocation and termination. Translation consists of initiation, elongation, translocation and termination.

7. 4. 4 State that translation occurs in a 5'→3' direction. Translation occurs in a 5'→3' direction. 7. 4. 5 Draw and label a diagram showing the structure of a peptide bond between two amino acids. 7. 4. 6 Explain the process of translation, including ribosomes, polysomes, start codons and stop codons.

Translation occurs in the cytoplasm. It starts off with the tRNA containing the matching anticodon for the start codon AUG binding to the small subunit of the ribosome. This tRNA carries the amino acid methionine and is always the first tRNA to bind to the P site. The small subunit of the ribosome then binds to the 5' end of the mRNA. This is because translation occurs in a 5'→3' direction. The small subunit will move along the mRNA until it reaches the start codon AUG. The large subunit of the ribosome can then binds to the small subunit. The next tRNA with the matching anticodon to the second codon on the mRNA binds to the A site of small subunit of the ribosome. The amino acids on the two tRNA molecules then form a peptide bond. Once this is done, the large subunit of the ribosome moves forward over the smaller one. The smaller subunit moves forward to join the larger subunit and as it does so the ribosome moves 3 nucleotides along the mRNA and the first tRNA is moved to the E site to be released. The second tRNA is now at the P site so that another tRNA with the matching anticodon can then bind to the A site. As this process continues the polypeptide is elongated. Once the ribosome reaches the stop codon on the mRNA translation will end as no tRNA will have a matching anticodon to the stop codon. The polypeptide is

then released. Many ribosomes can translate the same mRNA at the same time. They will all move along the mRNA in a 5'→3' direction. These groups of ribosomes on a single mRNA are called polysomes. Summary: 1. The tRNA containing the matching anticodon to the start codon binds to P site of the small subunit of the ribosome 2. The small subunit binds to the 5' end of the mRNA and moves along in a 5'→3' direction until it reaches the start codon 3. The large subunit then binds to the smaller one 4. The next tRNA with the matching anticodon to the next codon on the mRNA binds to the A site 5. The amino acids on the two tRNA molecules form a peptide bond 6. The larger subunit moves forward over the smaller one 7. The smaller subunit rejoins the larger one, this moves the ribosome 3 nucleotides along the mRNA and moves the first tRNA to the E site to be released 8. The second tRNA is now at the P site so that another tRNA with the matching anticodon to the codon on the mRNA can bind to the A site 9. As this process continues, the polypeptide is elongated 10. Once the ribosome reaches the stop codon on the mRNA translation ends and the polypeptide is released 11. Many ribosomes can translate a single mRNA at the same time, these groups of ribosomes are called polysomes 7. 4. 7 State that free ribosomes synthesise proteins for use primarily within the cell, and that bound ribosomes synthesise proteins primarily for secretion or for lysosomes. Free ribosomes synthesise proteins for use primarily within the cell while bound ribosomes synthesise proteins primarily for secretion or for lysosomes. | | Translation summary: 1. RNA polymerase binds to the promoter region 2. This initiates transcription 3. RNA polymerase uncoils the DNA 4. Only one strand is used, the template strand 5. Free nucleoside triphosphates bond to

their complementary bases on the template strand 6. Adenine binds to uracil instead of thymine 7. As the nucleoside triphosphates bind they become nucleotides and release energy by losing two phosphate groups 8. The mRNA is built in a 5'→3' direction 9. RNA polymerase forms covalent bonds between the nucleotides and keeps moving along the DNA until it reaches the terminator 10. The terminator signals the RNA polymerase to stop transcription 11. RNA polymerase is released and mRNA separates from the DNA 12. The DNA rewinds