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| **8.1.U1** |

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| **7.1.U1** | **DNA structure suggested a mechanism for DNA replication.*** Outline the features of DNA structure that suggested a mechanism for DNA replication.
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| **7.1.U2** | **Nucleosomes help to supercoil the DNA.*** Draw and label the structure of a nucleosome, including the H1 protein, the octamer core proteins, linker DNA and two wraps of DNA.
* Explain the levels of supercoiling (DNA→ nucleosome → beads on a string → 30nm fiber →  unreplicated interphase chromosome → replicated metaphase chromosome).
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| **7.1.U3** | **DNA replication is continuous on the leading strand and discontinuous on the lagging strand.*** Compare replication on the the leading strand and the lagging strand of DNA.
* Explain why replication is different on the leading and lagging strands of DNA.
* Outline the formation of Okazaki fragments on the lagging strand.
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| **7.1.U4** | **DNA replication is carried out by a complex system of enzymes.*** Outline the role of the following proteins in DNA replications:  helicase, topoisomerase (AKA gyrase), single stranded binding proteins, primase, DNA polymerase III, DNA polymerase I, and DNA ligase.
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| **7.1.U5** | **DNA polymerases can only add nucleotides to the 3’ end of a primer.*** Explain the need for RNA primers in DNA replication.
* Explain what is meant by DNA replication occurring in a 5' to 3' direction.
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| **7.1.U6** | **Some regions of DNA do not code for proteins but have other important functions.*** Define “coding sequences” and “repetitive sequences” of DNA.
* Outline five functions of non-coding DNA sequences found in genomes, one of which must be the telomere.
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| **7.1.A1** | **Rosalind Franklin and Maurice Wilkins’ investigation of DNA structures by X-ray diffraction.*** Outline the process of X-ray diffraction.
* Outline the deductions about DNA structure made from the X-ray diffraction pattern.
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| **7.1.A2** | **Tandem repeats are used in DNA profiling.*** Define VNTR.
* Explain why VNTR are used in DNA profiling
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| **7.1.A3** | **Use of nucleotides containing dideoxyrubonucleic acid to stop DNA replication in preparation of samples for base sequencing.*** Outline the process of DNA sequencing, including the role of chain terminator nucleotides, fluorescence, and electrophoresis.
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| **7.1.S1** | **Analysis of results of the Hershey and Chase experiment providing evidence that DNA is the genetic material.*** State the experimental question being tested in the Hershey and Chase experiment.
* Explain the procedure of the Hershey and Chase experiment.
* Explain how the results of the Hershey and Chase experiment supported the notion of nucleic acids as the genetic material.
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| **7.1.S2** | **Utilization of molecular visualization software to analyze the association between protein and DNA profiling.*** Identify nucleosome structures using molecular visualization software.
* Outline the mechanism of histone-DNA association.
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| **7.1.****NOS** | **Making careful observations-Rosalind Franklin’s X-ray diffraction provided crucial evidence that DNA is a double helix.*** Describe Rosalind Franklin’s role in the elucidation of the structure of DNA.
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| **7.2.U1** | **Gene expression is regulated by proteins that bind to specific base sequences in DNA.*** Define gene expression.
* State two reasons why gene expression must be regulated.
* Outline the environmental regulation of the breakdown of lactose in E. coli.
* Outline the role of enhancers, silencers and promoter-proximal elements in regulation of gene expression.
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| **7.2.U2** | **The environment of a cell and of an organism has an impact on gene expression.*** Describe the use of twin studies to measure the impact of environment on gene expression.
* Outline two examples of environmental influence on gene expression.
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| **7.2.U3** | **Nucleosomes help to regulate transcription in eukaryotes.*** Outline the effect of methylation of nucleosome tails on rates of gene expression.
* Outline the effect of acetylation of nucleosome tails on rates of gene expression.
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| **7.2.U4** | **Transcription occurs in a 5’ to 3’ direction.*** Describe the initiation of transcription, including the role of the promoter, transcription factors, the TATA box and RNA polymerase.
* Describe elongation of transcription, including the role of nucleotide triphosphates and the direction of transcription.
* Describe termination of transcription, including the role of the terminator.
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| **7.2.U5** | **Eukaryotic cells modify mRNA after transcription.*** List two major differences in gene expression between prokaryotic cells and eukaryotic cells.
* Describe the three post-transcriptional modifications of pre-mRNA in eukaryotes.
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| **7.2.U6** | **Splicing of mRNA increases the number of different proteins an organism can produce.*** Describe the process of alternative RNA splicing.
* Outline an example of alternative splicing the results in different protein products.
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| **7.2.A1** | **The promoter as an example of non-coding DNA with a function.*** Outline the role of promoter DNA.
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| **7.2.S1** | **Analysis of changes in the DNA methylation patterns.*** State the effect of DNA methylation on gene expression.
* Compare methylation patterns in twins using superimposed images of dyed chromosomes.
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| **7.2.****NOS** | **Looking for patterns, trends and discrepancies- there is mounting evidence that the environment can trigger heritable changes in epigenetic factors.*** Define epigenetic and epigenome.
* List types of epigenetic tags.
* Discuss the role of reprogramming and imprinting on epigenetic factors.
 |
| **7.3.U1** | **Initiation of translation involves assembly of the components that carry out the process.*** Outline the process of translation initiation.
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| **7.3.U2** | **Synthesis of the polypeptide involves a repeated cycle of events.*** Outline the process of translation elongation, including codon recognition, bond formation and translocation.
* State the direction of movement of the ribosome along the mRNA molecule.
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| **7.3.U3** | **Disassembly of the components follows termination of translation.*** Outline the process of translation termination, including the role of the stop codon.
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| **7.3.U4** | **Free ribosomes synthesize proteins primarily for secretion or use in lysosomes.*** State the difference between free and bound ribosomes.
* List destinations of proteins synthesized on free ribosomes.
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| **7.3.U5** | **Bound ribosomes synthesize proteins for use primarily within the cell.*** List destinations of proteins synthesized on bound ribosomes.
* Outline how a ribosome becomes bound to the endoplasmic reticulum.
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| **7.3.U6** | **Translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane.*** Compare the timing and location of transcription and translation between prokaryotes and eukaryotes.
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| **7.3.U7** | **The sequence and number of amino acids in the polypeptide is the primary structure.*** Describe the primary structure of a protein, including the type of bonding involved.
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| **7.3.U8** | **The secondary structure is the formation of alpha helices and beta pleated sheets stabilized by hydrogen bonding.*** Describe the secondary structure of a protein, including the type of bonding involved.
* Identify the alpha-helix and beta-pleated sheet in images of protein structure.
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| **7.3.U9** | **The tertiary structure is the further folding of the polypeptide stabilized by interactions between R groups.*** Describe the tertiary structure of a protein, including the types of R group interactions involved.
* Explain how the chemical characteristics of R groups in the polypeptide chain affect protein folding.
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| **7.3.U10** | **The quaternary structure exists in proteins with more than one polypeptide chain.*** Outline the quaternary structure of protein folding.
* Describe the structure of a conjugated protein, including the  prosthetic group.
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| **7.3.A1** | **tRNA-activating enzymes illustrate enzyme-substrate specificity and the role of phosphorylation.*** State the role of the tRNA activating enzymes.
* Outline the process of attaching an amino acid to tRNA by the tRNA activating enzyme.
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| **7.3.S1** | **The use of molecular visualization software to analyze the structure of eukaryotic ribosomes and tRNA molecules.*** Describe the structure of the ribosomes, including the small and large subunits and the names and roles of the tRNA binding sites.
* Use molecular visualization software to view and identify the small and large subunit and tRNA binding sites of the ribosome.
* Outline the structure of tRNA molecules.
* Use molecular visualization software to view and identify the anticodon and amino acid binding site of a tRNA.
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| **7.3.S2** | **Identification of polysomes in electron micrographs of prokaryotes and eukaryotes.*** Outline the structure of a polysome.
* Identify the beginning of an mRNA strand in a micrograph of polysomes.
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| **7.3.****NOS** | **Developments in scientific research follow improvements in computing- the use of commuters has enabled scientists to make advances in bioinformatics applications such as locating genes within genomes and identifying conserved sequences.*** Define bioinformatics.
* Outline why computers are necessary for genome analysis.
* List seven species for which the entire genome has been sequenced.
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**Metabolic pathways consist of chains and cycles of enzyme-catalyzed reactions.*** Contrast metabolic chain reaction pathways with cyclical reaction pathways.
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| **8.1.U2** | **Enzymes lower the activation energy of the chemical reactions that they catalyze.*** Define activation energy.
* Explain the role of enzymes in lowering the activation energy of a reaction.
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| **8.1.U3** | **Enzyme inhibitors can be competitive or non-competitive**.* Define enzyme inhibitor.
* Contrast competitive and noncompetitive enzyme inhibition.
* Outline one example of a competitive enzyme inhibitor and one example of a noncompetitive enzyme inhibitor.
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| **8.1.U4** | **Metabolic pathways can be controlled by end-product inhibition.*** Describe allosteric regulation of enzyme activity.
* Outline the mechanism and benefit of end-product inhibition.
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| **8.1.A1** | **End-product inhibition of the pathway that converts threonine is isoleucine.*** Illustrate end-product inhibition of the threonine to isoleucine metabolic pathway.
* State the consequence of an increase in isoleucine concentration.
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| **8.1.A2** | **Use of databases to identify potential new anti-malarial drugs.*** Outline the reasons for development of new anti-malarial drugs.
* Explain the use of databases in identification of potential new anti-malarial drugs.
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| **8.1.S1** | **Distinguish different types of inhibition from graphs at specified substrate concentration.*** Explain why the rate of reaction with increasing substrate concentration is lower with a non-competitive inhibitor compared to a competitive inhibitor.
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| **8.1.S2** | **Calculating and plotting rates of reaction from raw experimental results.*** State two methods for determining the rate of enzyme controlled reactions.
* State the unit for enzyme reaction rate.
* Given data, calculate and graph the rate of an enzyme catalyzed reaction.
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| **8.1.****NOS** | **Developments in scientific research follow improvements in computing- developments in bioinformatics, such as the interrogation of databases have facilitated research into metabolic pathways.*** Outline the use and benefits of the bioinformatics technique of chemogenomics in development of new pharmaceutical drugs.
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| **6.6.U1** | **Cell respiration involves the oxidation and reduction of electron carriers.** |
| **8.2.U2** | **Phosphorylation of molecules makes them less stable.** |

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| **8.2.U3** | **In glycolysis, glucose is converted to pyruvate in the cytoplasm.** |
| **8.2.U4** | **Glycolysis gives a small net gain of ATP without the use of oxygen.** |

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| **8.2.U5** | **In aerobic cell respiration pyruvate is decarboxylated and oxidized, and converted into acetyl compound and attached to coenzyme A to form acetyl coenzyme A in the link reaction.** |
| **8.2.U6** | **In the Krebs cycle, the oxidation of acetyl groups is coupled to the reduction of hydrogen carriers, liberating carbon dioxide.** |

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| **8.2.U7** | **Energy released by oxidation reactions is carried to the cristae of the mitochondria by reduced NAD and FAD.** |
| **8.2.U8** | **Transfer of the electrons between carriers in the electron transport chain in the membrane of the cristae is coupled to proton pumping.** |

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| **8.2.U9** | **In chemiosmosis protons diffuse through ATP synthase to generate ATP.** |
| **8.2.U10** | **Oxygen is needed to bind with the free protons to maintain the hydrogen gradient, resulting in the formation of water.** |

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| **8.2.U11** | **The structure of the mitochondrion is adapted to the function it performs.** |
| **8.2.A1** | **Electron tomography used to produce images of active mitochondria.** |

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| **8.2.S1** | **Analysis of diagrams of the pathways of aerobic respiration to decide where decarboxylation and oxidation reactions occur.** |
| **8.2.S2** | **Annotations of a diagram of mitochondrion to indicate the adaptations to its function.** |

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| **8.2.****NOS** | **Paradigm shift-chemiosmotic theory led to a paradigm shift in the field of bioenergetics.** |
| **8.3.U1** | **Light-dependent reactions take place in the intermembrane space of the thylakoids.** |
| **8.3.U2** | **Light –independent reactions take place in the stroma.** |

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| **8.3.U3** | **Reduced NADP and ATP are produced in the light-dependent reactions.** |
| **8.3.U4** | **Absorption of light by photosystems generates excited electrons.** |

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| **8.3.U5** | **Photolysis of water generates electrons for use in the light-independent reactions.** |
| **8.3.U6** | **Transfer of excited electrons occurs between carriers in thylakoid membranes.** |

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| **8.3.U7** | **Excited electrons from Photosytem II are used to contribute to generate a proton gradient.** |
| **8.3.U8** | **ATP synthase in thylakoids generates ATP using the proton gradient.** |

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| **8.3.U9** | **Excited electrons from Photosytem I are used to reduce NADP.** |
| **8.3.U10** | **In the light-independent reaction a carboxylase catalyzes the carboxylation of ribulose-bisphosphate.** |

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| **8.3.U11** | **Glycerate 3-phosphate is reduced to triose phosphate using a reduced NADP and ATP.** |
| **8.3.U12** | **Triose phosphate is used to regenerate RuBP and produce carbohydrates.** |

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| **8.3.U13** | **Ribulose bisphosphate is reformed using ATP.** |
| **8.3.U14** | **The structure of the chloroplast is adapted to its function in photosynthesis.** |

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| **8.3.A1** | **Calvin’s experiment to elucidate the carboxylation of RuBP.** |
| **8.3.S1** | **Annotation of a diagram to indicate the adaptations of a chloroplast to its function.** |

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| **8.3.****NOS** | **Developments in scientific research follow improvements in apparatus- sources of 14C and autoradiography enabled Calvin to elucidate the pathways of carbon fixation.** |