Biology Units 3&4 - Exam Revision Checklist

Key Knowledge

1. The relationship between nucleic acids and proteins

- nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides
- the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes
- the structure of genes: exons, introns and promoter and operator regions
- the basic elements of gene regulation: prokaryotic *trp* operon as a simplified example of a regulatory process
- amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein
- proteins as a diverse group of molecules that collectively make an organism's proteome, including enzymes as catalysts in biochemical pathways
- the role of rough endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins from a cell via the protein secretory pathway

2. DNA manipulation techniques and applications

- the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA
- the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome
- amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling
- the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin
- the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease.

3. Regulation of biochemical pathways in photosynthesis and cellular respiration

- the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product
- the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration

- the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors

4. Photosynthesis as an example of biochemical pathways

- inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C_3 plants (details of biochemical pathway mechanisms are not required)
- the role of Rubisco in photosynthesis, including adaptations of C_3, C_4 and CAM plants to maximise the efficiency of photosynthesis
- the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration

5. Cellular respiration as an example of biochemical pathways

- the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)
- the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts
- the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration

6. Biotechnological applications of biochemical pathways

- potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields
- uses and applications of anaerobic fermentation of biomass for biofuel production.

7. Responding to antigens

- physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants
- the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons
- initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens

8. Acquiring immunity

- the role of the lymphatic system in the immune response as a transport network and the role of lymph nodes as sites for antigen recognition by T and B lymphocytes
- the characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells
- the difference between natural and artificial immunity and active and passive strategies for acquiring immunity

9. Disease challenges and strategies

- the emergence of new pathogens and re-emergence of known pathogens in a globally connected world, including the impact of European arrival on Aboriginal and Torres Strait Islander peoples
- scientific and social strategies employed to identify and control the spread of pathogens, including identification of the pathogen and host, modes of transmission and measures to control transmission

- vaccination programs and their role in maintaining herd immunity for a specific disease in a human population
- the development of immunotherapy strategies, including the use of monoclonal antibodies for the treatment of autoimmune diseases and cancer.

10. Genetic changes in a population over time

- causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift and gene flow; and mutations as the source of new alleles
- biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity
- manipulation of gene pools through selective breeding programs
- consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens

11. Changes in species over time

- changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils
- evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and *Howea* palms on Lord Howe Island as an example of sympatric speciation

12. Determining the relatedness of species

- evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences
- the use and interpretation of phylogenetic trees as evidence for the relatedness between species

13. Human change over time

- the shared characteristics that define mammals, primates, hominoids and hominins
- evidence for major trends in hominin evolution from the genus *Australopithecus* to the genus *Homo*: changes in brain size and limb structure
- the human fossil record as an example of a classification scheme that is open to differing interpretations that are contested, refined or replaced when challenged by new evidence, including evidence for interbreeding between *Homo sapiens* and *Homo neanderthalensis* and evidence of new putative *Homo* species
- ways of using fossil and DNA evidence (mtDNA and whole genomes) to explain the migration of modern human populations around the world, including the migration of Aboriginal and Torres Strait Islander populations and their connection to Country and Place.

Science Skills

Key science skill	VCE Biology Units 1–4
Develop aims and questions, formulate hypotheses and make predictions	identify, research and construct aims and questions for investigation identify independent, dependent and controlled variables in controlled experiments formulate hypotheses to focus investigation predict possible outcomes
Plan and conduct investigations	determine appropriate investigation methodology: case study; classification and identification; controlled experiment; correlational study; fieldwork; literature review; modelling; product, process or system development; simulation design and conduct investigations; select and use methods appropriate to the investigation, including consideration of sampling technique and size, equipment and procedures, taking into account potential sources of error and uncertainty; determine the type and amount of qualitative and/or quantitative data to be generated or collated work independently and collaboratively as appropriate and within identified research constraints, adapting or extending processes as required and recording such modifications
Comply with safety and ethical guidelines	demonstrate safe laboratory practices when planning and conducting investigations by using risk assessments that are informed by safety data sheets (SDS), and accounting for risks apply relevant occupational health and safety guidelines while undertaking practical investigations demonstrate ethical conduct when undertaking and reporting investigations
Generate, collate and record data	systematically generate and record primary data, and collate secondary data, appropriate to the investigation, including use of databases and reputable online data sources record and summarise both qualitative and quantitative data, including use of a logbook as an authentication of generated or collated data organise and present data in useful and meaningful ways, including schematic diagrams, flow charts, tables, bar charts and line graphs plot graphs involving two variables that show linear and non-linear relationships
Analyse and evaluate data and investigation methods	process quantitative data using appropriate mathematical relationships and units, including calculations of ratios, percentages,

	percentage change and mean ≤ identify and analyse experimental data qualitatively, handing where appropriate concepts of: accuracy, precision, repeatability, reproducibility and validity of measurements; errors (random and systematic); and certainty in data, including effects of sample size in obtaining reliable data ≤ identify outliers, and contradictory or provisional data ≤ repeat experiments to ensure findings are robust ≤ evaluate investigation methods and possible sources of personal errors/mistakes or bias, and suggest improvements to increase accuracy and precision, and to reduce the likelihood of errors
Construct evidence-based arguments and draw conclusions	≤ distinguish between opinion, anecdote and evidence, and scientific and non-scientific ideas ≤ evaluate data to determine the degree to which the evidence supports the aim of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation ≤ evaluate data to determine the degree to which the evidence supports or refutes the initial prediction or hypothesis ≤ use reasoning to construct scientific arguments, and to draw and justify conclusions consistent with the evidence and relevant to the question under investigation ≤ identify, describe and explain the limitations of conclusions, including identification of further evidence required ≤ discuss the implications of research findings and proposals
Analyse, evaluate and communicate scientific ideas	≤ use appropriate biological terminology, representations and conventions, including standard abbreviations, graphing conventions and units of measurement ≤ discuss relevant biological information, ideas, concepts, theories and models and the connections between them ≤ analyse and explain how models and theories are used to organise and understand observed phenomena and concepts related to biology, identifying limitations of selected models/theories ≤ critically evaluate and interpret a range of scientific and media texts (including journal articles, mass media communications and opinions in the public domain), processes, claims and conclusions related to biology by considering the quality of available evidence ≤ analyse and evaluate bioethical issues using relevant approaches to bioethics and ethical concepts, including the influence of social, economic, legal and political factors relevant to the selected issue ≤ use clear, coherent and concise expression to communicate to specific audiences and for specific purposes in appropriate scientific genres, including scientific reports and posters ≤ acknowledge sources of information and assistance, and use standard scientific referencing conventions

Ethical approaches and concepts

VCE Biology requires consideration of:

1. Approaches to bioethics

There are three major approaches to resolving ethical issues that support students to identify bioethical issues, explore these bioethical issues in context, consider different perspectives on bioethical issues, reflect on courses of action, and choose a position or course of action on the basis of reasoning and reflection.

Depending on the bioethical issue being explored, one or more of the following approaches could be applied and/or considered:

- **Consequences-based** approach places central importance on the consideration of the consequences of an action (the ends), with the aim to achieve maximisation of positive outcomes and minimisation of negative effects.
- **Duty- and/or rule-based** approach is concerned with how people act (the means) and places central importance on the idea that people have a duty to act in a particular way, and/or that certain ethical rules must be followed, regardless of the consequences that may be produced.
- **Virtues-based** approach is person- rather than action-based. Consideration is given to the virtue or moral character of the person carrying out the action, providing guidance about the characteristics and behaviours a good person would seek to achieve to then be able to act in the right way.

2. Ethical concepts

Consideration of ethical concepts supports students in exploring bioethical issues. The concepts may be useful as standalone ways of exploring a bioethical issue under consideration or be used in conjunction with a particular ethical approach. Ethical concepts are general in nature and commonly used to inform any Codes of Ethics and ethical guidelines that apply when undertaking research involving human and non-human participants. They can also be used when identifying a bioethical issue and when deciding the extent to which the outcome of a particular course of action (the effect) or the action itself (the cause) is ethically acceptable.

While there are many ethical concepts that can support the investigation of bioethical issues, one or more of the following principles should be applied:

- **Integrity:** the commitment to searching for knowledge and understanding and the honest reporting of all sources of information and communication of results, whether favourable or unfavourable, in ways that permit scrutiny and contribute to public knowledge and understanding.
- **Justice:** the moral obligation to ensure that there is fair consideration of competing claims; that there is no unfair burden on a particular group from an action; and that there is fair distribution and access to the benefits of an action.
- **Beneficence:** the commitment to maximising benefits and minimising the risks and harms involved in taking a particular position or course of action.
- **Non-maleficence:** involves avoiding the causations of harm. However, as positions or courses of actions in scientific research may involve some degree of harm, the concept of non-maleficence implies that the harm resulting from any position or course of action should not be disproportionate to the benefits from any position or course of action.

- **Respect:** involves consideration of the extent to which living things have an intrinsic value and/or instrumental value; giving due regard to the welfare, liberty and autonomy, beliefs, perceptions, customs and cultural heritage of both the individual and the collective; consideration of the capacity of living things to make their own decisions; and when living things have diminished capacity to make their own decisions ensuring that they are empowered where possible and protected as necessary.

Data and measurement

A major aim of science is to develop explanations that are supported by evidence for natural phenomena and events. This involves considering the quality and quantity of evidence and, before conclusions are drawn from data, considering questions such as: 'Can I rely on the data I have generated when drawing conclusions?' and 'Does the difference between one measurement and another indicate a real change in what is being measured?'.

When analysing and discussing investigations of a quantitative nature, the following terms require consideration:

- **Accuracy:** the accuracy of a measurement relates to how close it is to the 'true' value of the quantity being measured.
- **Precision:** refers to how closely a set of measurement values agree with each other. Precision gives no indication of how close the measurements are to the true value and is therefore a separate consideration to accuracy.
- **Repeatability:** the closeness of the agreement between the results of successive measurements of the same quantity being measured, carried out under the same conditions of measurement. These conditions include the same measurement procedure, the same observer, the same measuring instrument used under the same conditions, the same location, and repetition over a short period of time.
- **Reproducibility:** the closeness of the agreement between the results of measurements of the same quantity being measured, carried out under changed conditions of measurement. These different conditions include a different method of measurement, different observer, different measuring instrument, different location, different conditions of use, and different time.
- **True value:** the value, or range of values, that would be found if the quantity could be measured perfectly.
- **Validity:** a measurement is said to be valid if it measures what it is supposed to be measuring.
  An experiment is said to be valid if it investigates what it sets out and/or claims to investigate.

Errors, uncertainty and outliers

It is important not to confuse the terms measurement error and personal error. Error, from a scientific measurement perspective, is the difference between the measured value and the true value of what is being measured. For the purposes of VCE Biology, two types of measurement error should be considered when evaluating the quality of data: systematic errors and random errors. Personal errors should be eliminated by performing the experiment again correctly the next time, and therefore do not form part of an analysis of data quality.

- **Personal errors:** include mistakes or miscalculations.
- **Random errors:** affect the precision of a measurement and are present in all measurements except for measurements involving counting. Random errors are unpredictable variations in the measurement process and result in a spread of readings. The effect of random errors can be reduced by making more or repeated measurements and calculating a new mean and/or by refining the measurement method or technique.
- **Systematic errors:** affect the accuracy of a measurement. Systematic errors cause readings to differ from the true value by a consistent amount each time a measurement is made, so that all the readings are shifted in one direction from the true value. The accuracy of measurements subject to systematic errors cannot be improved by repeating those measurements.

It is also important not to confuse the terms ‘error’ and ‘uncertainty’, which are not synonyms. Outliers in data are a separate consideration, and must be further analysed and accounted for, rather than being automatically dismissed.

- **Uncertainty:** The uncertainty of the result of a measurement reflects the lack of exact knowledge of the value of the quantity being measured. VCE Biology requires only a qualitative treatment of uncertainty. When evaluating personally sourced or provided data, students should be able to identify contradictory, provisional and incomplete data including possible sources of bias.
- **Outliers:** Readings that lie a long way from other results are sometimes called outliers. Repeating readings may be useful in further examining an outlier.