QCE Biology — Units 3 & 4

Notetaker Workbook

One fillable page per sub-topic — tick, define, explain, draw and self-test as you revise.

UNIT 3 · TOPIC 1 — BIODIVERSITY AND POPULATIONS

3.1.1 Biodiversity

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Genetic, species and ecosystem diversity
- ☐ Biological species concept and its limitations
- ☐ Linnaean classification (major taxa) and binomial nomenclature
- ☐ Dichotomous keys
- ☐ Specht's classification system
- ☐ Holdridge life zone classification scheme

KEY TERMS — WRITE YOUR OWN DEFINITION

Genetic diversity	**Species diversity**
Ecosystem diversity	**Biological species concept**
Binomial nomenclature	**Dichotomous key**
Specht's classification	**Holdridge life zones**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Explain the difference between genetic, species and ecosystem diversity, with an example of each.

2. State the biological species concept in your own words, and list two of its limitations.

3. List the major taxa of the Linnaean system in order, from largest to smallest group.

4. Compare Specht's classification and the Holdridge life zone scheme — what does each classify, and on what basis?

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw the Linnaean hierarchy (Domain → Species) as a nested diagram or flow chart.

EXAM-STYLE CHECK

A newly discovered plant cannot be crossed with any known species to produce fertile offspring. Explain why the biological species concept alone may not be sufficient to classify it.

UNIT 3 · TOPIC 1 — BIODIVERSITY AND POPULATIONS

3.1.2 Sampling

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Sampling methods: random, systematic, stratified
- ☐ Sampling techniques: quadrats, line transect, belt transect, capture–recapture
- ☐ Lincoln index (mark–recapture)
- ☐ Diversity measures: richness, evenness, % cover, % frequency, Simpson's Index
- ☐ Strategies to minimise bias
- ☐ Microhabitats, distribution patterns and validity/reliability of sampling

KEY TERMS — WRITE YOUR OWN DEFINITION

Random sampling	**Systematic sampling**
Stratified sampling	**Quadrat / transect**
Capture–recapture	**Lincoln index**
Species richness & evenness	**Simpson's Diversity Index**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Compare random, systematic and stratified sampling — when would you use each?

2. Describe how the Lincoln index is used to estimate population size (define each variable in N = M×n/m).

3. Explain the difference between species richness and evenness.

4. Explain how the spatial distribution of a species (uniform/random/clumped) affects your choice of sampling method.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Sketch a quadrat/transect sampling setup for a local ecosystem and label your sampling strategy.

EXAM-STYLE CHECK

A student wants to estimate the population size of a mobile skink species in a woodland. Outline the method they would use and the formula required.

3.1.3 Population ecology

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Exponential growth (J-curve)
- ☐ Logistic growth (S-curve) and carrying capacity
- ☐ r-strategists vs K-strategists
- ☐ Calculating population growth rate/change

KEY TERMS — WRITE YOUR OWN DEFINITION

Exponential growth	**Logistic growth**
Carrying capacity (K)	**r-strategist**
K-strategist	**Population growth rate**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Sketch and label the J-curve and S-curve on the same axes (population size vs time).

2. Explain why logistic growth slows as a population approaches carrying capacity.

3. Compare the reproductive strategies of r- and K-strategists in a table.

4. Write the formula for population change and define each term.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Graph space — sketch exponential and logistic growth curves, labelling carrying capacity (K).

EXAM-STYLE CHECK

A population of rabbits shows exponential growth for the first 5 years, then plateaus. Explain what is happening biologically at each stage.

3.2.1 Energy transfer

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Conversion of light into chemical energy
- ☐ Biomass production and links to the carbon cycle
- ☐ Energy loss as heat
- ☐ Food chains, energy flow diagrams, ecological pyramids
- ☐ Gross vs net primary productivity
- ☐ Energy loss via radiation, reflection, absorption

KEY TERMS — WRITE YOUR OWN DEFINITION

Photosynthesis	**Biomass**
Trophic level	**Energy pyramid**
Gross primary productivity	**Net primary productivity**
Transfer efficiency	

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Explain how light energy is transformed into chemical energy and then into biomass.

2. Explain why energy is lost as heat at each trophic transfer (link to the laws of thermodynamics).

3. Define GPP and NPP, and write the relationship between them.

4. List three ways energy can be lost before it is even captured by producers.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw an energy pyramid for a food chain of your choice, labelling energy values/percentages at each level.

EXAM-STYLE CHECK

Explain why food chains rarely have more than 4–5 trophic levels, using the concept of transfer efficiency.

3.2.2 Cycles

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Water cycle
- ☐ Carbon cycle
- ☐ Nitrogen cycle

KEY TERMS — WRITE YOUR OWN DEFINITION

Evaporation	**Transpiration**
Carbon fixation	**Decomposition**
Nitrogen fixation	**Nitrification**
Denitrification	**Assimilation**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Draw and label the water cycle, including evaporation, transpiration, condensation, precipitation and run-off.

2. Draw and label the carbon cycle, including photosynthesis, respiration, decomposition and combustion.

3. Draw and label the nitrogen cycle, including fixation, nitrification, assimilation, ammonification and denitrification.

4. For each cycle, identify one human activity that disrupts it.

EXAM-STYLE CHECK

Explain how the removal of a forest (deforestation) would disrupt both the carbon cycle and the water cycle.

UNIT 3 · TOPIC 2 — FUNCTIONING ECOSYSTEMS AND SUCCESSION

3.2.3 Niches

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Species interactions: predation, competition, mutualism, commensalism, parasitism
- ☐ Ecological niche concept
- ☐ Competitive exclusion principle
- ☐ Keystone species
- ☐ Analysing food webs and population data

KEY TERMS — WRITE YOUR OWN DEFINITION

Ecological niche	**Predation**
Competition	**Mutualism**
Commensalism	**Parasitism**
Competitive exclusion	**Keystone species**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Define each species interaction and give a +/−/o notation and example for each.

2. Explain the competitive exclusion principle and describe one possible outcome when two species compete for the same niche.

3. Explain the concept of a keystone species.

4. Describe how you would identify a keystone species from food web data.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw a simple food web and circle/label a possible keystone species. Show what would happen if it were removed.

EXAM-STYLE CHECK

Sea otters are considered a keystone species in kelp forest ecosystems. Predict what would happen to the ecosystem if sea otters were removed, and explain your reasoning.

3.2.4 Changing ecosystems

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Overexploitation, habitat destruction, monocultures, pollution
- ☐ Carrying capacity changes (biotic, abiotic, climatic)
- ☐ Primary and secondary succession
- ☐ Features of pioneer species
- ☐ Successional changes: species interactions, abiotic factors, r/K selection, biodiversity, biomass
- ☐ Comparing ecosystems across spatial/temporal scales

KEY TERMS — WRITE YOUR OWN DEFINITION

Overexploitation	**Monoculture**
Carrying capacity	**Primary succession**
Secondary succession	**Pioneer species**
Climax community	**Seral stage**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Explain how overexploitation, habitat destruction, monocultures and pollution each affect ecosystem functioning.

2. Compare primary and secondary succession in a table (starting conditions, speed, examples).

3. List the features that make a pioneer species an effective coloniser.

4. Explain how biodiversity, biomass and species interactions change over the course of succession.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw a succession timeline/flow diagram from a bare or disturbed site to a climax community, labelling each seral stage.

EXAM-STYLE CHECK

After a bushfire, an area of eucalypt forest begins to recover. Explain the type of succession that would occur and predict how the community will change over the next 50 years.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.1 DNA structure and replication

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ DNA structure: helix, nucleotide composition, base pairing, hydrogen bonds
- ☐ Introns, exons, promoter region
- ☐ Homologous chromosomes: chromatids, centromeres, telomeres, gene loci, alleles, histones
- ☐ Circular chromosomes and plasmids (prokaryotes, mitochondria, chloroplasts)
- ☐ DNA replication: helicase, DNA polymerase, Okazaki fragments, 5'/3' directionality

KEY TERMS — WRITE YOUR OWN DEFINITION

Nucleotide	**Complementary base pairing**
Exon & intron	**Homologous chromosome**
Centromere & telomere	**Allele**
Helicase & DNA polymerase	**Okazaki fragment**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Draw and label the structure of a DNA nucleotide and show complementary base pairing.

2. Label a homologous chromosome pair: sister chromatids, centromere, telomeres, gene locus, allele.

3. Explain the role of helicase, primase, DNA polymerase and ligase in DNA replication.

4. Explain why the leading and lagging strands are synthesised differently, referring to the 5' and 3' ends.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw a replication fork, labelling the leading strand, lagging strand, Okazaki fragments and key enzymes.

EXAM-STYLE CHECK

Explain why DNA replication only occurs in the 5' to 3' direction, and how this creates the need for Okazaki fragments on the lagging strand.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.2 Cellular replication and variation

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Stages of Meiosis I and Meiosis II
- ☐ Crossing over, independent assortment, random fertilisation
- ☐ Spermatogenesis vs oogenesis
- ☐ Errors in meiosis: insertions, deletions, duplications, inversions, translocations, aneuploidy
- ☐ Karyotypes and ploidy changes

KEY TERMS — WRITE YOUR OWN DEFINITION

Meiosis	**Crossing over**
Independent assortment	**Nondisjunction**
Aneuploidy	**Karyotype**
Spermatogenesis	**Oogenesis**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Draw and label the stages of Meiosis I and Meiosis II.

2. Explain how crossing over, independent assortment and random fertilisation each generate genetic variation.

3. Compare spermatogenesis and oogenesis (number of gametes, timing, cytoplasm division).

4. Explain how nondisjunction leads to aneuploidy, and name a resulting disorder.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw the stages of meiosis (Prophase I – Telophase II), labelling crossing over and independent assortment.

EXAM-STYLE CHECK

A karyotype shows three copies of chromosome 21. Explain the meiotic error that likely caused this and name the resulting condition.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.3 Gene expression

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Transcription (mRNA synthesis)
- ☐ RNA processing: 5' cap, splicing, poly-A tail
- ☐ Translation: codons, anticodons, tRNA, ribosome
- ☐ Protein synthesis overview (transcription → processing → translation)
- ☐ Regulation of gene expression: chromatin structure, transcription factors
- ☐ HOX genes and morphology

KEY TERMS — WRITE YOUR OWN DEFINITION

Transcription	**mRNA**
Splicing	**Codon & anticodon**
Translation	**Transcription factor**
Chromatin (hetero/euchromatin)	**HOX gene**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Outline the steps of transcription, including the role of RNA polymerase and the promoter.

2. Explain the three types of RNA processing (5' cap, splicing, poly-A tail) and why each is needed.

3. Outline the steps of translation.

4. Explain how chromatin structure and transcription factors regulate gene expression, and how HOX genes control morphology.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw the full pathway from gene → mRNA → protein, labelling transcription, RNA processing and translation.

EXAM-STYLE CHECK

Explain how two cells with identical DNA (e.g. a skin cell and a nerve cell) can look and function completely differently.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.4 Mutations

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Point mutations (causes: replication errors, physical/chemical damage)
- ☐ Frameshift mutations
- ☐ Effects of mutations on polypeptides: silent, missense, nonsense, frameshift

KEY TERMS — WRITE YOUR OWN DEFINITION

Point mutation	**Frameshift mutation**
Silent mutation	**Missense mutation**
Nonsense mutation	**Mutagen**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Explain the difference between a point mutation and a frameshift mutation.

2. Explain how a mutagen (physical or chemical) can cause DNA damage.

3. Using a codon table, explain the difference between silent, missense and nonsense mutations.

4. Explain why frameshift mutations usually have a greater effect on a protein than point mutations.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Show an original DNA/mRNA sequence, then illustrate the effect of a point mutation and a frameshift mutation on the resulting amino acid sequence.

EXAM-STYLE CHECK

A single nucleotide is deleted near the start of a gene. Predict and explain the effect this will have on the resulting protein, compared to a single nucleotide substitution.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.5 Inheritance

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Dominant and recessive inheritance
- ☐ Autosomal vs sex-linked inheritance
- ☐ Polygenic inheritance
- ☐ Multiple-allele inheritance
- ☐ Interpreting histograms, pedigrees and Punnett squares

KEY TERMS — WRITE YOUR OWN DEFINITION

Dominant / recessive allele	**Homozygous / heterozygous**
Autosomal	**Sex-linked**
Polygenic	**Multiple alleles**
Pedigree	**Punnett square**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Define dominant, recessive, autosomal and sex-linked inheritance, with an example of each.

2. Explain how polygenic inheritance produces continuous variation (link to histograms).

3. Explain multiple-allele inheritance using ABO blood groups as an example.

4. Practise reading a pedigree — how would you identify a recessive vs dominant trait?

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Blank Punnett square grid and blank pedigree space — practise a genetic cross and a family tree.

EXAM-STYLE CHECK

A recessive, sex-linked disorder appears in a family. Explain how you would identify this pattern from a pedigree, and why sons are more commonly affected than daughters.

UNIT 4 · TOPIC 1 — GENETICS AND HEREDITY

4.1.6 Biotechnology

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Recombinant DNA: restriction enzymes, plasmids, DNA ligase
- ☐ PCR (polymerase chain reaction)
- ☐ Gel electrophoresis
- ☐ Interpreting DNA profiles

KEY TERMS — WRITE YOUR OWN DEFINITION

Restriction enzyme	**Sticky ends**
Plasmid	**DNA ligase**
Transformation	**PCR & primers**
Gel electrophoresis	**DNA profile**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Outline the steps of making recombinant DNA, including restriction enzymes, plasmids and ligase.

2. Explain how PCR amplifies a specific region of DNA.

3. Explain how gel electrophoresis separates DNA fragments, and why band patterns differ between individuals.

4. Practise interpreting a DNA profile — how would you compare bands between two samples?

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw the process of inserting a gene into a plasmid.

EXAM-STYLE CHECK

Explain how gel electrophoresis could be used to determine whether a suspect's DNA matches a sample found at a crime scene.

UNIT 4 · TOPIC 2 — CONTINUITY OF LIFE ON EARTH

4.2.1 Evolution

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Microevolution vs macroevolution
- ☐ Comparative genomics and conserved sequences
- ☐ Cladograms, phylograms and molecular sequence data
- ☐ Evolutionary timescale, radiation and mass extinctions

KEY TERMS — WRITE YOUR OWN DEFINITION

Microevolution	**Macroevolution**
Comparative genomics	**Conserved sequence**
Cladogram	**Phylogram**
Evolutionary radiation	**Mass extinction**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Distinguish between microevolution and macroevolution, with an example of each.

2. Explain how comparative genomics and conserved sequences provide evidence for evolution and can be used to date divergence.

3. Explain the difference between a cladogram and a phylogram.

4. Explain what causes a mass extinction event and describe the pattern of evolutionary radiation that often follows.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Sketch a simple cladogram or phylogram for 4–5 related species, and mark a mass extinction event on an evolutionary timeline.

EXAM-STYLE CHECK

After a mass extinction event, evolutionary radiation is often observed shortly afterwards. Explain why this pattern occurs.

UNIT 4 · TOPIC 2 — CONTINUITY OF LIFE ON EARTH

4.2.2 Natural selection and microevolution

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Mutation, gene flow, genetic drift
- ☐ Natural selection: stabilising, directional, disruptive
- ☐ Calculating allele frequencies
- ☐ Positive vs negative selection

KEY TERMS — WRITE YOUR OWN DEFINITION

Gene flow	**Genetic drift**
Natural selection	**Fitness**
Stabilising selection	**Directional selection**
Disruptive selection	**Allele frequency**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Explain how mutation, gene flow and genetic drift each change allele frequencies in a population.

2. Define natural selection and explain the concept of fitness.

3. Explain the difference between positive and negative selection for an allele.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw three bell curves (before and after selection) to show stabilising, directional and disruptive selection.

EXAM-STYLE CHECK

A population of insects is sprayed with a pesticide. Over several generations, resistance to the pesticide increases. Explain this using the process of natural selection.

4.2.3 Macroevolution and speciation

SYLLABUS FOCUS — TICK OFF AS YOU REVISE

- ☐ Divergent, convergent and parallel evolution; coevolution
- ☐ Allopatric, sympatric and parapatric speciation
- ☐ Genetic diversity and extinction risk

KEY TERMS — WRITE YOUR OWN DEFINITION

Divergent evolution	**Convergent evolution**
Parallel evolution	**Coevolution**
Allopatric speciation	**Sympatric speciation**
Parapatric speciation	**Genetic diversity**

CORE CONCEPTS & PROCESSES — RESPOND TO EACH PROMPT

1. Define and give an example of divergent, convergent, parallel and coevolution.

2. Explain how geographic isolation leads to allopatric speciation.

3. Explain how speciation can occur without geographic separation (sympatric speciation).

4. Explain why populations with low genetic diversity are at greater risk of extinction.

DIAGRAM / FLOW CHART — DRAW AND ANNOTATE

Draw a diagram showing a population splitting into two species via geographic isolation (allopatric speciation), labelling each stage.

EXAM-STYLE CHECK

Two populations of the same fish species become separated when a new waterfall forms, blocking migration between the upper and lower river. Explain the process by which these populations could become two separate species over time.