MA99 EDUCATION

Biology: Practice Paper 1 01

NSW BIOLOGY STAGE 6 SYLLABUS 2017 FOR HSC 2027

1. General instructions

- Reading time: 5 minutes
- Working time: 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and periodic table are not required for this paper
- Write your Section II answers in the spaces provided in this paper, showing all relevant working in questions involving calculations
- Total marks: 100
- Section I: 20 marks, attempt all questions, allow about 35 minutes
- Section II: 80 marks, attempt all questions, allow about 2 hours 25 minutes. This paper draws on Module 5 (Heredity), Module 6 (Genetic Change), Module 7 (Infectious Disease) and Module 8 (Non-infectious Disease and Disorders).

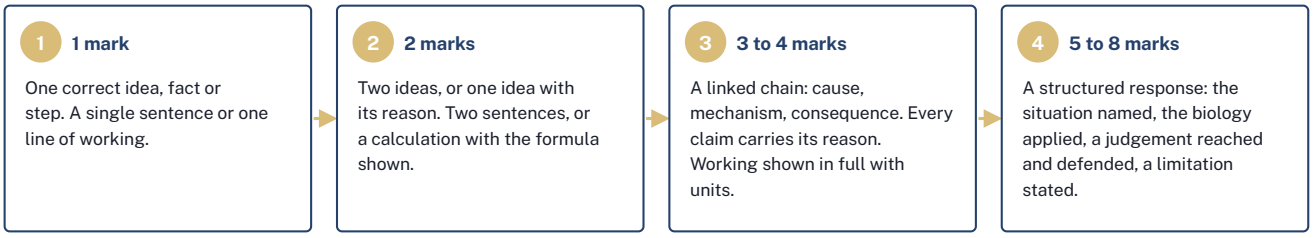


Figure 1 · What each mark value is asking you to produce. Check your answer length against this before you write.

2. Section I · Multiple choice

20 marks. Attempt all questions. Allow about 35 minutes for this section. Shade or write the letter (A) to (D) that best answers each question.

2.1 Section I answer grid

Circle the letter on the question, then copy it here.

Q	1	2	3	4	5	6	7	8	9	10
Q	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

Question 1

1 MARK

A pair of alleles that both contribute visibly to the phenotype, so a heterozygote shows a blended or intermediate trait, is an example of

A incomplete dominance
B complete dominance
C codominance
D polygenic inheritance

Question 2

1 MARK

Wes Colvin has blood type AB and his partner has blood type O. What are the possible blood types of their children?

A Only type A
B Only type B
C Type A or type B, never O or AB
D Type A, B, AB or O

Question 3

1 MARK

In meiosis, the process that shuffles maternal and paternal chromosomes into new combinations independently of any other homologous pair is called

A crossing over
B non-disjunction
C polyploidy
D independent assortment

Question 4

1 MARK

A recessive, X-linked trait in the Colvin family's working dogs (a hypothetical MA99 family) is carried by a phenotypically normal dam. Compared with her sons, her daughters are

A equally likely to show the trait
B able to show the trait only if the sire is affected
C always carriers, never affected
D always free of the mutation

Question 5

1 MARK

Bindarra thumb is a dominant autosomal trait. A heterozygous parent (Tt) is crossed with an unaffected parent (tt). What proportion of the offspring is expected to show the trait?

A 0%
B 25%
C 50%
D 100%

Question 6

1 MARK

A change to a single nucleotide base in a gene's coding sequence, with no change to chromosome number or structure, is best classified as a

A point mutation
B chromosomal mutation
C polyploid mutation
D somatic deletion

Question 7

1 MARK

On an agarose gel, DNA fragments are separated because the gel is run with an electric current and

A larger fragments migrate further toward the positive electrode
B all fragments migrate at the same rate regardless of size
C fragments migrate toward the negative electrode regardless of size
D smaller fragments migrate further toward the positive electrode

Question 8

1 MARK

In the polymerase chain reaction, short synthetic sequences called primers are needed to

A mark the start point for DNA polymerase to begin copying the target sequence
B cut the DNA at a specific restriction site
C stain the amplified DNA so it is visible under UV light
D unwind the double helix without heating

Question 9

1 MARK

A cattle breeding program mates the herd's best producing animals for several generations to increase the frequency of a desired trait. This is an example of

A genetic engineering
B selective breeding
C gene therapy
D recombinant DNA technology

Question 10

1 MARK

A concern raised about genetically modified crops, such as an insect-resistant crop variety, is that widespread planting of one resistance gene may

A increase genetic diversity in the crop population
B make the crop less nutritious in every case
C prevent any further mutation from occurring in the crop
D select for insect populations that are resistant to the same trait

Question 11

1 MARK

The first line of defence a pathogen meets on entering the human body, before any pathogen specific response is mounted, is part of the

A adaptive immune response
B innate immune response
C humoral memory response
D artificial passive immunity

Question 12

1 MARK

In the 1854 Broad Street cholera outbreak in London, John Snow's map linked cases to one public water pump whose well had been contaminated from a leaking cesspit. Cholera spreading this way is best described as

A direct transmission
B vector borne transmission
C indirect transmission
D vertical transmission

Question 13

1 MARK

Herd immunity in a population against a pathogen depends most directly on

A the proportion of the population that is immune, whether by infection or vaccination
B the number of hospital beds available in the district
C the age of the youngest case recorded
D the season in which the first case appeared

Question 14

1 MARK

A course of antibiotics stopped early, so that only the most susceptible bacteria in an infection are killed, is a practice most directly linked to

A the evolution of antibiotic resistant bacterial strains
B viral mutation rates
C an increase in vaccine effectiveness
D a reduction in herd immunity

Question 15

1 MARK

Unlike viruses, bacteria and fungi, a prion causes disease without containing

A any protein
B any three dimensional structure
C any capacity to be misfolded
D any nucleic acid

Question 16

1 MARK

A disruption to homeostasis in which a hormone level rises, is detected, and triggers a response that brings the level back down is an example of

A positive feedback
B negative feedback
C an innate immune response
D an adaptive immune response

Question 17

1 MARK

In a population health survey, the number of new cases of type 2 diabetes diagnosed during 2025, divided by the population at risk, is a measure of

A prevalence
B attack rate
C case fatality rate
D incidence

Question 18

1 MARK

A hypothetical observational study finds that adults who drink more than four cups of coffee a day have a lower rate of a certain liver condition. The single strongest reason this finding cannot be presented as coffee preventing the condition is that

A coffee always contains caffeine
B the sample size was zero
C correlation alone does not establish causation; other explanatory factors have not been ruled out
D liver conditions cannot be studied epidemiologically

Question 19

1 MARK

Which of the following is best described as a lifestyle risk factor for cardiovascular disease, rather than a genetic or purely environmental one?

A a family history of early heart attack
B long term exposure to particulate air pollution
C a diet high in saturated fat combined with low physical activity
D a chromosomal abnormality present from birth

Question 20

1 MARK

Genetic testing to identify a person's risk of developing a non-infectious disease before any symptom appears is an example of a technology used mainly for

A treatment
B detection and diagnosis
C quarantine
D vector control

3. Section II · Short answer, calculation and extended response

80 marks. Attempt all questions. Allow about 2 hours 25 minutes for this section. Show all relevant working in questions involving calculations.

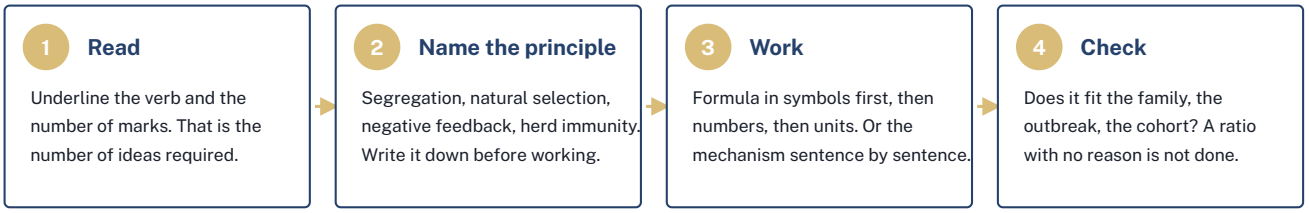


Figure 2 · The same four moves on every Section II item. Read, name the principle, work, then check the answer against the context.

Question 21

2 MARKS

State the difference between a genotype and a phenotype, using the Bindarra thumb trait as your example.

Question 22

3 MARKS

Wes Colvin (Bindarra thumb, genotype Tt) and Deb Colvin (no Bindarra thumb, genotype tt) have two children, Callum and Priya. Draw or describe a Punnett square for this cross and state the expected ratio of affected to unaffected offspring.

Question 23

4 MARKS

Ruth Colvin is a carrier for spot syndrome, a hypothetical recessive condition. Explain, in terms of meiosis, why two phenotypically unaffected carrier parents can produce a child who has the condition.

Question 24

3 MARKS

Meiosis produces genetic variation by two distinct mechanisms in addition to random fertilisation. Name each mechanism and describe how it increases variation.

Question 25

8 MARKS

Wes Colvin (TtSs) is heterozygous for both genes in this hypothetical (MA99) family: he has Bindarra thumb and is a carrier of spot syndrome, and Deb Colvin is ttSs (no thumb trait, a carrier for spot syndrome). The two genes assort independently.
(a) Set up the dihybrid cross and state the expected proportion of children who show the Bindarra thumb trait but are phenotypically free of spot syndrome.

(b) State the expected proportion of children who show neither the thumb trait nor spot syndrome. (c) Explain why independent assortment is required for this calculation to be valid.

Question 26

2 MARKS

Define the term point mutation and give one example of a point mutation type.

Question 27

3 MARKS

Distinguish between selective breeding and genetic engineering as methods used to change the traits of an organism.

Question 28

4 MARKS

A plant breeder tests a hypothetical DNA marker for rust resistance in a wheat line using PCR followed by gel electrophoresis. The wild type allele produces an uncut PCR product of 820 base pairs. A restriction enzyme cuts the mutant, resistant allele into two fragments of 540 base pairs and 280 base pairs. (a) Show that the two mutant fragment sizes are consistent with the wild type product length.

(b) Describe the banding pattern you would expect on the gel for a heterozygous plant carrying one wild type and one resistant allele.

Question 29

4 MARKS

Outline one social and one ethical implication that should be considered before a gene edited, herbicide tolerant wheat variety (a hypothetical example) is released for commercial planting.

Question 30

7 MARKS

A breeder mates cattle heterozygous for a coat colour gene and records the F2 generation (hypothetical data): 138 black calves and 42 red calves. (a) State the expected ratio under a simple dominant/recessive model and calculate the expected numbers for a sample of this size.

(b) Calculate the chi-square value for this data and state, with reference to a critical value of 3.84 at one degree of freedom, whether the data fits the expected ratio.

Question 31

2 MARKS

Define herd immunity.

Question 32

3 MARKS

Distinguish between active and passive immunity, using one real example of each.

Question 33

4 MARKS

Outline the steps of the humoral (antibody mediated) immune response that would occur in a person exposed to the measles virus for the first time.

Question 34

3 MARKS

During the COVID-19 pandemic, Australia placed returning travellers in hotel quarantine from late March 2020. Explain why quarantine of exposed but not yet symptomatic people was used, rather than isolating only confirmed cases.

Question 35

8 MARKS

In a hypothetical foodborne outbreak, 46 people attended a shared lunch and 29 of them later developed symptoms (hypothetical data). (a) Calculate the attack rate for this event, showing your working.

(b) The investigating team classifies the transmission at the lunch as indirect rather than direct. Justify this classification.

(c) The pathogen responsible has a basic reproduction number (R0) of 6 in an unvaccinated population. Calculate the herd immunity threshold and explain what this value means for a vaccination program against this pathogen.

Question 36

2 MARKS

Distinguish between the terms incidence and prevalence as used in epidemiology.

Question 37

3 MARKS

Explain why homeostasis relies on negative feedback rather than positive feedback for most everyday regulation, such as blood glucose control.

Question 38

4 MARKS

In a hypothetical town of 14,000 residents, 187 new diagnoses of type 2 diabetes are recorded over one year (hypothetical data). (a) Calculate the incidence of type 2 diabetes in the town for that year, as a percentage.

(b) Identify one lifestyle risk factor and one genetic risk factor a study team would investigate as possible contributors.

Question 39

4 MARKS

Cardiovascular disease, cancer and diabetes each result from an interaction of genetic, environmental and lifestyle causes. Using cardiovascular disease as your example, explain how a genetic cause and a lifestyle cause could interact to produce disease in one person.

Question 40

7 MARKS

Richard Doll and Austin Bradford Hill investigated smoking and lung cancer twice: first with a case-control study (BMJ, 1950), then with a prospective cohort, the British Doctors Study, which recorded the smoking habits of 34,439 male doctors from 1951. (a) Outline the difference between a cohort study design and a case-control study design, using these two studies.

(b) Explain one limitation of the 1950 case-control design, and how the cohort design reduced it.

4. Solutions

Section I · Answers

Q	ANSWER
1	(A) incomplete dominance
2	(C) Type A or type B, never O or AB
3	(D) independent assortment
4	(B) able to show the trait only if the sire is affected
5	(C) 50%
6	(A) point mutation
7	(D) smaller fragments migrate further toward the positive electrode
8	(A) mark the start point for DNA polymerase to begin copying the target sequence
9	(B) selective breeding
10	(D) select for insect populations that are resistant to the same trait

Q	ANSWER
11	(B) innate immune response
12	(C) indirect transmission
13	(A) the proportion of the population that is immune, whether by infection or vaccination
14	(A) the evolution of antibiotic resistant bacterial strains
15	(D) any nucleic acid
16	(B) negative feedback
17	(D) incidence
18	(C) correlation alone does not establish causation; other explanatory factors have not been ruled out
19	(C) a diet high in saturated fat combined with low physical activity
20	(B) detection and diagnosis

Section II · Model answers and mark allocations

QUESTION 21 · 2 MARKS

- Genotype is the allele combination an organism carries for a gene, for example Tt.
- Phenotype is the observable trait that results, for example a hyperextended thumb joint or a typical thumb.
- 1 mark for a correct distinction, 1 mark for correctly applying it to the Bindarra thumb trait.

QUESTION 22 · 3 MARKS

- Punnett square: Tt × tt gives offspring Tt, Tt, tt, tt.
- Expected ratio 1 : 1 affected to unaffected (50% each).
- 1 mark for the cross set up correctly, 1 mark for the correct genotype ratio, 1 mark for stating 50% affected.

QUESTION 23 · 4 MARKS

- Spot syndrome is a recessive autosomal condition, so a carrier (Ss) has one recessive allele masked by the dominant allele and is unaffected.
- During meiosis, the two alleles of each parent separate (segregate) into different gametes.
- If one gamete from each parent carries the recessive allele and the two combine at fertilisation, the child is homozygous recessive (ss) and shows the condition.
- This can happen even though neither parent shows the condition, because each parent's genotype is heterozygous.
- Award up to 4 marks for a logically sequenced explanation covering segregation, gamete formation and fertilisation.

QUESTION 24 · 3 MARKS

- Crossing over: homologous chromosomes exchange segments during prophase I, producing chromosomes with new combinations of alleles.
- Independent assortment: each homologous pair aligns and separates independently of other pairs during metaphase I and anaphase I, so gametes receive different combinations of maternal and paternal chromosomes.
- 1 mark per mechanism named, 1 mark for a correct description of either mechanism's effect.

QUESTION 25 · 8 MARKS

- (a) Set up: split the dihybrid cross into two independent monohybrid crosses: Tt × tt gives 1/2 Tt (thumb affected) : 1/2 tt; Ss × Ss gives 3/4 unaffected (S_) : 1/4 affected (ss).
- (a) Answer: P(thumb affected AND spot unaffected) = 1/2 × 3/4 = 3/8 (0.375, or 37.5%).
- (b) P(no thumb trait AND spot syndrome unaffected) = 1/2 × 3/4 = 3/8 (0.375, or 37.5%).
- (c) The two genes are on different chromosome pairs (or far enough apart to assort independently), so the probability of one outcome does not affect the probability of the other, and the individual probabilities can be multiplied together.
- Marking bands: 7 to 8 marks, both probabilities correct with working shown and a clear explanation of independent assortment; 4 to 6 marks, one probability correct or working shown with an arithmetic slip; 1 to 3 marks, the cross set up correctly but no correct final probability.

QUESTION 26 · 2 MARKS

- A point mutation is a change to a single nucleotide base pair in the DNA sequence.
- Example: substitution, insertion or deletion of a single base (any one accepted).

QUESTION 27 · 3 MARKS

- Selective breeding selects and mates organisms that already show a desired trait over many generations, working only with existing genetic variation within the population.
- Genetic engineering directly alters, inserts or removes specific genes in an organism's genome, and can introduce a gene from another species. For example, QUT inserted the MamRGA2 resistance gene from a wild banana into Cavendish bananas; after five crop cycles only 2% of the QCAV-4 line had Panama disease TR4, against 66% of unmodified Grand Nain plants (Harding et al., Plant Biotechnology Journal, 2025).
- 1 mark for each correct description, 1 mark for a clear point of difference such as speed, precision or the source of the new gene.

QUESTION 28 · 4 MARKS

- (a) 540 + 280 = 820 base pairs, equal to the wild type product of 820 base pairs, so the two fragments account for the whole original sequence.
- (b) A heterozygote carries both alleles, so its DNA sample contains both the uncut wild type product and the cut resistant fragments. The gel shows three bands: 820 bp, 540 bp and 280 bp.
- 2 marks for the arithmetic check in (a), 2 marks for a correct three band description in (b) (1 mark for stating three bands, 1 mark for the correct sizes).

QUESTION 29 · 4 MARKS

- Social implication, for example: neighbouring growers of non-modified wheat may be concerned about cross-pollination affecting their crop's market classification, or consumer acceptance of gene edited food may be mixed.
- Ethical implication, for example: the question of who owns the genetic technology and whether smaller growers can afford or access it, or whether adequate long term environmental testing has occurred before release.
- 2 marks for a clearly explained social implication, 2 marks for a clearly explained ethical implication, distinct from each other.

QUESTION 30 · 7 MARKS

- (a) Expected ratio 3 black : 1 red. Total = 180. Expected = 135 black, 45 red.
- (b) Chi-square = $(138\text{-}135)^2/135 + (42\text{-}45)^2/45 = 0.067 + 0.200 = 0.267$.
- (b) 0.267 is well below the critical value of 3.84, so the null hypothesis is not rejected: the observed data is consistent with a 3:1 ratio and a simple dominant/recessive model of inheritance for this coat colour gene.
- Marking bands: 6 to 7 marks, correct expected values, correct chi-square value with working, and a correct, justified conclusion; 3 to 5 marks, correct expected values and an attempted chi-square calculation with a minor error; 1 to 2 marks, correct expected values only.

QUESTION 31 · 2 MARKS

- Herd immunity is the indirect protection of a population from an infectious disease that occurs when a sufficiently high proportion of the population is immune, reducing the pathogen's ability to spread to those who are not immune.

QUESTION 32 · 3 MARKS

- Active immunity is produced by the person's own immune system, either after natural infection or after vaccination, and produces immune memory. Example: two doses of measles containing vaccine, free in NSW at 12 and 18 months, give long term protection for 99% of people (NSW Health, 2026).
- Passive immunity is acquired ready made from another source and does not produce lasting immune memory. Example: nirsevimab, a monoclonal antibody given to babies in Australia's RSV Maternal and Infant Protection Program (2025), was 89.6% effective against RSV hospitalisation (Wadia et al., Lancet Regional Health Western Pacific, 2026). Antibodies passed to the baby after the mother's RSV vaccination are also passive immunity for the baby.
- 1 mark for each correct definition, 1 mark for correctly matched real examples.

QUESTION 33 · 4 MARKS

- A B lymphocyte with a matching receptor recognises and binds a measles virus antigen.
- The B lymphocyte is activated, often with help from a helper T cell, and proliferates (clonal selection and expansion).
- Most of the resulting cells become plasma cells that secrete large numbers of antibodies specific to that antigen.
- A smaller number become memory B cells, which persist and allow a faster, stronger response if the same pathogen is encountered again.
- Award up to 4 marks for the steps in a logical sequence; award fewer marks for steps present but out of sequence or incomplete.

QUESTION 34 · 3 MARKS

- Some pathogens are transmissible during an incubation period, before symptoms appear, so a person can spread the disease without yet being identifiable as a case.
- Isolating only confirmed cases would miss this window of pre-symptomatic or early transmission, allowing the outbreak to continue spreading through the community.
- Quarantining everyone who may have been exposed, such as travellers arriving from overseas in 2020, for the length of the incubation period, reduces this risk even though most quarantined people will not become ill.
- Marks awarded for a clear causal explanation linking incubation period, transmissibility before symptoms, and the purpose of quarantine as distinct from isolation.

QUESTION 35 · 8 MARKS

- (a) Attack rate = 29/46 × 100 = 63.0%.
- (b) Indirect transmission occurs when the pathogen passes via a contaminated vehicle, such as shared food or water, rather than by direct person to person contact; a shared lunch fits this pattern because attendees did not need to contact each other directly to be exposed.
- (c) Herd immunity threshold = (1 -1/R0) × 100 = (1 - 1/6) × 100 = 83.3%.
- (c) This means about 83.3% of the population would need to be immune, by vaccination or prior infection, before the chain of transmission is expected to break down and protect those who remain susceptible.
- Marking bands: 7 to 8 marks, correct attack rate with working, a sound justification for indirect transmission, and a correct threshold calculation with a clear explanation of its meaning; 4 to 6 marks, two of the three parts fully correct; 1 to 3 marks, one part correct.

QUESTION 36 · 2 MARKS

- Incidence is the number of new cases of a disease occurring in a population over a defined time period, for example 627 new mesothelioma cases diagnosed in Australia in 2025 (AIHW, Mesothelioma in Australia, 2026).
- Prevalence is the total number of existing cases (new and pre-existing) in a population at a given point in time or over a period, for example about 1.3 million Australians aged 18 and over (6.5%) living with diabetes in 2022 to 24 (AIHW, Diabetes: Australian facts, 2026).

QUESTION 37 · 3 MARKS

- Negative feedback detects a change away from a set point and triggers a response that counteracts the change, returning the variable toward the set point.
- This keeps a variable such as blood glucose within a stable range, which is what homeostasis requires for normal cell function.
- Positive feedback amplifies a change rather than reversing it, so if used for routine regulation it would drive a variable further from its set point rather than restoring balance.

QUESTION 38 · 4 MARKS

- (a) Incidence = 187/14,000 × 100 = 1.34%.
- (b) Lifestyle risk factors: for example a diet high in refined sugar, low physical activity, or overweight and obesity, which was the leading risk factor for disease burden in Australia in 2024 (AIHW, Australian Burden of Disease Study 2024).
- (b) Genetic risk factor: for example a family history of type 2 diabetes, reflecting inherited variation in insulin sensitivity or insulin production.
- 2 marks for a correct incidence calculation, 1 mark each for a valid lifestyle and a valid genetic factor.

QUESTION 39 · 4 MARKS

- A genetic cause might be an inherited tendency toward higher LDL cholesterol levels, which on its own increases the risk of fatty deposits forming in artery walls (atherosclerosis).
- A lifestyle cause, such as a diet high in saturated fat and low physical activity, further raises LDL cholesterol and blood pressure.
- Where both factors are present in the same person, the risk is greater than either factor alone would predict, because the lifestyle factor compounds an already elevated genetic risk.
- Award marks for a clear, specific mechanism linking the two causes rather than a general statement that both matter.

QUESTION 40 · 7 MARKS

- (a) A cohort study records exposure first and follows people forward to see who develops the disease. The British Doctors Study recorded smoking habits in 1951 and followed the doctors' deaths to 2001 (Doll et al., BMJ, 2004). Because it counts outcomes in each exposure group, it measures incidence and relative risk directly: at 10 years the lung cancer death rate was 3.15 per 1,000 per year in men smoking 35 or more a day against 0.07 per 1,000 in non-smokers (Di Cicco et al., Breathe, 2016), a relative risk of 3.15/0.07 = 45.

- (a) A case-control study starts with people who already have the disease (cases) and people who do not (controls), and looks back at their past exposure. Doll and Hill's 1950 study found lung cancer risk rose with cigarettes smoked, about 25 times higher in people smoking more than 25 a day than in non-smokers (Di Cicco et al., 2016). It is faster and suits a rare disease, but cannot measure incidence directly.
- (b) Limitation: recall bias. Patients in the 1950 studies already knew their diagnosis when they reported their smoking, which could distort what they recalled (Jha, eLife, 2020). The cohort design reduced this because smoking was recorded in 1951, before anyone's outcome was known (White, Yale Journal of Biology and Medicine, 1990).
- (b) Confounding is also acceptable if clearly explained, since both designs are observational; a strong dose-response pattern is what made the causal case convincing.
- Marking bands: 6 to 7 marks, both designs clearly distinguished using the two studies and a specific limitation linked to how the cohort design reduced it; 3 to 5 marks, the designs distinguished but the limitation is generic; 1 to 2 marks, one design described only.

Practice Paper 1, tracked

Date each attempt, record the section marks separately, and name one change. Section I and Section II fail for different reasons. A single total out of 100 hides which one is costing you. Make one change per paper.

DATE	SECTION I AND SECTION II MARKS	THE ONE CHANGE I AM MAKING

Fill one row every time you sit a set. A tracker with three rows in it is worth more than a perfect one you never started, because the pattern you are looking for only appears across attempts.

About this resource

MA99 EDUCATION

Scope

NSW Biology, Year 12. Written to the NSW Biology Stage 6 Syllabus (2017), Modules 5 to 8, for students sitting the HSC in 2027. A new Biology syllabus is first examined in HSC 2028. The paper matches the HSC specification in total marks and section split. A few questions use the chi-square test as an extension beyond the syllabus content. Genetics problems use hypothetical families and traits, data questions are labelled where the data are hypothetical, and every named disease, study, program and technology is real. All calculations have been checked.

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