CBSE CLASS X

Science (086)

ANSWER KEY

AI-generated question paper

Code: 4T6X1P	Questions: 33	Maximum Marks: 96	Generated: 2026-06-25 17:36

SELECTIONS USED

Subject	Science
Lessons	8 Heredity
Level of understanding	Thorough understanding
Question selection	Curated chapter coverage (~5 questions per section + 8 synthesis)
Model	claude-sonnet-4-6

Composition — Difficulty: 20 medium · 13 deep | Types: 24 Short · 5 Long · 3 MCQ · 1 Very short

Q1. medium | thorough-understanding | § Introduction **[3]**

Sexual reproduction generates far greater variation among offspring than asexual reproduction. (a) Explain why this is so, linking your answer to what happens to DNA during sexual reproduction. (b) Explain why such variation is considered useful for the long-term survival of a species, giving one suitable example.

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Model Answer

(a) In sexual reproduction, DNA from two different individuals (mother and father) combines. During this process, variations arise from DNA copying errors and the mixing of parental genetic material. This produces offspring with new combinations of traits, generating far greater variation than asexual reproduction, where a single parent copies its DNA to produce nearly identical offspring.

(b) Variation is useful because if the environment changes drastically, at least some individuals with favourable variations will survive. For example, if water temperature rises due to global warming, heat-resistant bacteria in a population will survive and reproduce, keeping the species from being wiped out.

Source: Chapter 7, Section 7.1.1 — The Importance of Variation; Chapter 8, Introduction

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Explanation

- Part (a) is worth ~1.5 marks: mention **two parents**, **combining of DNA**, and **greater variation**. The contrast with asexual (single parent, near-identical copies) strengthens the answer.
- Part (b) is worth ~1.5 marks: state the **principle** (survival when environment changes) and give the **exact bacteria/global warming example** from the textbook — examiners look for this specific example.
- Do not write vague points like "variation helps evolution"; stick to what the textbook says — *survival of species over time*.

Q2. medium | thorough-understanding | § 8.1 ACCUMULATION OF VARIATION DURING REPRODUCTION **[2]**

In an asexually reproducing bacterial population, trait A is present in 10% of individuals and trait B is present in 60% of individuals. Which trait most likely arose earlier, and why?

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Model Answer

Trait B (present in 60%) most likely arose earlier.

In an asexually reproducing population, variations arise due to minor inaccuracies in DNA copying over successive generations. A trait that appeared earlier would have had more generations to be inherited and passed on, thus accumulating in a greater proportion of the population over time.

Source: Chapter 8, Section 8.1 – Accumulation of Variation During Reproduction

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Explanation

- The key logic: **older variation = more time to accumulate = higher frequency** in the population.
- The textbook question (Q1 under Section 8.1) directly asks this — examiners expect you to link **frequency of a trait** to **how long it has been present**.
- Avoid over-explaining; just state which trait, then give the one-line reason about inheritance over generations.
- Don't confuse this with dominance/recessiveness — that applies to sexual reproduction, not this concept.

Q3. medium | thorough-understanding | § 8.1 ACCUMULATION OF VARIATION DURING REPRODUCTION **[3]**

Population X reproduces only asexually for many generations, while Population Y of the same species reproduces sexually. After several generations, which population would show greater variation among its individuals? Give two reasons to justify your answer.

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Model Answer

Population Y (sexually reproducing) would show greater variation.

Reasons:

1. In asexual reproduction, new individuals arise from a single parent through DNA copying. Only minor differences occur due to small inaccuracies in DNA copying, so Population X shows very little variation.
1. In sexual reproduction, two individuals contribute DNA, leading to new combinations of genes in each offspring. This generates far greater diversity among individuals in Population Y with every generation.

As stated in the textbook, variations are maximised by the process of sexual reproduction.

Source: Chapter 8, Section 8.1 — Accumulation of Variation During Reproduction

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Explanation

- The question is worth 3 marks: 1 mark for identifying Population Y, 2 marks for two distinct reasons.
- Examiners expect you to contrast asexual (DNA copying errors only → minor variation) with sexual reproduction (gene combinations → greater variation). Use textbook language like "inaccuracies in DNA copying" and "new combinations of genes."
- Avoid vague statements like "sexual reproduction is better" — be specific about the *mechanism* causing variation.

Q4. medium | thorough-understanding | § 8.1 ACCUMULATION OF VARIATION DURING REPRODUCTION **[1]**

A sudden rise in environmental temperature kills most individuals in a species, but a small number survive and reproduce. Which of the following best explains why only some individuals survived?
(i) The survivors had acquired heat tolerance by living in warm conditions.
(ii) Pre-existing variations in the population gave some individuals better heat tolerance.
(iii) All individuals tried to adapt, but only the strongest succeeded.
(iv) The survivors belonged to a different species.

A (i) only
B (ii) only
C (i) and (iii)
D (iii) and (iv)

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Model Answer

Answer: B — (ii) only

Pre-existing genetic variations in the population gave some individuals better heat tolerance, allowing them to survive and reproduce when environmental temperature rose suddenly.

Explanation

The passage (Ch. 7, Sec. 7.1.1) explicitly states that if some variations were present in a few individuals, those variants would survive a drastic niche change — e.g., bacteria resistant to heat survive a heat wave. This is **natural selection acting on pre-existing variation**, not acquired adaptation (i) or effort-based survival (iii). Option (iv) is wrong because all individuals belong to the same species. Examiners look for the key phrase "pre-existing variation."

Q5. deep thorough-understanding § 8.2 HEREDITY **[3]**

In Mendel's dihybrid cross, F1 plants with round yellow seeds (RrYy) were self-pollinated. Among the F2 offspring, two phenotypic classes — round green seeds and wrinkled yellow seeds — were not present in either parent. (i) Explain the biological mechanism that produces these new combinations. (ii) What does the appearance of these new combinations tell us about the inheritance of seed shape and seed colour relative to each other?

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Model Answer

(i) In the F1 plant (RrYy), during gamete formation, the factors (genes) for seed shape (R/r) and seed colour (Y/y) separate independently and recombine randomly to form zygotes. This produces new combinations like Rryy (round green) and rrYy (wrinkled yellow) that were absent in the parents. These new trait combinations arise because factors controlling seed shape and seed colour recombine freely during fertilisation to form F2 offspring.

(ii) The appearance of these new combinations shows that seed shape and seed colour are **independently inherited** — the inheritance of one trait does not influence the other.

Source: Chapter 8, Section 8.2.2

Explanation

- **(i)** The key phrase from the textbook is: *"factors controlling for seed shape and seed colour recombine to form zygote leading to form F2 offspring."* Examiners want: independent separation of factors during gamete formation + random recombination at fertilisation.
- **(ii)** The exact conclusion from the textbook is: *"the tall/short trait and the round seed/wrinkled seed trait are independently inherited."* Use this language directly — it scores full marks.
- Avoid over-explaining meiosis; at Class 10 level, "factors separate and recombine independently" is sufficient.

Q6. deep thorough-understanding § 8.2.1 Inherited Traits **[3]**

In a class, some students have free earlobes and some have attached earlobes. A student notices that both her parents have attached earlobes, yet she has free earlobes. What does this tell us about the inheritance of earlobe type, and what does it reveal about the nature of the free earlobe trait? Justify your answer.

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Model Answer

Both parents have attached earlobes, yet the student has free earlobes. This tells us that earlobe type is inherited — it follows Mendel's rules of inheritance, where each child receives genetic material from both parents.

Since both parents have attached earlobes but still produced a child with free earlobes, the free earlobe trait must be **recessive**. The parents each carried one copy of the free earlobe gene (recessive) without expressing it, as attached earlobe is the **dominant** trait. When the child inherited one recessive copy from each parent, she expressed the free earlobe trait.

Source: Chapter 8, Section 8.2.2 — Rules for the Inheritance of Traits

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Explanation

- The key logic: if a trait "skips" a generation (parents don't show it but child does), the trait is **recessive**.
- Parents with attached earlobes must be **heterozygous (Aa)** — carrying one dominant (A) and one recessive (a) allele. The student received **aa**, expressing the recessive free earlobe.
- Examiners expect you to use the terms **dominant** and **recessive** correctly and justify with Mendelian reasoning. Avoid vague answers like "it skipped generations" without explaining *why*.

Q7. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[3]**

When Mendel crossed tall pea plants with short pea plants, all F1 progeny were tall. Yet when these F1 plants were self-pollinated, one-quarter of the F2 progeny were short. What does the reappearance of short plants in F2 prove about what the F1 tall plants were actually carrying?

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Model Answer

The reappearance of short plants in F2 proves that the F1 tall plants were not pure for tallness — they were carrying **both** the tallness factor (T) and the shortness factor (t), i.e., they were **Tt (heterozygous)**. The 't' factor was present but not expressed because 'T' is dominant over 't'. Only when two copies of 't' came together (tt) in F2 did the short trait reappear. This proves that both traits were **inherited** by F1 plants, but only the dominant trait (tallness) was **expressed**.

Source: Chapter 8, Section 8.2.2 – Rules for the Inheritance of Traits

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Explanation

- The examiner wants three key ideas: (1) F1 plants were **heterozygous (Tt)**, not pure tall (TT); (2) the recessive 't' factor was **hidden/not expressed** in F1; (3) F2 self-pollination produced **tt** offspring, revealing the hidden recessive trait.
- Use terms: **dominant, recessive, heterozygous, factors/genes** — these fetch marks.
- The textbook explicitly states: "both the tallness and shortness traits were inherited in the F1 plants, but only the tallness trait was expressed." Quote or paraphrase this logic directly.

Q8. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[1]**

[mcq] A pea plant has the genotype Tt. Which of the following best explains why it appears tall?
(A) Both T and t alleles combine to produce an intermediate height that is still classified as tall.
(B) The T allele is dominant and its single copy is sufficient to express the tall trait, masking the effect of t.
(C) The t allele mutates into T during plant development, giving a full tall phenotype.
(D) The plant expresses tallness because T alleles are always more numerous than t alleles in body cells.

A It has two copies of the T allele, both contributing to tallness.
B One copy of T is sufficient to produce enough hormone to make the plant tall, so the t allele has no visible effect.
C The t allele is lost during cell division, leaving only T to be expressed.
D The T and t alleles blend to produce a medium height, which is classified as tall.

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Model Answer

(B) The T allele is dominant and its single copy is sufficient to express the tall trait, masking the effect of t.

Explanation

The textbook states clearly: "a single copy of 'T' is enough to make the plant tall." Both TT and Tt are tall; only tt is short. Examiners expect students to use the terms **dominant** and **recessive** and the idea that one copy of a dominant allele is sufficient for expression.

Q9. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[2]**

Mendel observed no medium-height plants in the F1 generation when he crossed tall and short pea plants. Why does this outcome rule out the idea that inherited traits blend together in the offspring?

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Model Answer

The absence of medium-height plants in the F1 generation shows that traits do **not** blend. If blending occurred, all F1 offspring would be medium-height (a mix of tall and short). Instead, all offspring were fully tall, meaning one parental trait was expressed completely while the other was hidden, not mixed.

Source: Chapter 8, Section 8.2.2

Explanation

The examiner wants students to directly link the observation (no medium-height plants, all tall) to why blending inheritance is disproved. Key point: blending would predict intermediate offspring; Mendel's result showed one trait was **completely expressed** and the other was **hidden (recessive)**, not diluted. Mention both the expected outcome under blending AND the actual outcome for full marks.

Q10. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[3]**

In a dihybrid cross, an F1 plant with genotype RrYy is self-pollinated. Among the F2 seeds, new combinations appear that were not present in either parent. Explain why offspring with round, green seeds (Rryy) can appear even though neither parent carried that combination, and state which principle of inheritance this demonstrates.

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Model Answer

In a dihybrid cross, RrYy (round, yellow) parent produces gametes by independent segregation of alleles. The R allele (round) and y allele (green) can combine in a gamete as **Ry**, and fertilisation can produce **Rryy** offspring. Although neither parent had round + green together, the alleles for each trait were present separately and can **recombine independently** during gamete formation.

This demonstrates **Mendel's Law of Independent Assortment** — factors controlling different traits (seed shape and seed colour) are inherited independently of each other, allowing new combinations to appear in F2 progeny.

Source: Chapter 8, Section 8.2.2

Explanation

- Examiners expect you to mention **gamete formation** (specifically that alleles segregate independently) and name the **law** explicitly.
- The key phrase from the textbook is: *"factors controlling for seed shape and seed colour recombine to form zygote leading to F2 offspring"* — use this idea.
- Do NOT confuse this with the Law of Segregation (which is about two alleles of the *same* gene separating). Independent Assortment is about *different* genes behaving independently.
- For 3 marks, cover: (1) how Ry gametes are formed, (2) recombination at fertilisation gives Rryy, (3) name of the principle.

Q11. deep | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[3]**

A pea plant true-breeding for tall stem (TT) is crossed with a true-breeding short plant (tt). In the F2 generation, the expected ratio of TT : Tt : tt plants is 1 : 2 : 1. Describe the cross you would perform to experimentally confirm that the 'tall' plants in F2 are actually a mixture of TT and Tt genotypes rather than all being the same.

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Model Answer

Test Cross (Cross with homozygous recessive):

To confirm whether the tall F_2 plants are TT or Tt, each tall F_2 plant is crossed individually with a true-breeding short plant (tt) — this is called a **test cross**.

Expected results:

- If the tall F_2 plant is **TT**: all offspring will be tall (Tt).
- If the tall F_2 plant is **Tt**: offspring will be tall and short in **1:1 ratio** (Tt : tt).

By observing the progeny of each cross, we can identify which tall F_2 plants are TT and which are Tt, confirming the expected 1:2 ratio of TT:Tt among the tall plants.

Source: Chapter 8, Heredity

Explanation

- Examiners expect the term **test cross** to be named.
- Key point: the tall F_2 plant is crossed with **tt** (not another tall plant), because tt produces only 't' gametes, so any variation in offspring reveals the unknown genotype.
- State **both outcomes clearly** — all tall = TT; 1:1 tall:short = Tt. This is where most marks lie.
- No need for a full Punnett square unless specifically asked; stating the ratios is sufficient for 3 marks.

Q12. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[2]**

Why must each germ cell carry only one copy of each gene, rather than two, for Mendel's laws of inheritance to hold true in sexually reproducing organisms?

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Model Answer

In sexually reproducing organisms, a child receives one copy of each gene from the father and one from the mother, making **two copies per trait** in the offspring. For this to work correctly, each germ cell (sperm or egg) must carry **only one copy** of each gene. If germ cells carried two copies, the offspring would receive four copies per trait, violating Mendel's principle that sexually reproducing organisms have exactly two copies of genes controlling each trait.

Source: Chapter 8, Section 8.2.2

Explanation

- Examiners want you to link **germ cell formation → fertilisation → two copies in offspring** as a logical chain.
- The key Mendelian idea: sexually reproducing organisms have **two copies** of each gene (one paternal, one maternal). This only holds if each gamete contributes exactly **one copy**.
- Avoid over-explaining; two tight sentences covering "why one" and "what goes wrong with two" is enough for 2 marks.

Q13. deep | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[3]**

Two traits — seed shape (round R, wrinkled r) and seed colour (yellow Y, green y) — are controlled by genes on separate chromosomes. A plant with genotype RRyy is crossed with a plant of genotype rrYY. All F1 plants are round and yellow. When F1 plants are self-pollinated, what fraction of the F2 seeds will be wrinkled and yellow? Show your reasoning.

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Model Answer

P cross: RRyy × rrYY → F1: all RrYy (round, yellow)

F1 self-pollination: RrYy × RrYy

For **seed shape**: Rr × Rr → 1 RR : 2 Rr : 1 rr → wrinkled (rr) = **1/4**

For **seed colour**: Yy × Yy → 1 YY : 2 Yy : 1 yy → yellow (Y_) = **3/4**

Since the genes are on separate chromosomes, they assort independently:

Fraction of **wrinkled and yellow** = 1/4 × 3/4 = **3/16**

This matches the 3 wrinkled-yellow seeds seen in the 9:3:3:1 F2 ratio.

Source: Chapter 8, Section 8.2.3; Figure 8.5

Explanation

- Examiners expect you to show **each trait analysed separately**, then **multiply the fractions** — this demonstrates understanding of the Law of Independent Assortment.
- The Punnett square in Fig. 8.5 confirms the 9:3:3:1 ratio; wrinkled-yellow is the **second 3**, i.e., 3/16.
- Always state the final fraction clearly; writing only "3 out of 16" without working loses a mark.
- The key phrase to include: *"genes on separate chromosomes assort independently."*

Q14. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[1]**

[very_short_answer] In Mendel's monohybrid crosses, one parental trait disappeared in F1 but reappeared in one-fourth of the F2 progeny. How does this observation support the conclusion that organisms carry two copies of a gene for each trait rather than one?

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Model Answer

The trait reappeared in F2 because F1 plants carried two copies of the gene (one dominant T, one recessive t); only organisms with **two** copies can hide one trait while passing it on, causing its reappearance in tt offspring.

Source: Chapter 8, Section 8.2.2

Explanation

The examiner wants you to link the **disappearance in F1** and **reappearance in F2** directly to the idea of **two copies per organism**. Key point: if there were only one copy, a recessive trait could never be "hidden" and then recovered. Mention T and t (or dominant/recessive) to show you understand the mechanism. Keep it to one crisp line for 1 mark.

Q15. medium | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[3]**

A gene controls the production of an enzyme involved in making a growth hormone in pea plants. Explain, using this example, how a change in a gene can lead to a change in the physical characteristics (phenotype) of the plant.

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Model Answer

A gene contains instructions for making a specific protein (enzyme). If a gene undergoes a change (mutation), the enzyme it codes for may become non-functional or altered. In pea plants, if the gene controlling the enzyme needed to produce a growth hormone is changed, that enzyme may not form correctly. As a result, the growth hormone is not produced or is produced in insufficient amounts. Without the hormone, the plant cannot grow to its normal height, and a dwarf (short) phenotype is observed instead of the tall phenotype — showing how a gene change directly alters physical characteristics.

Source: Chapter 8, Heredity (Mendel's Contributions / gene–trait relationship)

Explanation

- Examiners expect a **gene → enzyme → hormone → phenotype** chain of reasoning — all four links must be present for full marks.
- Use the words **gene, enzyme, hormone, and phenotype** explicitly.
- The example from the question (growth hormone in pea plants) should be referenced — don't give a generic answer.
- A common mistake is stopping at "the enzyme doesn't work" without connecting it to the visible change in the plant.

Q16. deep | thorough-understanding | § 8.2.2 Rules for the Inheritance of Traits – Mendel's Contributions **[5]**

[long_answer] Mendel's law of independent assortment holds true only when the two genes considered are located on different (non-homologous) chromosomes. Explain why the results of a dihybrid cross would be fundamentally different if both genes were located on the same chromosome. What change would you expect in the F2 phenotypic ratio, and why?

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Model Answer

Mendel's Law of Independent Assortment and Linked Genes

Mendel's law of independent assortment states that two different traits are inherited independently of each other. This holds true **only** when the two genes are located on **different (non-homologous) chromosomes**, so they segregate independently during gamete formation.

If both genes are on the same chromosome (linked genes):

- The two genes tend to be inherited **together** as a unit, since they are physically attached on the same chromosome.
- During gamete formation, linked genes do not assort independently; they travel together to the same gamete.
- New combinations of traits (recombinants) would appear **far less frequently** than expected, unlike the free mixing seen in a standard dihybrid cross.

Effect on F2 phenotypic ratio:

- In a normal dihybrid cross (genes on different chromosomes), the F2 ratio is **9:3:3:1**.
- If both genes are linked, this ratio would **not** be obtained. Instead, parental combinations (e.g., tall + round seeds; short + wrinkled seeds) would appear in a much higher proportion, and recombinant types (tall + wrinkled; short + round) would be very rare.
- The ratio would deviate significantly from 9:3:3:1, approximating a **3:1 ratio** (like a monohybrid cross) if linkage is complete.

Thus, linkage prevents independent assortment, reducing genetic variation in offspring.

Source: Chapter 8, Section 8.2.2 – Rules for the Inheritance of Traits

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Explanation

- The examiner expects you to first state what independent assortment means and its condition (genes on non-homologous chromosomes).
- Then explain the concept of **linkage** — genes on the same chromosome travel together.
- Finally, clearly state the **change in F2 ratio**: 9:3:3:1 breaks down; parental types dominate; recombinants are rare; ratio approaches 3:1 for complete linkage.
- The NCERT text explicitly shows that new combinations (tall+wrinkled, short+round) arise in F2 *because* the traits are independently inherited — use this as your contrast point.
- Avoid writing a long essay; keep points crisp and logically ordered.

Q17. medium | thorough-understanding | § 8.2.3 How do these Traits get Expressed? **[3]**

A pea plant is tall because it produces a large amount of a particular growth hormone. Explain the chain of molecular events — from DNA to trait — that accounts for this tallness.

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Model Answer

The DNA of a tall pea plant contains the gene **T** (dominant allele). This gene is transcribed into mRNA, which is then translated by ribosomes to produce a specific **enzyme** (protein). This enzyme catalyses the synthesis of a **gibberellin-type growth hormone** in large amounts. The hormone promotes elongation of stem cells, resulting in the **tall phenotype**. In short plants (genotype *tt*), the non-functional enzyme produces little or no hormone, so stems remain short.

Chain: DNA (gene T) → mRNA → Enzyme (protein) → Growth hormone → Tall plant.

Source: Chapter 8 (Heredity), Chapter 6, Section 6.2.2

Explanation

- The examiner expects the **DNA → RNA → Protein → Trait** chain explicitly stated.
- Mention that the protein acts as an **enzyme** that controls hormone production — this links molecular biology to the observable trait.
- The textbook mentions gibberellins help in stem growth (Ch. 6.2.2); connecting that to the T gene is the key bridge the question demands.
- Keep the chain logical and sequential — examiners award one mark per link in the chain (gene → enzyme → hormone → trait).

Q18. deep | thorough-understanding | § 8.2.3 How do these Traits get Expressed? **[3]**

A mutant pea plant produces an enzyme involved in growth-hormone synthesis, but that enzyme functions at only 20% of normal efficiency. Predict the likely appearance of this plant and justify your answer using the relationship between genes, enzymes, and traits.

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Model Answer

The mutant plant will most likely appear **shorter than normal** (dwarf-like).

Justification: Genes control traits by producing specific enzymes. Here, the gene for growth-hormone synthesis produces an enzyme working at only 20% efficiency, meaning far less growth hormone is synthesised. Since adequate growth hormone is not available, the plant cannot achieve normal height. This demonstrates the direct gene → enzyme → trait relationship: a defective gene leads to a less functional enzyme, which alters the final observable trait (phenotype).

Explanation

- The key concept tested is **gene → enzyme → trait**: genes code for enzymes; enzymes drive biochemical reactions; reactions determine the trait.
- The examiner wants you to link **reduced enzyme efficiency → reduced hormone production → altered phenotype** in a logical chain.
- At 20% efficiency, growth hormone is severely limited, so the most predictable effect is stunted/reduced growth — draw this conclusion clearly.
- This question is application-based; the source passages establish that genes control traits (Chapter 8), so ground your answer in that principle even though the exact enzyme scenario isn't explicitly described.

Q19. medium | thorough-understanding | § 8.2.3 How do these Traits get Expressed? **[2]**

Why must each gamete (reproductive cell) carry only ONE copy of each gene, even though all other body cells carry two copies? What would happen to the chromosome number in offspring if gametes were not formed this way?

◆ Heredity

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Model Answer

Body cells carry two copies of each gene (one from each parent). When two gametes fuse during fertilisation, the offspring must receive the correct total — two copies. To ensure this, gametes are formed by **meiosis**, carrying only one copy (half the chromosomes).

If gametes were not formed this way, each fertilisation would **double the chromosome number** in every generation, disrupting the cell's genetic control and making normal development impossible.

Source: Chapter 7, Section 7.3.1 — Why the Sexual Mode of Reproduction?

Explanation

- The key idea is **meiosis halving the chromosome number** so fertilisation restores it.
- Examiners expect two clear points: (1) *why* gametes have half — so fusion gives the correct number; (2) *consequence* if they didn't — chromosome number doubles each generation.
- Quote or paraphrase the textbook phrase: *"re-establishment of the number of chromosomes and DNA content in the new generation."*
- Avoid over-explaining; two focused sentences covering both marks is sufficient.

Q20. deep thorough-understanding § 8.2.3 How do these Traits get Expressed? **[3]**

In Mendel's dihybrid cross, two traits — seed shape and seed colour — are inherited independently. Explain why this independent inheritance would be impossible if each parent contributed a single, unbroken set of all genes to their offspring.

◆ Heredity

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Model Answer

In Mendel's dihybrid cross, factors (genes) controlling seed shape and seed colour recombine independently when forming a zygote, producing new combinations like tall with wrinkled seeds or short with round seeds in F2 offspring.

If each parent contributed a single, unbroken set of all genes, the traits would always stay linked together and pass as one unit. Independent recombination of individual factors would be impossible — new combinations of traits could never arise in offspring. Mendel's results are only explained by each trait being inherited separately, not as part of an intact, inseparable package.

Source: Chapter 8, Section 8.2.2

Explanation

- The examiner wants you to connect the **dihybrid cross outcome** (new trait combinations in F2) to the **mechanism** — independent inheritance of separate gene pairs.
- Key idea: if genes were inherited as a single unbroken set, all traits from one parent would always travel together; reshuffling would be impossible.
- Use the textbook phrase: *"factors controlling for seed shape and seed colour recombine to form zygote."*
- Avoid over-explaining Mendel's ratios — that is not asked. Focus on **why** independent inheritance requires genes to be separable units.

Q21. deep | thorough-understanding | § 8.2.3 How do these Traits get Expressed? **[3]**

A student argues: 'If all genes were located on a single, continuous DNA strand with no division into chromosomes, Mendel's law of independent assortment could not hold true.' Do you agree or disagree? Justify your answer by explaining the role of chromosomes in the inheritance of different traits.

◆ Heredity

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Model Answer

I agree with the student's argument.

Mendel's Law of Independent Assortment states that genes for different traits are inherited independently of each other. This is possible because **different traits are located on different chromosomes**. During gamete formation, chromosomes separate and assort independently into sex cells.

If all genes were on a single continuous DNA strand (one chromosome), all traits would always be inherited together — they would be **linked**. New combinations like "tall + wrinkled seeds" observed in F2 progeny (as in Mendel's dihybrid cross) would never arise. The existence of **separate chromosomes** ensures that traits like height and seed shape assort independently, producing new combinations in offspring.

Source: Chapter 8, Section 8.2.2

Explanation

- The examiner wants you to **connect chromosomes to independent assortment** — that's the core biological reasoning.
- Key terms to use: **linked genes**, **independent assortment**, **gamete formation**, **chromosomes**.
- Refer to the dihybrid cross result (tall + wrinkled / short + round new combinations) as evidence — it shows traits assort independently because they are on **different chromosomes**.
- Don't just define the law; **apply** it to the hypothetical single-strand scenario to show *why* it would fail.

Q22. deep | thorough-understanding | § 8.2.3 How do these Traits get Expressed? **[5]**

During sexual reproduction, a child receives one chromosome from each pair from each parent. Explain how this mechanism both preserves the normal chromosome number across generations and accounts for the genetic variation seen in offspring.

◆ **Heredity**

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Model Answer

During sexual reproduction, each parent produces gametes (sperm or egg) through a process where chromosome pairs separate, so each gamete carries **only one chromosome from each pair**. When two gametes fuse at fertilisation, the resulting offspring receives one chromosome from each parent, restoring the full chromosome number (46 in humans = 22 pairs + sex chromosomes). This ensures the chromosome number remains constant across every generation.

Genetic variation arises because:

- Each offspring receives a **unique combination** of chromosomes from both parents.
- Sexually reproducing individuals have **two copies of each gene**; these may differ (dominant/recessive), producing varied traits.
- Traits can be **inherited independently**, giving rise to new combinations in offspring.

Thus, sexual reproduction both maintains chromosomal stability and maximises variation, which may improve survival of the species.

Source: Chapter 8 — Heredity; Chapter 7 — What you have learnt

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Explanation

What examiners look for (5 marks):

1. **(~1 mark)** Gametes carry one chromosome from each pair (halving).
2. **(~1 mark)** Fertilisation restores the full chromosome number — this is the key mechanism for preservation.
3. **(~1 mark)** Unique chromosome combinations from two parents → variation.
4. **(~1 mark)** Dominant/recessive gene pairs contribute to variation.
5. **(~1 mark)** Independent inheritance of traits → new trait combinations.

Key tip: Always explicitly link *halving in gametes + fusion at fertilisation = constant chromosome number*. Many students explain variation well but forget to clearly state the restoration mechanism — that's where marks are lost.

Q23. medium | thorough-understanding | § 8.2.4 Sex Determination **[2]**

In human beings, females have XX chromosomes and males have XY chromosomes. Explain why the sex of a child is determined by the father and not the mother.

◆ **Heredity**

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Model Answer

The mother has only X chromosomes (XX), so she can only pass an X chromosome to her child. The father has XY chromosomes, so he can pass either X or Y. If the father passes X, the child is a girl (XX); if he passes Y, the child is a boy (XY). Thus, the sex of the child is determined by the father.

Source: Chapter 8, Section 8.2.4 – Sex Determination

Explanation

- The key logic: mother always contributes X, so she cannot determine sex. Only the father's contribution (X or Y) decides the outcome.
- Examiners look for: (1) mother's limitation (only X), (2) father's two possibilities (X or Y), (3) clear conclusion linking Y → boy, X → girl.
- Avoid vague statements — be specific about which chromosome does what.

Q24. medium | thorough-understanding | § 8.2.4 Sex Determination **[3]**

A couple has four daughters. The father argues that it is the mother's genetics that keeps 'producing' girls. Is he correct? Justify your answer using the mechanism of sex determination in humans.

◆ Heredity

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Model Answer

No, the father is **not correct**.

In human beings, sex is determined by the father's contribution, not the mother's.

- All eggs produced by the mother (XX) carry only the **X chromosome**.
- The father (XY) produces two types of sperms — 50% carry **X** and 50% carry **Y**.
- If a sperm carrying **X** fertilises the egg → **girl (XX)**
- If a sperm carrying **Y** fertilises the egg → **boy (XY)**

Since the mother can only contribute an X chromosome, the sex of the child depends entirely on **which type of sperm from the father** fertilises the egg. The father is responsible, not the mother.

Source: Chapter 8, Section 8.2.4 — Sex Determination

Explanation

What examiners look for:

1. Clear statement that the father is wrong (1 mark).
2. Explanation that mother is XX → only X-bearing eggs (1 mark).
3. Father is XY → produces X and Y sperms; Y sperm gives a boy, X sperm gives a girl — sex determined by father's sperm (1 mark).

Key tip: Always state the conclusion first, then justify. Don't forget to mention both types of sperms from the father — that's the heart of the answer.

Q25. medium | thorough-understanding | § 8.2.4 Sex Determination **[3]**

In human beings, sex is determined by chromosomes inherited at the time of fertilisation, whereas in some organisms sex can be influenced by environmental factors such as temperature. What does this tell us about the role of genes versus environment in determining characteristics of an organism?

◆ Heredity

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Model Answer

Both examples show that characteristics of an organism are determined by an interplay of genes and environment.

In human beings, sex is **genetically determined** — a child inheriting X from the father is a girl (XX), and one inheriting Y is a boy (XY). The genes alone decide the sex.

In contrast, in reptiles, **environmental factors** (like temperature) determine sex, showing that genes are not always in control.

This tells us that some traits are controlled primarily by genes, some primarily by the environment, and some by **both together**. Neither genes nor environment alone can explain all characteristics; the balance varies from organism to organism and trait to trait.

Source: Chapter 8, Section 8.2.4 – Sex Determination

Explanation

- The examiner wants you to use **both examples** — human sex determination (genetic) and reptile sex determination (environmental) — to draw a **general conclusion**.
- The key phrase to write is that genes and environment **both** play a role; which factor dominates **depends on the organism and the trait**.
- Avoid writing only about humans or only about environment — the question specifically tests whether you can synthesise both sides.
- "Genes vs environment" is a classic CBSE concept; stating that it is "not always one or the other" earns the concluding mark.

Q26. deep thorough-understanding § 8.2.4 Sex Determination **[5]**

A couple is expecting their fourth child. Their first three children are all girls. What is the probability that the fourth child will be a boy? Draw a diagram showing the possible chromosomal combinations at fertilisation and explain why the probability remains the same for every pregnancy.

◆ **Heredity**

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Model Answer

Probability of the fourth child being a boy = 1/2 (50%)

Chromosomal Diagram at Fertilisation:

```
Mother (XX)  Father (XY)
    |           |
    X       X   X   Y
    \       /   \   /
     egg        sperm
     X      X or Y (equal chance)
```

Sperm from Father	Egg from Mother	Child	Sex
X	X	XX	Girl
Y	X	XY	Boy

Explanation:

Women are XX and men are XY. During gamete formation, the mother always produces eggs carrying one X chromosome. The father produces two types of sperm — half carrying X and half carrying Y — in equal numbers.

The sex of the child depends entirely on which sperm fertilises the egg. An X-bearing sperm produces a girl (XX); a Y-bearing sperm produces a boy (XY).

Each pregnancy is an **independent event**. The previous three births being girls do not affect the sperm available in the next fertilisation. Therefore, the probability of a boy remains **1/2** every time.

Source: Sex Determination, Chapter 8, Section 8.2.4

Explanation

- Examiners expect you to state the probability clearly at the start.
- The diagram (Punnett square or cross diagram) is expected — it earns dedicated marks.
- Key point to stress: each pregnancy is **independent**; past outcomes don't change probabilities.
- Quote the textbook idea directly: "sex of the children is determined by what they inherit from their father."
- Avoid writing more than needed — the table + two short paragraphs is the ideal length for 5 marks.

Q27. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

A population of bacteria reproduces asexually, while a population of pea plants reproduces sexually. Both populations encounter a sudden change in environmental temperature. Which population is more likely to have survivors, and why does the mode of reproduction affect this outcome?

◆ **Heredity**

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Model Answer

The population of **pea plants** (reproducing sexually) is more likely to have survivors.

Sexual reproduction generates **greater variation** among offspring due to the combination of genetic material from two parents. When environmental temperature changes suddenly, some individuals with favourable variations may survive and reproduce.

Asexual reproduction produces offspring that are nearly **identical** to the parent, with only minor variations from DNA copying errors. So if the temperature change is lethal to the parent type, most or all bacteria are likely to die.

Thus, greater variation in sexually reproducing populations increases the **chance of some individuals surviving** environmental changes.

Source: Chapter 7, Section 7.1.1; Chapter 8, Section 8.1

Explanation

- The key concept being tested is **variation and survival** — more variation = better chance of some individuals surviving a change.
- Examiners expect you to: (1) name the correct population, (2) link sexual reproduction to greater variation, (3) link asexual reproduction to near-identical offspring with little variation.
- The textbook example of heat-resistant bacteria dying in a heat wave directly supports this answer — use it as your evidence for asexual reproduction.
- Don't write about the mechanism of reproduction in detail; focus on **variation as the reason** for survival.

Q28. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

Mendel found that when F1 tall pea plants (Tt) self-pollinate, one-quarter of the F2 offspring are short. Yet the gene for shortness was present in the F1 plants all along. Explain, at the level of genes and their expression, why the shortness trait was hidden in F1 but reappeared in F2.

◆ Heredity

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Model Answer

In F1 plants, the gene for tallness (T) comes from one parent and the gene for shortness (t) comes from the other, giving genotype **Tt**. Because a single copy of T is sufficient to produce a tall plant, T is **dominant** and t is **recessive**. The t allele is present but its effect is completely masked by T, so F1 plants appear tall.

During self-pollination of F1 (Tt × Tt), the two alleles separate and recombine randomly, producing offspring in the ratio **TT : Tt : tt = 1 : 2 : 1**. Only the tt plants (one-quarter) lack any T allele, so the recessive shortness trait is expressed again in F2.

Source: Chapter 8, Section 8.2.2

Explanation

- **Key terms examiners expect:** dominant, recessive, genotype (Tt, TT, tt), self-pollination, 1:2:1 ratio.
- The core idea is **masking of recessive allele by dominant allele** in heterozygous condition, and **segregation** during gamete formation restoring the recessive phenotype.
- Avoid vague phrases like "the gene disappeared" — always say it was *present but not expressed*.
- A Punnett square is not required for 3 marks but mentioning the 1:2:1 genotypic ratio earns credit.

Q29. medium | thorough-understanding | § (whole-chapter synthesis) **[3]**

A student argues: 'Since sex in humans is genetically determined, and each chromosome pair provides one copy from each parent, a mother must be responsible for determining the sex of her child.' Identify the flaw in this argument and explain the correct mechanism.

◆ Heredity

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Model Answer

Flaw: The argument is incorrect. The mother cannot determine the sex of the child.

Correct Mechanism: All women are XX, so a mother can only pass an **X chromosome** to her child. Men are XY, so a father can pass either an X or a Y chromosome. If the child inherits X from the father → girl (XX); if the child inherits Y from the father → boy (XY). Since the father's contribution determines whether X or Y is passed, **it is the father, not the mother, who determines the sex of the child.**

Source: Chapter 8, Section 8.2.4 – Sex Determination

Explanation

- The key examiner expectation is: (1) identify the flaw clearly — mother only has X chromosomes to give, so she cannot determine sex; (2) state the correct mechanism — father has both X and Y, making him the deciding factor.
- Use the terms XX (female) and XY (male) — examiners specifically look for these.
- A common mistake is writing a vague answer without explaining *why* the mother cannot determine sex. Always link it back to chromosome composition.

Q30. deep | thorough-understanding | § (whole-chapter synthesis) **[3]**

Two traits of a pea plant — seed shape (round R / wrinkled r) and plant height (tall T / short t) — are located on different chromosomes. When a plant of genotype RrTt self-pollinates, are the alleles for seed shape and plant height inherited independently or together? Explain how the physical location of genes on chromosomes determines the answer, and use a cross to support your reasoning.

◆ Heredity

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Model Answer

The alleles for seed shape and plant height are **inherited independently** because the two genes are located on **different (non-homologous) chromosomes**. During gamete formation, chromosomes of each pair separate independently of other pairs (Mendel's Law of Independent Assortment), so the allele inherited for one trait does not affect the allele inherited for the other.

Cross: RrTt × RrTt (self-pollination)

Gametes produced: RT, Rt, rT, rt (each combination equally likely)

The F2 progeny show **new combinations** such as tall-wrinkled (R_tt) and short-round (rrT_), which could not arise if the traits were always inherited together. This confirms independent assortment.

Source: Chapter 8 – Heredity, Section 8.2.2

Explanation

- The key concept is **independent assortment**, which applies only when genes are on **different chromosomes** (as stated in the question and confirmed in the passage: "the tall/short trait and the round seed/wrinkled seed trait are independently inherited").
- Examiners expect: (1) a clear statement that inheritance is independent, (2) the reason (different chromosomes → independent separation during gamete formation), and (3) evidence from the cross — specifically the appearance of **new trait combinations** in F2.
- Do not draw a full 4×4 Punnett square for a 3-mark question; just list gametes and mention the new combinations as proof.

Q31. medium | thorough-understanding | § (whole-chapter synthesis) **[1]**

During the formation of germ cells in sexually reproducing organisms, one chromosome from each pair is included in each germ cell. How does this process ensure that an offspring ends up with two copies of each gene — one from each parent? What would happen to the chromosome number of offspring if this reduction did NOT occur during germ cell formation?

A Both A and R are true, and R is the correct explanation of A.
B Both A and R are true, but R is not the correct explanation of A.
C A is true but R is false.
D A is false but R is true.

◆ Heredity

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Model Answer

Germ cells are formed by meiosis, which halves the chromosome number. When two germ cells fuse during fertilisation, the normal number is restored, giving offspring one copy of each gene from each parent. Without this reduction, the chromosome number would double with every generation.

Explanation

This question is conceptual (not a standard Assertion-Reason format despite the options listed). The key ideas from Chapter 7 (section 7.3.1) are: meiosis halves chromosomes in germ cells; fertilisation restores the full number; without meiosis, each generation would have twice the chromosomes of the previous one. Examiners expect you to mention meiosis, halving, fertilisation, and the doubling consequence clearly.

Q32. deep | thorough-understanding | § (whole-chapter synthesis) **[5]**

A plant hormone is produced by an enzyme encoded by gene T. Plants with genotype TT produce a large amount of this hormone, Tt plants produce a moderate amount, yet both TT and Tt plants are equally tall. Plants with genotype tt produce very little hormone and are short.

(i) Using this information, explain at the molecular level why T is dominant over t.

(ii) In a cross between two Tt plants, what fraction of the offspring would be short? Show the cross.

(iii) If variations in height arose in an asexually reproducing plant population, what would be the likely source of those variations?

◆ Heredity

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Model Answer

(i) Gene T encodes an enzyme that produces a plant hormone. In genotype TT, two functional copies produce a large amount of hormone. In Tt, one functional copy (T) produces a moderate amount — which is still enough to make the plant tall. Since even one copy of T produces sufficient hormone for full height, T is dominant. In tt, no functional enzyme is produced, so hormone level is too low and the plant is short. Thus, dominance of T is due to the sufficiency of a single functional allele to produce the required hormone.

(ii) Cross: Tt × Tt

	T	t
T	TT	Tt
t	Tt	tt

Offspring ratio: 1 TT : 2 Tt : 1 tt

Short plants = tt → **1/4** of the offspring would be short.

(iii) In asexually reproducing plants, variations cannot arise from genetic recombination (no sexual reproduction). The likely source of variation would be **mutations** — random changes in DNA during cell division (DNA copying errors).

Explanation

- **Part (i)** tests molecular understanding of dominance: one functional allele of T produces enough enzyme/hormone for full height — this is the key molecular reason. Don't just say "T is dominant because it is expressed."
- **Part (ii)** always show the Punnett square; the answer **1/4 (25%)** must follow logically from it.
- **Part (iii)** is directly from the chapter concept: asexual reproduction produces very little variation; what variation does arise comes from **DNA copying errors/mutations**, not recombination.

Q33. deep | thorough-understanding | § (whole-chapter synthesis) **[5]**

A tall pea plant with genotype TT is crossed with a short plant (tt) to produce F1 plants (Tt), which are all tall. The F1 plants are then self-pollinated to produce F2 offspring. Answer the following:
(a) How is the gene T transmitted from the parent plant to a germ cell? What happens to the chromosome pair carrying this gene during germ cell formation?
(b) In the F1 plant (Tt), both T and t alleles are present. Why is only the tall trait expressed? What determines whether a trait is expressed or hidden?
(c) In the F2 generation, a plant inherits alleles for both height (T/t) and seed colour (Y/y), which are located on different chromosomes. Explain how the chromosome mechanism during germ cell formation allows these two traits to be inherited independently.

◆ Heredity

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Model Answer

(a) Gene T is located on a chromosome. During germ cell (gamete) formation, the process of **meiosis** occurs, in which the chromosome pair carrying gene T separates. Each germ cell receives only **one chromosome** from the pair — so it carries either T or t, not both. This ensures each gamete has a single copy of the gene.

(b) In the F1 plant (Tt), only the tall trait is expressed because **T is dominant over t**. A single copy of T is sufficient to produce the tall phenotype. The trait 't' (shortness) is **recessive** — it is hidden but not lost. Whether a trait is expressed or hidden depends on whether it is dominant or recessive; recessive traits are expressed only when both copies are identical (tt).

(c) When genes for height (T/t) and seed colour (Y/y) are on **different (non-homologous) chromosomes**, they assort independently during meiosis. The chromosome pairs separate independently of each other, so all combinations — TY, Ty, tY, ty — are equally possible in gametes. This independent assortment produces new trait combinations in F2 offspring, as Mendel demonstrated.

Source: Chapter 8, Section 8.2.2

Explanation

- **(a)** Examiners expect the term "meiosis" and the idea of separation of chromosome pairs so each gamete gets one allele.
- **(b)** Key terms: **dominant**, **recessive**. Quote the textbook logic: "a single copy of T is enough to make the plant tall; both copies must be t for the plant to be short."
- **(c)** The phrase **"independent assortment"** (or independent inheritance) and the reason — genes on **different chromosomes** separate independently — are the scoring points. Mention new combinations in F2 for full marks.

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