

Chromosomes, genes and proteins

Read online at pastopic.com/cambridge/biology-0610/notes/chromosomes-genes-and-proteins

Last checked 30 September 2026

Read first: [Biological molecules](#), [Sexual reproduction in humans](#)

© 2026 Pastopic. Free for personal study. Please share the link, not the file.

What you need to know

This topic is about where genetic information is kept (chromosomes, DNA and genes), how it decides whether a baby is a boy or a girl, and, on the Extended papers, how a gene is used to make a protein. Most questions are one-mark multiple choice on Papers 1 and 2; on Papers 3 and 4 it appears as a few parts of a longer question, often with a diagram of a cell making a protein. Outcomes marked **Extended only** are tested on Papers 2 and 4 only. By the end of this topic you should be able to:

1. **State that chromosomes are made of DNA**, and that DNA carries genetic information in the form of genes.
2. **Define a gene**: a length of DNA that codes for a protein.
3. **Define an allele**: an alternative form of a gene.
4. **Describe how sex is inherited in humans**, using the X and Y chromosomes.
5. **Extended only**: state that the order (sequence) of bases in a gene decides the order of amino acids used to make one particular protein. You don't need the details of how DNA's building blocks are put together.
6. **Extended only**: explain that different sequences of amino acids give protein molecules different shapes.
7. **Extended only**: explain that DNA controls what a cell does by controlling which proteins it makes, including enzymes, carrier proteins in the membrane and receptors for neurotransmitters.
8. **Extended only**: explain how a protein is made: the gene stays in the nucleus; a copy of it, messenger RNA (mRNA), is made in the nucleus and moves to the cytoplasm; the mRNA passes through ribosomes; the ribosome joins amino acids together into a protein; and the order of the amino acids is set by the order of the bases in the mRNA. You do not need the details of transcription or translation.
9. **Extended only**: explain that most body cells contain the same genes, but many genes in a cell are not expressed (not used), because each cell makes only the proteins it needs.
10. **Extended only**: describe a **haploid** nucleus as one with a single set of chromosomes.
11. **Extended only**: describe a **diploid** nucleus as one with two sets of chromosomes.
12. **Extended only**: state that a diploid cell has a pair of each type of chromosome, and that a human diploid cell has 23 pairs.

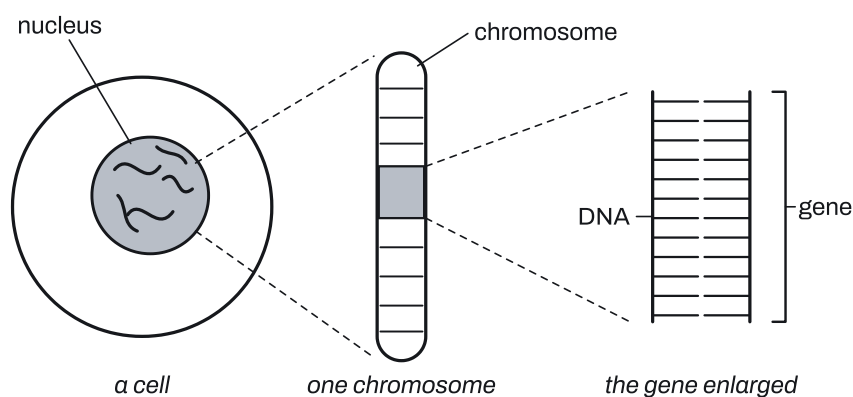
Questions here also ask you to define **inheritance**. That definition belongs to Monohybrid inheritance (topic 17.4), but it is short, so it is included below.

Understand it

Chromosomes, DNA and genes

Every living cell carries instructions for building and running the organism. In a human cell these instructions are kept in the **nucleus**, on **chromosomes**: long, thread-like structures made of **DNA**.

- A **chromosome** is one very long molecule of DNA (with some protein packed around it).
- A **gene** is a short length of that DNA that **codes for a protein**: it holds the instructions for making one particular protein. Each chromosome carries hundreds or thousands of genes, one after another.
- **DNA** is the chemical that chromosomes and genes are made of. Its structure (two strands in a double helix, with bases A, T, C and G paired across the middle) is in the Biological molecules note.



From largest to smallest: **cell** → **nucleus** → **chromosome** → **gene** (a gene is a part of a chromosome, and chromosomes are inside the nucleus).

So "a gene is a length of DNA that codes for a protein" packs in both halves of the idea: what it **is** (a length of DNA) and what it **does** (codes for a protein). A gene does **not** code for a carbohydrate, a fat or DNA itself. For example, the gene for the digestive enzyme lipase codes for lipase, which is a protein.

Alleles

Many genes come in slightly different versions. The gene for eyelash length, for example, has one version that gives long eyelashes and another that gives short ones. Each version is an **allele**: **an alternative form of a gene**. Alleles of the same gene sit at the same place on a chromosome. (How alleles are passed on and which one shows up is the Monohybrid inheritance topic.)

Inheritance is the **transmission of genetic information from generation to generation**: passing genes from parents to their offspring.

Chromosome numbers (Extended only)

Chromosomes come in **pairs**. In a normal body cell you have one chromosome of each pair from your mother and one from your father. A nucleus with **two sets** of chromosomes (a pair of each type) is **diploid**. A human diploid cell has **23 pairs**, which is $23 \times 2 = 46$ chromosomes.

Gametes (sperm and egg cells) are different: they have only **one set**, one chromosome from each pair. A nucleus with a single set is **haploid**. A human gamete has **23** chromosomes. At fertilisation two haploid nuclei fuse, $23 + 23 = 46$, so the zygote is diploid again.

Of the 23 pairs, 22 pairs are the same in males and females. The 23rd pair is the **sex chromosomes**. A human diploid cell therefore has **22 pairs of other chromosomes plus one pair of sex chromosomes**.

Inheritance of sex

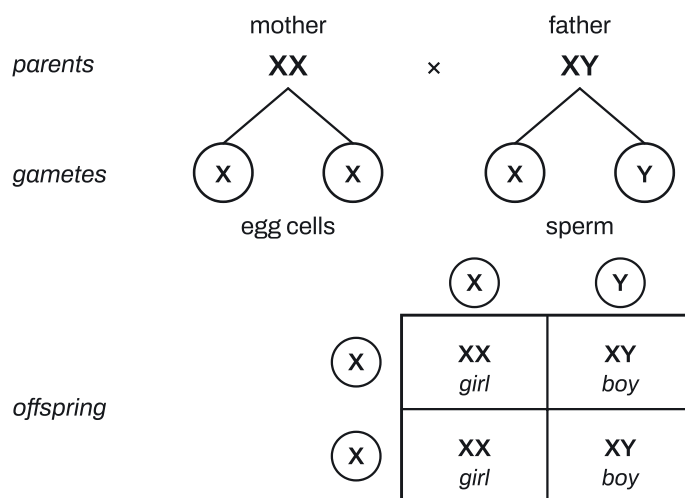
The sex chromosomes are called **X** and **Y**. The Y chromosome is much smaller than the X.

- A **female** has two X chromosomes: **XX**.
- A **male** has one X and one Y: **XY**.

When gametes form, each gets **one** of the two sex chromosomes:

- Every **egg cell** gets an **X** (a woman has only X chromosomes to give).
- **Half the sperm** get an **X** and **half** get a **Y**.

So it is the **sperm** that decides the sex of the child. An egg fertilised by an X sperm gives **XX, a girl**; an egg fertilised by a Y sperm gives **XY, a boy**. The embryo then grows by mitosis, so every cell of that child has the same sex chromosomes.



2 girls : 2 boys = 1 : 1, so probability of a girl = 0.5

Written as a Punnett square:

	Sperm: X	Sperm: Y
Egg: X	XX (girl)	XY (boy)
Egg: X	XX (girl)	XY (boy)

Two of the four boxes are girls and two are boys: a **1 : 1** ratio, so the chance of a girl is **0.5 (50%, or 1 in 2)** for **every** child. Earlier children make no difference: a couple with three sons still has a 50% chance that the next child is a daughter, because each fertilisation is a new, separate event.

Because both sexes have at least one X chromosome, **both** males and females inherit the genes on the X chromosome. Only males have a Y, so only males inherit genes on the Y chromosome.

How a gene controls a protein (Extended only)

A protein is a chain of **amino acids** joined in a particular order. There are about 20 kinds of amino acid, so they can be put together in a huge number of different orders. The **order of the bases in a gene** is a code for the **order of the amino acids** in one particular protein. Change the bases and you change the protein.

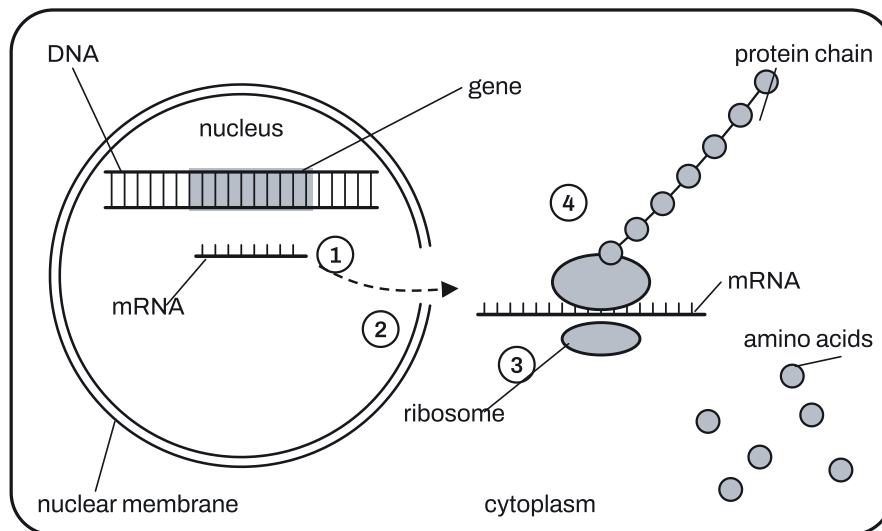
The order of amino acids decides how the chain **folds up**, and so the protein's **shape**. Different sequences of amino acids give proteins different shapes, and a protein's job depends on its shape:

- an **enzyme** has an active site whose shape fits (is complementary to) its substrate;
- a **receptor** for a neurotransmitter has a shape that the neurotransmitter fits into, so it can bind;
- a **carrier protein** in the cell membrane has a shape that lets one particular substance through;
- an **antibody** has a shape that fits one particular antigen.

So **DNA controls what a cell does** by controlling which proteins it makes: the enzymes decide which reactions happen, and the membrane proteins decide what gets in and out and which signals the cell responds to.

How a protein is made (Extended only)

The gene is in the nucleus, but proteins are made on **ribosomes** in the cytoplasm. DNA is far too big to leave the nucleus, so the cell sends out a copy of the gene instead: a molecule called **messenger RNA (mRNA)**.



1. The **gene** coding for the protein **stays in the nucleus**.
2. A copy of the gene, a molecule of **mRNA**, is made **in the nucleus**.
3. The mRNA **moves out of the nucleus into the cytoplasm**.
4. The mRNA **passes through a ribosome**.
5. The **ribosome assembles amino acids** (already free in the cytoplasm) into a protein molecule, joining them one after another.
6. The **sequence of bases in the mRNA** decides the **sequence of amino acids** in the protein.

Joining amino acids together needs energy, which comes from respiration. The ribosome does **not** make the amino acids; the cell takes them in from the blood (they come from digested food). The mRNA does not "turn into" amino acids either; it is the instructions, and it is used again and again.

Different cells, same genes (Extended only)

Almost every body cell has a nucleus with **exactly the same genes**: a copy of the whole set, made when cells divide by mitosis. Yet a neurone, a phagocyte and a cell in the pancreas are very different. The difference is which genes each cell **uses**.

A gene is **expressed** when the cell uses it to make its protein. In any one cell **many genes are not expressed**, because each cell makes only the proteins it needs for its own job. Cells in the pancreas express the insulin gene; a skin cell has the same insulin gene but does not express it. Lymphocytes are the only cells that express the genes for antibodies; other cells have those genes too, but do not use them.

Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt.

Formula	Status
Chromosomes are made of DNA; DNA carries genetic information as genes; chromosomes are in the nucleus	Learn it

Formula	Status
Gene: a length of DNA that codes for a protein	Learn it
Allele: an alternative form of a gene	Learn it
Inheritance: the transmission of genetic information from generation to generation	Learn it
Size order: gene < chromosome < nucleus < cell	Learn it
Female XX, male XY; every egg carries X; half the sperm carry X and half carry Y	Learn it
Chance of a girl (or a boy) = $\frac{2}{4} = 0.5 = 50\%$ for every child	Learn it
Extended: base sequence in a gene → amino acid sequence → shape of the protein → its function	Learn it
Extended: DNA controls cell function through proteins: enzymes, membrane carriers, receptors for neurotransmitters	Learn it
Extended: gene stays in the nucleus → mRNA copy made in the nucleus → mRNA to the cytoplasm → through a ribosome → ribosome assembles amino acids into a protein	Learn it
Extended: most body cells have the same genes; many genes are not expressed; a cell makes only the proteins it needs	Learn it
Extended: haploid = one set of chromosomes; diploid = two sets (a pair of each type); human diploid cell: 23 pairs = 46; human gamete: 23	Learn it
Extended: in DNA, %A = %T and %C = %G, and all four add up to 100%	Learn it

How to do it

We tagged 68 questions for this topic (2021–2025, Papers 1–4; 67 different, since one multiple-choice question appears on two papers). 9 of them mix types, so the counts add up to 82.

Question type	Questions
Chromosomes, genes and alleles: definitions and where they are	22
Inheritance of sex and X and Y chromosomes	22
How a protein is made	18
Amino acid sequence, protein shape and cell function	6

Question type	Questions
Defining inheritance	6
Gene expression in specialised cells	5
DNA structure and base percentages	2
Haploid, diploid and chromosome numbers	1

1. Chromosomes, genes and alleles: definitions and where they are (22 questions)

1. **Learn the definitions word for word:** a gene is "a length of DNA that codes for a protein"; an allele is "an alternative form of a gene"; chromosomes are "made of DNA".
2. **For a two-mark "define gene",** you need both halves: "length of DNA" (one mark) and "codes for a protein" (one mark).

Variations you will meet:

- **"Which term is defined as a length of DNA that codes for a protein?"** Gene. Not amino acid, chromosome, mutation or antibody.
- **"What does a gene code for?"** A protein. Reject carbohydrate, fat, starch, sugar and DNA. A question may name the protein instead, such as an enzyme (lipase), and give a base or glucose as wrong options.
- **"What are chromosomes made of?"** DNA. **"Where are they found?"** In the nucleus. **"Which part of the cell contains DNA?"** The nucleus.
- **"Which statement is correct?"** Chromosomes are made of DNA; a chromosome contains many genes (a chromosome does not make up a gene, and different forms of chromosomes are not alleles).
- **Put in order of size:** allele or gene (smallest) → chromosome → nucleus (→ cell).
- **"Genes are found at specific places on which molecule?"** DNA.
- **Thread-like structure of DNA carrying genes:** a chromosome.

2. Inheritance of sex and X and Y chromosomes (22 questions)

1. **Parents:** mother XX, father XY.
2. **Gametes:** eggs X and X; sperm X and Y. Draw each gamete separately (in a circle if the diagram has them).
3. **Offspring:** combine every egg with every sperm (a Punnett square): XX, XY, XX, XY.
4. **Probability:** girls 2 out of 4 = 0.5 (50%); boys 0.5 (50%).

Variations you will meet:

- **"Which sex chromosomes are in a sperm cell?"** Either X or Y (never both). **In an egg cell?** Only X. **In a male body cell?** XY. **In a female body cell?** XX.
- **"Which sperm makes a boy?"** One carrying a Y. **A girl?** An egg X and a sperm X.

- **"A couple have three sons. What is the chance the next child is a daughter?"** Still 50%: each child is a separate event.
- **Complete a genetic diagram:** parents' sex chromosomes → gametes → offspring → "probability of a girl = 0.5". Marks are for the gametes, the offspring and the probability.
- **"How does a female's set of chromosomes differ from a male's?"** A female has two X chromosomes; a male has an X and a (smaller) Y. The other 22 pairs are the same.
- **"Which chromosomes determine sex?"** The X and Y chromosomes (not genes, alleles or genotypes).
- **"State how sex is inherited"** (2–3 marks): females are XX and males XY; all eggs carry X; half the sperm carry X and half carry Y; X sperm + egg gives a girl, Y sperm + egg gives a boy; 50% chance of each.
- **Genes on sex chromosomes:** both men and women inherit genes on the X chromosome; only men inherit genes on the Y.
- **An embryo's sex chromosomes and its growth** (for example, egg X + sperm Y → male embryo XY): the embryo's cells are made by **mitosis**, not meiosis.

3. How a protein is made (18 questions, Extended)

1. **Name the parts on a diagram:** the gene (part of the DNA) in the nucleus; mRNA (a short strand crossing from the nucleus to the cytoplasm); the ribosome (where the mRNA passes through and amino acids join); amino acids (single units); the protein (the chain).
2. **Describe the process** in order, one point per mark: gene stays in the nucleus; mRNA is a copy of the gene; mRNA is made in the nucleus; it moves to the cytoplasm; it passes through a ribosome; the ribosome assembles amino acids into a protein; the order of bases in the mRNA decides the order of amino acids.

Variations you will meet:

- **"Put these steps in order"** (multiple choice): gene copied in the nucleus → mRNA carries the copy to the cytoplasm → mRNA passes through a ribosome → ribosome assembles amino acids into a protein. If "DNA in the nucleus" is a step, it comes first.
- **"Which statements are correct?"** Reject: the gene moves out of the nucleus (or into it); mRNA stays in the nucleus; ribosomes make amino acids; ribosomes assemble amino acids into DNA.
- **"What carries a copy of the gene to the cytoplasm?"** mRNA (not alleles, DNA or ribosomes).
- **"What is the function of the ribosome?"** It assembles amino acids into a chain (a protein). It does not carry the gene or contain the code.
- **"What is needed in the cytoplasm to make a protein at a ribosome?"** mRNA and amino acids (the DNA stays in the nucleus).
- **"What determines the sequence of amino acids?"** The **sequence of bases** in the mRNA (or in the gene or DNA). "DNA" or "mRNA" on its own is too vague.
- **"Explain the role of mRNA"** (3 marks): it is a copy of the gene; it carries the code from the nucleus to a ribosome in the cytoplasm; as it passes through the ribosome, its base sequence decides the order in which amino acids are joined.
- **Energy:** joining the amino acids needs energy from respiration (worth a mark in a long answer).

4. Amino acid sequence, protein shape and cell function (6 questions, Extended)

1. Link the chain: **base sequence** → **amino acid sequence** → **shape of the protein** → **its function**.
2. Tie the shape to the protein's job: an enzyme's active site fits its substrate; a receptor fits its neurotransmitter; a carrier lets one substance through.

Variations you will meet:

- **"Explain how the shape of a receptor protein is determined"**: by the sequence of amino acids, which is set by the sequence of bases in the gene (or mRNA).
- **"Why is the sequence of amino acids important for a receptor?"** It decides the receptor's shape; the shape must be complementary to the neurotransmitter so it can bind. A different sequence gives a different shape that does not fit.
- **"Outline how the base sequences in DNA control cell function"** (3 marks): base sequence decides the amino acid sequence; amino acids make a protein (protein synthesis); the sequence decides the protein's shape; name a protein, such as an enzyme, with its job.
- **"State the name of one type of protein"** (or two membrane proteins): enzymes; membrane carriers; receptors for neurotransmitters; also antibodies, haemoglobin, insulin, keratin. Don't write "cell membrane" or "phospholipid".
- **Receptor molecules, not receptor cells**: read the question carefully.

5. Defining inheritance (6 questions)

1. **Inheritance** is the transmission of genetic information from generation to generation. For two marks: "transmission of genetic information" (one) and "from generation to generation" (one).
2. In multiple choice, pick that wording; reject fertilisation, mitosis, meiosis, reproduction, selection and variation. "Beak shape passed from parent birds to their chicks" is an example of inheritance.

6. Gene expression in specialised cells (5 questions, Extended)

1. **Same genes**: almost every body cell has the same genes.
2. **Different expression**: each cell expresses (uses) only the genes for the proteins it needs, so it makes different proteins.

Variations you will meet:

- **"Why are pancreas cells the only cells that make insulin?"** The insulin gene is expressed only in those cells. Wrong: other cells lack the gene; pancreas cells have twice as many genes; all their genes are expressed.
- **"Why do different cells make different proteins?"** Only particular genes are expressed in each. Wrong: cells have different genes, or a different base sequence in their DNA.
- **"Which statements about a phagocyte and a neurone are correct?"** Both have the same genes; each expresses only the genes for the proteins it needs. They do **not** express the same genes.

- **"Explain why body cells can have different specialised functions even though they contain the same genes"** (3 marks): not all genes are expressed; each cell expresses only the genes for the proteins it needs; different proteins (for example enzymes) give different functions. Give an example.

7. DNA structure and base percentages (2 questions, Extended)

Covered in Biological molecules; here is what these questions need.

1. **Structure**: two strands, coiled into a double helix; four bases, A, T, C and G; bonds between the bases hold the strands together; A pairs with T and C with G.
2. **Percentages**: $A = T$ and $C = G$, and all four add up to 100%. For example, if 29% of the bases are T, then $A = 29\%$, so $A + T = 58\%$, $C + G = 42\%$, and $G = 21\%$.
3. **"Circle one pair of bases"**: one rung, both bases, not two rungs or a single base.

8. Haploid, diploid and chromosome numbers (1 question, Extended)

1. A diploid human cell has **23 pairs**: 22 pairs + 1 pair of sex chromosomes = 46 chromosomes.
2. A haploid human gamete has **23** single chromosomes: 22 + one sex chromosome (X or Y).
3. For another species, halve the diploid number: a diploid number of 78 means 39 pairs and 39 chromosomes in a gamete.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

Core. A human skin cell was stained so that its chromosomes could be seen.

- (a) State the part of the cell where the chromosomes are found, and the chemical that chromosomes are made of. **[2]**
- (b) Define the term *gene*. **[2]**
- (c) Define the term *allele*. **[1]**

(d) A man and a woman plan to have a child. Complete a genetic diagram to show the inheritance of sex, and state the probability that the child will be a girl. **[4]**

(e) The couple already have two daughters. State the probability that their next child will be a boy. **[1]**

(a) The nucleus **B1**; DNA **B1**.

(b) A length of DNA **B1** that codes for a protein **B1**.

(c) An alternative form of a gene **B1**.

(d) Parents: woman XX, man XY. Gametes: eggs X and X; sperm X and Y **B1**.

	Sperm: X	Sperm: Y
Egg: X	XX	XY
Egg: X	XX	XY

Offspring: XX, XY, XX, XY **B1**, which are girl, boy, girl, boy **B1**. Probability of a girl = $\frac{2}{4} = 0.5$ **B1**.

(e) 0.5 (50%) **B1**. Each child's sex depends only on which sperm fertilises the egg, so earlier children make no difference.

Example 2

Extended. Cells lining the stomach make the enzyme pepsin, which is a protein.

(a) State the name of the molecule that carries a copy of the pepsin gene out of the nucleus. **[1]**

(b) State the name of the cell structure where amino acids are joined to make pepsin. **[1]**

(c) Explain how the pepsin gene controls the production of pepsin. **[4]**

(d) Explain why a change in the sequence of amino acids could stop pepsin from working. **[3]**

(a) mRNA (messenger RNA) **B1**.

(b) A ribosome **B1**.

(c) Any four: the gene stays in the nucleus **B1**; an mRNA copy of the gene is made in the nucleus **B1**; the mRNA moves to the cytoplasm and passes through a ribosome **B1**; the ribosome assembles amino acids into a protein **B1**; the sequence of bases in the mRNA determines the sequence of amino acids **B1**.

(d) The sequence of amino acids determines the shape of the protein **B1**. A different sequence gives a different shape of active site **B1**, which is no longer complementary to the substrate (protein), so the substrate cannot bind and no enzyme–substrate complex forms **B1**.

Example 3

Extended.

- (a) In the DNA of a plant, 18% of the bases are A. Calculate the percentage of bases that are C. **[2]**
- (b) The body cells of a dog are diploid and contain 78 chromosomes. State (i) the number of pairs of chromosomes in a dog's body cell and (ii) the number of chromosomes in a dog's sperm cell. Describe what is meant by a *haploid* nucleus. **[3]**
- (c) Cells in the salivary glands make the enzyme amylase. Muscle cells contain the gene for amylase but do not make it. Explain why. **[2]**
- (d) DNA controls the function of a cell by controlling the proteins it makes. State two types of protein found in the cell membrane. **[2]**
- (a)** $A = T = 18\%$, so $A + T = 36\%$ and $C + G = 100 - 36 = 64\%$ **M1**. $C = G$, so $C = 64 \div 2 = 32\%$ **A1**.
- (b)** (i) 39 pairs **B1**. (ii) 39 **B1**. A haploid nucleus contains a single set of chromosomes **B1**.
- (c)** Muscle cells have the same genes as salivary gland cells, but the amylase gene is not expressed in them **B1**; a cell makes only the proteins it needs for its function **B1**.
- (d)** Membrane carriers (carrier proteins) **B1**; receptors for neurotransmitters **B1**.

Common mistakes

- **Leaving "codes for a protein" out of the definition of a gene.** "A unit of inheritance passed from parents" is not enough; examiners want "a length of DNA that codes for a protein". Don't say a gene is made of protein.
- **Not knowing where chromosomes are.** They are in the nucleus. Many candidates also did not know that chromosomes are made of DNA.
- **Saying an egg can carry a Y**, or that a sperm carries both X and Y. Eggs always carry X; each sperm carries X or Y.
- **Writing sex chromosomes in the wrong notation.** Write them as plain capital letters side by side, XX or XY, not as small raised letters like the ones used for blood-group alleles.
- **Thinking earlier children change the odds.** Every child has a 50% chance of each sex.
- **Saying mRNA goes into the nucleus**, leaves the cell, or that the gene or DNA leaves the nucleus. The gene stays; the mRNA copy is made in the nucleus and goes out to the cytoplasm.
- **Saying ribosomes make amino acids** or that mRNA is turned into amino acids. Ribosomes **join** amino acids that are already in the cytoplasm.
- **Being vague about the code.** "DNA" or "mRNA" alone does not answer "what determines the order of amino acids?". Say "the **sequence of bases** in the mRNA".
- **Writing about receptor cells** when the question is about receptor molecules (proteins on a membrane).
- **Saying different cells have different genes.** They have the same genes but express different ones.
- **Getting base percentages wrong** by forgetting that $A = T$ and $C = G$ and that the four add to 100%: with 29% T, the answer for G is 21%, not 71%, 79% or 29%.
- **Adding details of transcription or translation.** They are not needed and cost time; stick to the six steps.

How to get the marks

- **"Define"**: give the syllabus definition. Two marks usually means two parts: "length of DNA" + "codes for a protein"; "transmission of genetic information" + "from generation to generation".
- **"State" or "name"**: a word or short phrase: "nucleus", "mRNA", "ribosome", "XY", "0.5".
- **Genetic diagrams**: fill in every line (parents, gametes, offspring), write gametes separately, and give the probability in the form asked: 0.5, 50% or 1 in 2.
- **"Explain how a protein is made"**: steps in order, one idea per mark, using the exact words: gene, nucleus, mRNA, copy, cytoplasm, ribosome, amino acids, sequence of bases.
- **"Explain" a protein's function**: link the chain in full: sequence of amino acids → shape → fits (is complementary to) its substrate, neurotransmitter or the substance it carries.
- **"Explain why cells are different"**: use the word **expressed**: "the same genes, but only some are expressed".
- **Calculations**: show the working ($A = T$, $C = G$, total 100%) and give the unit, %.
- **Multiple choice with numbered statements**: test each statement on its own against the facts above before choosing the letter.

Quick check

1. Put these in order of size, smallest first: nucleus, gene, cell, chromosome.
2. Which sex chromosomes are found in (a) a human egg cell, (b) a human sperm cell, (c) a skin cell from a boy?
3. **Extended**: a human body cell has 46 chromosomes. (a) How many pairs is this? (b) How many chromosomes are in an egg cell? (c) Which of the two is haploid?
4. **Extended**: put these steps of protein synthesis in order: P, the ribosome assembles amino acids into a protein; Q, an mRNA copy of the gene is made in the nucleus; R, the mRNA passes through a ribosome; S, the mRNA moves into the cytoplasm.
5. **Extended**: in a sample of DNA, 35% of the bases are G. Calculate the percentage that are T.

Answers

1. Gene → chromosome → nucleus → cell.
2. (a) X; (b) X or Y (either one, not both); (c) XY.
3. (a) $46 \div 2 = 23$ pairs; (b) 23; (c) the egg cell (it has one set of chromosomes).
4. $Q \rightarrow S \rightarrow R \rightarrow P$.
5. $C = G = 35\%$, so $C + G = 70\%$ and $A + T = 100 - 70 = 30\%$. $A = T$, so $T = 30 \div 2 = 15\%$.

Past questions to try

- **0610/41/M/J/23 Q5**: naming the parts in a protein-synthesis diagram, why the amino acid sequence matters for a receptor, gene expression and alleles (Extended).
- **0610/42/M/J/23 Q2**: a base pair, a base percentage, the definition of a gene, how proteins are made and membrane proteins (Extended).
- **0610/32/F/M/23 Q3**: the definition of a gene, where chromosomes are found and the chromosomes that decide sex (Core).
- **0610/43/M/J/21 Q2**: the role of mRNA and the ribosome in making insulin (Extended).