NAME _____ CLASS _____ DATE _____

IB BIOLOGY · D1.3

Mutation and gene editing

Notes to fill in alongside the guide. Each numbered block matches a chapter of the guide, and of the lesson slides. Write in the gaps, answer the cues, annotate the figures, and sum up each section in your own words.

BY THE END YOU CAN

- [ ] Distinguish between substitutions, insertions and deletions as changes to the base sequence of a gene D1.3.1
- [ ] Explain why a base substitution may or may not change an amino acid, and what a SNP is D1.3.2
- [ ] Explain why insertions and deletions are likely to stop a polypeptide working, through a frameshift or a large change D1.3.3
- [ ] Outline the causes of gene mutation: mutagens, with chemical and radiation examples, and errors in replication or repair D1.3.4
- [ ] Explain in what sense mutation is random, and in what sense it is not D1.3.5
- [ ] Compare the consequences of mutation in germ cells and in somatic cells D1.3.6
- [ ] Explain why mutation is the original source of all genetic variation, and why it matters for evolution D1.3.7
- [ ] Outline how knocking out a gene is used to find out what it does D1.3.8
- [ ] Describe how CRISPR sequences and Cas9 are used to edit genes, with one successful use D1.3.9
- [ ] Evaluate two hypotheses for why some sequences are conserved across species D1.3.10

01 Three ways to change a gene

D1.3.1

CUES

Predict: A gene of 900 bases becomes 901 bases long. Which kind of mutation could this be?

What is meant by gene mutation?

What is meant by substitution?

What is meant by insertion?

What is meant by deletion?

NOTES

1 A _____ is a change to that sequence.

2 In a _____ one base is swapped for another.

3 In an _____ one or more bases are added.

4 In a _____ one or more bases are lost.

5 A _____ is a change to the base sequence of a gene.

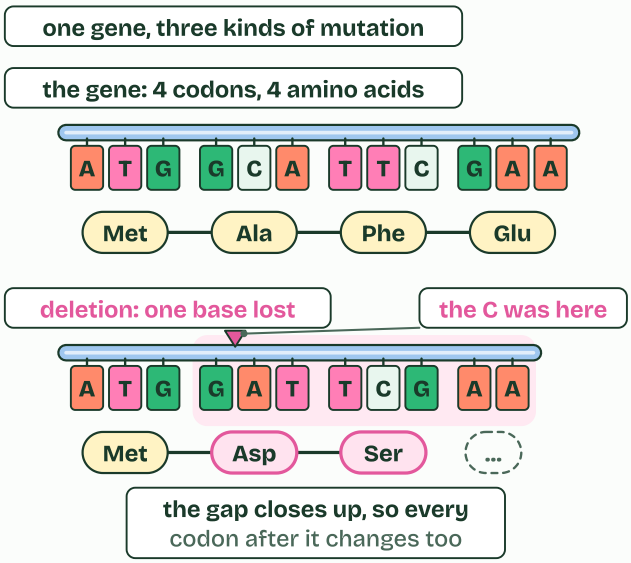
6 _____: one base replaced. Insertion: bases added. Deletion: bases lost.

7 A _____ keeps the gene's length; insertions and deletions change it.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each: 1 four codons; 2 substitution; 3 insertion; 4 deletion.



SPOT THE MISTAKE

What do students often get wrong about gene mutations as structural changes? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 01 in two or three sentences of your own.

02 One base swapped

D1.3.2

CUES

Predict: The codon GGU codes for glycine, and so do GGC, GGA and GGG. The U is replaced by an A. What is the result?

What is meant by degenerate?

What is meant by single-nucleotide polymorphism (SNP)?

NOTES

1 The genetic code is _____: most amino acids have more than one codon, and the codons for one amino acid usually differ only at the third base.

2 So a substitution can be _____: the codon changes, the amino acid does not, and the polypeptide is exactly as it was.

3 If the new codon codes for a different amino acid, the mutation is _____: one amino acid in the chain is different.

4 If the new codon is a stop codon, it is _____: translation ends early and the polypeptide is cut short.

5 A base substitution that is found in some members of a population is a _____.

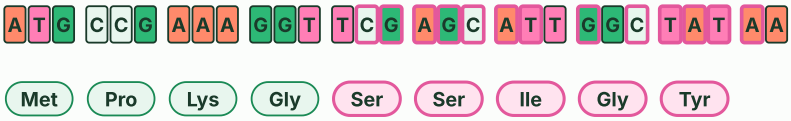
6 Silent: same amino acid, because the code is _____. Missense: a different amino acid. Nonsense: a stop codon.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each.

Each codon: DNA coding strand, then mRNA, then amino acid



A deletion: one base lost, the frame shifts

REMEMBER IT

What a swapped base can do

S Same	M Mistake	S Stop
S	M	S

SPOT THE MISTAKE

What do students often get wrong about consequences of base substitutions? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 02 in two or three sentences of your own.

03 Sickle cell, one base at a time

D1.3.2

CUES

Predict: A different substitution in the same codon turns GAG into GAA. What would happen to the haemoglobin?

NOTES

1 The usual allele, Hb^A, has GAG as its sixth codon (counting from after the start codon), and GAG codes for _____.

2 GAG becomes GTG, and GTG codes for _____.

3 In a red blood cell, molecules of _____ stay separate.

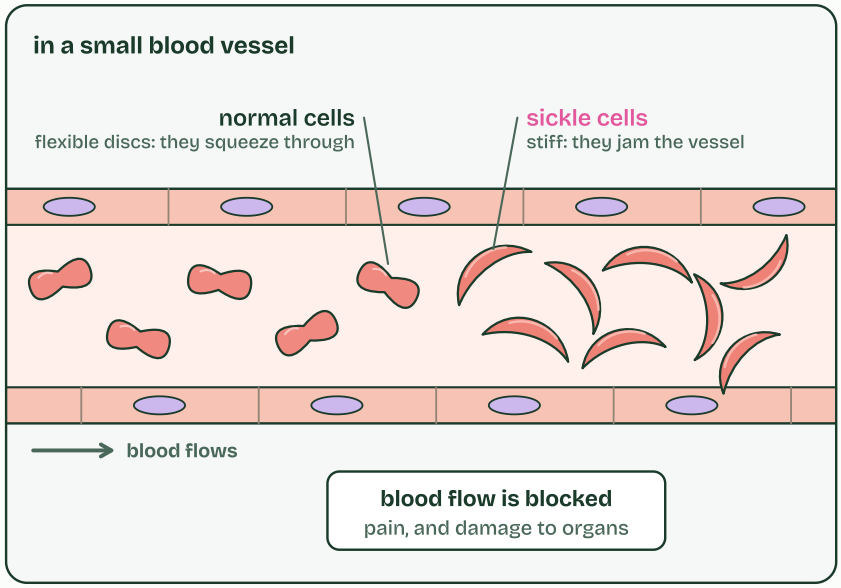
4 Molecules of _____, at low oxygen, stick together into long fibres.

5 The fibres bend the cell into a _____. Sickle cells are stiff and block small vessels.

Your own notes

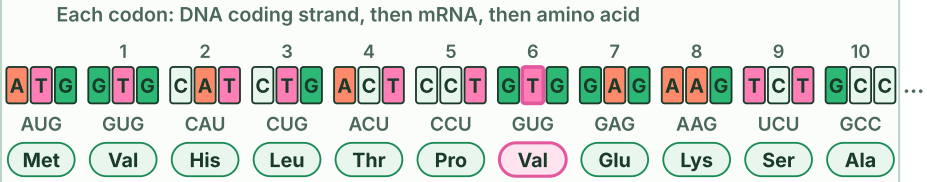
ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 haemoglobin A; 2 haemoglobin S; 3 sickle.



ANNOTATE THE FIGURE

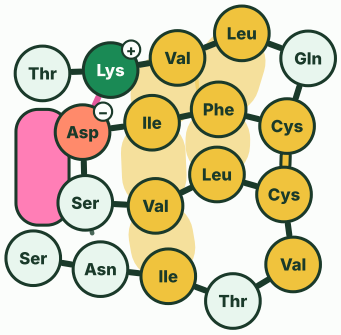
Number the 2 steps on the figure and note what happens at each: 1 GAG; 2 A to T, valine.



Sickle cell allele: A to T, so GTG, valine

ANNOTATE THE FIGURE

Number the 2 steps on the figure and note what happens at each.



SPOT THE MISTAKE

What do students often get wrong about a substitution with a known effect: sickle cell? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 03 in two or three sentences of your own.

04 Bases added or lost

D1.3.3

CUES

Predict: Three edits to the same gene: one base substituted, one base deleted, three bases in a row deleted. Which is most likely to stop the protein working?

What is meant by reading frame?

What is meant by frameshift?

NOTES

1 A ribosome reads mRNA in threes from the start codon, with nothing to mark where one codon ends and the next begins. That grouping into threes is the _____.

2 Every codon after the change is read in a new grouping, so every amino acid after it can change, and a stop codon usually turns up early, because three of the 64 codons are stops. This is a _____, and the polypeptide it makes almost never works.

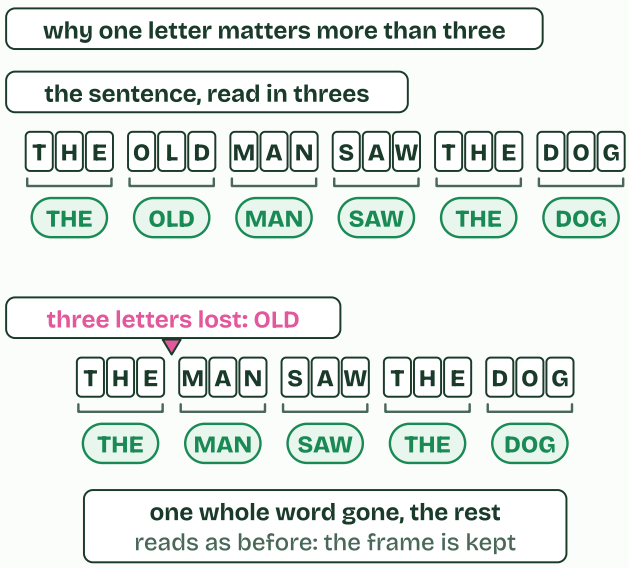
3 Inserting or deleting one or two bases shifts the _____: a frameshift.

4 After a _____ every codon changes and an early stop codon is likely, so the polypeptide is very unlikely to function.

Your own notes

ANNOTATE THE FIGURE

Number the 4 steps on the figure and note what happens at each.



SPOT THE MISTAKE

What do students often get wrong about consequences of insertions and deletions? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 04 in two or three sentences of your own.

05 Where mutations come from

D1.3.4 D1.3.5

CUES

Predict: A student says: "A population of insects in a hotter climate will mutate so that it can cope with heat." What is wrong with this?

What is meant by mutagen?

NOTES

1 So _____ are one cause.

2 The other is a _____.

3 Mutation is _____ in two senses, and not in a third.

4 An _____: a G is put opposite a T. Repair enzymes catch most such errors.

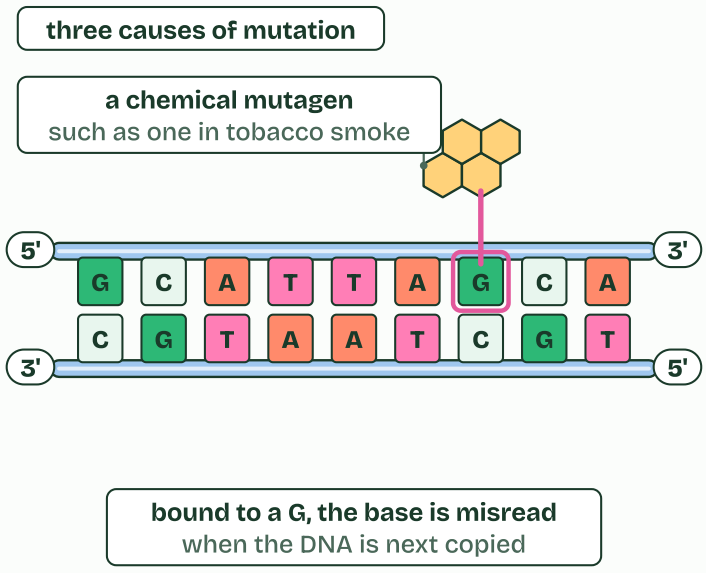
5 _____ joins two thymines next to each other. Copying past the join makes mistakes.

6 A _____ binds to a base, which is then misread when the DNA is copied.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 error in replication; 2 Ultraviolet light; 3 chemical mutagen.



REMEMBER IT

Mutagens

S Smoke	S Sun	S Scans
S	S	S

SPOT THE MISTAKE

What do students often get wrong about causes of mutation, and randomness? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 05 in two or three sentences of your own.

06 Passed on, or not

D1.3.6 D1.3.7

CUES

Predict: A man has a mutation in a lung cell after years of smoking. Could his children inherit it?

What is meant by somatic cells?

What is meant by germ cells?

NOTES

1 Most are _____, body cells.

2 A few lines of cells, the _____, make the gametes.

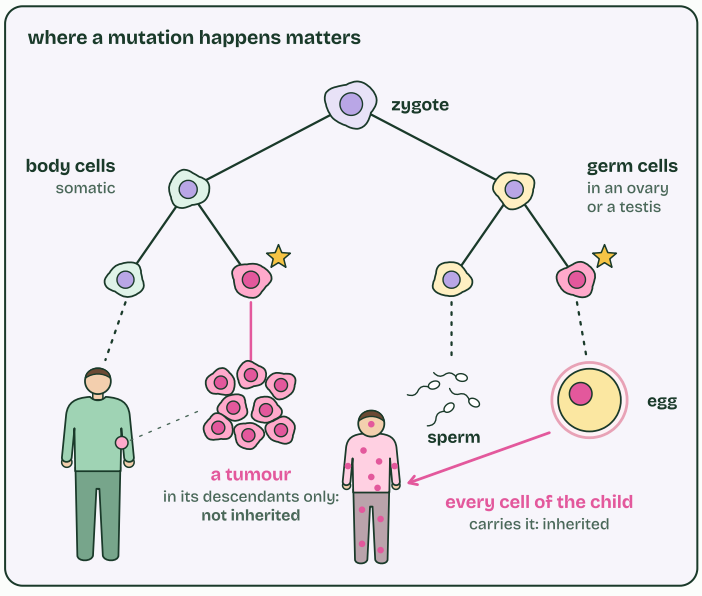
3 But if it hits genes that control cell division, that cell's descendants can divide without control and form a tumour: _____ begins with mutations in somatic cells, often several in one line of cells.

4 If that gamete is used in fertilisation, the mutation is in the zygote, so it is in _____ of the child, germ cells included, and it can be passed on again.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 zygote; 2 somatic cell; 3 germ cell.



SPOT THE MISTAKE

A student writes: “Most mutations are harmful.” Spot the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 06 in two or three sentences of your own.

07 Switch a gene off

D1.3.8 HL

CUES

Predict: A gene is knocked out in mice and the mice cannot smell. What is the best conclusion?

What is meant by gene knockout?

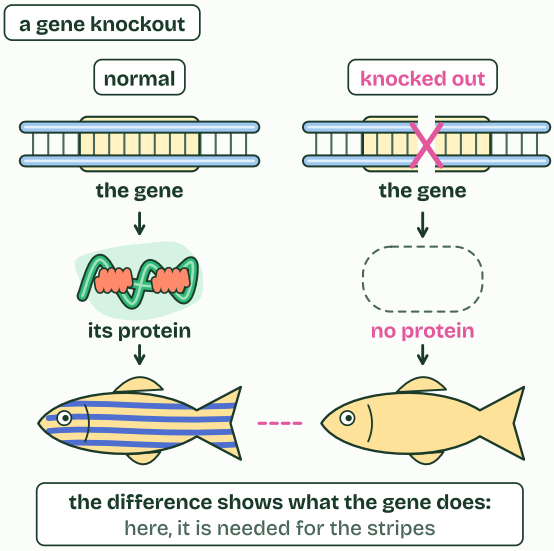
NOTES

1. In a _____, a gene is changed so that it can no longer make a working product.
2. Knockouts are made in _____: species that are easy to keep and breed and that share many genes with humans, such as mice, zebrafish, fruit flies, yeast and the plant *Arabidopsis*.
3. For some of them, scientists have built _____: collections with one strain for each of thousands of genes, so that a researcher can order a strain with the gene they study already switched off.
4. A _____ gene makes its protein, and the fish develops its stripes.
5. The same gene _____: no working protein, and no stripes.
6. Compare the two. The difference shows _____. The fish and the gene are drawn to show the idea.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each: 1 normal; 2 knocked out; 3 what the gene does.



SPOT THE MISTAKE

What do students often get wrong about gene knockout? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 07 in two or three sentences of your own.

08 Cut, then repair

D1.3.9 HL

CUES

Predict: Scientists want to change one base in a gene, not knock the gene out. What must they add besides Cas9 and a guide RNA?

What is meant by cas9?

What is meant by guide RNA?

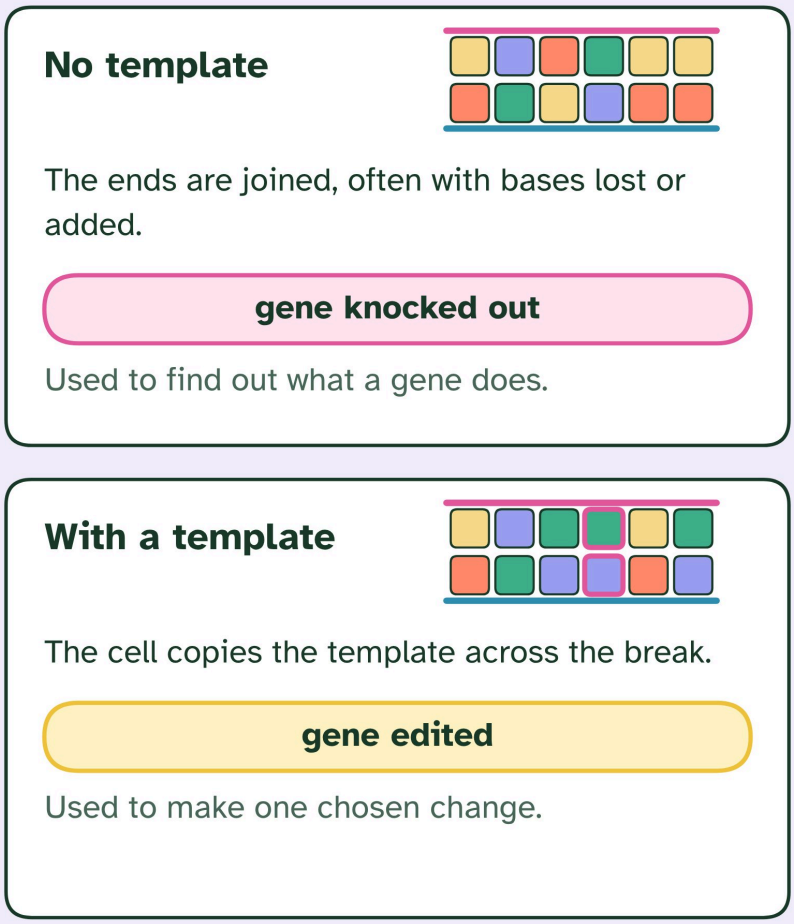
NOTES

1. _____ is an enzyme that cuts DNA.
2. It carries a _____, and the guide RNA decides where it cuts.
3. Usually it simply joins the ends, often losing or adding a few bases: a frameshift that _____.
4. If scientists also supply a piece of DNA with the sequence they want, the cell can copy it across the break: an _____, such as one chosen base changed.
5. A _____ matching the target leads Cas9 to it; Cas9 cuts both strands.

Your own notes

ANNOTATE THE FIGURE

Annotate this still from the animation (Cut and repair: CRISPR-Cas9): what is happening, and why?



SPOT THE MISTAKE

What do students often get wrong about gene editing with CRISPR and Cas9? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 08 in two or three sentences of your own.

09 Sequences that stay the same

D1.3.10 HL

CUES

Predict: In a conserved region of a gene, the amino acids are the same in ten species but the third bases of the codons differ. Which hypothesis does this support?

What is meant by conserved sequence?

What is meant by highly conserved sequence?

NOTES

1 A _____ is identical or similar across a species or a group of species.

2 A _____ has stayed the same over long periods of evolution: the histone H4 protein of a pea and of a cow differ in only two of about a hundred amino acids.

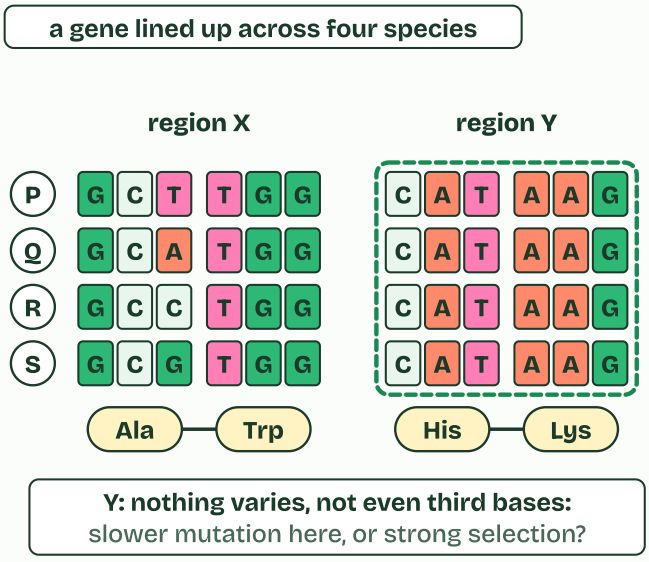
3 Region X: a _____ but the amino acids do not. That fits the _____ hypothesis.

4 Region Y: _____, not even third bases. That fits _____, or very strong selection.

Your own notes

ANNOTATE THE FIGURE

Number the 3 steps on the figure and note what happens at each.



SPOT THE MISTAKE

What do students often get wrong about conserved and highly conserved sequences? Write the mistake, then put it right.

The mistake

Put it right

SUMMARY

Sum up section 09 in two or three sentences of your own.

Check yourself

The check for this guide is online: a fresh paper of past-paper style questions from the exam bank on D1.3 each time, marked as you go, and saved to your Exam practice progress when you are signed in. Scan the code, or type the link.

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How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.