AP BIOLOGY | UNIT 6 | TOPICS 6.7 AND 6.8

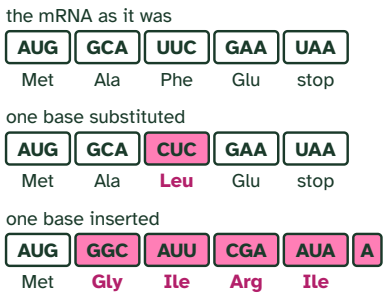
REVISION ON TWO PAGES

DNA that *changes*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

A mutation alters a DNA sequence, and can change a protein's type or amount. Random mutations are a source of variation.



Read in threes from AUG. A substitution changes one codon. An insertion changes every codon after it.

6.7.A START HERE

One nucleotide can change a *protein*

- A **mutation** is an alteration in a DNA sequence. It can change the **type** of protein made (a new amino acid sequence) or the **amount** (more, less or none), and so the phenotype.
- A **point mutation** substitutes one nucleotide for another. One codon changes, and the reading frame never moves.
- A **frameshift mutation** inserts or deletes nucleotides, so **every codon after it** is read differently. Three in or out adds or removes a whole codon and keeps the frame.

FOUR RESULTS FOR THE PROTEIN

S Silent — same amino acid: the code is redundant

C Changed — one amino acid is different

N Nonsense — a stop codon too early

F Frameshift — the frame moves

6.7.A 6.7.B THE VERDICT

Is it *beneficial*?

- A mutation is **beneficial, detrimental or neutral** by its effect on the protein and the phenotype. Most are neutral.
- It also depends on the **environment**: one allele can help in one place and harm in another.
- **Example:** a mutation gives a pocket mouse dark fur, and owls hunt by sight.

On dark rock beneficial
The mouse is hard to see, so it survives and reproduces.

On pale sand detrimental
The same mouse stands out.

6.7.B FOUR CAUSES, ONE RULE

Causes of *mutation*

- Mutations are **random**: they do not happen because an organism needs them.
- They are a **source of genetic variation**. Every new allele began as one.

COPYING
Replication
An error is not caught.

MENDING
Repair
Damage is fixed wrongly.

OUTSIDE
Radiation
Ultraviolet light, for one.

OUTSIDE
Chemicals
Reactive ones alter a base.

6.7.B NUMBER AND STRUCTURE

Whole *chromosomes*

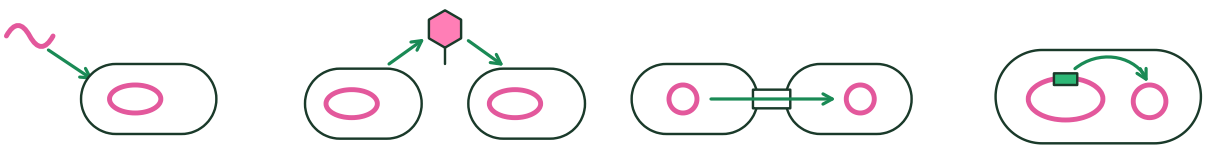
- Errors in **mitosis or meiosis** can change the phenotype without changing the sequence of any gene.
- In **nondisjunction** chromosomes fail to separate. Every gene on an extra chromosome is normal: there is one copy too many.

Number too many or too few
Often a new phenotype, and often a disorder that limits development.

Structure rearranged
A segment lost, repeated, turned around or moved can cause a genetic disorder.

6.7.C GENES THAT MOVE, AND SELECTION

Four ways a prokaryote *gains genes*



TRANSFORMATION
Loose DNA is taken up
from the surroundings.

TRANSDUCTION
A virus carries DNA
from one cell to the next.

CONJUGATION
Cell to cell
DNA passes between two joined cells.

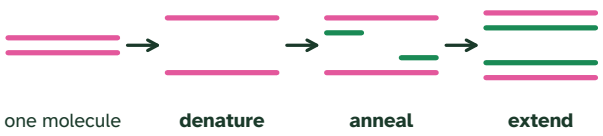
TRANSPOSITION
A segment moves
within or between DNA molecules.

- **Horizontal acquisition** of genetic information increases variation in prokaryotes. Related viruses that infect the same host cell can also **recombine** their genetic information.
- A change that raises survival and reproduction is **selected for by environmental conditions**. An antibiotic does not make resistance: it leaves resistant cells to reproduce.

Biotechnology: *copy*, sort, read and move DNA

6.8.A COPY

PCR *copies* one stretch of DNA

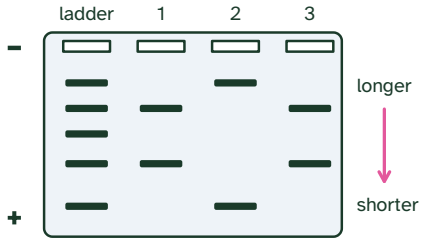


- The **polymerase chain reaction amplifies** a DNA fragment: many copies of one chosen stretch.
- **Denature:** heat separates the two strands. **Anneal:** short primers pair with the original strands, one each side of the target. **Extend:** DNA polymerase adds nucleotides to the 3′ end of each primer.
- Each cycle **doubles** the copies: 2^n after n cycles, about a billion after 30. The primers set which stretch is copied.
- **Used to** identify organisms and work out how they are related.

6.8.A SORT

A gel *sorts* fragments by length

- **Gel electrophoresis** separates DNA fragments by **size and charge**.
- DNA is negatively charged, so it moves toward the **positive electrode**. **Shorter fragments move farther** through the gel.
- A band is many copies of one length. A ladder of known lengths gives the sizes. **Used to** compare patterns from samples: forensic identification.



6.8.A READ

Sequencing *reads* the bases

- **DNA sequencing** determines the **order of nucleotides** in a DNA molecule.
- Line up the same stretch from different samples and count the differences: the fewer there are, the more closely related the samples.
- Lined up against the usual sequence, a sequence shows where a mutation is and what kind.

sample 1	A	T	G	C	C	T	A	G	G	A
sample 2	A	T	G	C	C	T	A	G	C	A
sample 3	A	T	A	C	C	T	T	G	C	A

PCR	A GEL	SEQUENCING
More of it?	**How long is it?**	**What does it say?**

6.8.A MOVE

Transformation *moves* a gene

- **Bacterial transformation** introduces foreign DNA into bacterial cells, usually a plasmid with the gene of interest and a gene for antibiotic resistance.
- Only a few cells take the plasmid up. On agar with the antibiotic only they grow, each into a colony.
- A transformed cell expresses the gene and copies the plasmid at every division: **gene cloning**. **Used to** make genetically modified organisms; transgenic animals carry another species' gene.



cells without the plasmid | cells with the plasmid

Both plates contain the antibiotic.

WATCH OUT

Five mistakes that *cost points*

- ✕ **Mutation does not mean harmful.** Most are neutral, and the verdict depends on the environment.
- ✕ **A point mutation never shifts the reading frame.** A frameshift needs an insertion or a deletion.
- ✕ **Mutations are not made to order.** An antibiotic selects resistant cells; it does not create them.
- ✕ **A mutation does not denature a protein.** The protein is built with a different sequence from the start.
- ✕ **PCR copies only the stretch between the primers,** and a gel shows lengths, not base sequences.

COVER THE SHEET

Can you *answer these?*

1. Describe a silent mutation and a nonsense mutation.
2. Predict the effect of deleting one base early in a gene.
3. Explain how one mutation can help or harm.
4. Identify three causes of mutation.
5. Predict the zygote: a gamete with 5 meets one with 4.
6. Describe two ways a prokaryote gains a gene.
7. Calculate the copies after 10 cycles of PCR.
8. Explain why transformed cells are plated on an antibiotic.

IN THE EXAM

Follow a mutation step by step: nucleotide, codon, amino acid, protein, phenotype. **For a technique,** say what the result shows, then name the idea from the unit that explains it.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.