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A single-base difference between individuals, resulting from a base substitution mutation.

A structural change to a gene at the molecular level: a substitution, insertion or deletion of bases.

Insertion or deletion of bases (not a multiple of three) shifts the reading frame, changing every following codon.

The genetic code is degenerate, so the new codon may code for the same amino acid.

Chemical: benzo[a]pyrene, nitrosamines (tobacco smoke), mustard gas. Radiation: UV, X-rays, gamma rays.

Mutagens (chemicals and radiation) and errors in DNA replication or repair.

Germ cell: can be inherited by offspring.
Somatic cell: not inherited, but can cause cancer.

Mutations can occur anywhere in the genome (some bases more often); no natural mechanism deliberately changes a base to change a trait.

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Why is mutation essential for evolution?

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Risk of commercial genetic tests

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Gene knockout

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Knockout libraries

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Roles of guide RNA and Cas9

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A successful use of CRISPR-Cas9

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Why is international regulation of CRISPR needed?

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Conserved vs highly conserved sequences

Without expert interpretation, information on future disease risk could be misunderstood.

It is the original source of all genetic variation (new alleles) on which natural selection acts.

Collections of model organisms (e.g. yeast, mice), each with a different gene knocked out, available to researchers.

Investigating a gene's function by making it inoperative and comparing the organism's phenotype with wild type.

Editing patients' blood stem cells so they make fetal haemoglobin, treating sickle-cell disease (approved 2023).

Guide RNA pairs with the target DNA sequence; Cas9 cuts both DNA strands at that site.

Conserved: similar across a species or group. Highly conserved: similar over long periods of evolution.

Some uses (e.g. germline editing) raise ethical issues, and countries have different regulatory systems.

Two hypotheses for conserved sequences

	Functional requirements of the gene product (selection removes changes) and slower rates of mutation.