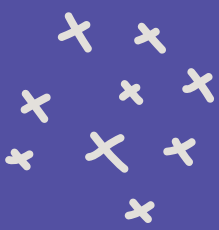




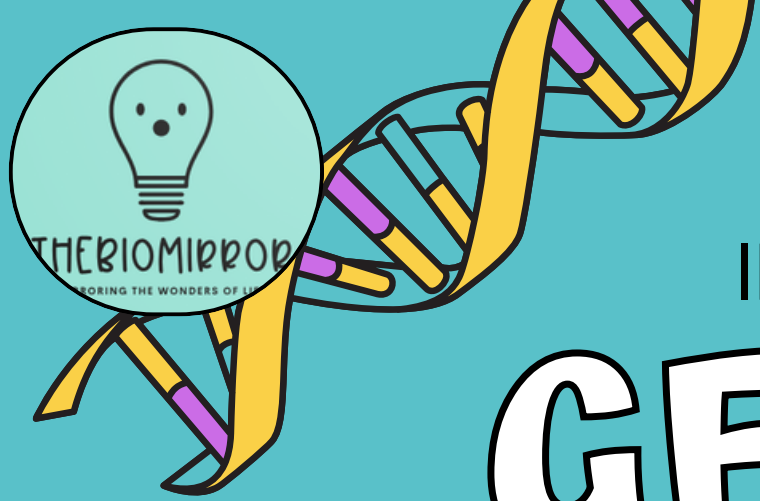
The Biology Mirror



Genetic Engineering



Genetic engineering, once the stuff of science fiction, is now a **transformative** field revolutionising **Biology**, medicine, and agriculture. It involves the deliberate modification of an organism's DNA to achieve desired traits or outcomes. However, this **power** comes with complex societal and ethical **responsibilities**.



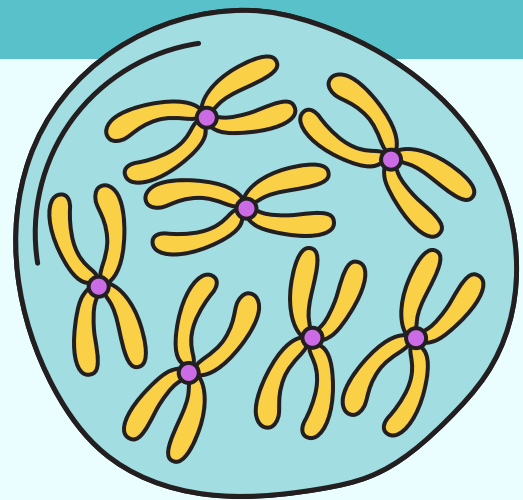
INTRODUCTION TO GENETICS

Genes carry information that gets passed from one generation to the next.

A gene is a section of DNA (deoxyribonucleic acid) that carries the instructions for different characteristics (or traits) of an organism.

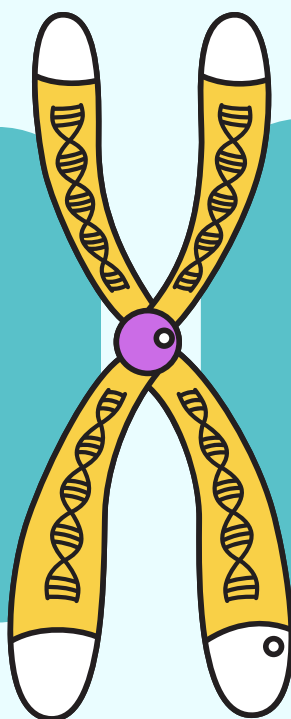
DNA lives in each cell of an organism on structures called chromosomes.

DNA molecules contain four different nucleotides – these store the 'code' for each organism's trait.



The four nucleotides are:

- Adenine (A)
- Cytosine (C)
- Guanine (G)
- Thymine (T)



The pattern for coding is:

- Adenine pairs with Thymine (A with T)
- Guanine pairs with Cytosine (G with C)

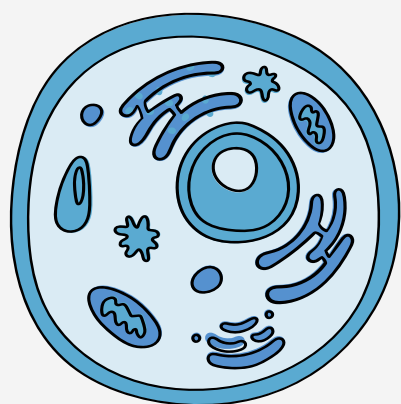
Many organisms pass on their genetic information through sexual reproduction. This involves each parent contributing half of their genes to their offspring.

The traits of the offspring will depend on which genes they 'inherit' from their parents.



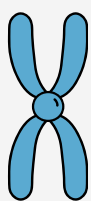
What is Inheritance?

(The science kind)



CELL

basic building block of living things



CHROMOSOME

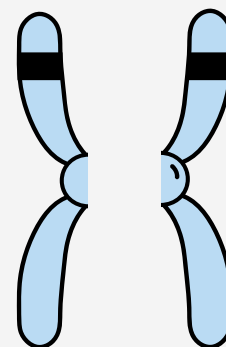
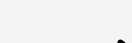
bundles of tightly-coiled DNA found in the nucleus



DNA

(deoxyribonucleic acid)
contains the genetic code

GENE
contains instructions that determine individual traits









ALLELE
an alternative form of a gene

Individuals inherit two alleles—one from each parent



Dominant and Recessive Alleles

		Parent 2 	
		b	b
Parent 1 	B	 Bb	 Bb
	b	 bb	 bb

B dominant brown eye allele
b recessive blue eye allele

Dominant allele masks the effect of the recessive allele

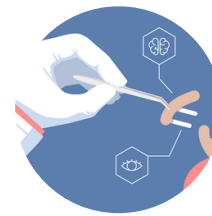
An individual needs two copies of the recessive allele for a recessive trait to appear



How does it work?

Genetic engineering is the process of directly manipulating an organism's genome using biotechnology. It encompasses a range of techniques that alter the genetic material—DNA or RNA—in ways that do not naturally occur. Unlike traditional breeding methods, genetic engineering provides precision and control, enabling scientists to:

- Introduce new traits.
- Eliminate undesirable characteristics.
- Repair faulty genes.



Step 1: Target Gene

- **Isolate** the gene of interest responsible for a specific trait or condition.
- For example, scientists may identify a gene that confers drought resistance in plants or one that causes cystic fibrosis.



Step 2: Choose a tool

1. **CRISPR-Cas9**: Cut DNA at precise locations. It uses a guide RNA to target specific DNA sequences and the Cas9 protein to make the cut.
2. **TALENs and ZFNs**: Also cut DNA at specific sites but are more complex to design compared to CRISPR.

Step 3: Choose a method

1. **Insertion**: New genes can be introduced
2. **Knockout/Deletion**: Remove problematic genes
3. **Gene Modification**: Edit a gene to enhance or suppress its function.

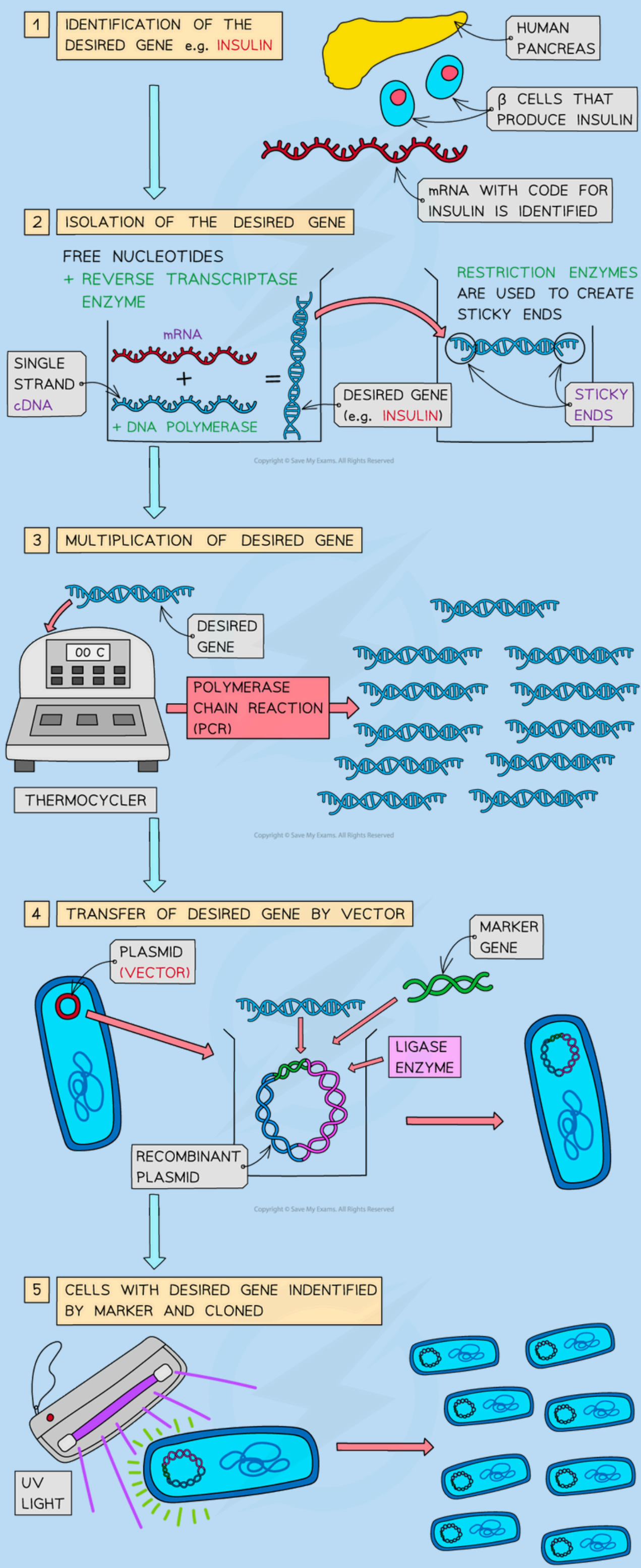
Step 4: Induction

- The modified gene is **introduced** into the target organism using vectors like **plasmids**, or via techniques like **electroporation** or **microinjection**. In humans, methods like **nanoparticles** are also explored.
- After editing, the organism is tested to ensure the desired genetic changes have occurred without **off-target** effects.





Detailed Infographic

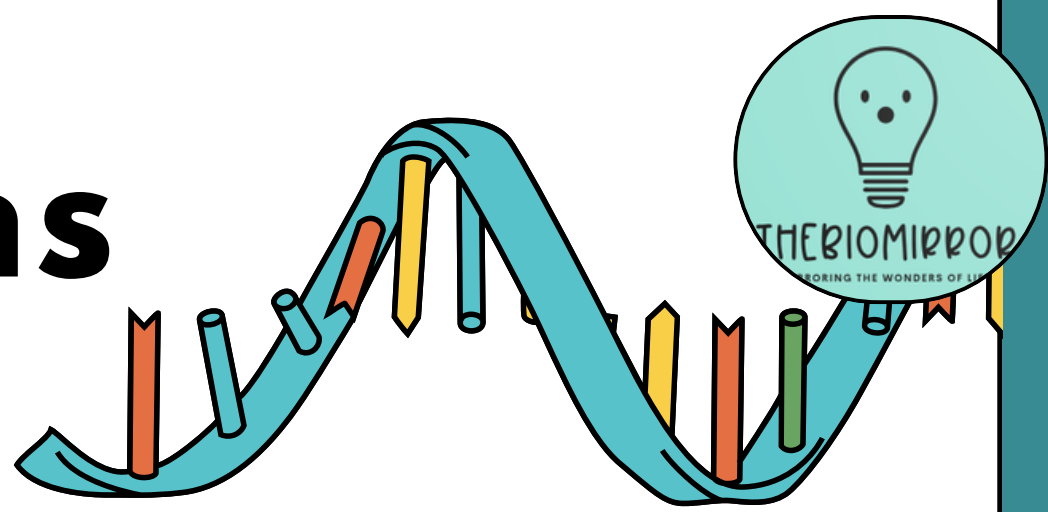


Reference

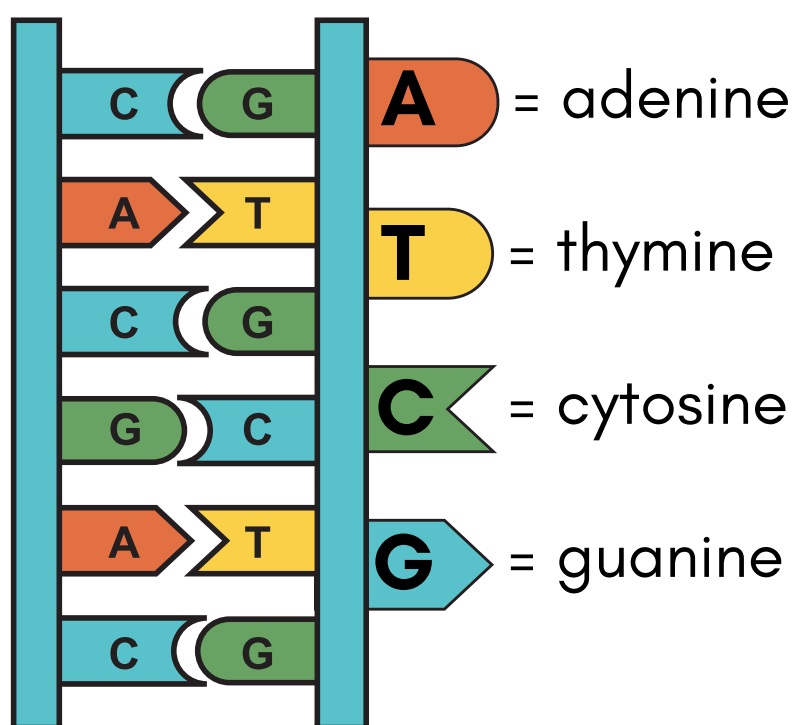
<https://www.savemyexams.com/a-level/biology/cie/22/revision-notes/19-genetic-technology/19-1-principles-of-genetic-technology/19-1-2-genetic-engineering/>

Applications

Genetic Engineering



Genetic engineering helps scientists study diseases, developmental processes, and evolutionary biology by manipulating genes and observing outcomes.



AGRICULTURE

- **Crop Improvement:** Designing crops that are pest-resistant, drought-tolerant, or nutritionally enhanced (e.g., Golden Rice fortified with Vitamin A).
- **Livestock Breeding:** Enhancing traits like disease resistance or growth rate in animals.

MEDICINE

- **Gene Therapy:** Treating genetic disorders like sickle cell anemia or muscular dystrophy by repairing defective genes.
- **Pharmaceutical Production:** Genetically modified organisms (GMOs) produce insulin, vaccines, and other critical drugs.
- **Cancer Research:** Engineering immune cells to target and destroy tumors, like CAR-T therapy

ENVIRONMENT

- **Sustainable Farming:** Reduce need for chemical pesticides and fertilizers by engineering natural resilience.
- **Bio-remediation:** Engineer microbes to clean up oil spills
- **Carbon Sequestration:** Develop plants with enhanced CO₂ absorption.



Concerns

Safety

Genetic modifications could lead to unforeseen effects, such as off-target mutations or new allergens.

Inequality

Advanced genetic therapies may initially be accessible only to the wealthy, exacerbating health disparities.

Ethics

Using genetic engineering for non-essential traits (e.g., height, intelligence) sparks intense debate.

Do we have the power to play god?

Misuse

Genetic engineering could be misused to create organisms with harmful traits, like biological weapons.

Solutions

Regulation

Governments + international bodies must establish clear guidelines for research and applications.

Public Engagement

Open dialogues with the public can foster understanding



DNA

The advancements in genetic engineering hold the **potential** to **reshape** human health, food security, and environmental sustainability.

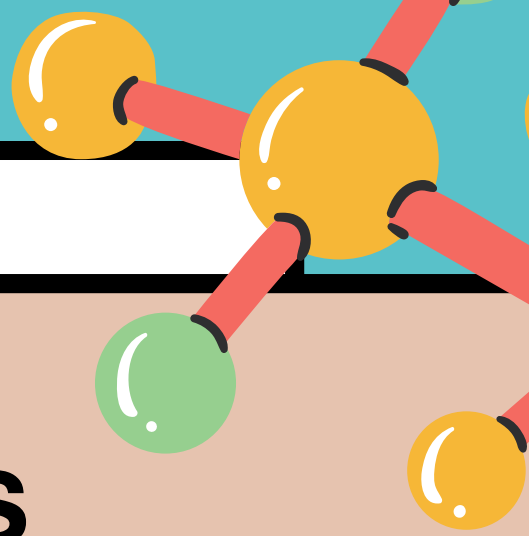
Yet, with **great power** comes **great responsibility**. As we explore the possibilities, we must tread carefully, ensuring that this revolutionary technology serves humanity **equitably** and **ethically**.

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By: Hayden Lim Khai Eun



ACKNOWLEDGEMENTS

1. [https://www.genome.gov/genetics-glossary/Genetic-Engineering#:~:text=Genetic%20engineering%20\(also%20called%20genetic,a%20new%20segment%20of%20DNA.](https://www.genome.gov/genetics-glossary/Genetic-Engineering#:~:text=Genetic%20engineering%20(also%20called%20genetic,a%20new%20segment%20of%20DNA.)
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