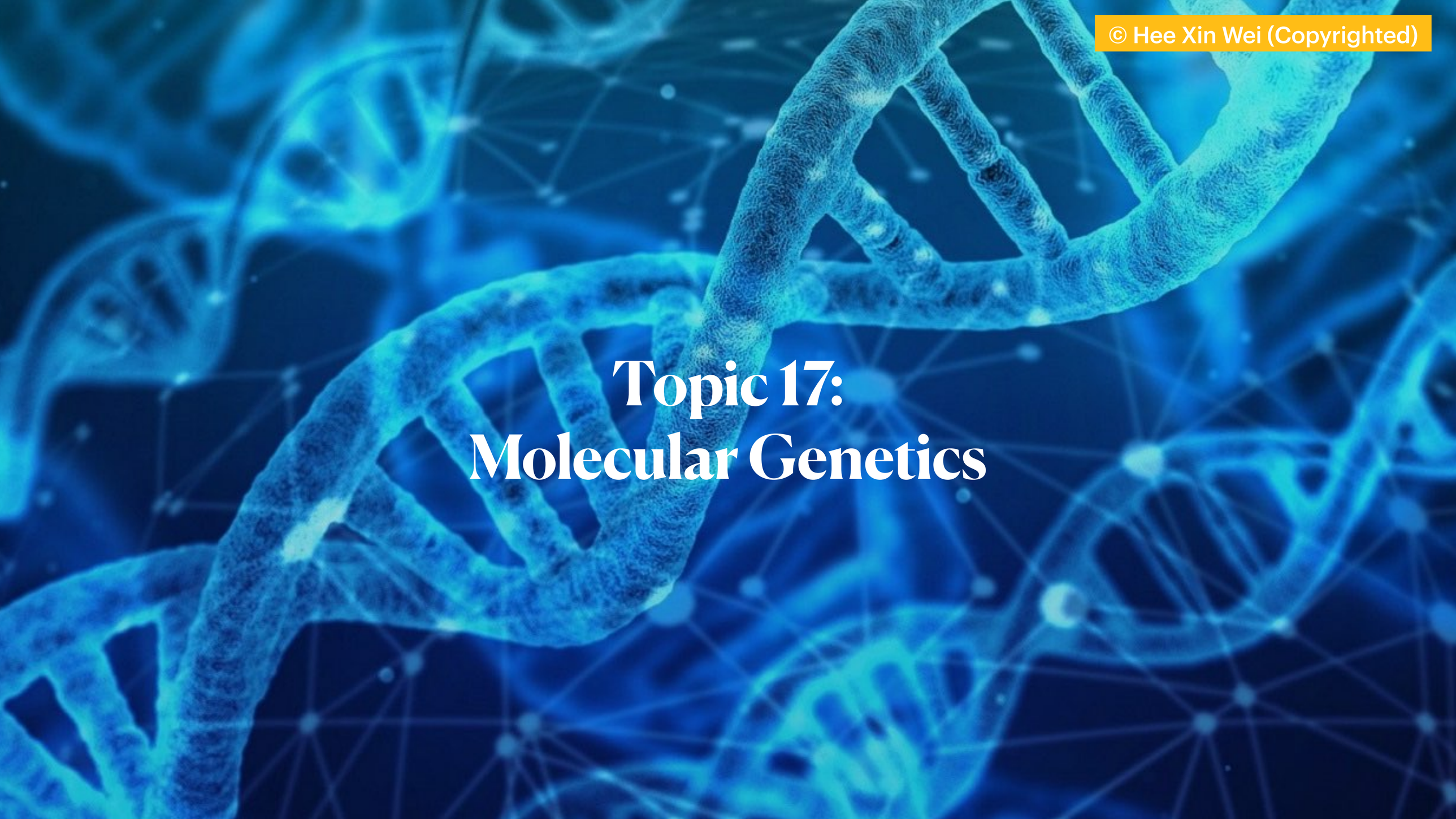
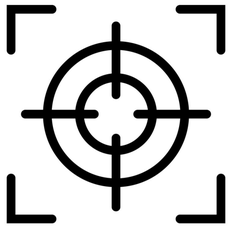


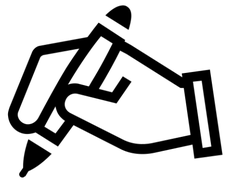
Topic 17:
Molecular Genetics

Chapter Analysis



FOCUS

- may be an abstract topic for some
- linked to inheritance chapter



EXAM

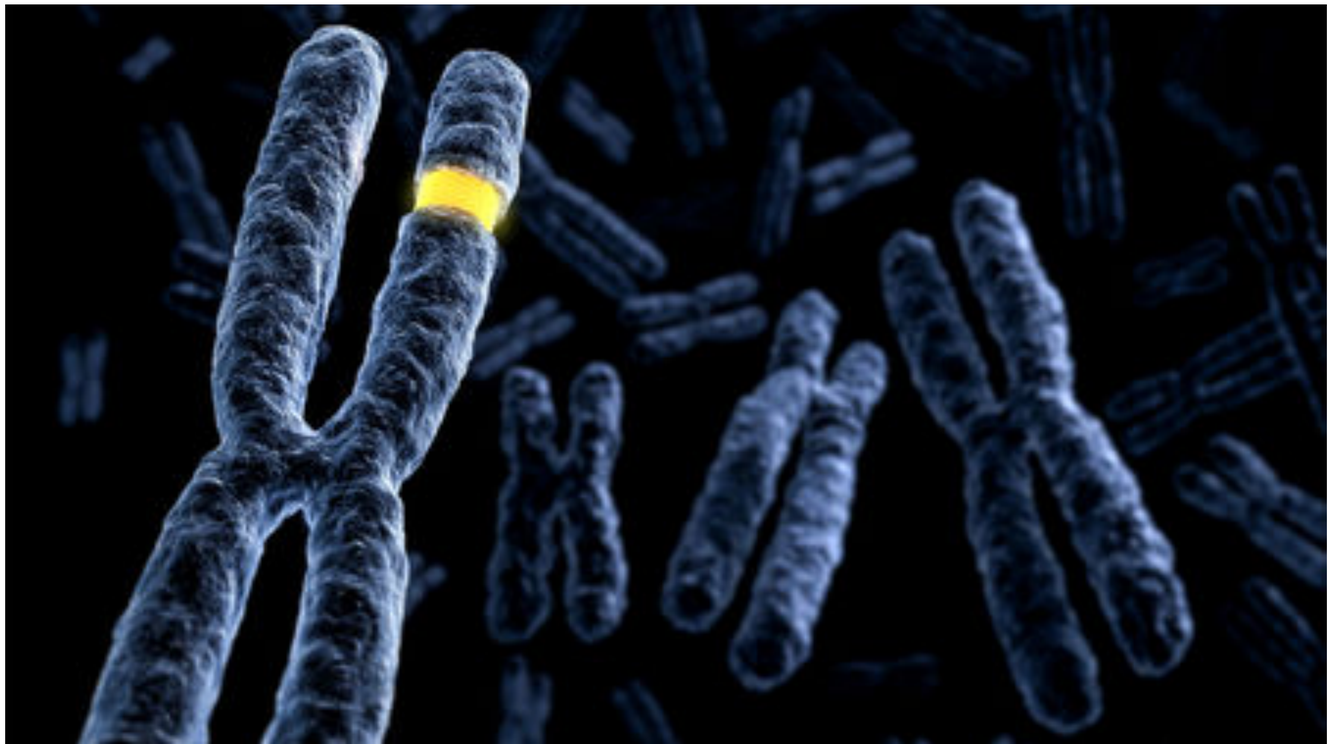
- commonly tested in MCQ and structured questions
- tested twice in section B in the past 5 years

WEIGHTAGE

- Constitute to around 5% in Paper 2 in the past 5 years

Key Concept

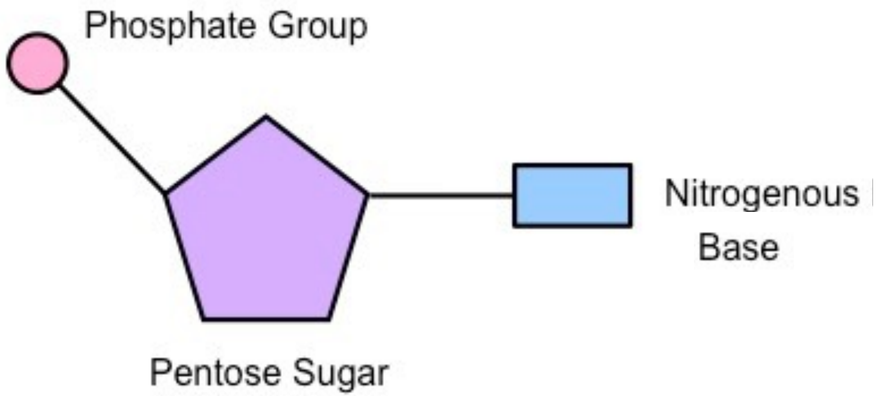
DNA, gene, chromosome



DNA

nucleotide

- Deoxyribonucleic acid (DNA) is a molecule that carries genetic code which is used to synthesise specific polypeptides
- DNA is a double stranded molecules that are twisted around each other to form **double helix structure** of DNA.
- The **basic units** of DNA is called **nucleotides.**

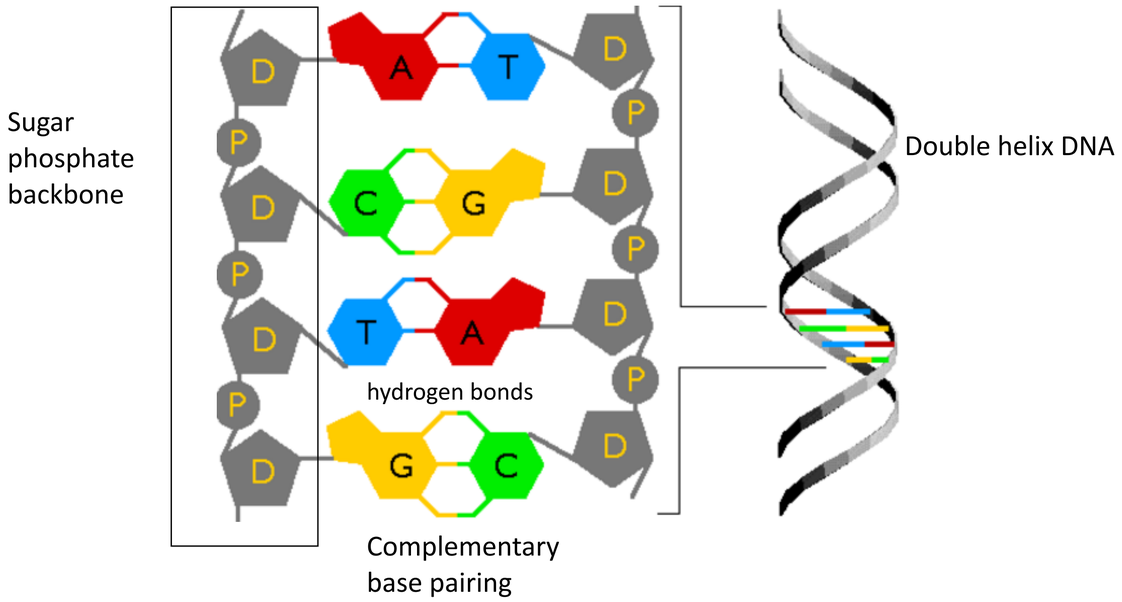


Each nucleotide consists of:
- A deoxyribose sugar
- A phosphate group
- A base containing nitrogen

There are **four types of nitrogenous bases**:
- Adenine (A)
- Guanine (G)
- Cytosine (C)
- Thymine (T)

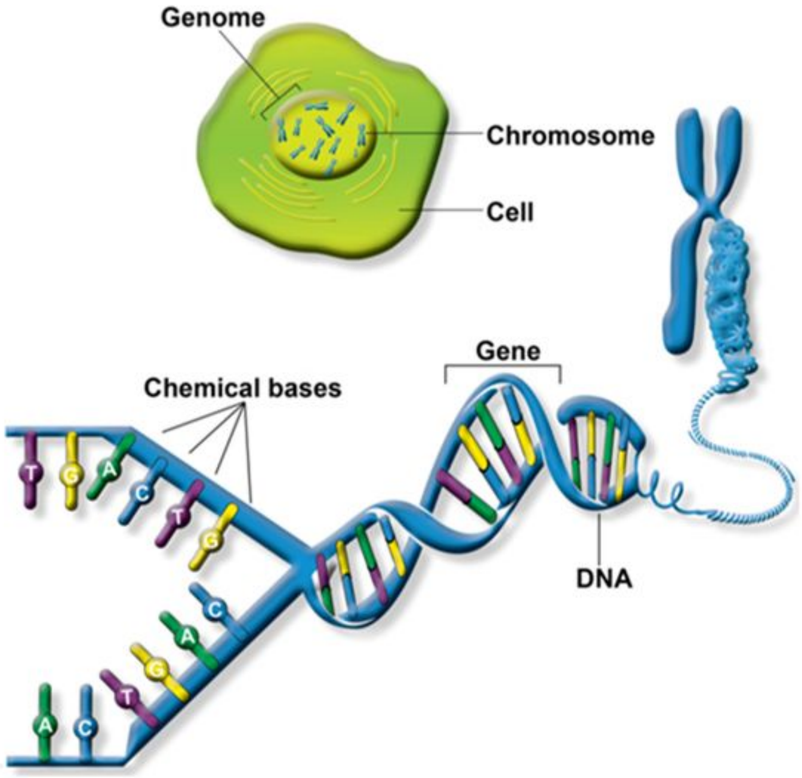
DNA

polynucleotide



- The nucleotides polymerise to form a polynucleotide when the deoxyribose sugars of the nucleotides are joined together by phosphate groups, forming the **sugar-phosphate backbone** of the DNA molecule.
- Double helix DNA strands are held together by **hydrogen bonds** between the **nitrogenous bases** by **complementary base pairing**
    - **Adenine** forms 2 hydrogen bonds with **Thymine**
    - **Cytosine** forms 3 hydrogen bonds to **Guanine**

gene & chromsome



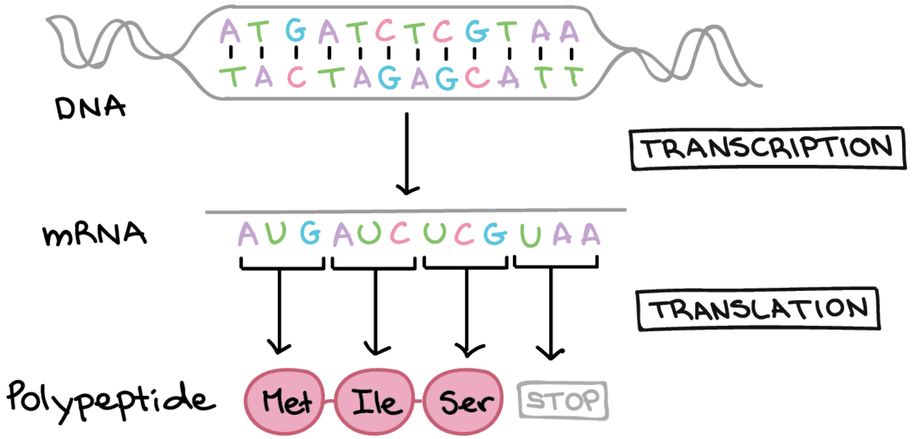
Gene

- Gene is **sequence of nucleotides**. It forms **part of a DNA molecule** that is used to synthesise specific polypeptides.
- This involves transcription and translation
- A DNA molecule contains many genes along its length.
- Eg a DNA molecule contains **eye colour gene** which codes for **pigment protein** that gives our iris colour

Chromosomes

- DNA is **wrapped around proteins** to form a chromatin fibre.
- The chromatin fibres **coil, condense, and shorten** to form the compact structures called chromosomes during **prophase** of cell division

transcription & translation



Transcription:

- Transcription is the process by which the DNA template is used to make a single-stranded molecule called messenger RNA (mRNA) by complementary base pairing
- There is no thymine in RNA, instead Adenine pairs with Uracil
- Thymine pairs with Adenine
- Guanine pairs with Cytosine, vice versa

Translation:

- Translation is the process by which the sequence of mRNA codons is used to make a polypeptide, which will fold into a protein
- **Ribosome is needed** for the process

Phenotype:

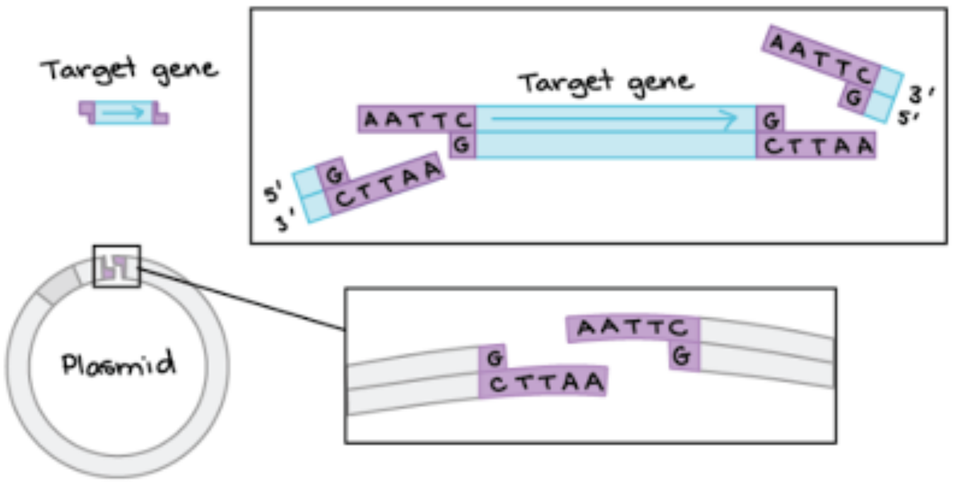
the protein formed from the gene are responsible for every aspect of a living organism

- appearance - protein that affect the pigment colour of iris
- disease - gene is faulty and doesn't produce insulin which causes Type 1 diabetes

Key Concept

Genetic Engineering

Genetic Engineering



Genetic Engineering

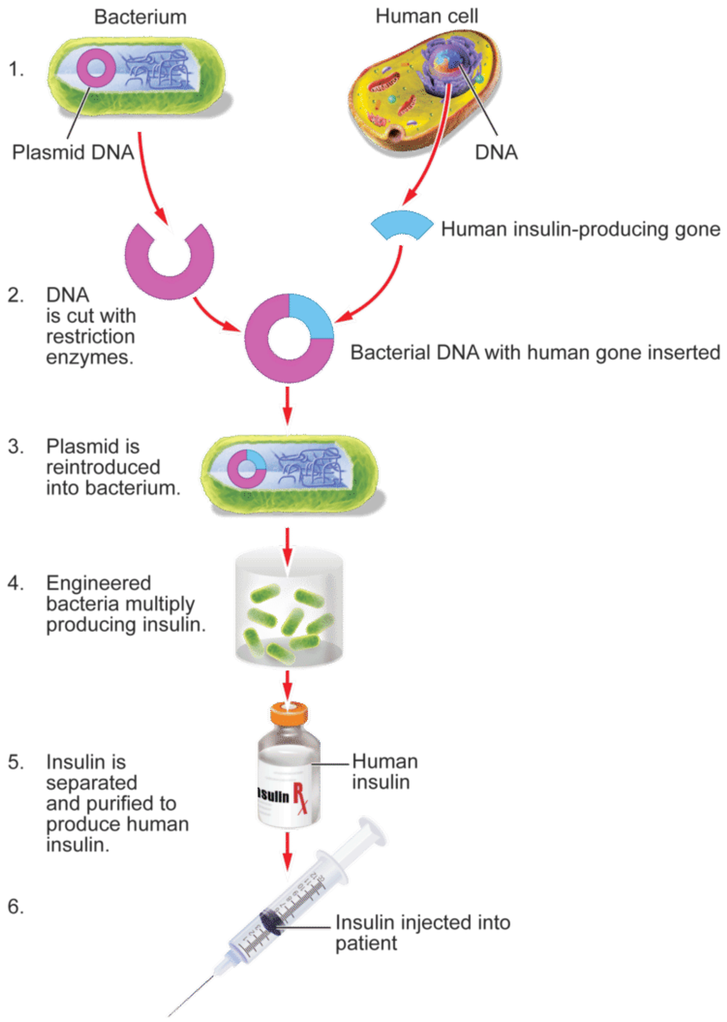
- **Genes may be transferred** between cells via genetic engineering
- Target genes may be cut off from the cells of one organism and inserted into the cells of **another organism of the same or different species**
- The plants or animals that received the genes is called **transgenic**.
- The transferred gene can express itself in the recipient organism.

Restriction enzyme

- Restriction enzyme cuts the genes at restriction sites to produce sticky ends
- When genes and plasmids are cut by the same restriction enzymes, they produce complementary sticky ends, which will anneal by complementary base pairings
- Restriction enzymes are essential in genetic engineering process

human insulin

genetic engineering



<u>Transfer of human insulin gene into bacteria E.coli</u>

1) **Human insulin gene** is isolated by adding **restriction enzyme** that cuts the gene, producing sticky ends.
2) **Plasmid from E.coli** is cut with the **same restriction enzyme**. This produces sticky ends **complementary** to those of the insulin gene.
3) Mix the plasmid with the DNA fragment containing the human insulin gene. The human insulin gene will bind to the plasmid by **complementary base pairing** between their sticky ends, forming **recombinant plasmid**
4) Add the enzyme **DNA ligase** to seal the nick.
5) Mix the recombinant plasmid with E.coli bacterium. **Heat shock or electric shock** is applied to open up pores on the cell surface membrane of the bacterium for plasmid to enter. The E.coli that contains this recombinant plasmid is a transgenic bacterium
6) The transgenic bacteria are placed in **large fermenters under optimal conditions** for growth and reproduction. Fermenter consists of:
   - a nutrient broth containing glucose water and salts
   - 37°C temperature maintained by a temperature probe
   - optimal pH maintained by a pH probe
   - air supply for aeration and a stirrer to mix substances evenly.
7) At the end of fermentation, the insulin protein is **extracted and purified** before it can be used.

advantages

genetic engineering

Human insulin production

Advantages:

- **Low cost and high yield** production of insulin can benefit the patients with diabetes as medicine is more affordable
- It does not induce **allergic response** or **immune rejection** in the patient as the insulin produced is **identical to human insulin**.
- There is **less risk of contamination** compared to insulin obtained from the pancreas of animals.
- The ethical concerns of vegetarians or religious groups can be overcome.

Agriculture

Advantages:

- Genes that **allow crops to survive in harsh environment** such as drought or reduce maturation period can be introduced into crops, which can increase food production
- Genes that **produce toxins** can be introduced into crops thus the crops produce its own toxins to **kills pests**, thus **reducing use of pesticides.**
  - **lower cost for farmer** which can be passed on to the consumers
  - **Reduce environmental pollution** as less pesticides are used.
- **Pesticide resistance genes** can be introduced into crops so the crops will not be affected by pesticides use, increasing survival of crops
- Genetically modified crops with **enhanced nutritional value** can be used to supply nutrients to people

social and ethical implication

Social implication of GM crops

- Insect pests may develop resistance to the poison produced by the plant.
- Potential health concerns including allergen transfer, transfer of antiobiotic resistance, unknown health effects.
- Pest-resistance may be spread to weeds through cross-pollination, producing super weed
- Useful insects such as insects that help with pollination such as butterfly and bees may be killed indiscriminately by the toxins produced by GM crops
- Upset the ecological balance.
- World food production would be controlled by a few biotechnology companies.
- Companies produce GM plants that produce sterile seeds means farmers have to purchase new seeds every year, which is a burden to the farmers

Ethical Implications

- Unnatural to mix genes across species, tampering with nature
- GM food labelling is not mandatory in some countries. Consumers might be unaware that they are purchasing and consuming GM products.
- GM food might not have been adequately tested, which means the long term impact it has on human is unknown

Other examples

- Genetic engineering may lead to class distinctions. Only individuals with sufficient financial means can afford certain gene technologies.
- morally wrong to exploit animals for medical research, especially when the animals are designed to suffer.

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