

CHAPTER 13.1 – GENETIC ENGINEERING

Genetic engineering and genetically modified organism (GMO)

- ✚ Genetic engineering is a gene manipulation technique to modify an organism's genetic material to produce new combination of genes
- ✚ An organism such as animal, plant or microorganism that is produced by recombinant DNA technology is known as a genetically modified organism (GMO)
- ✚ Genetic engineering involves the transfer of a DNA segment from one organism to another by DNA recombinant technology
- ✚ By using the techniques and procedures in the recombinant technology, biologists can recombine the DNA or genome (a complete set of DNAs) of an organism

Genetically modified organism (GMO)

- Genetically modified organisms (GMOs) are organisms that contain recombinant DNA
- Recombinant DNA technology enables production of new gene combinations
- An organism that contains recombinant DNA is known as a transgenic organism

- Examples of genetically modified organisms (GMO)
 - 1) The genetically modified cow produces milk which does not contain β -lactoglobulin, a type of protein that causes allergy among some children
 - 2) The genetically modified goat possesses the human gene which codes for a blood clotting factor and this blood coagulation factor is found in the goat's milk can be purified and used to treat haemophilic patients

Genetically modified food (GMF)

- Recombinant DNA technology has successfully produced many beneficial varieties of crops (paddy, oil palm, pineapple, corn and soya bean) and livestock (salmon, cattle and goat)
- Genetically modified food (GMF) possesses DNA from other species of plant or animal
- Consumption of GMF by humans may cause health implications which are still unknown

CHARACTERISTICS OF GMF

- ⊕ Resistance to herbicides
- ⊕ Resistance to disease
- ⊕ Application in medicine

- ⊕ Tolerance to heavy metals
- ⊕ Resistance to pest

THE ADVANTAGES OF GMF

- ⊡ Overcome worldwide food shortage by producing high quality transgenic crops and livestock
- ⊡ Reduce cost of food production
- ⊡ Increase nutritional value of crops
- ⊡ Reduce problems of crops related to pests
- ⊡ Reduce usage of pesticides
- ⊡ Increase in production reduces price of food, thus increase food availability

THE DISADVANTAGES OF GMF

- Δ Endangered natural species
- Δ There is a slight possibility that the foreign gene in GMF may be transferred to humans, for example, antibiotic-resistance gene
- Δ May have adverse effects on human health and genetic material

EXAMPLES OF GMF

Recombinant DNA technology

- A *Bacillus thuringiensis* gene is inserted into corn to increase its resistance against insect pest

Effect of growth on salmon

- ◇ Super Salmon is a genetically modified fish which is approved by the Food and Drug Administration (FDA) as a safe food for consumption in United States of America and Canada
- ◇ It is modified by inserting a growth hormone gene from a Chinook salmon

into the genome of an Atlantic salmon

- ◇ Hence, a Super Salmon is created which grows at a faster rate and can be produced throughout the year



Effect of frost on potatoes

- ❑ Potato is an important crop to people who live in cold climates
- ❑ It is very sensitive to low temperature and frost
- ❑ A gene from *Arabidopsis* sp. plant, which enables the plant to tolerate freezing condition is inserted into the potato genome to create a genetically modified potato that can grow well in cold climates

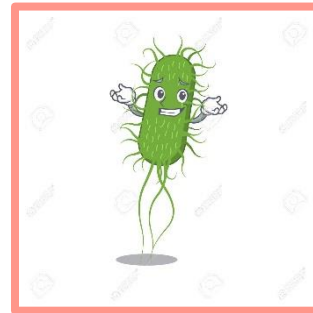


Insulin

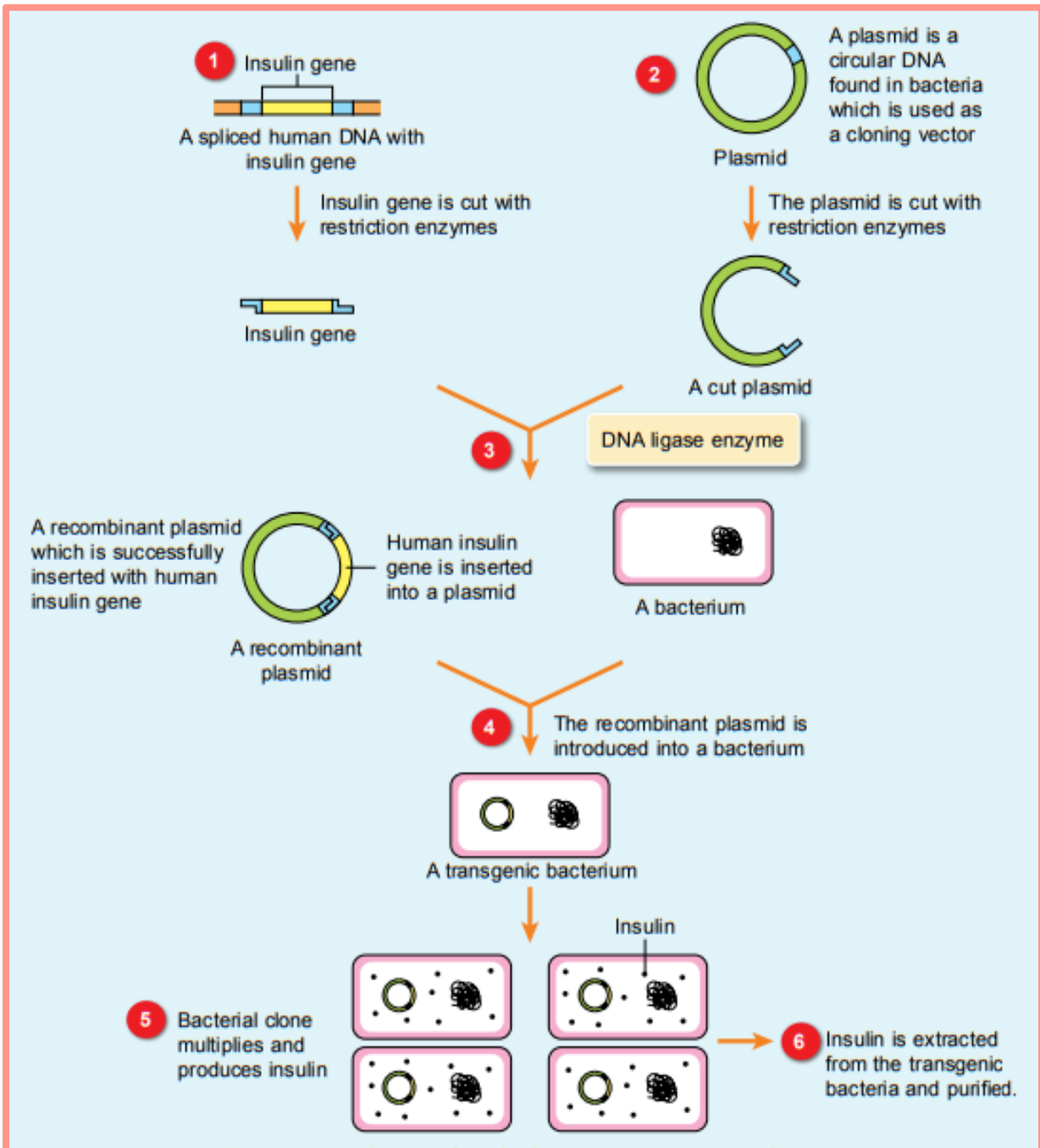
- ↳ You have already learnt the concept of homeostasis in regulating blood glucose level
- ↳ Insulin is an important hormone which controls blood glucose level

- In the older days, insulin was extracted from the pancreases of cattle or pigs to treat diabetes mellitus patients
- Nowadays, insulin can be commercially produced by genetic engineering for patients with diabetes mellitus
- Besides insulin, other successes of genetic engineering include hepatitis

B vaccine, blood clotting factor and growth hormone



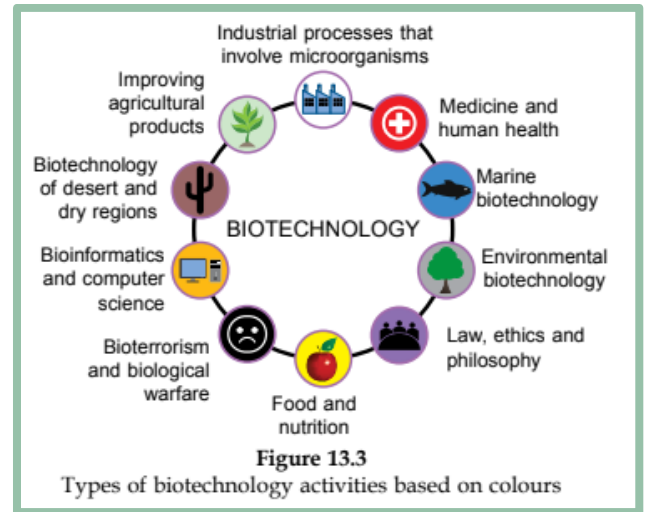
Escherichia coli



CHAPTER 13.2 – BIOTECHNOLOGY

Definition of biotechnology

- » Biotechnology is a field which utilises technology or method to manipulate organisms for the production of biological products
- » Biotechnology aims to improve the quality of livestock and crops as well as to develop the application of microorganisms for specific purposes
- » Since biotechnology involves various disciplines of science, therefore each discipline that involves the use of living organisms for a specific purpose is given a specific colour code
- » Although ten biotechnology activities are identified, the main ones are the green, white, yellow and blue biotechnology activities

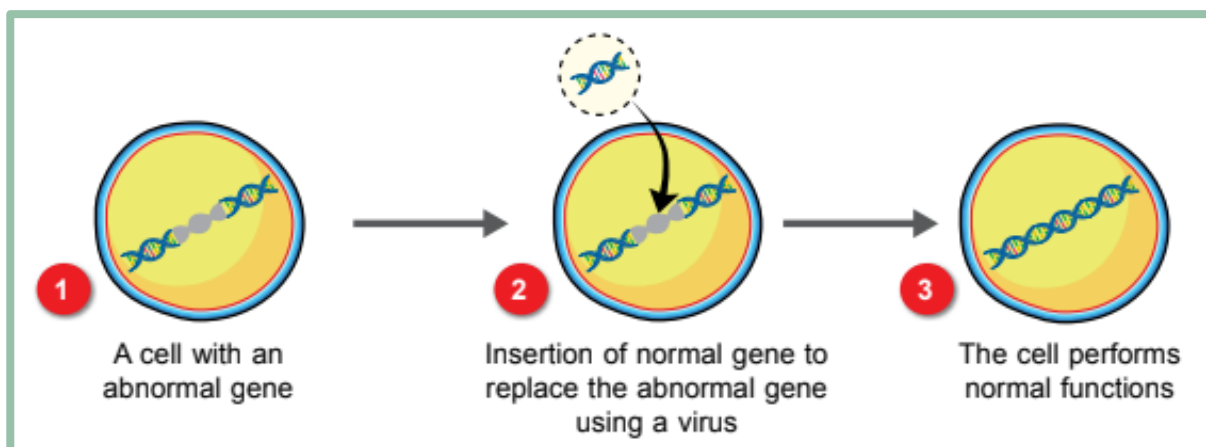


Applications of biotechnology in life

Gene therapy

- ❖ Gene therapy is used to treat or prevent genetic diseases
- ❖ In gene therapy, a normal gene is inserted into the patient to replace the abnormal gene
- ❖ The diseases that can be cured by gene therapy are cystic fibrosis, muscular dystrophy and a few types of cancer

TYPES OF BIOTECHNOLOGY ACTIVITIES BASED ON COLOURS



DNA profiling

- ♥ DNA profiling is a technique used in forensic to identify individuals, based on their DNA
- ♥ This is due to the fact that an individual's DNA is unique, except between identical twins
- ♥ A human DNA set is different from animals
- ♥ An individual can be identified based on the DNA obtained from his/her blood, semen (for male) or skin

THE APPLICATIONS OF DNA PROFILING

- Identify criminal
- Settle paternity and maternity dispute
- Identify genetic disease
- Determine suitability of organ donor and recipient

THE STEPS USED IN DNA PROFILING





- ✓ Blood, semen or skin sample is obtained from an investigation scene (e.g., a crime scene)
- ✓ DNA is extracted from the sample
- ✓ Restriction enzymes cut the DNA into different sizes of DNA fragments
- ✓ The DNA fragments of different sizes are then separated by gel electrophoresis
- ✓ DNA fragments of different sizes are transferred from the gel to a nylon membrane
- ✓ Radioactive probes are added to the nylon membrane
- ✓ X-ray film is then placed on top of the nylon membrane

- ✓ X-ray film is processed to show the positions of DNA bands that form the DNA profile

Production of insect tolerant plants

- Farming cotton breed with high yield and resistant to pests such as Bt cotton in cotton farms has reduced the use of pesticides
- The Bt crop is injected with genes from *Bacillus thuringiensis* (Bt), a type of soil bacteria that secretes toxins
- This effort has saved cost by reducing the use of pesticides and also increases cotton yield
- Besides cotton, other Bt crops are corn and brinjal

COMPARISON BETWEEN NORMAL CROP AND GMO CROP

NORMAL CROP	GMO CROP
 <p>Normal cotton</p>	 <p>Bt cotton</p>
 <p>Normal corn</p>	 <p>Bt cotton</p>

THE EFFECT OF BT CROPS ON PEST

- Gene that produces Bt toxins from *Bacillus thuringiensis* is inserted into the plant's genome
- Pest feeds on the plant which produces Bt toxins
- The toxins affect the digestive system of the pest and kills it

Cleaning of oil spills

- ❑ Bioremediation is a method which uses bacteria to clean up environmental pollutants
- ❑ It is effective to treat oil spillage in the ocean
- ❑ Most molecules in crude oil and purified oil products can be degraded by bacteria
- ❑ For example, *Alcanivorax borkumensis*, a type of bacteria that depends on oil for its source of energy is widely used to treat oil spills



Importance of biotechnology in life

- ⊕ The field of biotechnology has developed rapidly in Malaysia and has improved human lives in both developing and developed countries
- ⊕ Biotechnology is often associated with agriculture, industry, nutrition, medicine and other fields

- ⊕ Rapid development in biology and technology has replaced the old methods with the current and sophisticated approaches in producing many types of products that benefit humans
- ⊕ Besides contributing to increase the yields in food, agriculture and medicine, biotechnology also improves a country's economy specifically in the industrial sector

THE CONTRIBUTIONS OF BIOTECHNOLOGY TO LIFE

Agriculture

- ◇ Produce the best livestock and crop breeds as the tissue culture method and cloning technique have expedited plant reproduction
- ◇ Produce paddy varieties which give more yield and mature faster
- ◇ Animal cloning enables mass reproduction and produces disease-resistant clones
- ◇ Use of hormones expedite animal growth and maturity

Medicine

- ↘ Can modify the genetic contents of an individual
- ↘ Reduce risk of mental disease
- ↘ Prevent specific diseases such as cancer and inherited diseases
- ↘ Human with dwarf genetics can have normal children
- ↘ Assist mothers with difficulty to conceive

Forensic

- Δ Can identify **criminal** based on tissue or body fluid such as blood, semen, skin or hair follicle

Environment

- ✚ Microbes can expedite **decay of waste products** created by humans
- ✚ Microbes can also **degrade faeces completely**
- ✚ Reduce **pollution** to protect humans and the environment

