1.1 Describe the origins of biotechnology in early societies who collected seeds of wild plants and domesticated some species of wild animals

Domestication of wild animals

By choosing animals, such as cattle, with characteristics they favoured, such as more placid nature, the genes of their domestic stock would be different from those of the wild animals. This would be especially true after breeding for certain characteristics for many generations.

Benefits

- Convenient source of food, hides and wool as the animals are close to home
- Less energy expended hunting and gathering → change in lifestyle from Hunter Gatherers to settled farmers

Disadvantages

- Animals needed to be fed and given clean water
- Plants needed to be protected from pests, weeds and harsh weather
- Possibility of contracting disease by living in close contact with animals

Collection of seeds and wild plants

Developed medical and nutritional practises that kept the population by using seeds and wild plants:

- Using natural plant products to produce medicines to treat pain and fever

1.2 Explain why the collection of seeds and breeding of animals with desired characteristics, could be describes as early biotechnology

Breeding of animals:

Human selection of characteristics in animals (artificial selection) can be looked on as the use of living organisms to make products for humans, so it represents the first attempts at biotechnology.

Collection of seeds

- Although early societies didn't know about genetics, they knew through observation that if they took seeds from certain plants they would get some offspring with similar traits.
- By collecting seeds from plants with desirable characteristics such as heads that matured at the same time and produced seeds that tended not to be blown away by the wind easily.
- This intervention in the process of natural selection meant that humans, rather that the natural environment, became the selecting agents for certain traits in plant species.
- Selection by humans for most desirable characteristic = **artificial selection**
- This can be classified as early biotechnology as the artificial selection of wheat varieties has been beneficial to human society.

1.3 Describe the changes in one group of animals and one group of plants as a result of artificial selection of characteristics suitable for agricultural stock

Wheat

- In parts of the Middle East, the ancestors of wheat grew thickly enough naturally to be harvested
- When harvested, they selected the seed that naturally clung to the plant rather than being blown off by the wind → changed the plant genetically
- Humans would sow the seeds of the plants with clinging heads more often than the seeds that dispersed naturally → domesticated plant that cannot naturally reproduce without human intervention
- Selected for shorter stems so that wheat stalks wouldn't fall over and lose their seeds
- William Farrer selected for:
  - → rust resistant wheat
  - → high yields
  - → drought resistance
- He used drought resistant Indian wheat and fast maturing Canadian wheat to produce new varieties.
- Modern wheat is rust free, typically short
- Current wheat breeding programs are focusing on producing new rust-resistant varieties + varieties with softer grain

Sheep

- Domesticated approx. 10,000 years ago in Central Asia
- The Romans took sheep with fine wool to Spain where further breeding produced the Merino breed
- In England, during the eighteenth century, Robert Bakewell became the first to deliberately cross the best sheep to produce favourable varieties such as the Leicestershore
- John Macarthur imported Merino sheep from Spain into Australia (1797)
- He selected those suited to dry conditions and with fine wool.
- These sheep were crossed with other breeds with desirable characteristics such as high quality wool
- Today there are five main types of sheep based on wool types of:
    - → Fine
    - → Long
    - → Crossbred
    - → Medium
    - → Coarse
- In Australia and New Zealand, an attempt to breed a sheep useful for both wool and meat resulted in the Corriedale:
    - → Production of cross-breeding between fine and long-wooled sheep

1.a Describe the changes in a species of grain or animal as a result of domestication and agricultural processes

WHEAT (worksheet on wheat, does it nicely)

1.b Outline an ancient Australian Aboriginal use of biotechnology

Aquaculture

- Aquaculture = the raising of plants and animals in water. Products used mainly for food.
- Water quality is controlled to establish optimum growth.
- Aborigines built large and elaborate canals
- Connected naturally occurring swamps, increasing the numbers of eels and making it easier to trap them.

2.1 Outline the events that led to the use of biotechnological practises.

Fermentation

- Thousands of years ago, people who were producing bread, beer and cheeses were not aware that the **microbes** caused the changes and were not were able to control the processes involved.
- The events that led to the use of biotechnological practise were a combination of **chance** acts and the **need to preserve food for consumption outside of the growing season and without refrigeration**.
- ***Joseph Louis Gay-Lussac*** (French chemist) in 1810 proposed the basic chemistry of fermentation.
- Fermentation is **anaerobic respiration** (respiration without oxygen)

$$\text{Glucose} \xrightarrow{\text{yeast}} \text{ethanol + carbon dioxide}$$

Yeast in the manufacture of bread

- Evidence of the first bread dates back to the stone age – 10,000 years ago: thick cakes were made from wild grains.
- The first breads were flat.
- They enabled food to be preserved and eaten later when fresh food was not available.
- The first leavened bread probably arose by accident when wild yeast found its way into dough.
- Up until the 18th century, the leftover semi-solid 'goo' from the brewing of beer was used as the yeast culture to make bread dough rise.
- Louis Pasteur investigated fermentation conditions to allow for a better quality 'yeast biomass' that could be produced for baking large quantities of bread for the fast-growing cities.
- Today, each bread is made with known, specialised yeast varieties whose quality is tightly controlled.

Yeast and the fermentation for alcohol production

- Evidence of plant materials and storage vessels for a whole range of fermented drinks have been found
- Pasteur investigated why some batches of alcohol turned sour and others were of good quality:
  → Good quality batches contained round yeast cells, while the sour batches contained rod-shaped microbes as well.

→ Contaminated the good batches with the rod-shaped microbes and then they turned sour.
→ Concluded that the rod-shaped microbes were the cause of the contamination, and that the round yeast organisms were responsible for fermentation.
→ Developed pasteurisation to sterilise wine, beer and milk without their taste or nutrient qualities.

- Beer brewers and winemakers can now select certain strains of yeast which will produce different flavours.

<u>Microorganisms used to manufacture yoghurt and cheese</u>

- Yoghurt + cheese rely on microorganisms that produce lactic acid.
- Yoghurt
  → Bacteria enters milk and makes it curdle
  → Early manufacturers of yoghurt had to be able to control which type of bacteria contaminated their milk so it was safe to eat
  → People from ancient Mediterranean countries and India learnt to use particular samples that already contained the appropriate microorganisms to ensure that there was less spoiled yoghurt and more available to eat.
- Cheese
  → Evidence of cheese-making as early as 3000 BCE in Egypt and Europe.
  → People experimented with different kinds of bacteria after yoghurt-making became controlled.
  → Was popular as it could be stored for a year or more, which was good as sheep, cows and goats could not produce milk all year round.
  → 1960s: Dr Joe Czulak developed a mechanical cheese-maker → revolutionised cheese-making.
  → In modern-cheese making there is a primary pasteurisation stage to sterilise the milk to reduce the wrong kind of bacteria spoiling and wasting the milk during the fermentation process.

2.a Perform a first-hand investigation to demonstrate the use of fermentation processes in break or alcohol production

PRAC BOOK

3.2 Describe strain isolation methods developed in the 1940s

Serial dilution of a sample	
Sample of fluid containing microorganisms is streaked across plate	
Incubation	
Mass growth of microorganisms	
Tiny sample is transferred to clean, sterile place **(subsampling)**	
Incubation	
Repeat subsampling + incubation until individual colonies grow	
Each colony represents a different strain from the original species	

Isolating a strain that produces an antibiotic	
Sample from a colony in step 1 (pink) is streaked across plate (test microorganism)	
Dilute sample of pathogenic bacteria (blue) is streaked at right angles to microorganism	
Incubation	
Microorganism multiplies	
Blue bacteria are killed where they contact the microorganism	

3.3 Describe the benefits of strain isolation methods used in biotechnology in the 20th century → PENICILLIN

Penicillin

- **1928:** discovered by **Alexander Fleming**
- **Between 1939 and 1942**: shown that was non-toxic to humans and effective by **Howard Florey** and **Ernst Chain**
- **1940: Norman Heatley** found out how to isolate penicillin from the strain o *Penicillium notatum* which was available in England at the time
- US gov't helped produce large quantities and investigated different strains + species of Penicillium
- Discovered strain of the mould P. notatum which produced more penicillin than any other researchers had seen
- Process of isolating certain strands that produced more, then from this isolating another strand which would produce even more
- Used **large stainless steel tanks** which would sterilise and prevent cross-contamination to create **optimum growth** conditions
- Used waste corn mush as a carbohydrate source for the mould which increased the efficiency of penicillin production by 10
- **1943**: production moved to Russia to treat soldiers fighting there
- **1945:** enough penicillin for all Allied wounded troops in Europe

Benefits

- WWII → demand for better quality and mass supply of antibiotics to counter the infectious diseases faced in WWI
- Penicillin was active against a wider range of pathogens than the 'sulfa' drugs which had been the antibiotics used at the time but were not effective against pathogenic bacteria.
- Useful for wounds and skin infections
- Effective in treating **puerperal fever** (childbirth fever which caused women to die shortly after childbirth)

3.4 Identify that developments in the 1950's led to biotransformation technologies that could produce required organic compounds such as cortisone and sex hormones

Biotransformation: using microorganisms to change the structure of a readily available organic compound to make a useful pharmaceutical product.

From the 1940s it became known that:

- Steroids can be used to successfully treat some medical conditions (eg cortisone = anti-inflammatory)
- Female sex hormones can be used as contraceptives and to alleviate effects of hormone imbalances
- Male sex hormones can be used to maintain strength in people with muscle-wasting diseases

More efficient methods of steroid production:

- To make cortisone in the lab from bile = 37 steps involved
  - → Not economical + low yield
- Scientists then looked at microbes for other more efficient solutions
- Some microbes (bacteria + fungi) can transform steroids by making changed to the steroid molecule (biotransformation)
  - → Scientists are now able to isolate a strain of a particular microbe to use

Example 1: Anti-inflammatory steroids

- Isolated a strain of the filamentous fungus *Rhizopus arrhizus* which decreased the amount of chemical reactions involved to produce progesterone from diosgenin from yams.
- Once it was understood that this was successful, scientists began to experiment with other isolated strains of microorganisms to produce more steroids.
- Was found that sometimes an analogue (a molecule that is chemically similar, but biologically different) could be made more easily and was just as effective or even more effective than the natural hormone.
- Anti-inflammatory drugs = **prednisone and prednisolone** which are used to fight arthritis and asthma. They are made from cortisone by microorganisms.
- 6 steps to produce progesterone precursor from yams and to produce diosgenin using the fungus *Rhizopus arrhizus*.
  - → Higher yield
  - → Cost effective

Example 2: The Pill

- Male hormone testosterone was added to sale of progesterone
    - → The availability of hormones increased
    - → The price decreased to approx. $1 per gram
- An analogue (a molecule which is chemically similar, but biologically different) of progesterone was synthesised which acts as a contraception
    - → Easily converted to the compound **norethindrone**. This became the first oral contraceptive.

3.1 Describe the expansion of fermentation since the early 18th century to include the production of several organic compounds, including glycerol, lactic acid, citric acid and yeast biomass for baker's yeast.

- Major discoveries about the biology and chemistry of fermentation and distillation since the early 18th century → possible to produce cheaper alcohol on a large scale.
- Over the next 200 years, organic compounds were fermented using carbohydrates and organisms to produce: glycerol, lactic acid, citric acid + yeast biomass.
- 18th + 19th centuries:
    - → European cities expanded due to the Industrial Revolution → want to improve manufacturing processes (especially fermentation)
- 19th + 20th centuries:
    - → Systematic approaches to fermentation processes
    - → By changing the conditions they could alter the metabolism of various strains of microbes → produce a range of different products
    - → Stimulated the development of improved ways of separating + purifying the desired products from the resultant mixture
    - → Understanding of sterile conditions, chemistry, advancement in technology → scientists able to investigate the various roles of different microorganisms in industrial processes
    - → Quality control of fermentation techniques + isolation + purification of the different strains of bacteria → larger quantities + higher quality foods to be manufactured.
- 21st century:
    - → Microorganisms can be genetically modified to produce particular products/ eliminate certain pollutants
- **Glycerol**:
    - → Produced: sodium bisulfite + fermentation of sugar → glycerol
    - → Uses:
        - Solvent
        - Sweetener
        - Antifreeze mixtures
        - In medicine
        - Production of dynamite

→ Produced: Glucose ⟶ citric acid
→ Uses:
- Flavour enhancer in food industries

- **Lactic acid**:
→ Produced: Lactose $\xrightarrow{\text{bacteria}}$ fermented to lactic acid.
→ Produces:
- Cottage cheese
- Yoghurt
- Sour milk

→ Uses:
- Medicines
- Textile dyeing
- Leather tanning
- Manufacture of plastics

- **Yeast biomass**
→ Produced:
→ Pasteur was able to produce large quantities of pure yeast that could be harvest and dried into cakes
→ Uses:
- Domestic cooking

3.a Gather and process information from secondary sources (industrial fermentation, products of fermentation, use of product, impact on society)

- **Gather information** from a range of resources including the Internet, scientific journals and text books. As you gather general information on fermentation you will need to choose a particular industrial fermentation process to investigate. Make sure the information you have gathered includes the micro-organism used and the products of the fermentation. You may need a separate web site to find the impact of the use of the fermentation product on society at the time of its introduction.

- **Process the information** you have gathered by assessing the reliability of the information from various sources. This is best done by comparing similar information from different sources. If you are uncertain about the reliability of one source, check it against a third source.

- **Use the available evidence** you have gathered to assess the impact of the use of the fermentation product on society at the time of its introduction.

Lactic Acid	
Industrial fermentation process	Carbohydrates (esp. sugars + molasses) are fermented in bioreactors. **Bioreactors**: - Can hold several thousand litres of the fermentation mixture - Contain nutrients, stirrers, pH and temperature controls + aeration devices
Microorganism used	Bacteria:

	- **Lactobacillus bulgaricus**
Products	Converted to **glucose → pyruvic acid → lactic acid**
Use of product	Use of products: - Pharmaceutical products - Solvents - Leather tanning - Inks - Lacquers - Biodegradable plastics Used to produce: - Yoghurt - Cheese - Pickles
Impact of product of society at the time of its introduction	Huge demand for the biodegradable plastics (lactic acid product) which can replace plastics made from fossil fuels in the future. Can be used to make: - Surgical sewing thread - Screws + plates to repair broken bones

3.b Process and analyse information from secondary sources to demonstrate how changes in technology and scientific knowledge have modified traditional uses of biotechnology, such as fermentation

Investigating fermentation conditions (Pasteur) to produce better quality yeast biomass (pg15+19 text book)

Development of sterile techniques by Joseph Lister and Robert Koch

Separation of yeast cells by Eduard and Hans Buchner, discovery of antibiotics by Alexander Fleming

1930s strain isolation methods

1944 2nd antibiotic discovered – streptomycin. Over 10,000 cultures of Streptomyces griseus were tested by strain isolation methods before streptomycin was discovered.

Plant production (in sterile stainless-steel tanks) for the large scale production of microbes

Make sure talk about consistency because now with the technology we have its all the same as we produce in mass to get the same best optimum result.

1933 – cells are first described by Hooke
1830 – proteins are discovered
1833 – cell nucleus is discovered – first enzymes are isolated
1855 – The Escherichia coli bacterium is discovered which later became majorly used in biotechnology
1863 – Mendel discovered that characteristics were passed from parents to their offspring
Early biotechnology: - Bread, alcohol, cheese and yoghurt production - Didn't know the cause of the fermentation process due to lack of scientific knowledge and technology - Obtained starter cultures through chance and trial-and-error
It was difficult for microbiologists to obtain pure cultures of bacteria as they had not developed the agar plate technique. First technique was to grow bacteria on potatoes, but this only worked for a few organisms and only until the bacteria decomposed the potato surface. The necessary lab and industrial methods of microscopy and sterilisation and safe equipment had not been developed sufficiently for individual strains to be identified, isolated or cultures
Louis Pasteur investigated fermentation conditions so that a better quality yeast biomass could be produced to make large quantities of bread for fast-growing cities.
1954 - cell culturing techniques are developed
1956 – Kornberg discovers the enzyme DNA polymerase I, leading to an understanding of how DNA is replicated
1961 – The genetic code is used for the first time
1977 – Genetically engineered bacteria are used to synthesize human growth protein

4.1 Outline the steps in the synthesis of a protein in the cell

- **The differences between DNA and RNA**

Structure	DNA	RNA
Sugar	- Deoxyribose	- Ribose
Base	- Thymine (T)	- Uracil (U)
Strands	- Double stranded - Helical	- Strands much shorter than DNA - Not double helical
Location	- Only nucleus	- Throughout the cell
Type	- Only one type	- mRNA - tRNA - rRNA

- **The production of messenger RNA – Transcription**
  1. DNA strands start to unwind
  2. Enzymes direct the transcription of the gene by the mRNA
  3. Nucleotides (RNA) bind to the bases of the exposed surface of the DNA

5. The enzyme **RNA polymerase** joins these nucleotides together in the correct order to form mRNA
6. mRNA chains pass through the nuclear membrane into the cytoplasm of the cell

- **The role of transfer RNA – Translation**

- tRNA molecules in cytoplasm are each **specific** for the amino acid present in the cell
- tRNA have a **binding site** that bonds to its own amino acid
- Also have an **anticodon** = 3 sets of bases that is the complementary code for this amino acid. Complementary to the **codon** on the mRNA strand

- **The formation of the polypeptide chain(s)**

1. There are 2 parts of the ribosome which join together
2. mRNA strand lines up between these two parts of the ribosome
3. at the same time, each individual tRNA molecule binds to its own specific amino acid that's floating around
4. the tRNA attaches the mRNA which is attached to the ribosome
5. The ribosome moves along the mRNA, turning it so each codon, one at a time, is pressed to one of the binding sites on the ribosome.
6. The tRNA molecule with the correct complementary anticodon binds to the site with the mRNA (the first tRNA molecule has the 'start' amino acid)
7. The tRNA molecule then moves along, leaving its amino acid available and the next tRNA molecule binds itself to the mRNA.
8. The mRNA moves along the ribosome, binding with the complementary tRNA strands, producing a chain of amino acids, called a polypeptide chain

- **The formation of the protein from polypeptide chains**

- All proteins are polypeptides
- The different amino acids on the polypeptide chains cause varying chemical attractions + repulsions which causes the chain to twist and fold in many ways, resulting in a protein.
- Molecular chaperones are molecules which ensure that newly produced polypeptide chains are folded correctly to produce the required protein every time.
- The surrounding medium can also affect the function of the protein.

5.1 Describe the three essentials of gene manipulation as:

- **Cutting and joining DNA**

1. The DNA that is required is cut from a long strand of DNA (a chromosome) using an **enzyme**. Eg the gene used for making human insulin is cut from a human pancreas cell using a **restriction enzyme**.
2. A **plasmid** (circular piece of DNA) is removed and is cut open using the same restriction enzyme.
3. The cut out human gene is then mixed with the bacterial plasmid in a test tube. Because they have been cut with the same restriction enzyme, the cut ends (sticky ends) of the plasmid and the human gene match.
4. The enzyme **DNA ligase** is then used to stick the ends together.

- **Monitoring the cutting and joining – Gel Electrophoresis + Resistance to antibiotics**

  This has to be done to make sure the correct gene is spliced into the plasmid. We remove the unwanted DNA fragments using gel electrophoresis.

  Gel electrophoresis:

  1. The samples to be separated are loaded into wells at one end of the gel.
  2. An electric current is applied to the gel.
  3. The DNA molecules are negatively charged, so the DNA fragments travel through the gel towards the positive end.
  4. The various fragments are separated by size because the smaller pieces move faster than larger ones.
  5. The correct genes are easily obtained once they are separated in the gel and are placed into the plasmids in the **cutting and joining process**.

  We also have to isolate the host bacteria that contain the gene that has been spliced as you don't want the bacteria that don't contain this gene. To isolate this bacteria that's been spliced, we add another gene on the same plasmid that gives resistance to an antibiotic. The other bacteria can be removed by culturing the bacteria in a medium that contains the antibiotic. The bacteria containing the resistance to the antibiotic will survive and the others will be killed by the antibiotic.

- **Transforming hosts, such as DNA, with the recombinant DNA**

  We need to make the recombinant DNA go back into the bacterial cells so that they can **multiply** and make more copies of the designed gene.

  - Combine plasmid with **calcium chloride** which makes the membranes of the bacteria more porous, allowing the plasmids to move into the bacterial cells.
  - Not all bacteria will take up a plasmid and this is why the antibiotic resistance method must happen.

5.2 Describe the following recombinant DNA techniques used in biotechnology:

- **Gene splicing using restriction enzymes and ligases to produce recombinant DNA**

  Explained in 5.1.
  - Restriction enzyme: cuts the DNA out of plasmid and a section of DNA from a longer strand of DNA.
  - Ligase: joins the DNA and plasmid together
- **Polymerase chain reaction to amplify or modify DNA sequences**
  - Primers = small pieces of DNA that attach to the 3' end of the DNA
  - Taq DNA polymerase = special form of DNA polymerase that can work at high temperatures

  Primers are needed because DNA polymerase can only add bases to an existing piece of DNA, so they provide a place for DNA polymerase to start working.

  Process:

  1. Temperature heated to 95°C to separate DNA strands
  2. Temperature decreased to 37°C + **primers** join to the 3' end of the DNA strands
  3. Temperature increased to 72°C and **Taq** DNA polymerase adds the bases complementary to the template strands to make new DNA strands

  - After each cycle of PCR the DNA strands formed will double (one cycle = 2; two cycles = 4; 3 cycles = 8)
  - The Taq DNA polymerase adds nucleotides complementary from the 3' end with the primers and travels towards the 5' end
- **Use of DNA vectors and microinjection for carrying genes into nuclear DNA in the production of transgenic multicellular organisms**

  Recombinant DNA is either transformed into bacterial cells which are then introduced into the organism, or the plasmid is directly inserted into the plant cells.
  - <u>Using pathogens:</u>

    → **<u>Bacteriophages</u>**:
    - Virus-like particles that naturally infect bacteria
    - We can select the DNA (we use recombinant DNA) that the bacteriophage injects into the bacteria

→ **Viruses**
  - We alter the DNA that is carried by the virus which then infects the host cells of the organism with the recombinant DNA

- Directly inserting plasmid into organism:
  → **Electroporation**
    - Electric shock makes the cell membranes more porous so the plasmids + foreign DNA can enter the cells of the organism
  → **The DNA 'gun'** or **biolistics**
    - DNA is precipitated onto small pellets which are shot into plant cells from a specially designed gun
    - The introduced DNA integrates with the plant DNA
  → **Microinjection**
    - Introduces foreign DNA into animal cells
    - The foreign DNA is inserted into the fertilised egg which is then placed into the uterus of the surrogate mother who gives birth some months later after going through a normal pregnancy

5.c Gather and analyse information to outline the purpose of a current application of transgenic technology, naming the organism and gene transfer technique involved

Transgenic organism = an organism developing from a cell into which foreign DNA has been inserted.

Example of transgenic organism = **Bt Cotton**

Organism the gene was extracted from	Soil bacterium *Bacillus thuringiensis*
Organism receiving gene transfer	Cotton plant
Vector	*Agrobacterium tumefaciens* *Or* *Agrobacterium* species
Gene transfer technique	1. Cut normal seedlings into small pieces and place them on a growth medium so they can grow into calluses. 2. Callus cells are transferred to a liquid medium 3. Bt gene extracted from *Bacillus thuringiensis* 4. Bt gene transferred into cotton embryos through the

	5. Cotton embryos dipped into a solution containing the vector which contains the extracted Bt gene → vector bacteria insert Bt genes into the cotton cells 6. Embryos containing the Bt genes are grown culture, then placed on a solid medium and germinated into small plants, then planted in pots and grown in grass houses

5.d Identify that complementary DNA is produced by reverse transcribing RNA or the polymerase chain reaction

Reverse transcription is used to produce a selected section of DNA from its complementary mRNA within the cell.

- **Introns** (long, non-coding sections of DNA) are not included in the resulting gene
- **Reverse transcriptase** = enzyme that produces a single strand of complementary DNA from the mRNA
- **DNA polymerase** stimulates the production of a double strand of the complementary DNA

Process:

Double stranded DNA containing **introns** + **exons**	
Transcription of the DNA occurs in the cell to form mRNA	
Introns are **removed** from the mRNA and it is **extracted** from the cell	
Reverse transcriptase forms a single strand of DNA that is complementary to the mRNA	
With the help of **DNA polymerase** the single	

template to make another strand → **double stranded**	

6.1 Outline one way that forensic scientists can use DNA analysis to help solve cases

DNA fingerprinting

Used to compare DNA from two sources to determine whether they are identical.

- Can be used to:
  - → Compare the DNA of a suspect with the DNA found at a crime
  - → Paternity tests
- Uses the introns
  - → Introns have short sequences of bases that are repeated many times
  - → The exact number of repeats vary greatly between individuals
- Process:
  1. DNA is isolated from tissue samples (blood, semen, hair, skin, etc.)
  2. DNA is cut into pieces by restriction enzymes
  3. Pieces are separated by gel electrophoresis
  4. The number of repeats produces different lengths of DNA
     - → These show up as a particular set of bands called fingerprints or profiles

6.2 Describe the production of a synthetic hormone such as insulin (application of biotechnology in medicine)

- Initially, insulin was extracted from pig or cow pancreases and injected under the skin of diabetics
  - ➢ Some patients suffered from immune or allergic responses if there were impurities in the animal insulin
  - ➢ Expensive to produce
- Synthetic form of insulin first created using biotechnology in **1978**
  - ➢ Has been available commercially since **1983**
  - ➢ Produced using recombinant DNA technology
  - ➢ Modelled on the human insulin structure
  - ➢ Cheaper + easier to produce than animal-derived insulin
  - ➢ Huge economic success

- In **1978** a synthetic version of the human insulin gene was constructed and inserted into the bacterium *Eschericia coli*
  1. The piece of foreign DNA is inserted into a plasmid
  2. This recombinant plasmid is reintroduced into another bacterial cell
  3. Inside the cell, the protein-making molecules can read the human gene on the plasmid

6.3 Describe the production of monoclonal antibodies (application of animal/plant biotechnology)

- Monoclonal antibodies are the result of the fusion of a B cell that produces a specific antibody with a harmless tumour cell that divides continuously
  - The fused product can produce many copies of the required antibody
    - Thus, the antibody is cloned
- **Production:**
  1. Antigen for which the antibody is required is injected into a mouse or a rabbit, resulting in the production of the specific antibody
  2. The B cells that produced the antibody are isolated and fused with rapidly growing tumour cells to form **hybridomas** (cells)
  3. Hybridomas are grown in culture to produce monoclonal antibodies in great quantities
     - **B cell part:** produces the antibodies
     - **Tumour cell part:** divides rapidly to reproduce more cells → more antibodies
  4. Monoclonal antibodies can be extracted and purified + used to detect or treat disease caused by the antigen that originated them

6.4 Describe the farming of a marine animal (application of aquaculture)

- Aquaculture produces large quantities of seafood without the problems associated with harvesting wild populations
- **<u>Oysters</u>**
  - Larval oysters are caught by encouraging them to settle on sticks placed in the water column
  - Sticks are then nailed onto wooden racks in the intertidal zone
  - Oysters can feed on phytoplankton during the high tide

- Oysters are protected from diseases + pests during low tide
- After 2-3 years they are harvested

6.a Identify data sources, gather, analyse and process information to present one case study on the application of biotechnology in each of the following:

	Medicine
Process used	Monoclonal antibodies to treat cancer
Organisms or tissue involved	- Cancer cells from a person with cancer - A mouse
Outcome of the biotechnological process	1. Cancer cells injected into mouse which then produces antibodies against the cancer cells 2. Mouse antibodies isolated and combined with a human antibody 3. B-lymphocyte that produces the antibodies is fused with a myeloma cell to produce a **hybridoma**
Efficiency of the process and the advantages and disadvantages	**<u>Advantages</u>** - Produces large amounts of an antibody specific for a certain type of cancer → Increases the chance of destroying the cancer - Continually produces the same antibody - Des not cause and immune response as the monoclonal antibody is 'humanised' by adding a human antibody onto the mouse antibody **<u>Disadvantages</u>** - Long + tedious process to produce the antibody - Likely to be expensive

	Animal biotechnology
Process used	Recombinant DNA to produce a vaccine to treat cattle ticks
Organisms or tissue involved	- A particular protein making gene from the tick's gut - A bacterial plasmid
Outcome of the biotechnological process	1. Gut protein produced by rapidly reproducing transformed bacteria 2. This protein (TickGARD) is injected into cattle + acted as a vaccine → the animal's immune system produces antibodies against the gut protein - Tick population is rapidly reduced is all animals in a herd are vaccinated
Efficiency of the	**<u>Advantages</u>**

advantages and disadvantages	against parasites that has been registered for commercial use - No longer need to spray or dip cattle in chemicals to ill the ticks which may have affected the milk + meat - Overcomes the problem of ticks developing resistance to pesticide **<u>Disadvantages</u>** - If farmers don't do vaccinations themselves it will cost for vaccines + vet fees - Farmers may adopt this system at different rates

	Aquaculture
Process used	Artificial selection/artificial breeding
Organisms or tissue involved	Freshwater yabby = *Cherax destructor*
Outcome of the biotechnological process	- Animals with faster growth rates are selected for breeding - Produces a breeding line that grows faster + is more profitable - **Other characteristics:** → Larger tails with large amounts of edible meat → Efficient conversion of food to meat
Efficiency of the process and the advantages and disadvantages	**<u>Advantages</u>** - Yabby farming has become a profitable industry - Resulted in strongest + most suitable yabbies for survival in aquaculture - Improves characteristics of the yabby population **<u>Disadvantages</u>** - Yabby farmer may have to discard some of the individuals I the selection process (**however,** this will be an advantage in the long term)

7.1 Explain why different groups in society may have different views about the use of DNA technology

- Cultural backgrounds/previous experiences
  → Life/death situations using DNA technologies where it saves life of a friend or family member
  → Religion may be against it
- Businesses at the head of production concerning DNA technologies aim to **make money** to satisfy the shareholders

→ Shareholders are often concerned about ethical issues, so this is not straightforward

- Animal liberationists
  - → Against the use of animals in biotechnology
  - → Don't consider the benefits of this research
    - ➢ Consider the welfare of the animal paramount
- Differing information
  - → May have viewed and experienced the labs first-hand and don't like it from that
  - → However, may have learnt false information
- Allergies
  - → Can have allergies to the organism which the introduced gene came from

7.2 Identify and evaluate ethical issues related to the development of genetically modified organisms (GMOs)

Issue 1:

Can accidentally release GMOs into the environment

Problem:

The recombinant DNA in the GMOs may be taken up by unrelated organisms which may have the potential to be pests or cause a disease.

This is possible because viral vectors may transfer the transgene between unrelated animals

Solution:

- Strict and rigorous controls over the production + release of GMOs
- GMOs could have specific genes deleted so their growth requirements are only met in controlled environments. Then they won't be able to grow if they escape

Issue 2:

Introduced gene(s) may disrupt normal gene function in the organism

Problem:

- Disrupting genes may cause **cancer**
- Frequently low success rate of expressing the desired gene

Solution:

Combination of the following to ensure that **only** those cells that have been **successfully transformed** are used to **produce organisms**:

- Genetic engineering
- Cloning
- Genetic screening

Issue 3:

Using transgenic organisms in the environment that are targeted for specific problems

Problem:

Once they have completed their desired function (eg environmental clean-up) they may be undesirable invaders in the ecosystem

Solution:

- **"suicide genes"**
  → GMOs can be engineered with these genes so that they only survive for a short amount of time in the new environment after completing their task

7.a Use available evidence to identify and discuss ethical and social issues associated with the use of biotechnology

- Biotechnology is the use of living organisms to make or modify a product so that it is more beneficial

2. Define ethical issues
   - A system of morale principals by which human actions and proposals may be judged good or bad or right or wrong
3. Define social issues
   - Issues relating to the community and relationships in community; including poverty, economy, politics, health + environment
4. Ethical issues
   - **Cloning**:
     - people are concerned that the eugenics movements will return as we know so much about human genes
   - **Transgenic animals**:
     - Transgenic pigs grow faster + leaner but unable to stand due to arthritis
     - Alter the pathway of evolution → do we have the right to change this?
     - Possible extinction of species
       → Transgenic **salmon** with growth hormone to grow full size within a year. If they escaped to the wild and bread with normal salmon they wouldn't be able to:
       a) swim from predators
       b) swim fast
       c) catch prey
5. Social issues:
   - **Transgenic species:**
     - potential for creating biological forms that could be used as **weapons**
   - **Genetically modified organisms:**
     - Promotes inequalities between people who have access to technologies and those who don't
   - **Escape of GMOs**:
     - If some GMOs escape they may interbreed which would alter the genome of the entire population
       → Eg weedicide resistant varieties of canola and soy beans may cross pollinate with nearby weeds, promoting resistant weed species

→ Continuing...pest resistant plants might promote the development of super resistant pests eg would be VERY bad for cotton