IMMUNE SYSTEM:

- Classed as homeostatic mechanisms
- Should our body age infected, the immune system will remove that and return it back to normal
- Pathogens are living organisms that can cause diseases EG cold is caused by a virus
- Antigens are proteins that cause diseases
- Toxins are proteins that are waste products from bacteria - Tetanus

Types of Pathogens:

Bacteria - tetanus, chlamydia
Viruses - HIV, COVID - 19
Fungi - ringworm, thrush
Animal Parasite - malaria, tapeworms

Micro-organism:

- Bacteria 0.5 - 2.0 micrometer
- Viruses 20-750 nanometers

Transmission of pathogens:

- Communicable diseases can be spread from one person to another
- A contagious disease can be passed directly one person to another
- Other communicable disease are spread by voted (an intermediate host) EG the malaria is spread by the mosquito (the vector)

Methods of transmission:

1. Contact - spread of pathogen through physical contact. Can be direct or indirect
2. Ingestion - food or drink ingested contaminated with pathogen result in disease. EG typhoid fever and salmonella
3. Body fluids - transfer of body fluids form one person to another result in infections. When blood or other body fluids from an infected person comes int contacts with mucous membranes such s nose, mouth, blood stream allows pathogens to enter an uninflected person
4. Droplets - occur when Tony droplet of moisture containing pathogenic organisms are emitted when breathing, talking, sneezing or coughing. Droplets may be breathed in by others
5. Airborne - when moisture in exhaled droplets evaporated, many bacteria are killed but viruses and some bacteria remain viable and can cause infection when inhale due to particles being lighters they can be viable for a greater distance
6. Vectors - transmission of pathogens by animals, insects, ticks or mites. Some vectors transfer the pathogen directly, or other can spread through food or water. Many

TYPES OF IMMUNITY

There are 2 main types of immunity

1. **Non-specific**
    - External non-specific
    - Protective reflexes
    - Internal non-specific defences

External non-specific:

Skin - effective barrier covering outside of the body.

- Stops the entry of micro-organisms
- Bacteria occupies skin which makes it difficult for outguns to be established
- Sebum (oily secretion) contains substances that kill some pathogenic bacteria
- Sweat secreted on skin contains salts and fatty acids that revert growth of many micro-organisms

Mucous membranes - line body cavities that open to the exterior

- Secretes mucus which traps particles and inhibits the entry of micro-organisms to organs
- Digestive, urinary and reproductive tracts protected this way

Hairs - found in nasal cavity and ears

- Hairs and a layer of mucus trap up to 90% particles inhaled when breathing (nose)

Cilia - tiny hair-like projections from cells that are capable motion

- Beating of cilia moves mucus, containing trapped particles and micro-organisms towards the throat were it might be coughed up or swallowed

Acids
- Stomach juices are highly acidic
- Acid kills many of the bacteria taken in with food or thane contained in mUCUS swallowed from the nose and windpipe
- The vagina also has acid secretions that reduce the growth of micro-organisms
- Urine an sweat on the skin are also slightly acidic

Lysozyme - enzyme that kills bacteria
- Eyes are protected by actions of tears which contain enzymes
- Also found in Slava, sweat and secretions of nose and tissue fluid

Cerumen - ear wax
- Protects g=the outer ear against infection by some bacteria
- It is slightly acidic and contains lysozyme

Movement of fluid - flushing action of body fluids
- Keep some areas relatively free of pathogens
- Urine flowing through the urethra has cleaning action
- Prevents bacterial growth and helps to stop bacteria reaching under bladder and kidneys
- Tears, sweat and saliva are also involved in flushing and cleansing

Protective reflexes: automatic, involuntary responses

Sneezing - the stimulus for sneezing is irritation of the walls of nasal cavity
- Irritation may be caused by noxious fumes or dust particles which carry micro-organisms
- Forceful expulsion of air from the lungs carries mucus, foreign particles and irritating gasses out the nose and mouth

Coughing - stimulus is irritation in the lower respiratory tract (bronchi and bronchioles)
- Air is forced from the lungs to try and remove the irritant
- The air drives mucus and foreign matter up the trachea towards the throat and mouth

Vomiting - psychological stimuli
- Excessive stretching of the stomach and bacterial toxins can all induce vitiating
- Contraction of the muscles of the abdomen and the diaphragm, nit the contraction of the stomach expels the stomach contents

Diarrhoea - irritation of the small and large intestines by bacteria, viruses or protozoans
- Irritation causes increased contractions of the muscles of the wall of the intestines so that the irritant is removed as quickly as possible
- Material does not stay in the large intestine Xiong enough for water to be absorbed, s the faeces are watery

Internal non-specific defences:

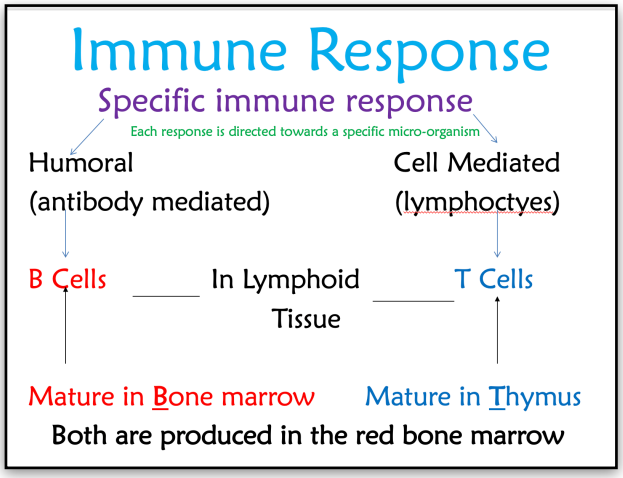
Organisms that penetrate our external defences are attacked by phagocytes

Monocytes and macrophages - when tissues become inflames and infected, monocytes leave the blood stream and enter the tissue
- Here they differentiate into macrophages
- Macrophages move through the tissues look for and destroy pathogens
- Others are fixed and let pathogens come to them
- Remove microbes and dying cells through phagocytosis

Neutrophils - granulated leucocyte
- Due to the grails visible in their cytoplasm
- During infection, they are the first cells to move into tissue destroying pathogen
- Kills pathogen inside cells
- Make up puss after an infection

Dendritic cells - projections from the cytoplasm
- Have the ability to detect, engulf and process foreign articles

- Use information about the ingested particles to assist with specific immunity



2. Specific

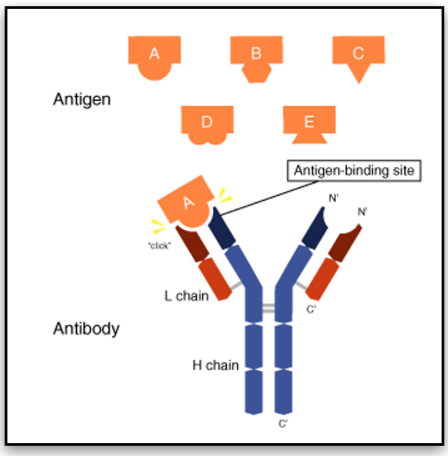
- Specific immune response; Each response is directed towards a specific micro-organism
- our body's mechanisms will only stop one particular pathogen/antigen due to shape (lock and key)
- EG Measles virus will only be stopped by one type of antibody, that anybody cannot 'stop' any other virus
- The key cells involved on the immune repos e are B-cells and T-cells (white blood cells called lymphocytes)
- B-cells and T-cells are both produced in the bone marrow and end up in the lymphoid tissue, yet mature different routes
- **Humour response -** involves the production of special proteins called antibodies by B-cells which circulate around the body and attack invading agents
- **Cell-mediated response** - due to T-cells and involves the formation of special lymphocytes that destroy invading agents

Antigens:

- Any substance capable of causing a specific immune response
- Can be protein, carbohydrate, lipid or nucleic acid or toxins produced by bacterium
- **Self-antigen** - Large molecules produced in person's own body & don't cause immune response
- **Non-self antigen** - Foreign compounds that DO trigger an immune response

Antibodies:

- A specialised protein that is produced in response to a NON-SELF antigen
- Antigen molecules have specific active sites & it is here that an antibody can combine with the antigen.
- Antigen + Antibody = Antigen-antibody complex.
- Lock & Key Model



T-lymphocytes:

- Mature in the thymus
- Migrate into the bloodstream, lymph nodes & lymphoid tissue
- Highly mobile and continually circulate throughout the body
- Involved in **cell-mediated** immunity
- Provides resistance once foreign micro-organism enters cell

B-lymphocytes:

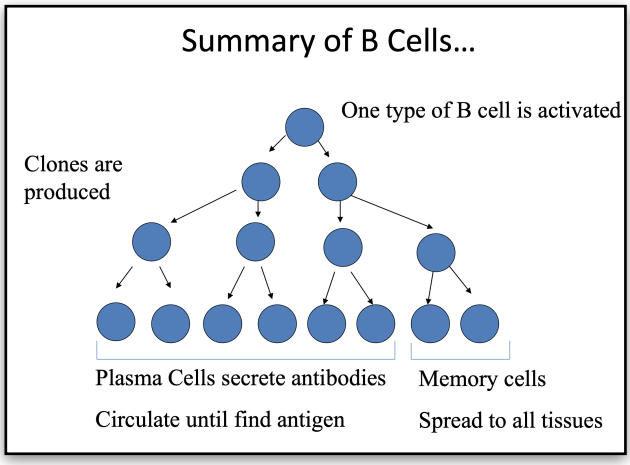
- Mature in red bone marrow
- Released into bloodstream, migrate to lymph nodes & lymphoid tissue
- Less mobile than T cells
- Shorter life span
- Replaced continuously
- Involved in antibody-mediated immunity **(humoral response)**
- Provides resistance BEFORE micro-organism enters cell.

Similarities of B & T cells:

- Both are antigen specific - Will only react to those antigens they have been trained to recognise
- Both develop a memory - once they have been exposed to the specific antigen they produce memory cells that are able to respond very quickly on subsequent exposures

The humeral response: antibody-mediated response

- B cells involved
- B cells can become activated in two ways:
- **Macrophages** can ingest the pathogen and then present the antigen to a B cell
- Antigen makes direct contact with a B cell
- Activation of B cell occurs if the antigen matches the receptor (antibody) located on the B cell
- Once activated:
  - B cell enlarges
  - Undergoes repeated mitotic division and forms a clone
  - Most of the millions of resulting daughter cells become **plasma cells**
- Plasma cells secrete **antibody** into the lymph and blood plasma
- Some B daughter cells become **memory cells** which allow the response to be quicker on subsequent exposure
- secreted antibody circulates throughout body until it comes into contact with matching antigen
- Antibody reacts with antigen to form antigen-antibody complex
- All antibodies combine with the antigen for which they are **specific.**



Different Response when antibodies come into contact with antigens:

1. Combine with foreign enzymes/toxins to inactivate them & inhibit reactions
2. Bind to viruses surface to prevent virus entering cells
3. Coat bacteria therefore bacteria easier to consume by phagocytes
4. Cause bacteria, viruses or foreign blood cells to clump together – agglutination
5. Dissolve antigens
6. React with soluble substances to make them insoluble therefore easily consumed

Lymphatic system: homeostatic role in humeral response:

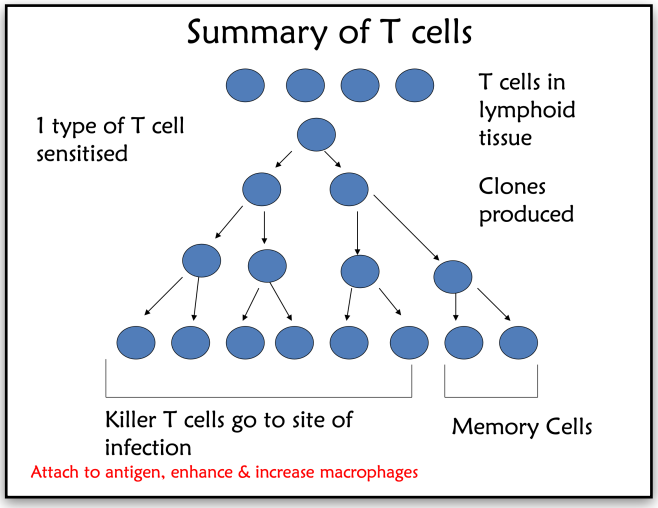
- Main function is to absorb excess fluid and return back to circulatory system
- Lymph capillaries can easily absorb antigens
- The lymph (liquid in the capillary) moves back to towards the circulatory system
- Involves production and release of antibodies into the blood and lymph
- Lymphoid tissues contain lots of B-cells , each with a. Specific records for a specific virus
- When antigen-presenting cells presents the antigen to the specific B-cell, the B-cell is activated
- When the B-cell is activated. They enlarge and divide intro groups called clones
- Most clones become plasma cells which secret the specific antibody capable attaching to the active site of the antigen
- These antibodies circulate in the blood and lymph and extracellular fluid to reach site of invasion
- Remaining B-cells become memory cells
- Memory cells spread to body tissues to allow the response to occur more rapidly

Cell mediated immunity:

- T cells can only react to an antigen if the antigen has **entered** a cell
- Very good at counteracting viral diseases
- Cell is able to alert the immune system by displaying **non-self protein fragments** on outer surface
- Thousands of different T cells made to interact with specific antigen
- Once activated:
- T cell divides rapidly forming clone cells
- **T killer cells** (cytotoxic T cells) leave lymph nodes and migrate infection site
- Attack infected cells directly by destroying them
- Attract macrophages to engulf cells
- Releasing a substance that speeds up macrophage activity

- Activate other lymphocytes
- **T helper cells** secrete substances that amplify and control immune system. E.g. responsible for activating B & T cells
- **T memory cells** which enhance the secondary response to any subsequent infection

* **cytokines** are chemicals released from T cells



Process of cell mediated immunity:

- When antigen-presenting cells presents the antigen to the specific t-cell, the T-cell is activated
- When the T-cell is activated. They enlarge and divide intro groups called clones
- Cells of clone remain in tissue as memory cells which can recognise the original invading antigen and initiate a faster response
- Those that don't become memory cells develop into different type of T-cells
- **Killer T-cells** migrate to site of infection and attach to the invading cells and release chemicals that will destroy the antigen
- **Helper T-cells** bind to the antigen on antigen-presenting cells, stimulating the secretion of cytokines that:
  - Attract lymphocytes to the infection site which become sensitised and activated, thus intensifying response
  - Attract macrophages to the place of infection so that the macrophages can destroy antigens by phagocytosis
  - Intensify the phagocytic activity of macrophages
  - Promote the action of killer T-cells
- **Suppressor T-cells** act when the immune activity becomes excessive or the inception has been dealt with successfully. The release substances that inhibit T and B cells activity, slowing down the immune response

Cell mediated immune response:

- T lymphocytes (originate in the Thymus)
- Attack host cells infected with viruses or fungi, transplanted cells or cancer cells
- Attack pathogens inside cells by destroying the host cell

1. Attach to invading cells and destroy them
2. Secrete substances that recruit more lymphocytes
3. Secrete a substance to attract macrophages
4. Release substance that increases phagocytic activity

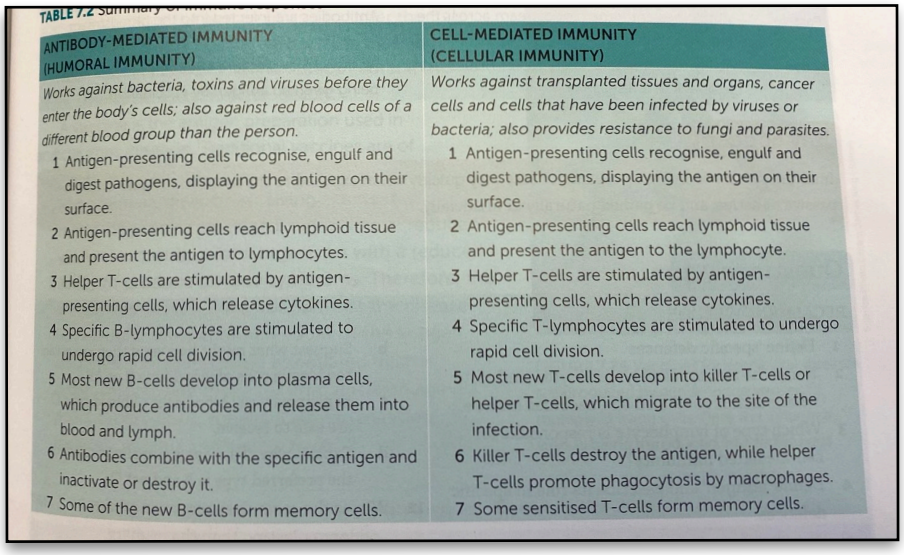


TABLE 7.2

ANTIBODY-MEDIATED IMMUNITY (HUMORAL IMMUNITY)	CELL-MEDIATED IMMUNITY (CELLULAR IMMUNITY)
Works against bacteria, toxins and viruses before they enter the body's cells; also against red blood cells of a different blood group than the person.	*Works against transplanted tissues and organs, cancer cells and cells that have been infected by viruses or bacteria; also provides resistance to fungi and parasites.*
1 Antigen-presenting cells recognise, engulf and digest pathogens, displaying the antigen on their surface.	1 Antigen-presenting cells recognise, engulf and digest pathogens, displaying the antigen on their surface.
2 Antigen-presenting cells reach lymphoid tissue and present the antigen to lymphocytes.	2 Antigen-presenting cells reach lymphoid tissue and present the antigen to the lymphocyte.
3 Helper T-cells are stimulated by antigen-presenting cells, which release cytokines.	3 Helper T-cells are stimulated by antigen-presenting cells, which release cytokines.
4 Specific B-lymphocytes are stimulated to undergo rapid cell division.	4 Specific T-lymphocytes are stimulated to undergo rapid cell division.
5 Most new B-cells develop into plasma cells, which produce antibodies and release them into blood and lymph.	5 Most new T-cells develop into killer T-cells or helper T-cells, which migrate to the site of the infection.
6 Antibodies combine with the specific antigen and inactivate or destroy it.	6 Killer T-cells destroy the antigen, while helper T-cells promote phagocytosis by macrophages.
7 Some of the new B-cells form memory cells.	7 Some sensitised T-cells form memory cells.

BACTERIA AND VIRUSES

Antibiotics:

- Group of drugs that react with bacteria in some way to stop them from reproducing or to destroy them
- Antibiotics do not react with bruises and are not suitable asa treatment against diseases caused by viruses
- Antibiotics with and destroy bacteria in the following ways:

1. Inhibition of DNA synthesis - these antibiotics stop the bacteria from reproducing/dividing successfully
2. Inhibition of cell wall synthesis - these antibiotics stop the bacteria fro, producing the cell wall successfully
3. Lysis of the cell wall synthesis - these antibiotics stop the bacteria by penetrating the cell membrane and allowing liquids to quickly diffuse into the cell causing it to rapture
4. Inhibition of protein synthesis - these antibiotics stop the bacteria from producing proteins essential to its survival and normal functioning

Antivirals: the virus life cycle

- A virus consists of genome (a specific DNA or RNA sequence) anda. Few enzymes all encased in a protein capsule

5. A virus reproduces according to the following stages attachment to a host cell
6. Release of viral DNA or RNA and possibly enzymes into the host cell
7. Replication of viral comments using host-cell machinery
8. Assembly of viral comments into complete viral particles
9. Release of viral particles to infect shot cells

Limitation of vaccines:

- Used to produce that 'bolster' to help the immune system to resist infection by viruses
- But the vaccination system has limitations in that it cannot treat a patient already infected

Antiviral targeting:

- Contain various types of molecules that bind to the viral DNA or RNA
- Bind to the host cell or interfere with the transcription of translation process
- The type of action applied by the antiviral drug is dependent upon the stage of the virus' life cycle

1. Before life cycle - viruses can be isolated before they enter a cell in two ways; using agents to mimic the virus association protein and attach to the cell membrane receptor site thereby blocking off the receptor so the virus cannot attach to the cell membrane
2. Uncoating inhibitors - drugs that prevent the virus from 'uncoating' that is when the castle splits to release the viral DNA or RNA and enzymes into the host cell
3. Viral synthesis - drugs called 'nucleotide analogues' deactivate the enzymes in the cell that synthesis the DNA or RNA. Of the cell cannot synthesise DNA or RNA then the viruses cannot replicate inside the cell
4. Transcription - the production of mRNA in the nucleus. Other antiviral drugs are being prepared that stop the transcription of viral mRNA by blocking the transcription factors that start the transcription process
5. Translation - the production of new viral DNA or RNA on the ribosomes. Antisense molecules can attach to the viral RNA at critical points to block the normal operation of the viral genome. Ribozymes can cut viral DNA or RNA at specific sites and interfere with the transaction phase of replication
6. Releasing phase - antiviral drug developers are producing drugs that block the neuraminidase molecule found on the surface of newly made flu viruses and hence stop the host cell from releasing the trial particles

Immune system stimulation:

- A group of drugs are being developed that stimulate the body's own immune sutra (lymphocytes) to produce interferons
- Interferons are our own natural

VACCINES

- Immunisation means programming the immune system so that the body can respond rapidly to infecting micro-organisms; hence developing immunity
- Can occur naturally or artificially
- Vaccination is the artificial introduction of antigens of pathogenic organisms so that the ability to produce the appropriate antibodies is acquired without the person having to suffer the disease
- A vaccine is the antigen preparation used in artificial immunisation

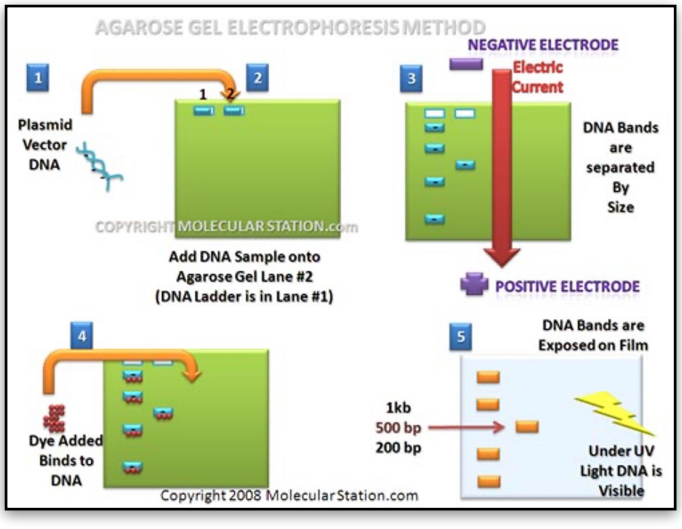
Types of vaccines:
Live attenuated vaccines: Living attenuated micro-organisms are micro-organisms of reduced virulence; that is, micro-organisms a reduced ability to produce disease symptoms. Therefore the immunised person does not contract the disease but manufacturers antibodies against the antigen. Contain living attenuated living organisms
Inactivated vaccines: contain dead micro-organisms. They produce an immunity that is shorter lasting than immunisation using live attended micro-organisms
Toxoid vaccine: toxins produced by bacteria can be inactivated, so that when they are injected someone they do not make the person ill
Sub-unit: fragment of an organism can be used to provoke the immune response

BIOTECHNOLOGY:
1. The human genome project
2. DNA sequence and bioinformatics
3. Profiling techniques (gel electrophoresis)
4. Polymerase chain reaction
   - Denaturing
   - Annealing
   - Synthesis
5. Genetic probes
6. Genetic engineering (recombinant DNA technology)
7. Gene therapy
8. Cell replacement therapy

The human genome project:
- Mapping the location of the genes on all the 46 chromosomes
- 20 000- 25 000 genes
- Identify the location of genes involved in genetic diseases
- Gene replacement therapy, genetic screening

DNA Sequencing:
- The determination of the exact order of nucleotides in a DNA sample
- By mapping sequences and comparing them in different samples in the same stretch of DNA, 'changed' genes can be detected and show if an individual has a specific disease
- Used for genetic screening
- Nucleotides- deoxynucleotide triphosphate
- Nucleotides bond at the hydroxyl group
- Synthetic nucleotides without the OH are added to growing nucleotides making them stop because there is no OH to bond with the next nucleotide. Allow for size of the strands to be determined so that position number can be determined
- Allows changed alleles to be compared

Gel electrophoresis:
1. DNA is cut at specific sequences using restriction enzymes (the length of each segment is unique to each person [exons and introns])
2. DNA is amplified using Polymerase Chain Reaction
3. DNA is placed on a semi-solid gel
4. A current is passed through the gel
5. Negatively charged DNA is attracted to the positive electrode
6. Smaller pieces moves faster (further) than larger ones resulting in a DNA profile



Polymerase chain reaction:

- Sometimes there is not enough DNA to test
- An enzyme called DNA polymerase is used to produce duplicates
- Original DNA fragment is split and copies made
- Each time this process takes place the number of DNA fragments doubles
- The DNA is amplified to create millions of fragments

Denaturing:

- Heat to 96°C
- DNA separates into 2 complimentary strands.

Annealing:

- Primers are added
- Primers are a complimentary base sequences at the start of the coding section.
- Cooling to 70 °C causes primers to bind to single strand DNA.

Synthesis:

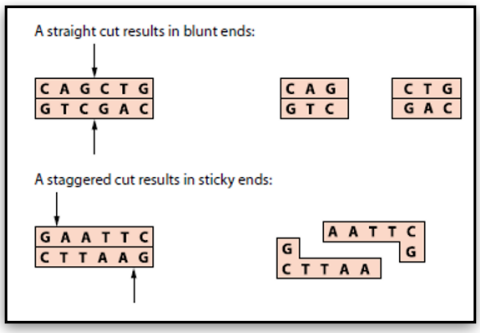
- DNA polymerase added (Taq polymerase can withstand high temps) and heated to 78°C to increase the rate of the process.
- DNA polymerase binds free nucleotides together to make new section of DNA using DNA ligase to "glue" the nucleotides in position.
- The process is repeated until millions of copies of the target gene are produced.

Genetic probes:

- Is a fragment of DNA labelled with a radioactive isotope or fluorescent marker
- If the sequence for a genetic disorder is known, a complementary strand of normal DNA is made and marked with an isotope or fluorescent substance
- The DNA is denatured then cooled to allow the marker DNA to bind with subjects DNA therefore locating the gene responsible for the disorder, the marked DNA will only bind with subjects DNA if the sequence is normal.
- Used to detect Cystic Fibrosis, Huntington's, Duchenne's Muscular Dystrophy, thalassaemia

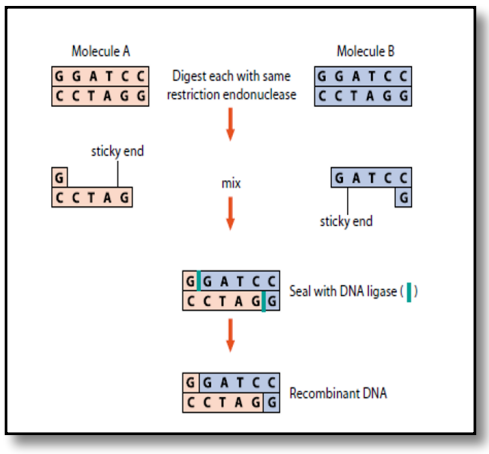
Recombinant DNA technology:

- Also called "genetic engineering".
- Placing foreign or modified DNA into cells of a different organism creating a transgenic organism.
- Introduced genes become part of the transgenic organism's DNA and are passed on to the offspring.



Creating transgenic organisms:

1. Isolate the gene of interest.
2. Place gene into the bacterial plasmid (the vector).
3. The recombinant DNA (the plasmid + the gene) is cloned to produce many copies.
4. The copies can be placed into host cells.
5. Host cells incorporate Recombinant DNA with their own DNA and produce proteins from the instructions on the inserted gene



Placing recombinant DNA into the vector:

- DNA is **cut** by a **restriction enzyme** at a particular point (base sequence) known as the **recognition site**
- Blunt ends are produced by a straight cut.
- Sticky ends are produced by a staggered cut
- **Sticky ends** are more useful in molecular cloning because they ensure that the human DNA fragment is inserted into the plasmid **in the right direction.**
- Sticky ends have unpaired nucleotides which enable them to be joined to complimentary strands with sticky ends.**DNA ligase** is used to **glue** the recombinant into a bacterial plasmid

Uses of recombinant DNA technology:

- Producing Insulin
- Producing Human Growth Hormone (hGH)
- Producing Factor VIII for haemophilia (blood clotting protein).
- Vaccines –Hepatitis B.

Gene therapy:

- Gene therapy is a branch of Science that aims to treat genetic diseases by replacing faulty genes with healthy genes
- The Human Genome Project has located the position of over 4000 faulty genes on our chromosomes
- Single–gene disorders like Huntington's disease and muscular dystrophy are likely to be the first to benefit from gene therapy.

Cell replacement therapy:

- Stem cells are undifferentiated cells and have the potential to specialise and turn into any type of cell in the body.
- Stem cells are found in embryos and in umbilical cord blood.
- Cell replacement therapy can used for any disorder where body cells have been lost or injured.
- Neurodegenerative diseases such as Parkinson's and Alzheimer's diseases are of interest due to their debilitating symptoms.
- Stem cells are transplanted into the patient where they differentiate into the same cells as those in the area of the transplant
- Tissue engineering requires a scaffold onto which cells of a particular type can grow
- Stem cells are then added to the cells on the scaffold and they specialise into the same cell type
- The scaffold and the cells can then be transplanted into the patient.
- The scaffold slowly degrades over time leaving healthy tissue to replace the lost or injured tissue, thus reducing the need for organ transplants.