Synergy Science Knowledge Organiser
9 Preventing, Treating and Curing Disease

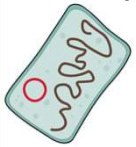
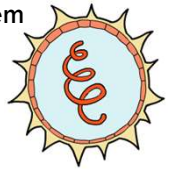
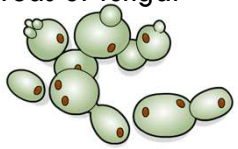
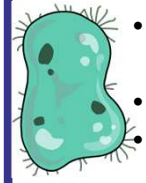
Disease Transmission

- Harmful microorganisms (pathogens) that cause disease can spread:
  - through the air when people cough or sneeze
  - through food that is contaminated with bacteria
  - through drinking water that is contaminated with microorganisms
  - through contact with other people, or surfaces that infected people have touched
  - by animals that scratch, bite or draw blood.

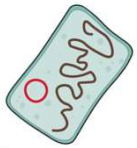


Pathogens

- Harmful microorganisms (pathogens) that cause disease are:
  - Bacteria
    - Divide rapidly by splitting in two
    - May produce toxins which make you feel ill
    - May damage cells
  - Virus
    - Live and reproduce inside body cells, damaging and destroying them
  - Fungi
    - The skin, respiratory system, intestines, and the genital-urinary tract are common areas of fungal infection.
    - E.g. ringworm
  - Protozoa
    - microscopic, single-celled organisms which multiply in humans causing parasitic infectious diseases such as malaria
    - Can cause tissue damage which leads to disease
    - Can cause an immune response to the parasite and/or to host antigens

Diseases and symptoms



- Salmonella food poisoning is spread by bacteria ingested in food, or on food prepared in unhygienic conditions.
  - Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete.
  - Salmonella bacteria are killed by cooking and pasteurisation.
  - In the UK, poultry are vaccinated against Salmonella to control the spread.

- Measles is a viral disease
  - Symptoms are fever and a red skin rash.
  - Measles is a serious illness that can be fatal if complications arise. For this reason most young children are vaccinated against measles.
  - The measles virus is spread by inhalation of droplets from sneezes and coughs.

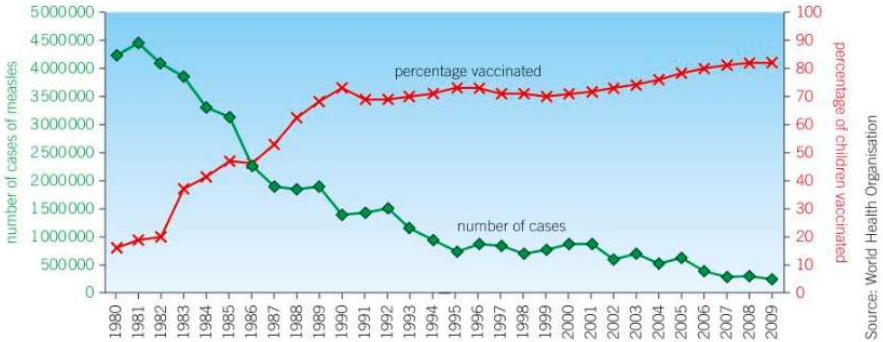
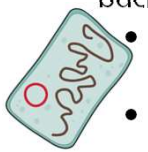


Figure 2 *Trends in global vaccination against measles and the numbers of reported measles cases*

- Gonorrhoea is a sexually transmitted disease (STD) caused by a bacteria
  - Symptoms of a thick yellow or green discharge and pain on urinating.
  - The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom.
- HIV is a virus that attacks the body's immune cells
  - Causes a 'flu like illness'.
  - Treated with antiretroviral drugs
  - Late stage HIV, or AIDS, occurs when the body's immune system is no longer able to deal with other infections or cancers.

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First Line of Defence

- The human body defends itself against the entry of pathogens in the following ways:

- Skin
  - the skin is a physical barrier
  - produces antimicrobial secretions to kill pathogens
  - The blood clots to form a scab, a physical barrier

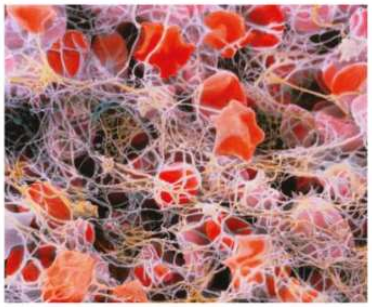


Figure 1 *This false colour scanning electron micrograph shows a scab that restores the protective barrier of the skin and prevents pathogens getting in. It is made of red blood cells tangled in a network of fibrin strands – magnification – ×2000*

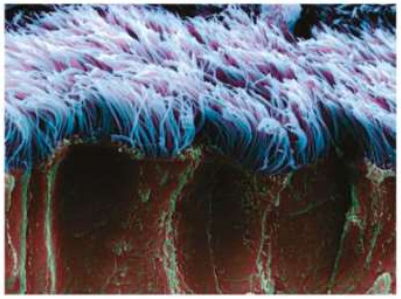
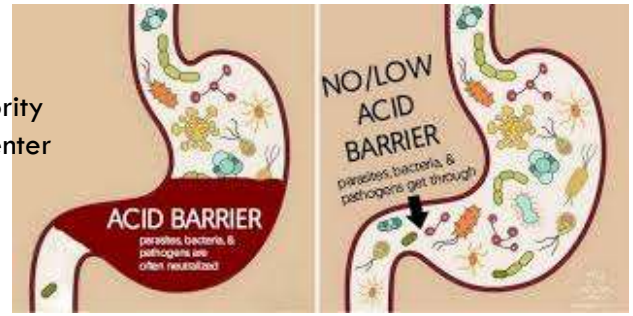


Figure 2 *The cilia of the airways, shown here magnified thousands of times in a false colour scanning electron micrgraph, beat together to move mucus containing trapped pathogens away from the lungs*

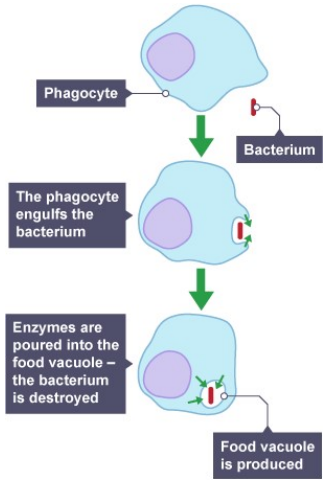
- Mucus and cilia
  - the lining of the respiratory system, including the nose, trachea and bronchi produce mucus, which traps foreign particles, including bacteria and viruses.
  - tiny hair-like structures called cilia beat to remove mucus from the respiratory system

- Stomach
  - produces acid
  - which kills the majority of pathogens that enter via the mouth.



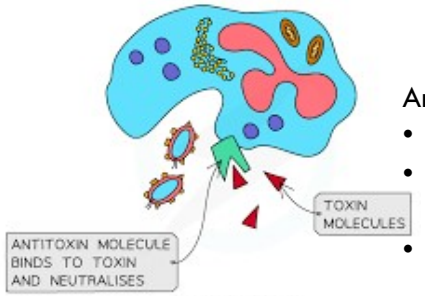
Second Line of Defence

- If a pathogen enters the body the immune system tries to destroy the pathogen. White blood cells are an important part of the immune system. They help to defend against pathogens through:
  - Phagocytosis
  - producing antibodies
  - producing antitoxins.



Phagocytosis

- Some white blood cells ingest (take in) pathogens, digesting and destroying them so they cannot make you ill.

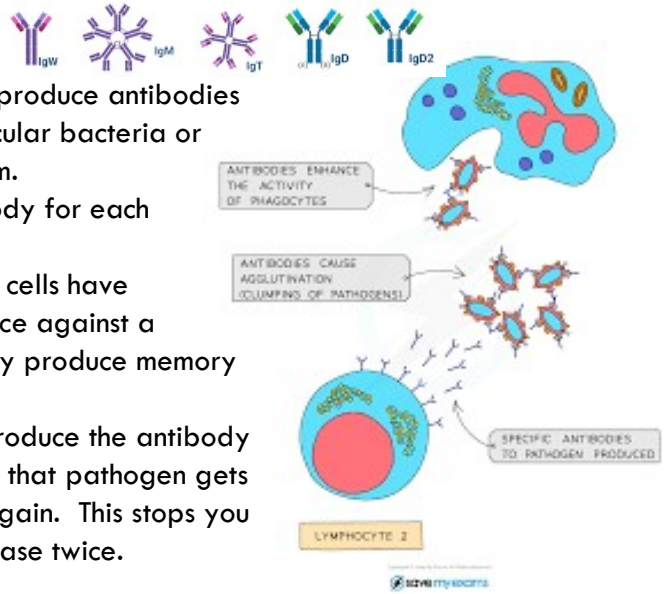


Antitoxins

- Some white blood cells produce antitoxins
- Antitoxins neutralise the toxins released by pathogens.
- It is the toxins that make you feel ill

Antibodies

- Some white blood cells produce antibodies
- Antibodies target particular bacteria or viruses and destroy them.
- There is a unique antibody for each pathogen
- When your white blood cells have produced antibodies once against a particular pathogen they produce memory cells
  - Memory cells produce the antibody again quickly if that pathogen gets into the body again. This stops you getting the disease twice.



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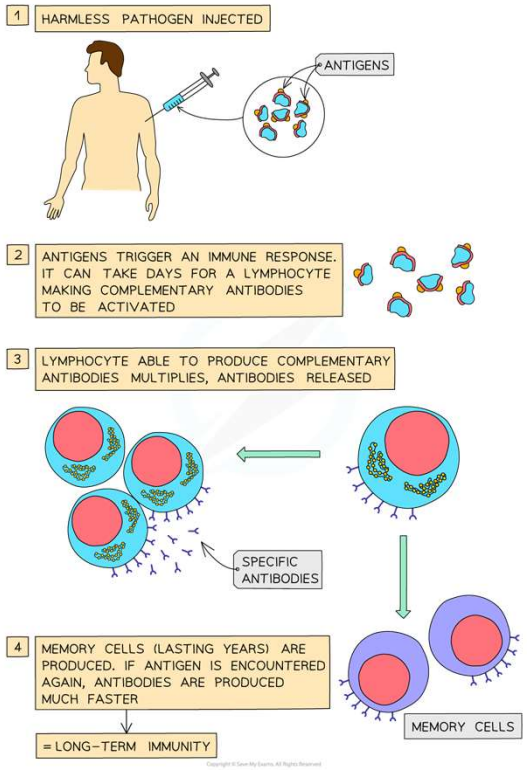
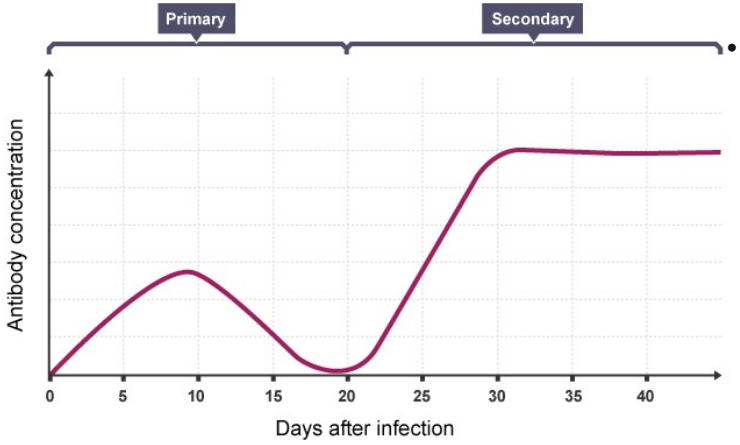
Vaccination

- Vaccination involves introducing small quantities of dead or inactive forms of a pathogen into the body to stimulate the white blood cells to produce antibodies. If the same pathogen re-enters the body the white blood cells respond quickly to produce antibodies, preventing infection.



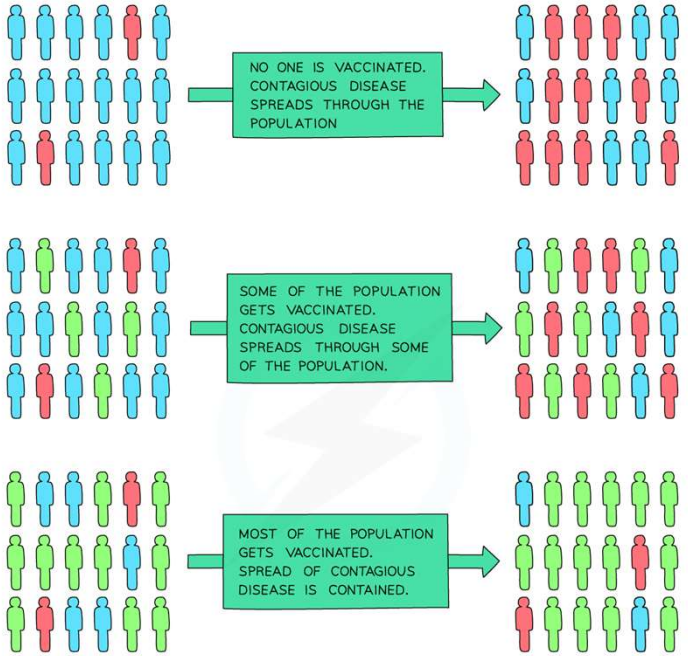
- During the primary infection the antibodies slowly increase, peak at around ten days and then gradually decrease.



- A **second** exposure to the same pathogen causes the white blood cells to respond quickly in order to produce lots of the relevant antibodies, which prevents infection.

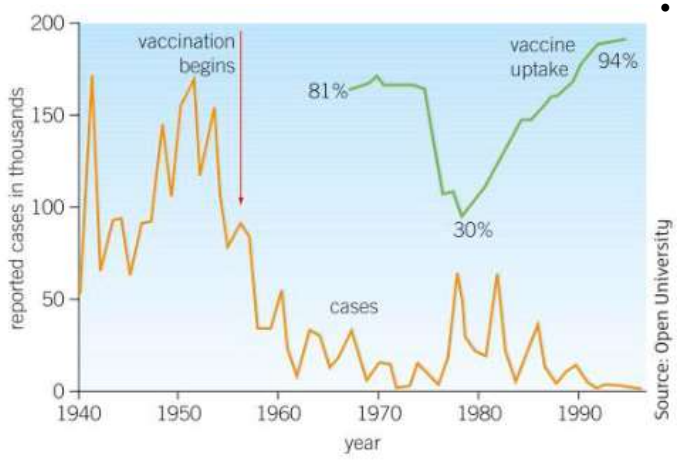
Herd Immunity

- If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced. This is called Herd Immunity.



- Herd immunity gives protection to vulnerable people such as newborn babies, elderly people and those who are too sick to be vaccinated

- In the UK in the 1970's when there was a scare about the safety of the whooping cough vaccine. Vaccination rates fell from over 80% to around 30%.



- Thousands of children got whooping cough again and a large number died. Yet the vaccine was as safe as any medicine. Eventually people realised this and enough children were vaccinated for herd immunity to be effective again.

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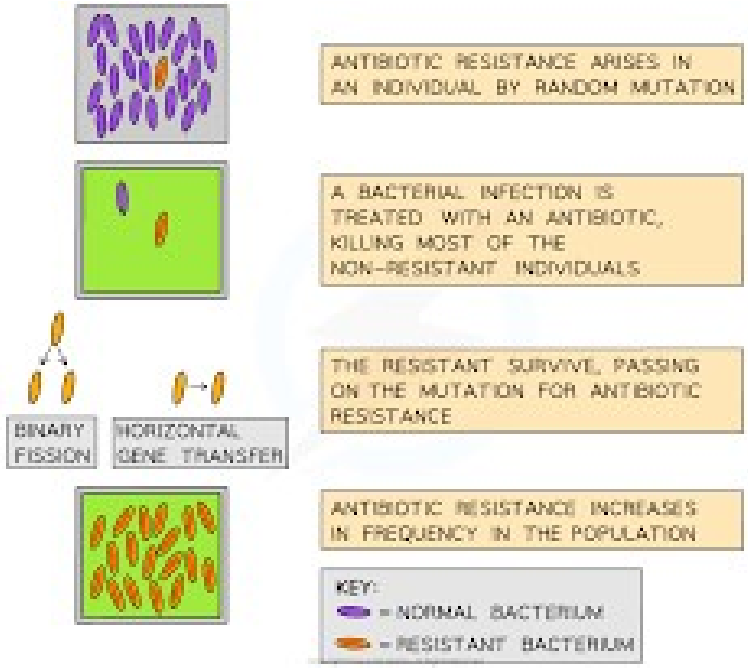
Medicines - painkillers

- Painkillers and other medicines are used to treat the symptoms of disease. They do not kill pathogens.
- Most medicines are mixtures. They are formulations made by mixing the ingredients in carefully measured quantities to ensure that the product has the required properties. One or more of the ingredients may be the drug, such as aspirin, but other ingredients make it easier or more pleasant for a patient to take the drug in solution or as a capsule or tablet.

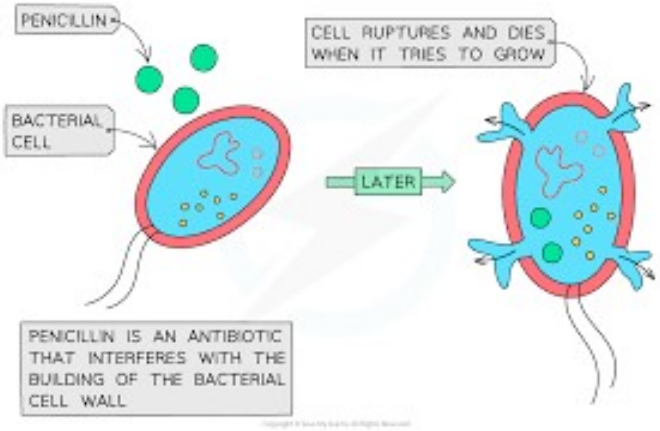
Antibiotic resistance

- The use of antibiotics has greatly reduced deaths from infectious bacterial diseases. However, the emergence of strains of bacteria resistant to antibiotics is becoming a serious threat.

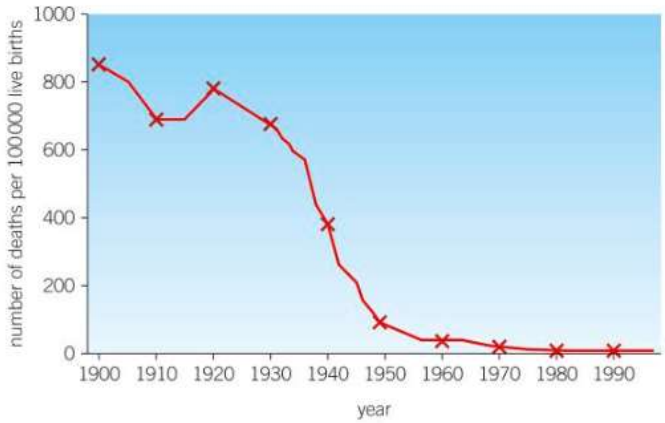


Medicines - antibiotics

- Antibiotics, such as penicillin, are medicines that help to cure bacterial disease by killing infective bacteria inside the body. It is important that specific bacteria should be treated by specific antibiotics.



- Antibiotics cannot kill viral pathogens.
- Viruses reproduce inside body cells, so it is extremely difficult to develop drugs that will kill the virus without damaging the cells and tissues of you body at the same time.
- Penicillin was the first antibiotic. The introduction of antibiotics in the 1940s had a huge impact on the numbers of women dying from infections after childbirth. Now there are many different ones that kill different types of bacterium.



- Several different antibiotics are being tested on an agar plate. Clear areas around the antibiotic patches appear when the bacteria are killed or cannot grow. They show how effectively each antibiotic has controlled the bacteria.

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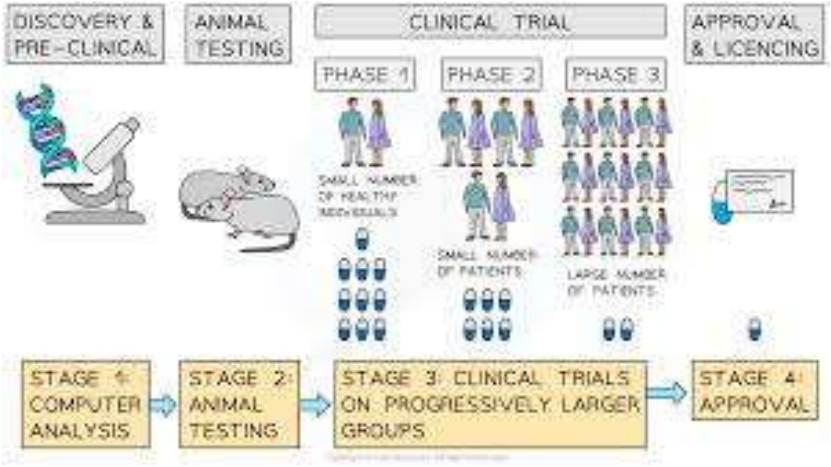
Testing New Drugs

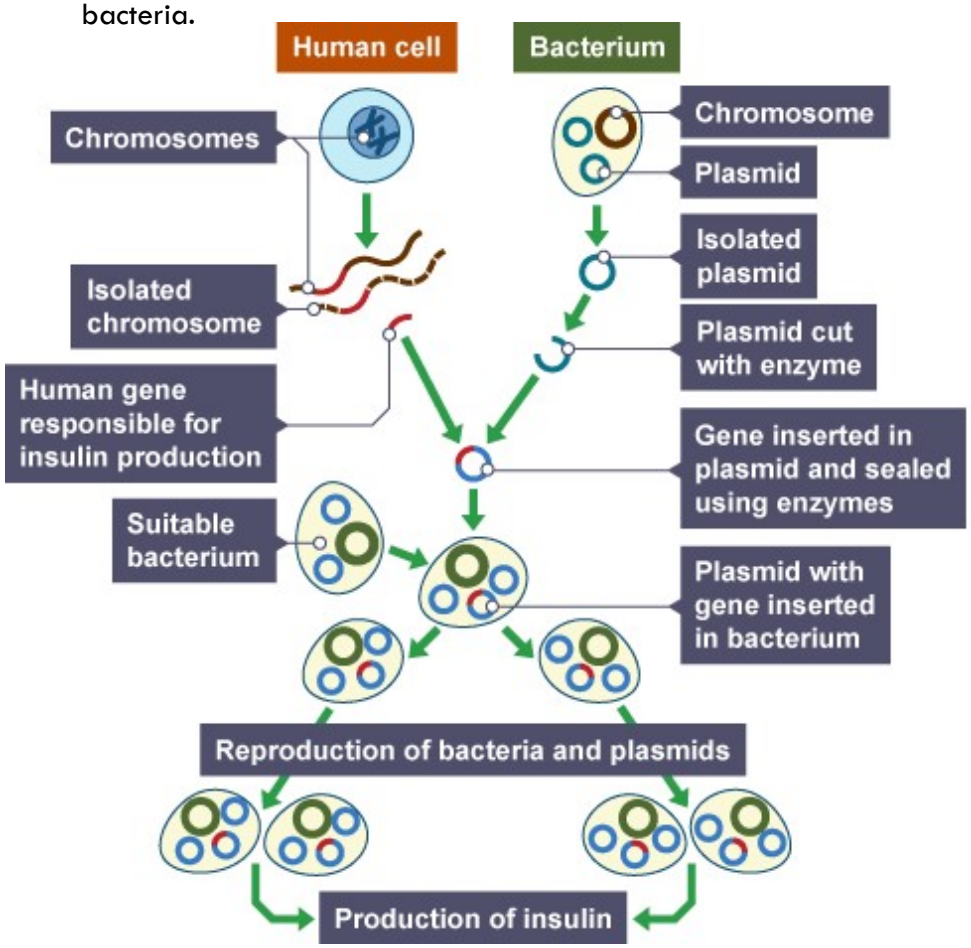
- When new medical drugs are devised, they have to be extensively tested and trialled before being used. Drugs are tested in a series of stages to find out if they are safe and effective.
- New drugs are extensively tested for toxicity, efficacy and dose:
  - in the laboratory, using cells, tissues and live animals
  - then in clinical trials involving healthy volunteers and patients. Very low doses of the drug are given at the start of the clinical trial. If the drug is found to be safe, further clinical trials are carried out to find the optimum dose for the drug.
  - In double-blind trials, some patients are given a placebo. Patients are allocated randomly to groups so that neither the doctors nor the patients know who has received a placebo and who has received the drug until the trial is complete.



- The results of drug tests and trials, like all scientific research are published in journals after they have been scrutinised in a process of peer review.
- Peer review means that other scientists working in the same area can check the results, helping to prevent false claims.

Genetic Modification, GM

- New medical products have been produced by genetically modifying bacteria.



- Insulin for the treatment of Type 1 diabetes is produced by cultivating genetically modified bacteria.
- Sheep and goats have been genetically modified to produce chemicals in their milk that can be used to treat disease. In one example the milk produced contains a protein needed to treat patients with cystic fibrosis.
- Research is also exploring the possibility of providing tissues needed for transplants from animals that have been genetically modified so that the tissues are not rejected by the human immune system.

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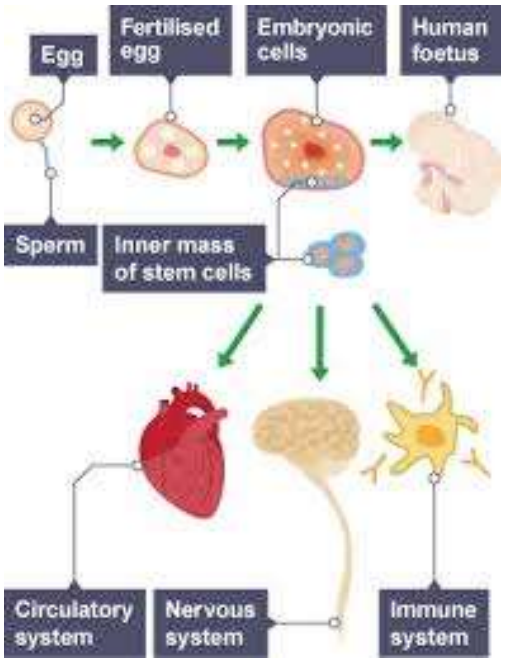
Stem Cells

- One medical use of stem cells is well established: this is the use of stem cells from bone marrow in transplants to provide a supply of new blood cells for the person receiving the transplant. This is used to treat leukaemia.
- Most medical uses of stem cells are still experimental. Treatments based on stem cells are being investigated for treating diseases such as:
  - heart disease – using the patient's own stem cells from bone marrow
  - Type 1 diabetes – using embryo or fetal stem cells.
  - The properties of stem cells are not fully understood. Scientists do not yet know how their differentiation is controlled. This means that there is a fear that their ability to proliferate could lead to cancer when they are transplanted into a patient.



- Stem cells for research may be based on:
  - stem cells from embryos that are a few days old
  - adult stem cells from selected parts of the body such as bone marrow
  - fetal stem cells taken from blood in the umbilical cord.
- Embryonic stem cells can develop into any of the many types of cells in the body. Adult stem cells can only give rise to the types of cells found in the tissues that the adult stem cells come from.

Stem cell dilemmas

- There are benefits, risks, social and ethical issues associated with the use of stem cells in medical research and treatments

Embryonic stem cells	Adult stem cells
Indefinite growth in ideal conditions	Limited ability to reproduce
Can become any cell type	Produced a limited range of cells types
Obtained by destroying the embryo	Easily accessible from different tissues of adults
More likely to be rejected	Low risk of transplant rejection
Prevents birth defects and infertility problems	Cure several chronic diseases
Expensive and hard to control	May trigger an immune response

Disease Interactions

- Different types of disease may interact. Some examples include:
  - defects in the immune system mean that an individual is more likely to suffer from infectious diseases
  - viruses living in cells can be the trigger for cancers
  - immune reactions initially caused by a pathogen can trigger allergies such as skin rashes and asthma
  - severe physical ill health can lead to depression and other mental illness.

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Stem Cells

- Task: Colour the advantages in green and the negatives in red

Embryonic stem cells	Adult stem cells
Indefinite growth in ideal conditions	Limited ability to reproduce
Can become any cell type	Produced a limited range of cells types
Obtained by destroying the embryo	Easily accessible from different tissues of adults
More likely to be rejected	Low risk of transplant rejection
Prevents birth defects and infertility problems	Cure several chronic diseases
Expensive and hard to control	May trigger an immune response

First line of defence

- Task: Complete the missing words

- The skin is a physical _____ that produces antimicrobial secretions to kill pathogens. The blood _____ to form a scab, a physical barrier.
- The lining of the respiratory system, including the nose, trachea and bronchi produce _____, which traps foreign particles, including bacteria and viruses.
- Tiny hair-like structures called _____ beat to remove mucus from the respiratory system
- The stomach produces _____ which kills the majority of pathogens that enter via the mouth.

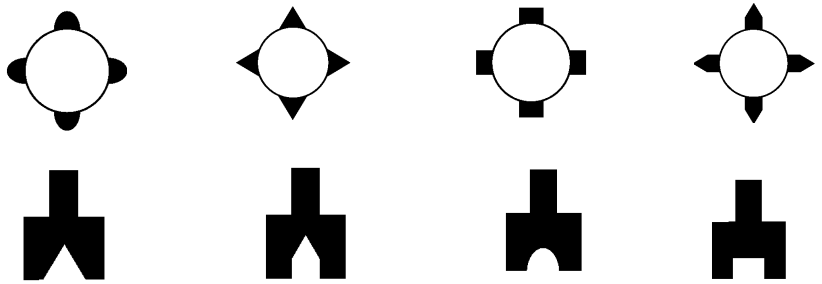
Disease Transmission

- Task: Match the pathogen to the disease and the symptoms

Pathogen	Disease	Symptoms
Bacteria	Ringworm	Fever, abdominal cramps, vomiting and diarrhoea
Virus	Salmonella	tissue damage which leads to disease
Fungi	Malaria	fever and a red skin rash
Protozoa	Measles	Skin rash

Antibodies

- Task: Match the antibody to the pathogen



Highlight the keywords: Bacteria, Virus, Fungi, Protozoa, Salmonella, Measles, Gonorrhoea, HIV / AIDS, Cilia, Epithelial cells, Mucus, Blood clot, Antibodies, White blood cells, mutate, resistance, Antibiotics, Antiseptic, Disinfectant, Placebo, Blind trial, Double blind trial, Control group, Insulin, transgenic, transplant, Stem cells, differentiation, specialised, embryo, Interaction, Peer review