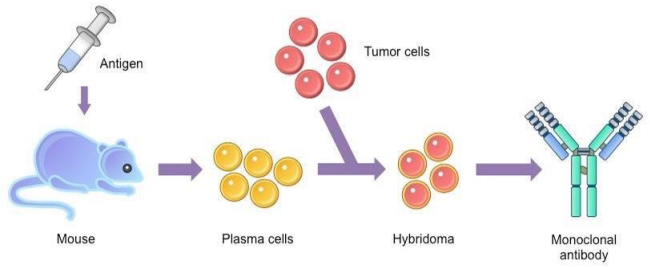
Biology Knowledge Organiser
B6 - Preventing and treating disease - Triple science only

Monoclonal antibodies

Antibodies are natural tools for recognising specific molecules. This property can be fantastically useful. Monoclonal antibodies are copies of the same antibody, produced in a lab for a specific purpose. Here's how they are made: (also see diagram at bottom of page)

1. Mouse **lymphocytes** are stimulated to make a specific antibody, by giving them a specific antigen
2. These lymphocytes are combined with a type of tumour cell to make a **hybridoma** cell.
3. Like other cancer cells, this hybridoma cell can divide rapidly. It also makes the antibody that is desired.
4. The hybridoma cell is cloned, to there are many identical copies all making the same antibody.
5. After a large amount has been made, the antibody is separated from the cells for use.



Lymphocytes

Key Terms	Definitions
Monoclonal	All the same, due to all coming from cloned cells
Antibody	Protein molecule made by white blood cells to fight pathogens. Each antibody is specific to one antigen.
Antigen	A molecule found on the surface of cells (or viruses), often made of protein. Antibodies, if they are the right sort, bind to antigens.
Bind	Stick to, due to having shapes that fit together.
Lymphocyte	Type of white blood cell that makes antibodies.
Chlorosis	Yellowing of leaves.

Plant diseases

Obviously a plant can't tell you when it is sick. But some easy signs can indicate disease:

- Stunted growth (which may be caused by deficiency in **nitrates**, since nitrates are needed to make protein)
- Spots on leaves
- Areas of decay
- Growths that shouldn't be there (like tumours)
- Malformed stems/leaves
- Discolouration (including **chlorosis**, which is caused by a deficiency in magnesium – since magnesium is used to make chlorophyll)
- Presence of pests

If you see these dreadful signs, you could identify the specific disease by:

- Checking your gardening books/websites
- Taking infected plants to a lab to identify the pathogen
- Using testing kits containing **monoclonal antibodies**!

Plant defences against disease, or against getting eaten

Plants can prevent invasions by microbes with physical defences, such as:

- Cellulose cell walls
- The tough waxy cuticles on their leaves
- Layers of dead cells (e.g. bark) around stems that can be shed (fall off)

Plants also have chemical defences, including:

- Antibacterial chemicals
- Poisons to stop herbivorous animals from eating them

Plants also have mechanical adaptations to defend themselves:

- Thorns and hairs to deter animals from eating them
- Leaves which droop or curl up when they are touched
- **Mimicry** to trick animals into thinking they are poisonous/bad to eat

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Human defence systems

Pathogens are all over the place, so humans have evolved defence systems to deal with them. We have **non-specific defences**, which keep pathogens from entering the body (although, of course, they can fail to do this – otherwise you'd never get sick!). If pathogens do get in, we have the **immune system**, which destroys the pathogen inside the body.

Non-specific defences:

- The **skin**! Our main barrier against pathogens getting in. The vast majority of pathogens cannot get through the skin at all – they have to enter somewhere else. Also, the skin scabs over to provide a quick barrier if there is a cut or wound.
- The **nose** has hairs and mucus to trap microorganisms so they don't get any further than the nose. If you don't blow your nose, the mucus ends up in the back of the throat and you swallow it – this is harmless, because the stomach acid kills any microorganisms in there.
- The **trachea** and **bronchi** also contain mucus. This traps microorganisms that are breathed in, and the mucus, again, can be swallowed harmlessly.
- The **stomach** produces hydrochloric acid (at pH 2), which kills most microorganisms that are swallowed.

The immune system responds if pathogens enter the body properly – i.e. if they get into the bloodstream. The most important cells in the immune system are the white blood cells. They help defend against pathogens by:

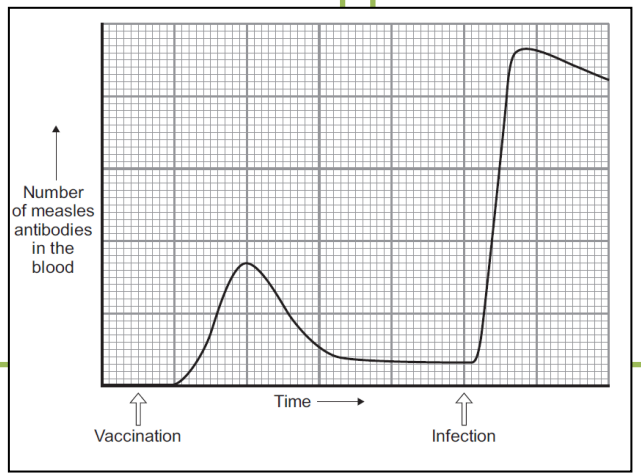
- **Phagocytosis**. This is the *engulfing* and *digesting* of pathogens by white blood cells, destroying the pathogens.
- **Antibody production**. White blood cells produce chemicals called antibodies that bind to pathogens and destroy them. These are *specific*, meaning only one particular antibody type will bind to one particular pathogen.
- **Antitoxin production**. Some pathogens, especially bacteria, produce poisonous toxins. These are neutralised by antitoxins – another sort of chemical produced by white blood cells. Again, antitoxins are specific to specific toxins.

Key Terms	Definitions
Defence systems	Structures and mechanisms we have to prevent pathogens entering the body, and to fight them off if they do enter. Includes non-specific defences (act on any pathogen) and specific defences (target the particular pathogen you've been infected by).
Mucus	A sticky substance produced by many epithelial (surface-covering) tissues in the body, to trap dust particles and microorganisms so they can't enter the body.
Antibody	Chemical produced by white blood cells that destroys specific pathogens.
Antitoxin	Chemical produced by white blood cells that neutralises specific toxins.

Vaccination

Vaccination is great on two fronts: it stops the vaccinated individual from getting ill AND it helps prevent the spread of communicable diseases. If a large proportion of the population is vaccinated, it is very unlikely that an *unvaccinated* person would be exposed to the pathogen, so everyone is protected.

1. A vaccine contains a small quantity of a **dead or inactive** form of a **pathogen** (usually a virus, such as the measles virus – see graph).
2. Delivering a vaccine stimulates a **primary** immune response. White blood cells produce antibodies to destroy the pathogen, but this is slow.
3. Specialised white blood cells (memory cells) remain in the blood afterwards.
4. This means that if an infection by the real pathogen takes place in the future, there is a **secondary** immune response by the white blood cells, which is *quicker* than the primary immune response.
5. The secondary immune response starts faster (see graph), involves the production of far more antibodies (a *stronger* response) and the level of antibodies stays higher for longer.
6. This means the pathogen is destroyed before you even realise you are ill.



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Treating disease with drugs

Despite our non-specific defences and our immune systems, we still get sick due to communicable diseases. Fortunately, we've developed a huge range of drugs to treat diseases. (Drugs and medicines are synonymous; we can also say 'medical drugs' to mean those that treat disease rather than drugs taken for recreation.)

Antibiotics

Antibiotics have only been produced since the 1940s, but they have changed the world in that time. The first antibiotic was discovered (not made – it was produced by a fungus!) by Alexander Fleming. He found that a fungus called *Penicillium* worked to kill bacteria he was growing in an agar plate. Named for the fungus that produced the chemical, this was the first antibiotic: penicillin. It is still used today.

Antibiotics treat **bacterial** diseases **only**, because they kill pathogenic bacteria in the body. In this way, they can cure bacterial diseases. Antibiotics are *specific* – so you need to use the right antibiotic to kill the particular bacteria that has infected you. So, antibiotics have saved millions of lives, by successfully treating people with bacterial infections. However, a big issue with the use of antibiotics is that many strains (types) of **resistant bacteria** have emerged (more on this in topic 16).

Antibiotics CANNOT kill viruses, so cannot treat viral diseases. Since viruses live *inside* host cells, it is very difficult to kill viruses without also damaging the body tissues they live in.

Painkillers

Painkillers are examples of medical drugs that treat the **symptoms** of disease, without actually getting to the cause and killing the pathogens. An example is **aspirin**, a painkiller that was first extracted from the bark of willow trees.

Discovering new drugs

There is a constant demand for new drugs – for better treatments, to treat diseases without any current cures, and to deal with antibiotic resistance. Chemicals that *might* work as effective drugs are constantly being discovered or synthesised in labs. Many drugs were discovered in living organisms: e.g. the heart drug **digitalis** originates from **foxgloves**. There are other examples above. However, any of these newly discovered/made chemicals must be thoroughly tested before they can be used in humans.

Key Terms	Definitions
Drug	Any chemical that causes chemical changes in the body. Most drugs are medical – used to treat disease.
Antibiotic	Type of drug that treats bacterial disease by killing pathogenic bacteria.
Antiretroviral	Type of drug that *can* kill viruses: these are used to treat infection by HIV.
Painkiller	Drug that only treats the symptoms of disease, rather than killing pathogens.
Symptoms	Problems with the body arising from disease and indicating that there is a disease. E.g. coughing, headaches, vomiting.
Toxicity	From 'toxic', toxicity means how harmful a drug is to healthy body tissues.
Efficacy	How well a drug actually treats the disease it is designed to treat.
Dose	How much of a drug is given to a patient, and how many times a day and so on.

Development and testing of new drugs

New chemicals, potential medical drugs, are tested to find out if they are **safe** and **effective** (they actually treat the disease they are supposed to!). There are many stages to this testing. We refer to the part before giving the drug to humans as 'preclinical testing' and to the stages where humans received the drugs as ' clinical trials'. Together, these stages tell us about the drug **toxicity, efficacy** and information about the **dose** that should be given. Here's the sequence:

1. **Preclinical testing** is in a lab. The drug is tested on cells and tissues grown for drug testing, and on animals like rats bred for drug testing. This checks that the drug is not toxic, and can give information about efficacy too.
2. **Clinical trials** are tests on humans. First, new drugs are given in very low doses to healthy volunteers, to check that they are not toxic and don't cause major side effects.
3. If the drug is safe, clinical trials using people with the disease take place. These trials test how well the drug works for the disease, and identifies the optimum dose.

In any clinical trial, **double blind** testing is often used. Some patients are given a **placebo** (fake version of the drug), and neither scientist/doctor or patient know who has the placebo and who has the real drug until afterwards. This ensures that effects due to people's expectations can be ruled out.