Biology Knowledge Organiser
Topic 3: Infection & Response

Key Terms	Definitions
Disease	Any condition that reduces health/causes ill-health.
Communicable	Type of disease that can be passed on. These diseases are caused by pathogens, such as viruses. Be clear that the pathogen is the microorganism, and the disease is the collection of symptoms resulting from infection by the pathogen.
Non-communicable	Describes diseases that are not caused by pathogens and cannot be passed on. These are often caused by many factors acting together, known as risk factors for the disease.
Pathogen	A microorganism that can infect another organism (a host) and cause disease in that organism. E.g. bacteria and viruses.
Risk factor	Any factor that increases the chance of developing a non-communicable disease, such as smoking or diet.

Communicable diseases and pathogens

Communicable diseases are sometimes called infectious disease, since they always result from an infection by a pathogen. All organisms can be infected by pathogens, so all organisms can suffer from communicable diseases (yes, including plants, and even bacteria can be infected by viruses!). You need to know details of specific diseases (next page), but here is a general description of how each kind of pathogen causes disease:

- ‡ Bacteria can cause disease if they enter our bodies. They reproduce rapidly and can release poisonous chemicals, called toxins, that damage our cells. Examples of diseases caused by pathogenic bacteria include cholera, tuberculosis (TB) and food poisoning.
- ‡ Viruses need a host to survive. They cause disease symptoms by reproducing inside cells, and bursting the cell from the inside. This releases them, so they can be passed onto other host cells or other people (e.g. by coughing or sneezing out mucus that contains the viruses).
- ‡ Fungi can also cause disease, by growing on living tissue (for example, athlete's foot is caused by a fungus).
- ‡ Protists can cause disease, as they can live in host organisms. A good example is the malarial protist, that causes malaria.

Key Terms	Definitions
Mutation	Change to DNA, altering its function (this is not necessarily dangerous). In cancer, a specific mutation causes cells to divide uncontrollably.
Protist	Whole kingdom of organisms, including some that cause disease.
Transmission	The passing of a pathogen from one organism to another, leading to the spread of communicable (infectious) disease.
Host	The organism that a pathogen lives in or on. When you have a cold, you are the host for the cold virus.

Spread of communicable diseases is caused by the transmission of pathogens

A big problem with pathogens is that they can be passed from one host to another, so the disease they cause can spread. See the table for the methods by which pathogens can be transmitted.

We can attempt to reduce the transmission of pathogens by: vaccinating people; destroying vectors (e.g. killing mosquitos with pesticides); being hygienic (i.e. washing our hands!); isolating people who are infected in special hospital wards.

Direct types of transmission	Indirect types of transmission
Direct contact e.g. shaking hands or kissing	A vector (animal) carries the pathogen e.g. mosquitos carry the pathogen that causes malaria
Sexual contact	Droplet infection: droplets of mucus containing a pathogen are sneezed or coughed out by an infected person, and breathed in by someone else. We can also say the pathogen is airborne.
From mother to foetus over the placenta	Waterborne – the pathogen infects water and moves between people when they drink the water

Biology Knowledge Organiser

Topic 3: Infection & Response

Viral diseases

Measles is caused by a virus. It is spread by droplet infection: you'd catch it if you inhaled the droplets containing the virus that someone infected coughed or sneezed out. The symptoms include fever and a red rash on the skin. Measles is a serious disease – it can even be fatal if there are complications. So, most young children are vaccinated against measles.

HIV is a virus that can only be spread by exchange of body fluids: sexual contact or when blood is mixed – which can happen when *intravenous drug users* share needles. HIV cannot be transmitted by kissing or by droplet infection. Infection with HIV causes flu-like symptoms first, but these go away after a couple of weeks. However, the virus has not gone from body – it is living inside immune cells (white blood cells). HIV is NOT the same thing as AIDS, but AIDS can arise from infection by HIV unless treatment takes place. The treatment is antiretroviral drugs (so called because HIV is a type of virus called a retrovirus). Without this treatment, AIDS will occur. Here, the body's immune system is so badly damaged it cannot fight off other infections or cancers – so it is very serious.

Tobacco mosaic virus (TMV for short) is a pathogen affecting plants. In spite of its name, it affects many species of plant (including tomatoes – see photo). TMV causes discolouration of the leaves, giving a mosaic pattern. This hinders photosynthesis, so plants don't grow very well if they are infected by TMV.

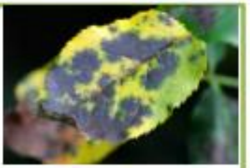
Bacterial diseases

Salmonella food poisoning is caused by a bacteria found in food, or on food where it is prepared in unhygienic conditions. The bacteria can be found in poultry (e.g. chickens), so these animals are vaccinated against *Salmonella* to reduce the spread of the pathogen. Inside the body, the bacteria reproduce and produce toxins which cause disease. Symptoms of *Salmonella* food poisoning include: fever, abdominal cramps, vomiting and diarrhoea.

Gonorrhoea is the name of a sexually transmitted disease (STD or STI), rather than the name of the pathogen. The pathogen is a bacterium that is transmitted by sexual contact, so transmission can be prevented with a barrier-type of contraception, like a condom. The symptoms include a thick yellow or green discharge from the vagina or penis and pain when urinating (weeing). It used to be that gonorrhoea was easily treated with an antibiotic (penicillin, in this case), but there are now many resistant strains of bacteria that cause gonorrhoea. (Resistant strains are species of the bacteria on which certain antibiotics do not work.)

Key Terms	Definitions
Fever	Disease symptom linked to raised body temperature, thanks to disruption of the normal homeostasis mechanisms.
HIV	Human Immunodeficiency Virus. A virus that uses immune cells as host cells. HIV infection causes AIDS, but if treated properly, AIDS will never develop in an infected individual.
AIDS	Acquired Immunodeficiency Syndrome. A condition in which the immune system is seriously weakened due to infection by the HIV virus.
Salmonella	A genus of bacteria that can cause food poisoning.
Discharge	A substance being produced by the body that should not be there – a sign of disease.

Fungal diseases



Rose black spot is a fungal disease that affects plants. It causes purple or black spots to develop on leaves (hence the name – see picture). The whole leaf often turns yellow and drops early (i.e. before autumn). Like TMV, the plant's growth is inhibited because the rate of photosynthesis is reduced. The fungus is spread on the wind or in water, transmitting the pathogen to other plants. Treatment options: remove the affected leaves, or use a fungicide (a chemical that kills fungi).

Protist diseases

Malaria is a disease caused by a *protist* (see topic 6 for a reminder). The protist has a life cycle that requires it to live inside a mosquito for some of the life cycle, and in the body of a mammal – like a human – for other stages of the life cycle. In the mosquito, the protist is found in the salivary glands, which is why the protist can be transmitted to a person when the mosquito sucks their blood. The mosquito acts as a vector. In the human, the protist causes malaria. Symptoms include recurrent (repeating) fever and malaria can be fatal. We can attempt to reduce transmission by targeting the mosquitos: preventing them breeding and avoiding bites using mosquito nets.

Biology Knowledge Organiser

Topic 3: Infection & Response - Triple

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)

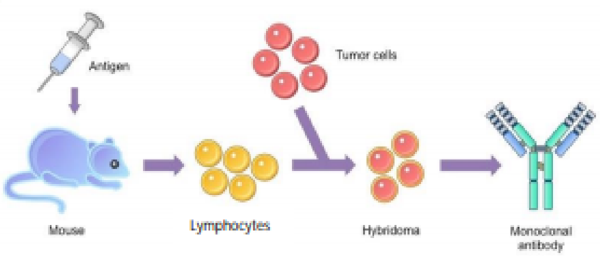
1. Mouse lymphocytes are stimulated to make a specific antibody, by giving them a specific antigen
2. These lymphocytes are combined with a type of tumour cell to make a hybridoma cell.
3. Like other cancer cells, this hybridoma cell can divide rapidly. It also makes the antibody that is desired.
4. 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.

Using monoclonal antibodies

There are dozens of uses for monoclonal antibodies: the thing to remember is that they are used when a specific molecule needs to be recognised. Examples to know:

- Pregnancy tests use monoclonal antibodies that specifically bind to a hormone made in the placenta – which is only present in pregnant women.
- Lab tests for levels of specific chemicals in blood samples, or to detect specific pathogens.
- To identify specific molecules in a cell or tissue. One way to do this is to attach a fluorescent dye to the antibodies, so under a microscope you can see exactly where the specific molecule is located in the cells/tissues.
- Disease treatment, although not commonly. Monoclonal antibodies can have drug molecules attached to them, and because they only bind to certain antigens you can get them to stick to cancer cells ONLY – so the chemotherapy hits the tumour, but not the healthy cells of the body. Smart.

Although there's great promise, using monoclonal antibodies in medicine is not so widespread – there are quite a few side effects. They are also expensive to produce.



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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Topic 3: Infection & Response

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:

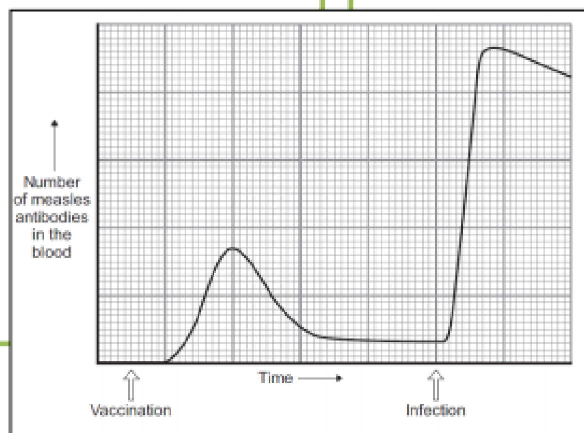
- Phagocytosis. This is the *engulfing* and *digesting* of pathogens by white blood cells, destroying the pathogens.
- Antibody production. White blood cells produce chemicals called antibodies that bind to pathogens and destroy them. These are *specific*, meaning only one particular antibody type will 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.



Biology Knowledge Organiser
Topic 3: Infection & Response

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.

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