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**Year 10 – Knowledge Booklet (Trilogy)**

Key Stage 4 Science:

**Infection & Response**

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**This booklet is for use in your Science lessons. Please look after it in the same way you would your exercise book and ensure that your presentation is always PROUD.**

**Ensure that your booklet is returned to your class book box at the end of the lesson.**

**Lesson Breakdown**

Lesson 1: 4.3.1.1 Communicable diseases

Lesson 2: 4.3.1.2 – 4.3.1.4 Viral diseases, bacterial diseases, fungal diseases

Lesson 3: 4.3.1.2 – 4.3.1.4 Viral diseases, bacterial diseases, fungal diseases

Lesson 4: 4.3.1.5 Protist diseases (including malaria)

**Lesson 5 (HT only): 4.3.3.1** **Detecting and identification of plant diseases**

**Lesson 6: 4.3.3.1 Plant defence responses**

Lesson 7: 4.3.1.6 Human defence systems (barriers and symptoms)

Lesson 8: 4.3.1.6 Human defence systems (white blood cells)

Lesson 9: 4.3.1.7 Vaccination

Lesson 10: 4.3.1.8 Antibiotics and painkillers

Lesson 11: 4.3.1.9 Discovery and development of drugs

Lesson 12: 4.3.1.9 Discovery and development of drugs (placebo effects,

double blind trials etc).

**Lesson 13 (HT only): 4.3.2.1 Producing monoclonal antibodies**

**Lesson 14 (HT only): 4.3.2.1 Uses of monoclonal antibodies**

**Keystone words**

Microorganism

Communicable

Pathogen

Vector

Response

Infection

Resistance

Immune

**Lesson 1: What are communicable diseases?**

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| 1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18 | **CONNECT**  In the Organisation topic you studied examples of non-communicable diseases (CHD and cancer).  Coronary heart disease is the term that describes what happens when your heart's blood supply is blocked or interrupted by a build-up of fatty substances in the coronary arteries.  Over time, the walls of your arteries can become furred up with fatty deposits. This process is known as atherosclerosis and the fatty deposits are called atheroma.  Atherosclerosis can be caused by lifestyle factors, such as smoking and regularly drinking excessive amounts of alcohol.  You're also more at risk of getting atherosclerosis if you have conditions like high cholesterol, high blood pressure (hypertension) or diabetes. Coronary heart disease cannot be cured but treatment can help manage the symptoms and reduce the chances of problems such as heart attacks.  Treatment can include:   * lifestyle changes, such as regular exercise and stopping smoking * medicines * angioplasty – where balloons and stents are used to treat narrow heart arteries * surgery |  |
|  | What Happens When You Hold Back a Sneeze? |  |
| 19  20  21  22  23  24 | The image shows a man sneezing because he has influenza (the flu). When he sneezes water droplets are sprayed into the air. If another person breathes the water droplets in, they can catch influenza too. Scientists call diseases that you can catch from other living things communicable diseases.  Scientists call diseases that cannot be passed from one living thing to another non-communicable diseases. |  |
| 25  26  27  28  29  30 | Communicable diseases can move from one living thing to another; they are also called infectious diseases. For example, the man sneezed, and water droplets were sprayed into the air. Anybody who breathed in the droplets could catch influenza. Scientists call the movement of disease between organisms, transmission. Disease can be transmitted in several ways: in airborne droplets (e.g., influenza or Sars - Cov-2), waterborne (e.g., cholera) or transmitted by direct contact (e.g., HIV). |  |
| 31  32  33  34  35  36  37  38  39 | Communicable diseases can be transmitted, or passed, from one organism to another. Diseases are caused by pathogens. Pathogens are microorganisms that harm other living things. There are four types:  • Viruses  • Bacteria  • Fungi  • Protists  Each communicable disease is caused by a different pathogen and is transmitted in a specific way. |  |
| 40  41  42  43  44  45 | Bacteria and viruses are two types of pathogens. They make us feel ill because they reproduce rapidly inside our bodies. Bacterial pathogens are prokaryotic cells that can produce toxins which attack our tissues. Once inside our tissues they reproduce by binary fission. Viruses live and reproduce inside living cells (not by binary fission) and damage the cells by causing it to burst. Viruses are about 100 times smaller than a bacterial cell. |  |

**Lesson 2: What are viral diseases and how can we control them?**

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| 1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18 | HIV (human immunodeficiency virus) is a virus that damages the cells in your immune system and weakens your ability to fight everyday infections and disease.  AIDS (acquired immune deficiency syndrome) is the name used to describe a number of potentially life-threatening infections and illnesses that happen when your immune system has been severely damaged by the HIV virus.  While AIDS cannot be transmitted from 1 person to another, the HIV virus can.  There's currently no cure for HIV, but are very effective drug treatments that enable most people with the virus to live a long and healthy life.  With an early diagnosis and effective treatments, most people with HIV will  not develop any AIDS-related illnesses and will live a near-normal lifespan.  To prevent HIV. You can use strategies such as abstinence (not having sex),  never sharing needles, and using condoms the right way every time you have sex. You may also be able to take advantage of HIV prevention medicines such use antiretroviral drugs or screen blood used for transfusions. However it is advisable to have regular tests to see if you have HIV. |  |
| 19  20  21  22  23  24  25  26 | Viruses are pathogens that reproduce inside cells. The structure of viruses is diverse, however, they all have the following things in common:   * A protein capsule around the outside * Genetic material (either DNA or RNA) inside the virus.   Viruses reproduce inside cells; they are not cells themselves. They do this by inserting their genetic material into a cell. This forces the cell to make lots of copies of the virus. Eventually the cell bursts because so many virus particles have been made. |  |
| 27  28  29  30  31 | Measles is a disease caused by a virus. It is a communicable disease that is transmitted through the air by droplets from sneezes and coughs. The common symptoms are fever and a red rash. However, it can cause complications that are fatal. We vaccinate children against measles because of this. |  |
| 32  33  34  35  36  37  38 | HIV is a viral pathogen that is transmitted through direct contact with blood (e.g. when drug users share needles), sexual contact or other bodily fluids. It initially causes flu-like symptoms. Doctors attempt to control it using antiretroviral drugs. If this is unsuccessful, the virus attacks the immune systems. During late-stage HIV the person develops AIDS. When this happens the immune system is too weak to fight other diseases such as infections or cancers. These diseases can eventually kill the person. |  |
| 39  40  41  42  43 | Tobacco mosaic virus is a plant pathogen that attacks many plants including tomatoes. It causes the leaves of plants to develop leaves with a ‘mosaic’ pattern. This can result in stunted growth. This is because, the discoloured parts of the leaves do not contain chlorophyll. The amount of light absorbed by the leaves is reduced so the rate of photosynthesis is much lower. |  |
|  | The viral reproductive cycle. |  |

**Lesson 3: Which diseases are caused by bacteria and fungi?**

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| 1  2  3  4 | **CONNECT**  See the source image  Misconception ALERT:  Virus 0.02-0.07um  Bactria: 0.5- 2.0um |  |
| 5  6 | Bacterial pathogens are prokaryotic cells that can produce toxins which attack our tissues. Once inside our tissues they reproduce by binary fission. |  |
| 7  8  9  10 | Salmonella food poisoning is spread by bacteria ingested in food, or on food prepared in unhygienic conditions. In the UK, poultry are vaccinated against salmonella to control the spread. Fever, abdominal cramps, vomiting and diarrhoea are caused by the bacteria and the toxins they secrete. |  |
| 1  12  13  14  15  16 | Gonorrhoea is a sexually transmitted disease (STD) with symptoms of a thick yellow or green discharge from the vagina or penis and pain on urinating. It is caused by a bacterium and was easily treated with the antibiotic penicillin until many resistant strains appeared. Gonorrhoea is spread by sexual contact. The spread can be controlled by treatment with antibiotics or the use of a barrier method of contraception such as a condom. |  |
| 17  18  19  20  21  22  23  24  25  26  27  28  29 | Rose black spot is a fungal infection that affects rose leaves. Purple or black spots develop on leaves, which often turn yellow and drop early. It is spread in the environment by spores that are airborne or water borne: It can also be spread by direct contact. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves. The spores can remain dormant over the winter so it is important to remove infected leaves.  Rose black spot can cause plants to have stunted growth. This is because the plant absorbs less light that can be used for photosynthesis. The plant absorbs less light because its leaves contain less chlorophyll. Less glucose is produced because the rate of photosynthesis is lower. So, less glucose is available to make amino acids and cellulose which are used for growth. Also, less energy is released because less glucose is available for respiration. |  |

**Lesson 4: What causes malaria and how do we control it?**

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|  | **CONNECT** |  |
| 1  2  3  4  5  6  7  8  9  10 | Malaria is a disease that affects very large numbers of people every year. More than 800,000 African children under the age of 5 die from malaria every year. It also contributes to malnutrition which is indirectly linked to the death of over half of children under the age of five across the globe. Malaria can also cause anaemia in women, especially pregnant women, resulting in babies having a low birth weight.  Malaria is caused by a protist. Mosquitoes carry the protist (the mosquito is a vector); the protist is injected into humans when they get bitten by an infected mosquito. The symptoms include chills, sweats, headaches and diarrhoea. |  |
| 11  12  13  14  15 | Protists are simple organisms that have some features in common with eukaryotes and fungi. Some protists are similar to plant cells and others are similar to animal cells. For example, they have a nucleus and mitochondria just like eukaryotic cells.  The protist, plasmodium, causes malaria in humans. |  |
| 16  17  18  19  20  21  22  23  24  25  26 | This content is covered because it enables students to rationalise the control methods.  Mosquitos are the vector for malaria; this means that they carry the pathogen from one place to another. This means that if we can understand the mosquito’s life cycle, we can control the population of mosquitos; if there are less mosquitos, malaria will be transmitted less.  Mosquitos lay eggs. When the eggs hatch, larvae emerge. Larvae need to live in water.  The larvae develop into pupae; pupae also live in water.  Eventually the pupae, develop into adult mosquitos that can fly; the adult mosquitos are the vector and carry the protist to other humans. |  |
| 27  28  29  30  31  32  33  34  35 | Control measures focus on either interrupting the mosquitos life cycle or preventing adult mosquitos from biting people; the disease is transmitted by mosquito bites.  Control measures are therefore:   1. Preventing the mosquitoes from biting humans (e.g. using mosquito nets) 2. Preventing the mosquito from breeding by reducing the amount of water in the environment 3. Preventing the mosquito from breeding by sterilising male mosquitos. |  |

**Lesson 5: How do we detect and identify plant diseases?**

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| 1  2  3  4  5  6  7  8  9  10  11  12 | All organisms, including plants, can get diseases. Some of these diseases are non-communicable and some are communicable. Humans get symptoms when they get a disease. Similarly, plants get symptoms. You have come across some of these symptoms in the lessons on pathogens.  If plants get a disease, they might get some of the following symptoms:   * Stunted growth * Spots on leaves * Areas of decay or rot * Growths * Malformed stems and leaves * Discolouration * Pests might be present |  |
| 13  14  15  16  17  18  19 | Plant disease can be identified from the symptoms. Depending on the disease, you might be able to identify the disease using a gardening manual or website. This is the quickest and cheapest method. Sometimes, it is more difficult to identify a disease. If this is the case, a sample might be sent to a laboratory for identification. This takes longer and is more expensive. Finally, testing kits can be used to identify diseases. These often contain monoclonal antibodies; these contain antibodies for the specific pathogen. |  |
| 20  21  22  23  24  25  26  27  28  29  30  31 | Communicable diseases in plants are often caused by pathogens. They can also have non-communicable diseases; for example, those caused by mineral deficiencies.  Nitrate deficiency can cause stunted growth. This is because plants use nitrate to make amino acids (they react it with glucose). Amino acids are used for growth. So, if the plant doesn’t get enough nitrate, it can not make enough protein to grow quickly; it’s growth will be stunted.  Chlorophyll contains a magnesium ion; if the plant has a chlorophyll deficiency it won’t contain much chlorophyll. If the plant has a magnesium deficiency it can not make enough chlorophyll; it will have yellow patches. This is called chlorosis. This can also cause stunted growth because the plant won’t be able to perform photosynthesis efficiently. |  |

**Lesson 6: How do plants respond to disease?**

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| 1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18 | All living things have adaptations. Adaptations are characteristics that help the organism to survive. For example, tigers are camouflaged. This helps them to remain hidden when hunting for prey.  Plants have adaptations also. These are often defence responses; they help to protect them from harm.  Plant defences can be classified as physical defence responses, chemical defence responses and mechanical adaptations. They include:  Physical defence responses to resist invasion of microorganisms.  • Cellulose cell walls.  • Tough waxy cuticle on leaves.  • Layers of dead cells around stems (bark on trees) which fall off.  Chemical plant defence responses.  • Antibacterial chemicals.  • Poisons to deter herbivores.  Mechanical adaptations.  • Thorns and hairs deter animals.  • Leaves which droop or curl when touched.  • Mimicry to trick animals. |  |

**Lesson 7: How do our bodies protect themselves against pathogens?**

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| 1  2  3  4  5  6  7  8  9  10 | The immune system protects us from pathogens; pathogens are micro-organisms that cause harm (e.g. bacteria, viruses, fungi and protists). Our bodies have specific and non-specific responses to pathogens. Non-specific responses attempt to address all pathogens. For example, the skin acts as a barrier to prevent all pathogens entering our organs and tissues.  If a pathogen does enter the body, the uses specific responses involving white blood cells; the processes involved are very complicated but there are three general strategies. The white blood cells respond to specific pathogens (e.g. a specific strain of SARS-Cov-2) and specific toxins that bacteria produce. |  |
| 11  12  13 | Some white blood cells, called macrophages, find and engulf pathogens and then digest them. They use enzymes to digest the pathogen. This process is called phagocytosis. |  |
| 14  15  16  17  18  19  20  21  22  23  24 | All cells and viruses have antigens on their surface. These help white blood cells to recognise which cells are foreign and which cells are part of the organism.  White blood cells use the antigens to identify foreign cells. Once they have done this, they then produce antibodies that adhere to the antigen on the surface of the pathogen and cause them to clump together (this is called agglutination). This is a signal to other white blood cells to engulf and digest the pathogen. The body retains the ability to produce the antibodies very quickly and in large amounts; this protects the body from re-infection. The body can do this because it has a type of white blood cell called a memory cell. |  |

**Lesson 8: How do our bodies destroy pathogens and toxins?**

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|  | **CONNECT** |  |
| 1  2  3  4  5  6  7  8  9  10 | The immune system protects us from pathogens; pathogens are micro-organisms that cause harm (e.g. bacteria, viruses, fungi and protists). Our bodies have specific and non-specific responses to pathogens. Non-specific responses attempt to address all pathogens. For example, the skin acts as a barrier to prevent all pathogens entering our organs and tissues.  If a pathogen does enter the body, the uses specific responses involving white blood cells; the processes involved are very complicated but there are three general strategies. The white blood cells respond to specific pathogens (e.g. a specific strain of SARS-Cov-2) and specific toxins that bacteria produce. |  |
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| 24  25  26  27  28 | Some pathogens, including bacteria, release toxins (poisons) into the body. The toxins cause some of the symptoms of the infection. Some white blood cells identify the toxins in the body and make antitoxins. The antitoxins are released into the blood. When they find a toxin molecule, they break it down. |  |

**Lesson 9: How can we protect ourselves against future infections?**

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| 1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18 | **CONNECT**  Preventing diseases caused by insects and microscopic organisms is one of the most fundamental and vital steps we can take to protect ourselves and our community. There are numerous methods for preventing the occurrence of diseases. These methods are designed to maintain proper hygiene. Ensure that there are no open rubbish dumps or stagnant water in our neighbourhood. This will prevent insects from breeding, perhaps saving us from vector-borne diseases such as malaria, dengue fever, and cholera. Use of insecticides helps to keep them away. Avoid water-borne diseases by providing safe drinking water or boiling water, or by using a water treatment method to destroy any microbial contamination. Diseases that are very contagious, such as leprosy, measles, and chickenpox, can be prevented by isolating the affected person. Airborne diseases such as influenza, TB, the common cold, and pneumonia can be avoided by avoiding overcrowding and inhaling clean air. A healthy diet can build an immune system that produces antibodies and fights diseases. Some other prevention like washing vegetables, fruits, and covering food  and water all the time. Washing hands& cleaning our bodies on a regular basis is essential, as is the usage of a face mask. |  |
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| 19  20  21  22  23  24  25  26  27  28 | Communicable diseases spread from one organism to another. This can be prevented if herd immunity exists in a population. Herd immunity occurs when the majority of a population are immune to a communicable disease. For example, of the majority or the population have been vaccinated against a disease, it is very unlikely that unvaccinated people will catch the communicable disease. This is because they are very unlikely to meet somebody who has the communicable disease.  Herd immunity can also occur if the majority of the population has been infected with the pathogen. However, this only works if the pathogen has a stable strain. |  |
| 29  30  31  32  33  34  35  36  37  38  39  40 | A vaccine contains small quantities of a dead or inactive form of a pathogen; this contains antigens that white blood cells respond to. When the vaccine is introduced into the body, white blood cells respond as if the live pathogen is there:  White blood cells use the antigens to identify foreign cells or viruses. Once they have done this, they then produce antibodies that adhere to the antigen on the surface of the dead or inactive pathogen and cause them to clump together (this is called agglutination). This is a signal to other white blood cells to engulf and digest the dead or inactive pathogen. The body retains the ability to produce the antibodies very quickly and in large amounts; this protects the body from re-infection. The body can do this because it has a type of white blood cell called a memory cell |  |
| 41  42  43  44  45  46 | If a vaccinated person is exposed to the live pathogen, the body has a very rapid and strong response. White blood cells can make the correct antibodies very quickly and in large quantities. The pathogen population is killed very quickly so they do not produce a large enough population to cause the disease. This also means that the population is too small to produce enough toxin to cause symptoms. |  |

**Lesson 10: Which medicines should we use if we have an infection?**

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| 1  2  3  4  5  6  7  8  9  10 | Drugs are substances that modify or affect the chemical reactions in the body. They include illegal substances, like cocaine, and legal substances such as caffeine, paracetamol and antihistamines. Traditionally drugs were extracted from plants and microorganisms. For example:   * Digitalis is a heart drug that comes from foxgloves * Aspirin comes from willow leaves * Penicillin comes from the Penicillium mould (a type of fungi) and was discovered by Alexander Fleming.   Drugs are now designed and tested. However, they are often based on substances found in living things. |  |
| 11  12  13  14  15  16 | When you have a communicable disease, you might take drugs for several reason. These include drugs:   * To reduce the symptoms of the disease * To kill the pathogen causing the communicable disease   Pain is a common symptom. Painkillers are a group of drugs that are used to reduce pain. |  |
| 17  18  19  20  21  22  23  24  25  26  27 | Some drugs can be used to kill pathogens. Viruses can be treated with anti-viral drugs. However, it is hard to develop anti-viral drugs that do not damage the patient’s tissues. This is why they are rarely prescribed.  Antibiotics, such as Penicillin, can cure bacterial diseases by killing the bacteria causing the infection; they can not be used to kill viruses because the drug cannot reach the virus when it is inside a cell. It is important to use specific antibiotics for specific bacteria; this is because an antibiotic will only be effective against some bacteria.  Doctors do not like to prescribe antibiotics because if they are used too much, antibiotic resistant strains of bacteria can emerge. These bacteria are hard to kill using antibiotics. |  |
| 28  29  30  31  32  33  34 | Antibiotic resistant bacteria arise due to natural selection. Natural selection enables populations to adapt to changes in the environment (e.g. the presence of antibiotics). Natural selection follows well known steps:   1. Mutations in the population cause variation 2. The best adapted individuals survive 3. Those that survive reproduce 4. Beneficial genes are passed on to offspring |  |

**Lesson 11: How are new drugs discovered and developed?**

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| 1  2  3  4 | Medicinal or pharmaceutical chemists design and make new drugs. They screen thousands of chemicals for the properties that they need a drug to have. They then modify any substances that look promising to improve their properties. |  |
| 5  6  7  8  9 | New medicines must be tested thoroughly before being used with people. They do this to check that the drug is safe and effective. The new drug is usually tested on cells and tissues first. They are then tested on live animals. The preclinical trials can be stopped at any point if the drug is found to be unsafe or if it doesn’t react the way it was designed to. |  |
| 10  11  12  13  14  15  16  17 | The scientists use three criteria to assess the effectiveness of a drug:  1. Toxicity  2. Efficacy  3. Dose required  If a drug has adverse effects at therapeutic doses it is said to be toxic. Some toxicity might be allowed if the benefits of the drug outweigh the problems caused by toxicity.  The efficacy of a drug is its ability to do what it was designed to do. |  |
|  | Drugs testing protocol, downloadable IB Biology revision notes |  |

**Lesson 12: How are new drugs discovered and developed? #2**

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| 1  2  3  4  5  6  7  8  9  10 | When a new drug is being developed it needs to be tested. Scientists test for efficacy, toxicity and the required dose. The first tests are called pre-clinical tests and are performed on cells, tissues and live animals. If the test results are promising, the scientists can start clinical tests. Clinical tests are performed on humans. In clinical trials, the drugs are tested on healthy volunteers first. This enables scientists to assess toxicity in humans. The first tests use low doses.  If this stage is successful, the drug is tested on patients with the disease. This allows scientists to assess the efficacy (whether the drug does what it is designed to do). It also enables them to determine the dosage required. |  |
| 11  12  13  14  15  16  17  18  19  20 | Trials of new drugs must be carried out carefully to avoid bias. For example, a scientist might be biased if they would receive a large bonus if the trials were successful. They might also be biased if they worked hard to develop a drug and they naturally want the trials to be successful.  Clinical trials use placebos to reduce bias. Volunteers are either given the real drug or an alternative (a placebo). The volunteers do not know if they are receiving the real drug or a placebo. The scientists then compare the results. The placebo acts as a control; by comparing the results the scientists can see the effect of the drug on patients. It also takes into account psychological effects. |  |
| 21  22  23  24  25  26  27 | Bias can also be reduced using a double-blind trial. In a double blind trial neither the volunteers or the scientists know which volunteers received the drug and which ones received the placebo. The data is then analysed independently.  If the trials are successful, the results are published in journals that are peer-reviewed. This means that other scientists scrutinise and check the results. |  |

**Lesson 13: How do we produce monoclonal antibodies?**

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| 1  2  3  4  5  6 | Monoclonal antibodies are antibodies that are specific to one antigen. This means that they can be used to target specific chemicals or cells. The fact that they are specific makes them useful for a range of things. These include, identifying pathogens, pregnancy test kits and treatment of some diseases. Whilst they have a lot of potential, they also cause more side effects than doctors expected when they were first developed. |  |
| 7  8  9  10  11  12  13  14  15  16  17 | Monoclonal antibodies are made in laboratories. For them to be useful, they need to be produced in large amounts quickly. They must also be specific to one chemical or a specific type of cell in the body.  In the first step, mouse lymphocytes (white blood cells) are stimulated to produce a particular antibody. Unfortunately, the cells divide slowly so only small amounts of antibody’s are produced. Antibodies are produced more quickly by fusing the lymphocytes with a cancer cell; cancer cells divide very quickly. This cell is called a hybridoma cell; it can divide quickly and make the antibody.  Single hybridoma cells are cloned to produce many cells that produce the same antibody. The antibody is then collected and purified. |  |

**Lesson 14: What do we use monoclonal antibodies for?**

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| 1  2  3  4  5  6  7  8  9  10  11 | Monoclonal antibodies have many uses. One of the uses with the most potential is to deliver drugs or other chemicals to specific cells in living things. For example, to deliver, anti-cancer drugs directly to tumour cells. This means that only the tumour cells are affected by the drug.  This only works because monoclonal antibodies will bind to specific cells or chemicals. Monoclonal antibodies for the cell are produced in the same way that we talked about yesterday. The drug is then attached to the monoclonal antibody.  The antibodies are then injected into the patient. They travel around the body in the blood stream. When the antibodies find a target cell they bind to the antigens on its surface and the drug is released into the cell. |  |
| 12  13  14  15  16  17  18  19  20 | Fluorescent or coloured molecules can be attached to monoclonal antibodies instead of a drug. These can be used to identify specific types of cells in a sample. For example, cancerous cells.  Monoclonal antibodies are made as described in the previous lesson. They are made so that they are specific to the target cell or molecule. They are then added to a slide containing a sample. The monoclonal antibodies will bind to the target cell or molecule and show where they are.  This method is also used in pregnancy test kits and lateral flow tests for Covid. |  |