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

Key Stage 4 Science:

**Infection & Response**

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**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: 4.3.1.6 Human defence systems (barriers and symptoms)

Lesson 6: 4.3.1.6 Human defence systems (white blood cells)

Lesson 7: 4.3.1.7 Vaccination

Lesson 8: 4.3.1.8 Antibiotics and painkillers

Lesson 9: 4.3.1.9 Discovery and development of drugs

Lesson 10: 4.3.1.9 Discovery and development of drugs (placebo effects,

double blind trials etc).

**Keystone words**

Microorganism

Communicable

Pathogen

Vector

Response

Infection

Resistance

Immune

**Lesson 1: Teacher notes**

**AQA Content**

**Students should be able to** explain how diseases caused by viruses, bacteria, protists, and fungi are spread in animals and plants.

**Students should be able to** explain how the spread of diseases can be reduced or prevented.

Pathogens are microorganisms that cause infectious disease. Pathogens may be viruses, bacteria, protists, or fungi. They may infect plants or animals and can be spread by direct contact, by water or by air. Bacteria and viruses may reproduce rapidly inside the body. Bacteria may produce poisons (toxins) that damage tissues and make us feel ill. Viruses live and reproduce inside cells, causing cell damage.

**Chunking**

1. Defining communicable and non-communicable diseases
2. How communicable diseases are transmitted (airborne, water borne, and direct contact via micro-organisms)
3. The four types of pathogens (virus, bacteria, protist, and fungi)
4. How bacteria and viruses affect the body

**Key direct and explicit teacher explanations:**

1. 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 are called **non-communicable diseases**.

**USE EXAMPLES AND NON-EXAMPLES TO ILLUSTRATE THE DIFFERENCE.**

1. **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).

**USE EXAMPLES AND NON-EXAMPLES TO ILLUSTRATE MODES OF TRANSISSION.**

1. **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.

**USE EXAMPLES AND NON-EXAMPLES TO ILLUSTRATE TYPE OF PATHOGEN AND MODE OF TRANSMISSION.**

1. 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.

**Examples: A range of examples and non-examples are given to enable interpolation and limit extrapolation:**

**Communicable diseases affect plants and animals.**

**Communicable disease transmission can be airborne, waterborne or via direct contact.**

**Communicable diseases are caused by viruses, bacteria, fungi, and protists (pathogens).**

Influenza – airborne virus

SARS-CoV-2 – airborne virus

Measles – airborne virus

Hepatitis A – waterborne virus

HIV – direct contact / virus

**TMV – direct contact virus in plants**

Typhoid – waterborne bacteria

Cholera – waterborne bacteria

Salmonella – airborne / direct contact bacteria

Gonorrhoea – direct contact / bacteria

**Rose black spot – airborne / fungus that affects plants**

Malaria – direct contact / protist

**Non-examples: The non-examples are usually caused by lifestyle factors.**

Coronary heart disease (see Organisation)

Cancers (see Organisation)

Diabetes

Arthritis

Chronic respiratory disease

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 1: Communicable Disease**

**Objective: By the end of this lesson, you will be able to define ‘communicable disease’ and explain how they are transmitted.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

In the Organisation topic you studied examples of non-communicable diseases (CHD and cancer).

1. **Which organ is affected by CHD?**

Coronary Heart Disease affects the heart

1. **What causes CHD?**

In coronary heart disease layers of fatty material build up inside the coronary arteries, narrowing them. This reduces the flow of blood through the coronary arteries, resulting in a lack of oxygen for the heart muscle.

1. **In what three ways can CHD be treated?**
2. Stents are used to keep the coronary arteries open.
3. Statins are widely used to reduce blood cholesterol levels which slows down the rate of fatty material deposit.
4. Lifestyle changes.
5. **Classify each disease as communicable, non-communicable or both using the Venn diagram.**

Asthma Diabetes Arthritis

Influenza Measles SARS-Cov-2 HIV TMV Cholera Malaria Rose black spot

**2. There were almost 24 million cases of SARS-CoV-2 (Covid) during the pandemic in the 2020’s. These resulted in over 200,000 deaths and caused global disruption.**

1. **Was SARS-CoV-2 transmitted through airborne droplets, water supply or by direct contact?**

Airborne droplets

1. **List three measures that the government took to reduce the rate of transmission.**

Face masks when in public places

Distancing

Hand sanitiser etc

1. **Pick one measure that the government took and explain how it prevented or reduced transmission of SARS-CoV-2.**

Dependent on the student’s response.

E.g., face masks reduced airborne transmission by up to 40% by reducing aerosol dispersion of droplets.

**Influenza Measles Asthma SARS-CoV-2 Diabetes HIV Tobacco mosaic virus Cholera Rose black spot Arthritis Malaria**

**Both**

**Non-communicable**

**Communicable**

**3. JOHN SNOW'S THEORY OF HOW CHOLERA SPREAD**

A person sitting in a chair

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14. He eventually convinced local officials to remove the handle of the pump, although by that time the

15. worst of the epidemic had actually passed. It was later established that a leaking sewer ran near the

16. well from which the water was drawn.

17. Unfortunately, Snow failed to convince many in the medical establishment of his theory, including

18. William Farr, who was responsible for medical statistics at the General Register Office. Farr took part

19. in the General Board of Health's 1854 Committee for Scientific Enquiries on the cholera outbreak but

20. although they accepted Snow's data, they dismissed his theory that the mode of transmission for

21. cholera was waterborne.

22. Farr was finally converted to Snow's theory in the wake of the final London cholera epidemic of

23. 1866.  He produced a monograph which showed that mortality was extremely high for people who 24. drew their water from the Old Ford Reservoir in East London. Farr's work was then considered

25. conclusive.

1. **Is Cholera transmitted through the airborne droplets, through water or by direct contact?**

Cholera is waterborne.

1. **What evidence did John Snow have to show how Cholera was transmitted?**

John Snow collected statistical evidence from Broad Street in London. He recorded the location of deaths and showed that the majority were clustered around a public water pump. This suggested that Cholera is waterborne.

1. **How could the transmission of Cholera be controlled if John Snow was correct?**

Examples might include:

* Sterilise water using heat (there are other methods but they probably would not have been known to John Snow).
* Avoid the water pumps in areas where deaths occurred.
* Drink beer / wine instead of water (historians theorise that this was common in the middle ages).

1. In 1848–49 there was a second outbreak of cholera, and this was
2. followed by a further outbreak in 1853–54. Towards the end of the
3. second outbreak, John Snow, a London-based physician, published
4. a paper, On the Mode of Communication of Cholera (1849), in
5. which he proposed that cholera was not transmitted by bad air but
6. by a water-borne infection. However, little attention was paid to the
7. paper.
8. Following the third cholera outbreak in 1854, Snow published an
9. update to his theory, with statistical evidence that he had collected
10. from an area of London around Broad Street, Soho. By recording
11. the location of deaths related to cholera in the area, Snow was able
12. to show that the majority were clustered around one particular
13. public water pump in Broad Street.

**4. Pathogens**

**a. Name four types of pathogen.**

Bacteria, viruses, fungi and protists.

**b. Name one example of a communicable disease caused by each type of pathogen.**

Bacteria – typhoid, cholera, salmonella, gonorrhoea etc

Virus – Influenza, SARS-Cov-2

Fungi – Rose black spot, athletes foot

Protists – Malaria

Allow correct alternatives.

**c. Compare bacterial and viral pathogens and how they make us feel ill.**

Bacteria and viruses are both pathogens; they are microorganisms that do harm.

Bacteria reproduce by binary fission, mainly within our tissues.

Viruses reproduce inside living cells and cause cells to burst.

Bacteria also release toxins that cause some symptoms.

Viruses are about 100 times smaller than bacterial cells.

**d. Scientists have been tracking an outbreak of a new form of Ebola. It is has a high transmission rate and is thought to be spread by direct contact with blood and other body fluids. It is also thought to be waterborne because it is more stable that wild-type Ebola.**

**The prime minister has asked you to advise him on how to control the outbreak.**

* **List the measures that you would advise the prime minister to take.**
* **Explain why each measure would reduce the rate of transmission.**

Expect answers such as:

Waterborne:

1. Sterilise water that might be contaminated using heat to reduce exposure
2. Avoid water sources that might be contaminated to reduce exposure
3. Drink other fluids to reduce exposure

Direct contact:

1. Avoid being near animals that might have the disease. This reduces the risk of direct contact
2. Don’t eat meat from contaminated animals. This reduces exposure to their blood and other bodily fluids.
3. Use basic hygiene measures to remove pathogen if exposed to it.

Students might give alternative responses. Credit those that make sense.

**Lesson 2: Teacher notes**

**AQA Content**

Measles is a viral disease showing symptoms of 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.

HIV initially causes a flu-like illness. Unless successfully controlled with antiretroviral drugs the virus attacks the body’s immune cells. Late-stage HIV infection, or AIDS, occurs when the body's immune system becomes so severely damaged it can no longer deal with other infections or cancers. HIV is spread by sexual contact or exchange of body fluids such as blood which occurs when drug users share needles.

Tobacco mosaic virus (TMV) is a widespread plant pathogen affecting many species of plants including tomatoes. It gives a distinctive ‘mosaic’ pattern of discolouration on the leaves which affects the growth of the plant due to lack of photosynthesis.

**Students should be able to** explain how diseases caused by viruses, bacteria, protists and fungi are spread in animals and plants. **Students should be able to** explain how the spread of diseases can be reduced or prevented.

**Chunking**

1. Structure and mode of action of viruses.
2. Measles: Symptoms and mode of transmission.
3. HIV: Mode of action and mode of transmission.
4. TMV: Symptoms and why TMV stunts the growth of plants. ￼

**Key direct and explicit teacher explanations:**

1. **Viruses** are **pathogens** that reproduce inside cells. The structure of viruses is diverse, however, they all have the following things in common:
2. A **protein capsule** around the outside
3. **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.

**MICROGRAPHS SHOW THE DIVERSITY OF STRUCTURE BEFORE DISCUSSING THE GENERIC STRUCTURE AND MODE OF ACTION.**

1. 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.
2. 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.
3. 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.

**Examples and non-examples: A range of examples and non-examples are given to enable interpolation and limit**

**extrapolation:**

Examples of viruses: They show a range of morphology. However, they all have a protein coat and contain genetic material).

Some viruses have a lipid envelope derived from the host cells (e.g., HIV). This makes it harder for the immune system to recognise.

Ebola: RNA Smallpox: DNA Tobacco rattle virus: RNA SARS-CoV-2: RNA

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 2: Viral Diseases**

**Skills Drill / Retrieval**

**Objective: By the end of this lesson, you will be able to describe how communicable diseases caused by viruses affect the host and how their transmission can be reduced.**

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| --- | --- | --- |
| Answer | | PA / SA |
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**Connect**

1. **Viruses reproduce inside cells. Describe the reproductive cycle of a virus.**

The virus identifies a host cell

The virus injects its genetic material into the host cell

The genetic material uses the cells organelles to make more copies of the virus

The cell eventually bursts

Viruses are dispersed into the environment where they can infect other cells.

1. **HIV**
2. How is HIV transmitted?

Sexual contact

Exchange of bodily fluids

1. Which part of the body does HIV attack?

The immune system

1. How is HIV different to AIDS?

HIV is a virus

AIDS is a condition caused by the HIV virus compromising the immune system.

**Graphical user interface, text, application, email

Description automatically generated**

Any **two** from: Avoid sexual contact; use a condom; do not share needles; use antiretroviral drugs; screen blood used for transfusions; regular tests to see if you have HIV

Ignore: handwashing; social distancing; protection unqualified; contraception unqualified; use medication unqualified

If no other marks are given award **1 mark** for do not exchange bodily fluids.

X

1. **Measles**
2. How is measles transmitted?

Air borne droplets from sneezes and coughs.

1. Name two symptoms of measles.

Fever and red rash.

**Graphical user interface, email

Description automatically generated**

4.5

2030 – 91 = 1939

1939/2030 x 100 = 4.5%

Any **one** from: Not everyone would go to the doctor; sample will not always be sent for analysis; some cases not tested / diagnosed / confirmed.

Allow: Not all cases recorded; only medically confirmed cases recorded; idea of doctor making judgement error or misdiagnosis. Ignore some cases unknown.

1. **Tobacco Mosaic Virus**

**Graphical user interface, text, email

Description automatically generated**

64

16 micrometres = 1.6 x 10-5m **OR** 2.5 x 10-7m = 0.25 micrometres

1.6 x 10-5m / 2.5 x 10-7m **OR** 16 / 0.25

= 64

Electron microscope. Ignore microscope unqualified. Ignore scanning tunnelling. Do **not** accept light microscope.

**A picture containing text

Description automatically generated**

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Accept any sensible measure. These might include:

Media campaign to raise awareness with general public

Workplace training for those likely to be exposed

Widespread use of personal protection equipment in relevant workplaces

Needle banks supplying clean needles

Widespread availability of condoms

Increase funding to research institutes to develop an understanding of the virus and potential cures

Attempts to produce a vaccination / medicines

Icon

Description automatically generated

Activity 5.

1. The first case of HIV occurred in 1959 in a Congolese man. The AIDS epidemic
2. officially started in 1981. Between 1959 there were numerous cases of HIV
3. detected but they occurred in isolated clusters.
4. Very little was known about the disease and how it was transmitted at the start of
5. the epidemic. However, it was known that the AIDS was common in addicts that
6. injected drugs and sex workers.
7. Use this information to suggest measures that the government should have taken
8. to control or reduce transmission of the disease.

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**Lesson 3: Teacher notes**

**AQA Content**

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.

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.

Rose black spot is a fungal disease where purple or black spots develop on leaves, which often turn yellow and drop early. It affects the growth of the plant as photosynthesis is reduced. It is spread in the environment by water or wind. Rose black spot can be treated by using fungicides and/or removing and destroying the affected leaves.

**Students should be able to** explain how diseases caused by viruses, bacteria, protists, and fungi are spread in animals and plants.

**Students should be able to** explain how the spread of diseases can be reduced or prevented.

**Chunking**

1. Review of bacterial infection
2. Salmonella as a bacterial infection
3. Gonorrhoea as a bacterial infection
4. Rose Black Spot as a fungal infection in plants
5. Why plants with rose black spot have stunted growth

**Key direct and explicit teacher explanations:**

1. Bacterial pathogens are prokaryotic cells that can produce **toxins** which attack our tissues. Once inside our tissues they reproduce by **binary fission**.
2. 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.
3. 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.
4. 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.
5. 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**.

**Examples: A range of examples and non-examples are given to enable interpolation and limit extrapolation:**

**Examples:**

Fungal infections require warm and damp conditions. For example:

Athletes foot; nail bed infections; oral thrush; ringworm; rose black spot; powdery mildew.

Examples of bacterial infections: Tuberculosis; Anthrax; Tetanus; Pneumonia; Cholera; MRSA

Examples should focus on prokaryotic structure as this differentiates them from viruses and fungi.

**Non-examples:** Choose alternative pathogen groups for structural comparisons.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 3: Bacterial and Fungal Diseases**

**Objective: By the end of this lesson, you will be able to describe how communicable diseases caused by bacteria and fungi affect the host and how their transmission might be reduced.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

Viruses are one of the types of pathogens that can cause communicable diseases.

Compare the structure of a virus to the structure of a bacterial cell.

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Viruses are composed of genetic material within a protein capsule. Some viruses have additional components (e.g HIV has a membrane). The genetic material is not found in a membrane bound nucleus.

Bacterial cells also have DNA ‘naked’ in the cytosol. They can have additional circular pieces of DNA called plasmids.

Bacterial cells have a complex cell wall whereas viruses have a relatively simple capsule.

Bacterial cells have a cell membrane. Some viruses also have a membrane.

The cytoplasm of the bacterial cell is relatively complex and includes other organelles / sub-cellular structures not found in viruses. E.g., ribosomes.

Fungicidal sprays / anti-fungal sprays

Removal of infected leaves and burn them. Remove and burn infected plants etc.

Rose black spot.

Discoloured leaves with black / dark purple spots.

Tobacco mosaic virus / TMV / ToMV

Mosaic pattern of discolouration.

**Graphical user interface

Description automatically generated**

The leaves on the rose bush have black and purple spots.

The leaves on the tomato plant and mottled with green and yellow areas.

Text

Description automatically generated with medium confidence

Graphical user interface, website

Description automatically generated with medium confidence

**Short term:**

Advise that eggs and chicken should be cooked thoroughly

Hands should be washed after handling eggs and chicken

**Long term:**

Introduce safety standard for eggs and chicken (e.g. the red lion mark on eggs)

Quality control eggs and chicken before selling for consumption

Other answers are possible.

1. On December 3, 1988, Edwina Currie, a British politician, stood in front of reporters and
2. television cameras on a mild December morning and delivered a death sentence to the egg
3. industry. “Most of the egg production in this country, sadly, is now affected with salmonella,”
4. she announced in an official statement to the waiting journalists and TV crew. Elaboration
5. would have clarified that only the flocks had been “mostly” infected, not necessarily
6. their eggs—and the fact that, once properly cooked, all eggs were perfectly safe to eat.

*Extract from: https://www.myrecipes.com/extracrispy/how-one-politician-nearly-broke-the-british-egg-industry*

**Salmonella bacteria cause food poisoning.**

**Suggest ways that the incidences of food poisoning caused by Salmonella could be reduced**

1. **In the short term**
2. **In the long term**

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Roses that become infected by rose black spot usually have stunted growth.

Tomato plants also have stunted growth if they become infected with tobacco mosaic virus.

Explain why both of these communicable diseases cause stunted growth.

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Infected parts produce less chlorophyll

The rate of photosynthesis is lower

So, less energy is available for growth

Because less glucose is available for respiration

**And / or**

Less glucose is available for making amino acids / proteins / cellulose

**Lesson 4: Teacher notes**

**AQA Content**

The pathogens that cause malaria are protists. The malarial protist has a life cycle that includes the mosquito. Malaria causes recurrent episodes of fever and can be fatal. The spread of malaria is controlled by preventing the vectors, mosquitos, from breeding and by using mosquito nets to avoid being bitten.

**Students should be able to** explain how diseases caused by viruses, bacteria, protists, and fungi are spread in animals and plants.

**Students should be able to** explain how the spread of diseases can be reduced or prevented.

**Chunking**

* **What is malaria and where is it found?**
* **What are protists?**
* **Mosquitos as a vector**
* **Controlling the spread of malaria**

**Key direct and explicit teacher explanations:**

1. **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.

1. **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.

1. **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.

1. **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.

There have also been attempts to produce a vaccine for malaria. So far, the attempts have not been successful.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 4: Protist Diseases**

**Objective: By the end of this lesson, you will be able to describe how communicable diseases caused by a protist affect the host and how their transmission might be reduced.**

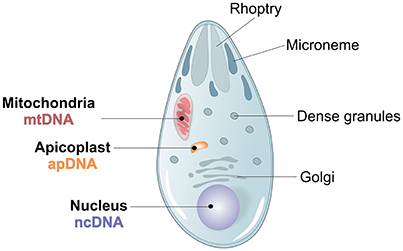
**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

An image of a protist is shown on the left. Compare its structure to the structure of a prokaryotic cell.

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Both have a cell membrane.

Protists have a nucleus whilst prokaryotes do not; the DNA is found in the cytoplasm.

Protists have mitochondria whereas prokaryotes do not.

Protists have additional sub-cellular structures such as a rhoptry, microneme and apicoplast.

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Sterile male mosquitoes compete for mates with the other male mosquitoes. This reduces the birth rate and so reduces the population size over time.

Mosquitoes are the vector for malaria. Their lifecycle requires access to pools of water. If these are removed, the mosquito’s lifecycle is interrupted so their population would decrease in size. The rate of transmission would decrease because the vector population has decreased in size.

Effective vaccines would ensure that the body can protect itself if it becomes infected (details have not been taught yet).

Mosquitoes are the vector for malaria. Insect repellents repel the mosquitoes, so humans are bitten less often.

Mosquitoes infect humans by biting; this transfers the protist into them. The mosquito net protects people from being bitten.

Mosquitoes can be turned into carriers when they bite an infected person. This is prevented by mosquito nets.

Mosquitoes are the vector for the protist that causes malaria.

Insecticides kill the vector and so reduce the rate of infection in animal species.

Icon

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Explain why the following methods can be used to control the spread of malaria:

1. **I DO** - Insecticides

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1. **WE DO / YOU DO** - Mosquito nets

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1. **WE DO / YOU DO** - Insect repellents

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1. **WE DO / YOU DO** - Vaccination

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1. **WE DO / YOU DO** - Draining paddy fields that are used to grow rice

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1. **WE DO / YOU DO** - Releasing sterilised male mosquitos into habitats

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**Future:**

Vaccination programmes so the protist can not survive in the human hosts.

Releasing sterile male mosquitoes so the mosquito population decreases in size.

Draining rice paddy fields and encouraging alternative forms of agriculture. This reduces the size of the habitat available to the mosquito population.

**Quick:**

Mosquito nets could be given to the local human population. This will reduce the incidences of people being bitten by mosquitoes (the vector for malaria).

Insecticides and insect repellents decrease the frequency of humans being bitten.

1. Bill Gates is one of the richest men in the world. He has invested $200,000,000 into
2. eradicating malaria via the Bill Gates Foundation. A key part of their strategy is to
3. use complex surveillance techniques and data management to identify when and
4. where outbreaks are likely. They then support communities in addressing the
5. malaria outbreak.

**List two methods that could be implemented quickly to respond to an outbreak.**

**Explain how they can help minimise cases of malaria.**

Method 1: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Method 2: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**List two methods that could be used to reduce the risk of future outbreaks.**

**Explain how each method reduces the risk of future outbreaks.**

Method 1: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Explanation:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Method 2: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Explanation:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 5: Teacher notes**

**Key direct and explicit teacher explanations:**

1. The body is constantly being attacked by **pathogens**. The body has two ways of defending itself:
2. **Non-specific defences** prevent pathogens from entering our tissues
3. **Specific defences** that are used if pathogens enter our bodies. These are extremely complex.

**Non-specific defences** can be found in the nose, skin, trachea and bronchi and stomach.

1. The skin is the largest organ in the human body. It has many roles. One important role is that it acts as a **physical barrier** to pathogens. If the skin is damaged it begins to repair itself quickly. This process often started with forming a scab over the damaged area. The skin is a physical barrier.
2. **Airborne pathogens** often enter the body through the nose or mouth. The body has several ways to trap these **pathogens** and kill them:
3. The nose produces **mucus** that traps the **pathogens** because it is sticky. When you blow your nose, you remove the trapped **pathogens**.
4. If the **pathogens** don’t get trapped by **mucus** in the nose, they can get trapped by **mucus** produced by **goblet cells** produced in the **trachea and bronchi**. The **trachea and bronchi** also contain **ciliated epithelial cells**. The **cilia** look like small hairs. Their function is to waft mucus to the top of the throat; it is then swallowed or spat out.

The mucus is a **physical barrier**.

1. The stomach produces **hydrochloric acid** which is then **churned** with food. This **hydrochloric acid** is strong enough to kill **pathogens**. This is a **chemical barrier**.

**Examples: A range of examples and non-examples are given to enable interpolation and limit extrapolation:**

**Examples:** Non-specific responses -Skin (physical barrier), stomach acid (chemical barrier), mucus and cilia (physical barrier)

**Non-examples:** White blood cells (specific response)

**Chunking**

1. Preventing pathogens from entering out tissues.
2. The skin as a barrier.
3. Protection against airborne pathogens.
4. Protection against pathogens in food.

**AQA Content**

**Students should be able to** describe the non-specific defence systems of the human body against pathogens, including the: • skin • nose • trachea and bronchi • stomach.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 5: Human defence symptoms**

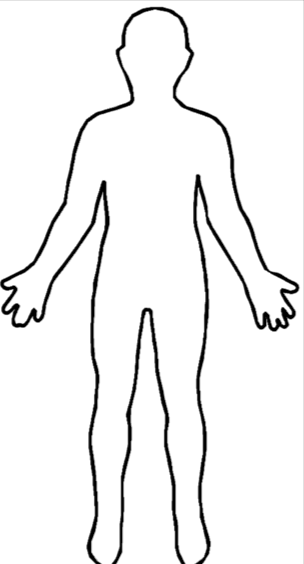
**Objective: By the end of this lesson, you will be able to explain how the human body uses three non-specific defences to combat pathogens.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

List the different ways that pathogens can enter the body



The trachea contains goblet cells that release mucus.

The mucus is a physical barrier that traps pathogens.

Ciliata on ciliated epithelial cells waft the mucus to the top of our throats and so remove pathogens from the airways.

The purpose of the mucus in our respiratory system is to trap dust and pathogens.

In a dusty area, the dust is trapped which makes the mucus appear black.

**I DO**

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Text, letter

Description automatically generated

**In an area where there is a lot of air pollution or somewhere very dusty and dirty, the mucus produced is black in colour when the nose is blown. Explain why.**

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The skin is a physical barrier that prevents pathogens from entering tissues. The skin can repair itself quickly.

The airways contain goblet cells that release mucus. This traps pathogens. The mucus is moved to the top of the throat by cilia on ciliated epithelial cells.

The stomach produces hydrochloric acid. This is mixed with food. The acid kills pathogens in the food.

Icon

Description automatically generated with medium confidence

**WE DO / YOU DO -** The figure below shows some of the ways that the body defends itself against infectious diseases.

Diagram

Description automatically generated

(d)  Describe how the skin, airways and stomach defend against diseases.

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**Lesson 6: Teacher notes**

**AQA Content**

**Students should be able to** explain the role of the immune system in the defence against disease.

If a pathogen enters the body the immune system tries to destroy the pathogen.

White blood cells help to defend against pathogens by: • phagocytosis • antibody production • antitoxin production..

**Key direct and explicit teacher explanations:**

1. 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.

1. 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**.
2. 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**.

1. 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.

**Chunking**

1. Specific and non-specific immune responses
2. Phagocytosis
3. Antibody production
4. Antitoxin production

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 6: Specific human defence symptoms**

**Objective: By the end of this lesson, you will be able to explain how the human body uses three specific defences to combat pathogens.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
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**Connect**

State the different components of blood & describe the function of each

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
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Graphical user interface, application

Description automatically generated

1. Macrophages find, engulf and digest pathogens.
2. Produce antibodies that adhere to antigens on the surface of specific pathogens. They cause the antigens to agglutinate / clump together.
3. Produce antitoxins that are released into the blood. They find and break down toxins that are released by bacterial cells.

Bacteria release toxins into the body. The antitoxins find and break down the toxin molecules.

Antibodies attach to the antigens of specific pathogens. They cause pathogens to clump together (agglutinate). Other white blood cells then destroy the pathogens.

Describe the roles of white blood cells when a pathogen enters the body.

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White blood cells make and release antitoxins and antibodies when you have a bacterial infection.

Explain why they release both antitoxins and antibodies.

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After an infection, a type of white blood cell called a memory cell remains in the body.

If the pathogen reinfects the body, the memory cells can cause massive amounts of antibodies, specific to the pathogen, to be released into the blood very quickly.

Describe the role of memory cells in protecting our bodies from future infections.

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**Lesson 7: Teacher notes**

**AQA Content**

**Students should be able to** explain how vaccination will prevent illness in an individual, and how the spread of pathogens can be reduced by immunising a large proportion of the population.

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 the correct antibodies, preventing infection. **Students do not need to know details of vaccination schedules and side effects associated with specific vaccines.**

WS 1.4 Evaluate the global use of vaccination in the prevention of disease.

**Key direct and explicit teacher explanations:**

1. **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.**

1. 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**

1. 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.

**Chunking**

1. Herd immunity
2. What do vaccines contain? How does the body respond to vaccinations?
3. How does a vaccinated person’s body respond to an infection?

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 7: Vaccinations**

**Objective: By the end of this lesson, you will be able to explain how vaccinations and herd immunity are used to fight disease.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

State and describe five different ways of preventing spread of disease

1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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2. No open rubbish bins or stagnant water – removes breeding grounds for insects which act as vectors (e.g. for malaria)
3. Provide safe drinking water or means to boil / treat water – reduces microbial contamination
4. Isolate infected people to reduce exposure of others
5. Avoid overcrowding – reduces transmission of airborne disease
6. Healthy diet – to build the immune system

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A vaccine contains small quantities of a dead or inactive form of a pathogen; this contains antigens that white blood cells respond to. The white blood cells produce antibodies.

Memory cells are also produced. These respond to the live pathogen by producing massive amounts of the specific antibody quickly.

Herd immunity occurs when the majority of a population are immune to a disease. For example, if they have been vaccinated or if most of the population have had the disease.

Unvaccinated people are protected because they are very unlikely to encounter a person who is carrying the disease.

Describe the concept of herd immunity.

Explain how herd immunity can prevent unvaccinated people from contracting a communicable disease.

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Explain how vaccination makes a person immune to a disease.

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•   dead / inactive / weakened form of pathogen / bacterium / microorganism is introduced / injected

*allow introduce / inject antigen(s) from the pathogen*

*allow dead / inactive / weakened form of Gonorrhoea (bacteria) introduced / injected*

*do****not****accept inject Gonorrhoea disease*

•   white blood cells stimulated to produce antibodies

*do****not****accept incorrect white blood cell, eg phagocyte*

•   reference to memory cells made or remain

•   on re-exposure specific / correct antibodies are made (very) quickly

*allow on re-exposure specific / correct antibodies are produced in large quantities*

•   bacteria / pathogens / microorganisms killed and do not produce a large enough population to cause the disease

*allow bacteria / pathogens / microorganisms killed and do not produce a large enough population to produce toxins*

Gonorrhoea is a bacterial disease.

A new vaccine is being developed against gonorrhoea.

Describe how a vaccine would work to prevent gonorrhoea.

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**Level 3:** Relevant points (comparisons / reasons) are identified, given in detail and logically linked to form a clear account.

**5−6**

**Level 2:** Relevant points (comparisons / reasons) are identified and there are attempts at logical linking. The resulting account is not fully clear.

**3−4**

**Level 1:** Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.

**1−2**

**No relevant content**

**0**

**Indicative content**

**differences (after exposure to measles virus):**

•   greater number / higher concentration of antibodies produced

•   quantitative statement, e.g. 9 times higher **or** 0.8 to 7.2

•   antibodies produced sooner − idea of immediate response

•   antibodies produced quicker

•   antibodies stay (in higher concentration) for longer

**explanation**

•   white blood cells / leucocytes / lymphocytes / B cells

    ignore phagocytes / macrophages

•   reference to previous exposure (of white blood cells) to pathogen / virus

•   (white blood cells) recognise pathogen / virus / antigen

•   memory cells

•   production of specific / correct antibodies

Icon

Description automatically generated

The graph below shows the concentration of measles antibodies in the blood of a boy.

Chart, line chart

Description automatically generated

Explain the differences between antibody production after the vaccine injection and after exposure to the measles virus.

You should include data from the graph above.

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Small pox and cow pox are very similar viruses.

When exposed to the cow pox virus, Phipps’s white blood cells would have reacted by producing antibodies to suppress / destroy the virus.

His body would also have produced memory cells.

When infected with the small pox virus, Phipps’s memory cells would have produced large amounts of antibodies very quickly. The antibodies would destroy the small pox virus because it was very similar to the cow pox virus (so it had similar antigens).

**Edward Jenner – the first vaccination**

1. Edward Jenner tested the hypothesis that infection with cowpox could protect a
2. person from smallpox infection.
3. Cowpox is an uncommon illness in cattle, usually mild, that can be spread from a cow to
4. humans via sores on the cow. During an infection, dairy workers may have pustules on
5. their hands. Sufferers can spread the infection to other parts of the body.
6. We know now that the cowpox virus belongs to the Orthopox family of viruses.
7. Orthopox viruses also include horsepox virus, monkeypox virus, and variola virus, which
8. causes smallpox.
9. On May 14, 1796, Jenner inoculated eight-year-old James Phipps with matter from a
10. cowpox sore on the hand of milkmaid Sarah Nelmes.Phipps suffered a local reaction and
11. felt poorly for several days but made a full recovery. In July 1796, Jenner inoculated Phipps
12. with matter taken from a fresh human smallpox sore, as if he were variolating the boy, in an
13. attempt to challenge the protection from cowpox. Phipps remained healthy. Jenner next
14. demonstrated that cowpox matter transferred in a human chain, from one person to the
15. next, provided protection from smallpox.
16. Jenner was not precisely sure about the nature of the cowpox material he used. He
17. suspected that cowpox actually came from horsepox; in other words, he speculated that
18. cows became infected with the same agent that caused a similar disease in horses. Recent
19. genetic analysis ofold samples of smallpox vaccine have revealed that the samples were
20. more closely related to horsepox virus than cowpox virus.

**Edward Jenner did not understand why his procedure protected people from smallpox.**

**Use your knowledge of vaccinations and white blood cells to explain why his procedure worked.**

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**Lesson 8: Teacher notes**

**AQA Content**

Painkillers and other medicines are used to treat the symptoms of disease but do not kill pathogens. It is difficult to develop drugs that kill viruses without also damaging the body’s tissues.

Traditionally drugs were extracted from plants and microorganisms. • The heart drug digitalis originates from foxgloves. • The painkiller aspirin originates from willow. • Penicillin was discovered by Alexander Fleming from the Penicillium mould.

**Students should be able to** explain the use of antibiotics and other medicines in treating disease.

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.

The use of antibiotics has reduced deaths from infectious bacterial diseases. However, the emergence of strains resistant to antibiotics is of great concern.

Antibiotics cannot kill viral pathogens.

**Chunking**

1. What is a drug? Here do they come from?
2. Painkillers – treating symptoms
3. Antibiotics and anti-viral drugs
4. Natural selection

**Key direct and explicit teacher explanations:**

1. **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.

1. 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.

1. 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.**

1. **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:
2. Mutations in the population cause **variation**
3. The best **adapted** individuals survive
4. Those that survive **reproduce**
5. Beneficial **genes** are passed on to offspring

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 8: Antibiotics and painkillers**

**Objective: By the end of this lesson, you will be able to explain how drugs are used to treat people with communicable diseases.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

Categorise the following medicines

Penicillin Advil Paracetamol Asprin Caffeine Streptomycin Digitalis Statins Ibuprofen Amoxicillin Doxycycli**ne**

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  | PAINKILLERS - advil ,paracetamol, asprin, Ibuprofen  ANTIBIOTIC - Penicillin Streptomycin Amoxicillin Doxycycli**ne**  NEITHER Caffeine, Statin, Digitalis |  |

Viruses reproduce inside cells.

The antibiotics can not reach the virus once it is inside the cell.

The antibiotic may not be effective because they viruses are very different to bacteria (e.g. in terms of biochemistry, lifecycle etc).

Overuse of antibiotics in the past has caused antibiotic resistant bacteria to develop. These bacteria are hard to treat because treatments other than antibiotics need to be found.

Antiviral drugs, when they are available, can cause a lot of damage to the patient’s tissues.

They also want to avoid viruses developing widespread resistance to the drugs.

To reduce pain felt by the patient.

A patient has a viral infection.

Explain why the doctor:

1. Might prescribe painkillers

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1. Is unlikely to prescribe antiviral drugs

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1. Won’t prescribe antibiotics

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Explain why antibiotics cannot be used to treat viral infections.

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Variation exists in the population / a mutation occurred

So, some head lice are resistant to the chemical / not killed by it

These survive

And reproduce

And pass on the gene for resistance to offspring.

The shell colour and banding varies (variation)

Those with plain brown shells are camouflaged in the hedgerow

The plain brown shelled snails are less likely to get eaten

The plain brown shelled snails are more likely to survive

And reproduce

The gene for plain brown shells is passed on to offspring

Icon

Description automatically generated with medium confidence



**WE DO / YOU DO – Natural Selection**

Head lice live on people’s heads and feed on their blood.  
Head lice cause itching and people may develop open wounds from scratching.

A poisonous chemical has been used to kill head lice for many years.  
Recently, the chemical has not been as successful at killing head lice. Many head lice now survive treatment with the chemical.

Explain in terms of **natural selection** why most head lice are no longer killed by the chemical.

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**I DO – Natural Selection**

A particular species of snail has a shell which may be pink, yellow or brown. It may also be plain or have bands running round it.

The snails are eaten by song thrushes.

Explain why snails with plain brown shells are the most common in hedgerows.

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**WE DO / YOU DO – Natural Selection**

Penicillin is an antibiotic which stops bacteria from reproducing. It was used a lot in

the past to treat bacterial infections in humans and other animals. In many hospitals

there are now strains of penicillin resistant bacteria.

Explain how natural selection could have produced these strains of penicillin resistant bacteria.

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Variation exists in the population / a mutation occurred

So, some bacteria are resistant to the Penicillin / are not killed by it

These survive

And reproduce

And pass on the gene for resistance to offspring.

Much of the rain forests are unexplored; we do not know which species live there and how they might benefit us.

Using your knowledge of drugs and where they originate from, to explain why destroying the rain forests could harm the human population.

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 **Lesson 9: Teacher notes** 

Many drugs originate in plants, fungi etc

The rain forest contains many species, some of these haven’t been discovered yet

These species may contain useful substances

If their habitat is destroyed they might become extinct before the useful substances are discovered

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**AQA Content**

**Students should be able to** describe the process of discovery and development of potential new medicines, including preclinical and clinical testing.

Most new drugs are synthesised by chemists in the pharmaceutical industry. However, the starting point may still be a chemical extracted from a plant.

New medical drugs must be tested and trialled before being used to check that they are safe and effective. New drugs are extensively tested for toxicity, efficacy, and dose. Preclinical testing is done in a laboratory using cells, tissues, and live animals.

**Key direct and explicit teacher explanations:**

1. 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.
2. 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.
3. The scientists use three criteria to assess the effectiveness of a drug:
4. Toxicity
5. Efficacy
6. 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.

**Chunking**

1. Medicinal / pharmaceutical chemists
2. Preclinical trials
3. Toxicity, efficacy and dose

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 9: Discovery and development of new drugs** 

**Objective: By the end of this lesson, you will be able to describe how new drugs are developed and assessed using pre-clinical trials.**

**Skills Drill / Retrieval**

|  |  |  |
| --- | --- | --- |
| Answer | | PA / SA |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |

**Connect**

Scientists need to understand the life cycle of pathogens and their vectors (if they have one) so that they can development control measures and treatments.

Mosquitoes are the vector for the protist that causes malaria.

1. Outline the life cycle of a mosquito.
2. Suggest control measures to prevent the spread of malaria.

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1. 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

1. Mosquito nets; insecticides; insect repellents; vaccination; draining paddy fields and other still bodies of water; releasing sterile male mosquito.
2. **Medicinal chemists play a vital role in the process of drug discovery, helping**
3. **to create new and more effective medicines**
4. As a medicinal chemist, you'll use a range of chemistry techniques, primarily synthetic organic chemistry and
5. data analysis tools, to design and create new pharmaceutically active molecules to combat a particular disease
6. or condition. You'll also work on improving existing pharmaceuticals.
7. Working closely with other scientists within a project team, you'll carry out biological testing of the compounds
8. that you've created to see if they're effective. You'll then analyse the results of these tests to identify how the
9. molecule could be improved until there's sufficient evidence that it works and is safe for testing in people.
10. Alternative job titles include synthetic organic chemist, (graduate) scientist and research chemist. It's important
11. to look beyond titles to the job description, to ensure you're finding roles in medicinal chemistry.

Responsibilities

1. As a medicinal chemist, you'll need to:
2. plan and conduct scientific experiments in the lab to create and refine target molecules
3. follow health and safety guidelines and safe working practices
4. undertake data analysis to assess the results of experiments and the characteristics of the molecules produced
5. ensure the structure and purity of compounds are correct
6. write up experiments accurately
7. work closely with other scientific colleagues across different disciplines
8. use computational techniques to model the properties of new molecules
9. explore how it may be possible to 'scale up' production of useful compounds that are created
10. generate reports and deliver presentations about your work for colleagues, partners and clients
11. attend and contribute to internal and external project meetings
12. liaise with partners and clients and respond to queries about the progress of your research
13. keep up to date with scientific literature
14. undertake ongoing professional development by attending training and conferences.

Salary

1. Starting salaries for medicinal chemists are between £22,750 and £33,000.
2. With experience, the salary range for medicinal chemists is between £38,300 and £83,000, with the median being £56,200.
3. General managers can earn a median salary of £82,000.
4. Salaries vary depending on a range of factors including location, the size of the company, the sector you work in
5. and the nature of the job.
6. Some employers will also offer additional benefits such as pension schemes, healthcare plans, share ownership
7. schemes and other employee lifestyle benefits.

**Questions (answer on the next page)**

1. **What do medicinal chemists do?**
2. **Which of the skills shown below would be useful if you were a medicinal chemist?**
3. **Explain your answer to question 2.**
4. **Which of the skills would be most important?**
5. **Explain your answer to question 4.**

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1. They design and create pharmaceutically active molecules

2 – 5. Answers will be variable. Students do need to justify their answers. For example:

Teamwork would be an important skill as medicinal chemists work closely with other colleagues across a variety of disciplines.

The low efficacy makes the drug ineffective. The low toxicity has no bearing on the decision in this case.

The trial should be aborted.

The drug has high efficacy and so has high potential. The low toxicity is not a barrier. So clinical trials should proceed.

Abort because the drug is too toxic to use with patients.

A possible exception would be a drug that treats a lethal condition. The benefits would outweigh the risk in tis case.



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Would you abort or continue trials of a new drug if preclinical trials showed that:

1. **I DO -** Efficacy was high and toxicity was high?

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1. **WE DO / YOU DO** Efficacy was high and toxicity was low?

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1. **WE DO / YOU DO** Efficacy was low and toxicity was low?

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Microorganisms cause infections.

The human body has many ways of defending itself against microorganisms.

(a)     Describe **two** ways the body prevents the entry of microorganisms.

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(b)     In 2014 the Ebola virus killed almost 8000 people in Africa.

Drug companies have developed a new drug to treat Ebola.

Explain what testing must be done before the drug can be tested on humans.

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**Level 3 (5–6 marks):**

A clear, logical and coherent answer, with no significant redundancy. The student understands the process and links this to reasons for clinical trials.

**Level 2 (3–4 marks):**

A partial answer with errors and ineffective reasoning or linkage.

**Level 1 (1–2 marks):**

One or two relevant points but little linkage of points or logical reasoning.

**0 marks:**

No relevant content.

**Indicative content**

* Preclinical trials
* Test on cells and tissues
* Test on live animals
* Test for toxicity
* Test for dosage required
* Test for efficacy

Skin – physical barrier

Stomach acid – chemical barrier

Mucus and cilia – physical barrier

**Lesson 10: Teacher notes**

**AQA Content**

**Students should be able to** describe the process of discovery and development of potential new medicines, including preclinical and clinical testing.

Clinical trials use 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.

WS 1.6 Understand that the results of testing and trials are published only after scrutiny by peer review.

**Key direct and explicit teacher explanations:**

1. 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.

1. 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.

1. 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.

**Chunking**

1. What is a clinical trial?
2. Placebos.
3. Double blind trials.

**Teacher notes (e.g. key questions, examples, non-examples, explanations)**

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**Lesson 10: Discovery and development of new drugs**

**Objective: By the end of this lesson, you will be able to describe how new drugs are developed and assessed.**

**Skills Drill / Retrieval**

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| --- | --- | --- |
| Answer | | PA / SA |
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**Connect**

Describe the steps that might be used in preclinical trials of a new drug.

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* Test on cells and tissues
* Test on live animals
* Test for toxicity
* Test for dosage required
* Test for efficacy

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**0 marks:**

No relevant content.

**Indicative content**

•        pre-clinical trials of the new drug on cells / tissues / live animals

•        to test toxicity, dosage and efficacy

•        clinical trials / test on healthy volunteers and Ebola patients at very low doses

•        so that you can monitor for safety / side effects

•        and only then do trials to find the optimum dosage and test for efficacy

•        double blind trial / use of placebo

•        which does not contain the new drug

•        random allocation of Ebola patients to groups

•        so no one knows who has placebo / the new drug

•        peer review of data

•        to help prevent false claims



Explain why placebos are used in clinical trials.

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Explain why double-blind trials are used during clinical trials.

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**I DO -**  In 2014 the Ebola virus killed almost 8000 people in Africa.

Drug companies have developed a new drug to treat Ebola.

Explain what testing must be done before this new drug can be used to treat people.

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**Level 2:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.

**4−6**

**Level 1:** Facts, events or processes are identified and simply stated but their relevance is not clear.

**1−3**

No relevant content

**0**

**Indicative content**

•   given first to healthy volunteers

○   at (very) low dose

○   to test it is safe **or** to test for toxicity **or** to check for any side effects

•   then to some patients (with the disease) **or** people with the disease

○   to test for the correct / optimum dose

○   to check for any side effects

○   to test for efficacy **or** to test if it works

○   in a double blind trial

○   where neither patients nor doctors know who has the mAbs and who has a placebo (or alternative treatment)

•   reference to large trial **or** long duration **or** control variables



**Key terms:** Dose toxicity efficacy placebo double blind control

**PARTIAL RESPONSE WE DO / YOU DO**

Monoclonal antibodies (mAbs) have many uses in medicine. For example, they are

being developed for treatment of *Candida albicans*.

It has been shown that this mAbs treatment is effective in the laboratory using both:

•   infected tissue culture cells

•   infected live animals.

The mAbs treatment for *Candida albicans* is now ready for clinical trials on people.

Describe how the clinical trials should be carried out.

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**WE DO / YOU DO -**

Dravet syndrome is caused by a genetic mutation.

Dravet syndrome causes epileptic seizures. An epileptic seizure is caused by unusual brain activity.

Scientists have transferred the mutated gene for Dravet syndrome into zebrafish using genetic engineering.

This means the scientists could test a new drug to treat Dravet syndrome on the zebrafish.

Describe the processes that then need to happen to test the new drug before it can be used to treat all children with Dravet syndrome.

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**Level 2:** Scientifically relevant facts, events or processes are identified and given in detail to form an accurate account.

**4−6**

**Level 1:** Facts, events or processes are identified and simply stated but their relevance is not clear.

**1−3**

**No relevant content**

**0**

**Indicative content**

•   pre-clinical trials of the new drug on cells / tissues / live animals

•   to test for toxicity / dosage / efficacy

•   clinical trials / tests on healthy volunteers

•   clinical trials / tests on children with Dravet syndrome at very low doses

•   so you can monitor for safety / side effects

•   and only after these stages trial to find optimum dosage / test for efficacy

•   trial could be double blind / use a placebo

•   which does not contain the new drug

•   children with Dravet syndrome would be randomly allocated to the test groups

•   so no one knows who has the drug / placebo

•   comparison to existing drugs

•   peer review of data

•   to help prevent false claims

•   approval by NICE

to access **level 2** the key ideas of testing on healthy volunteers followed by testing on patients must be given