Surname	Date	Tutor
First name(s)		

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GCE A LEVEL

BW-A2-OptionA-W1

WORKSHEET 1 – OPTION A IMMUNOLOGY AND DISEASE

BIOLOGY – A2 unit 4

Variation, Inheritance and Options

Suggested time: 3 hours 35 minutes

For Tutor's use only

Question	Maximum Mark	Mark Awarded	Question	Maximum Mark	Mark Awarded
1.	9		9.	10	
2.	10		10.	10	
3.	10		11.	11	
4.	12		12.	10	
5.	13		13.	12	
6.	11		14.	12	
7.	10		15.	9	
8.	11		Total	160	

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ADDITIONAL MATERIALS

In addition to this worksheet, you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name and the date in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you are working on screen, write your answers on paper and number each one clearly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question. The worksheet is out of **160** marks.

The assessment of the quality of extended response (QER) will take place in question **15**.

The quality of written communication will affect the awarding of marks.

This worksheet is written by BioWelsh in the style of the WJEC A level Biology examination, following the WJEC specification (topic Option A). It is not an official WJEC paper.

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Answer **all** questions.

1. Leptospirosis is a bacterial disease caused by *Leptospira*. Rats carry the bacteria in their kidneys without showing any symptoms and release them in their urine. People are infected when water or soil contaminated with rat urine enters cuts in the skin or the lining of the mouth or eyes. **Table 1.1** shows the number of cases recorded each month in one district of Sri Lanka in a year when severe floods occurred at the end of June.

Table 1.1

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cases	18	21	17	19	22	96	310	184	41	23	20	19

(a) Define the term **disease reservoir**. [1]

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(b) Explain why rats are described as **carriers** of *Leptospira*. [1]

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(c) Using **Table 1.1**, explain why leptospirosis is described as endemic in this district but became epidemic in July. [2]

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(d) Calculate the percentage increase in the number of cases from May to July. Give your answer to the nearest whole number. [2]

Percentage increase = ... %

(e) Explain why the human body is described as a host for *Leptospira*. [1]

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(f) Suggest **two** measures that could reduce the number of cases after future floods. [2]

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2. An outbreak of cholera began in a refugee camp where many families shared a small number of water taps and latrines. **Image 2.1** is a scanning electron micrograph of bacteria cultured from a stool sample of one patient.

C

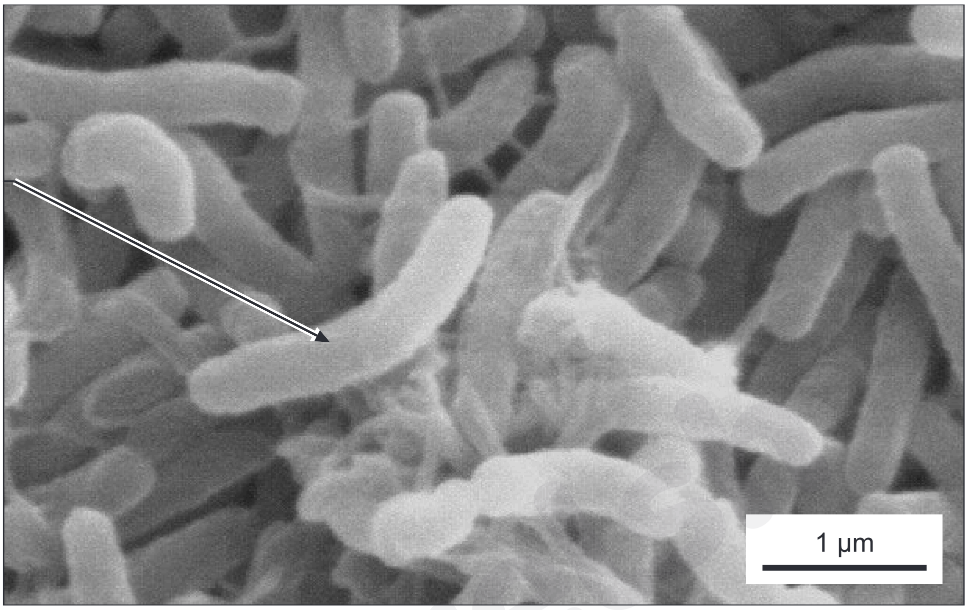

Image 2.1

(a) Describe the shape of the bacteria in **Image 2.1**. [1]

....

....

(b) Use the scale bar to calculate the actual length of bacterium **C** in μm. Show your working. [2]

Length = ... μm

(c) Cholera toxin binds to the epithelial cells of the small intestine. Explain how this leads to severe, watery diarrhoea. [3]

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(d) Patients are given oral rehydration solution, which contains water, glucose and sodium chloride, rather than water alone. Suggest why. [2]

(e) Suggest why the outbreak spread rapidly through the camp. [2]

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3. Tuberculosis (TB) is caused by the bacterium *Mycobacterium tuberculosis*. **Image 3.1** shows a sample of sputum (mucus coughed up from the lungs) from a patient with TB, stained with an acid-fast stain. The bacteria appear red and the rest of the sample appears blue.

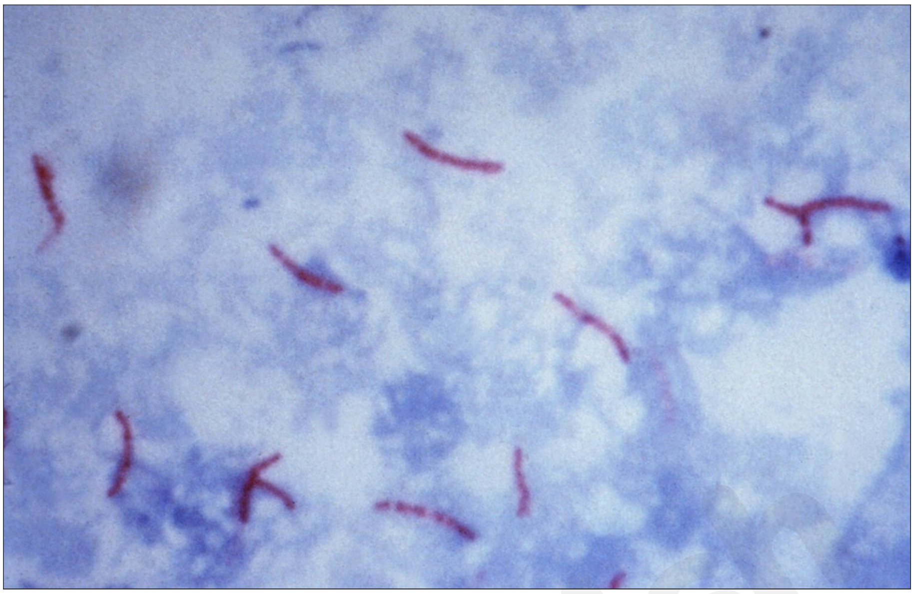

Image 3.1

(a) Suggest why the bacteria stay red after the stained sample has been washed with acid and alcohol. [1]

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Table 3.2 shows the percentage of overcrowded households and the number of TB cases in four districts of one city.

Table 3.2

District	Overcrowded households / %	TB cases per 100 000 people per year
A	4	8
B	9	19
C	15	34
D	22	51

(b) (i) Describe the relationship shown in **Table 3.2**. [1]

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(ii) Explain this relationship. [2]

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(c) Patients with TB take four different antibiotics together for at least six months. Explain why several antibiotics are taken together. [2]

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(d) In one year, 5400 cases of TB were recorded in a country and 81 of them were caused by multidrug-resistant strains. Calculate the percentage of cases that were multidrug-resistant. [1]

Percentage = ... %

(e) Some patients stop taking their antibiotics after a few weeks because they feel better. Suggest why this increases the spread of multidrug-resistant TB. [2]

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(f) Name the vaccine that is used to protect against TB. [1]

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4. Smallpox was caused by the variola virus. It was declared eradicated in 1980 after a worldwide vaccination programme. **Image 4.1** is a transmission electron micrograph of a variola virus particle.

Image 4.1

(a) Identify the parts labelled **A** and **B**. [2]

A ....

B ....

(b) Complete **Table 4.2**, which compares smallpox with influenza. [3]

Table 4.2

Feature	Smallpox	Influenza
Nucleic acid	DNA	RNA
Number of antigenic types	....	many
Animal reservoir	none	....
People infected but without symptoms	....	yes

(c) Use **Table 4.2** to explain why smallpox could be eradicated by vaccination but influenza cannot. [3]

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(d) In the final years of the programme, health workers used ring vaccination: when a case was found, the patient was isolated and everyone who had been in contact with them was vaccinated. Explain how this stopped outbreaks without vaccinating the whole population. [2]

(e) The vaccine contained live vaccinia virus, a related virus that causes only a mild infection. Suggest why vaccination with vaccinia protected people against variola. [2]

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5. **Image 5.1** shows the structure of an influenza virus particle.

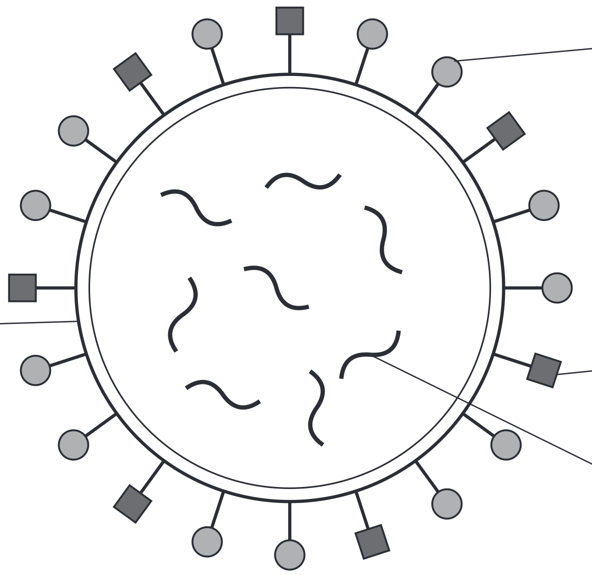

Image 5.1

(a) Identify the structures labelled **P**, **Q**, **R** and **S**. [2]

P ....

Q ....

R ....

S ....

A new influenza vaccine is made every year. The strains to include are chosen about six months before the winter. **Table 5.2** shows how effective the vaccine was at preventing influenza in five winters.

Table 5.2

Winter	2016–17	2017–18	2018–19	2019–20	2022–23
Vaccine effectiveness / %	40	15	44	45	54

(b) (i) Calculate the mean vaccine effectiveness for these five winters. [1]

Mean = ... %

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(ii) Suggest why the vaccine was much less effective in 2017–18 than in the other winters. [3]

(c) Explain how antigenic shift can lead to an influenza pandemic. [3]

(d) Explain how mucus and ciliated epithelium in the airways reduce the chance of influenza viruses infecting cells. [2]

(e) The vaccine is offered free to people over 65 and to pregnant women, but not to most healthy adults. Suggest **two** reasons for this policy. [2]

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6. Malaria is caused by *Plasmodium*, a protoctist carried by female *Anopheles* mosquitoes. **Image 6.1** shows a simplified life cycle of *Plasmodium*. The letters **W**, **X** and **Y** show stages of the parasite and **Z** shows a part of the mosquito.

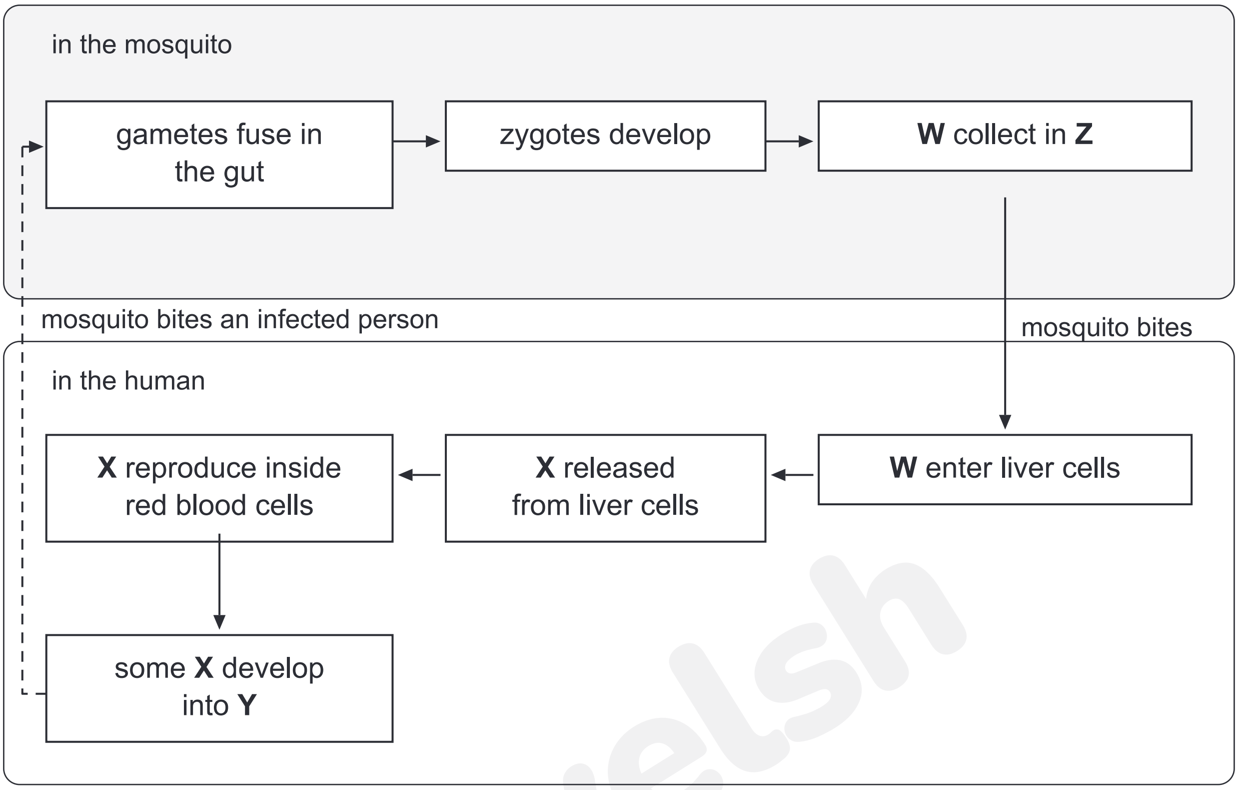

Image 6.1

(a) Name **W**, **X**, **Y** and **Z**. [2]

W ....

X ....

Y ....

Z ....

(b) State where in the life cycle sexual reproduction takes place. [1]

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Image 6.2 is a light micrograph of a stained blood smear from a patient with malaria.

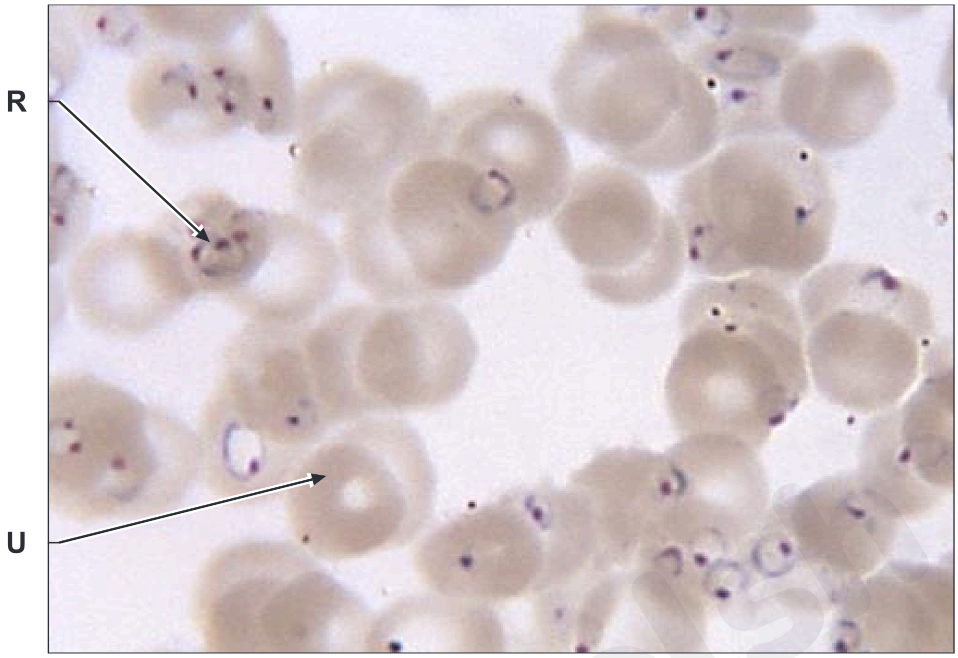

Image 6.2

(c) (i) Describe how cell **R** differs from cell **U**. [1]

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(ii) The patient has a fever every 48 hours. Using **Image 6.1**, explain why. [2]

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(iii) In the blood of this patient, 6.5 % of the red blood cells were infected. The patient had 4.8×10^6 red blood cells per mm^3 of blood. Calculate the number of infected red blood cells per mm^3. **Give your answer in standard form.** [2]

Number = ... per mm^3

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(d) Using your knowledge of the life cycle, explain why it has proved very difficult to develop a fully effective vaccine against malaria. [3]

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7. Insecticide-treated bed nets were given to every household in one district of Malawi in 2014 and 2015. **Table 7.1** shows the number of malaria cases per 1000 people in the district.

Table 7.1

Year	2010	2012	2014	2016	2018	2020	2022
Malaria cases per 1000 people	412	398	405	268	190	176	214

(a) Plot a graph of the data in **Table 7.1** on the grid below. Join the points with straight lines. [4]

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(b) Describe how the number of cases changed after the bed nets were introduced. [2]

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(c) Explain how insecticide-treated bed nets reduce the transmission of malaria. [2]

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(d) Suggest **two** reasons why the number of cases rose again after 2020. [2]

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8. **Image 8.1** shows four stages in the lytic cycle of a virus, drawn out of order.

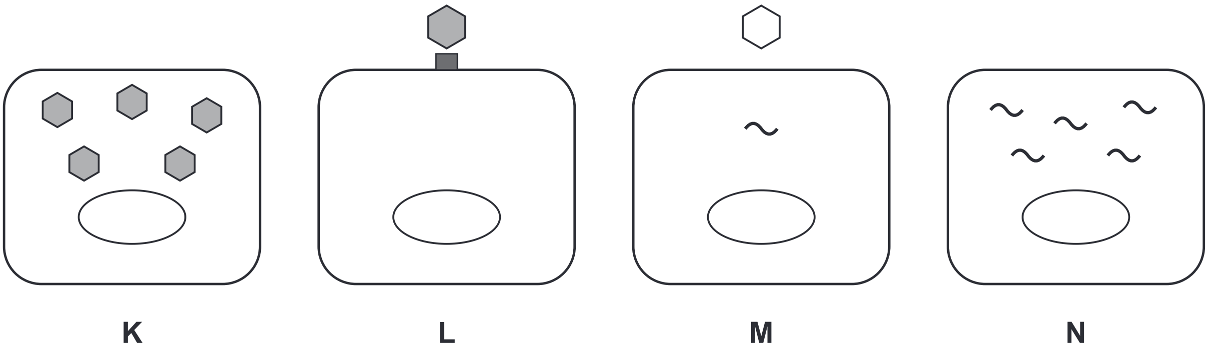

Image 8.1

(a) Give the letters of the stages in the correct order. [1]

....

(b) Explain what is happening in the host cell at stage **N**. [2]

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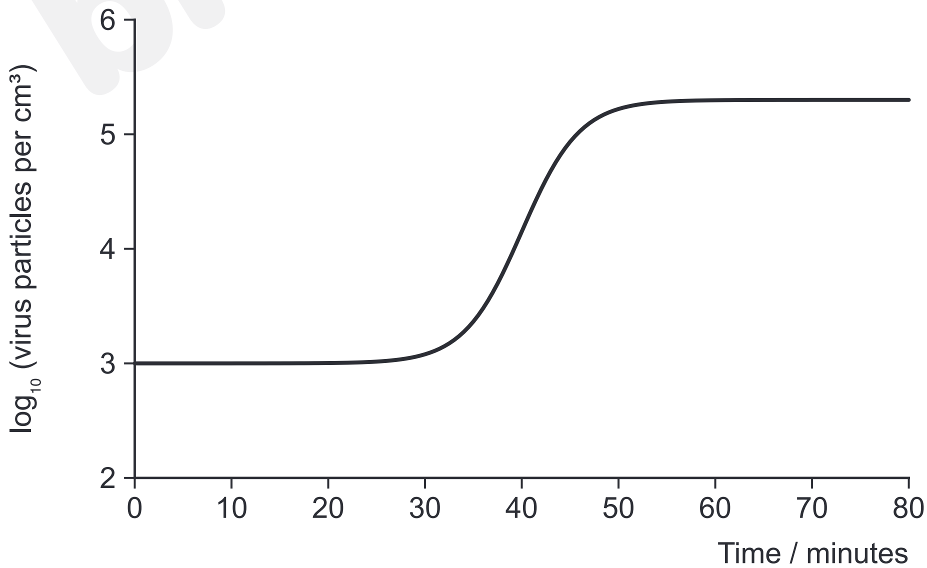
Scientists added a virus to a culture of bacteria so that every bacterium was infected at the same moment, then measured the number of free virus particles. **Graph 8.2** shows the results.



Graph 8.2

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(c) (i) Explain why the number of free virus particles did not change for the first 30 minutes. [2]

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(ii) Use **Graph 8.2** to calculate the mean number of virus particles released from each infected cell. Assume that each infected cell received one virus particle. [2]

Number released per cell = ...

(d) People infected with herpes simplex virus can have cold sores that return every few months or years, even though they are not infected again. Suggest how this happens. [2]

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(e) Explain how T killer cells limit the spread of a virus through a tissue. [2]

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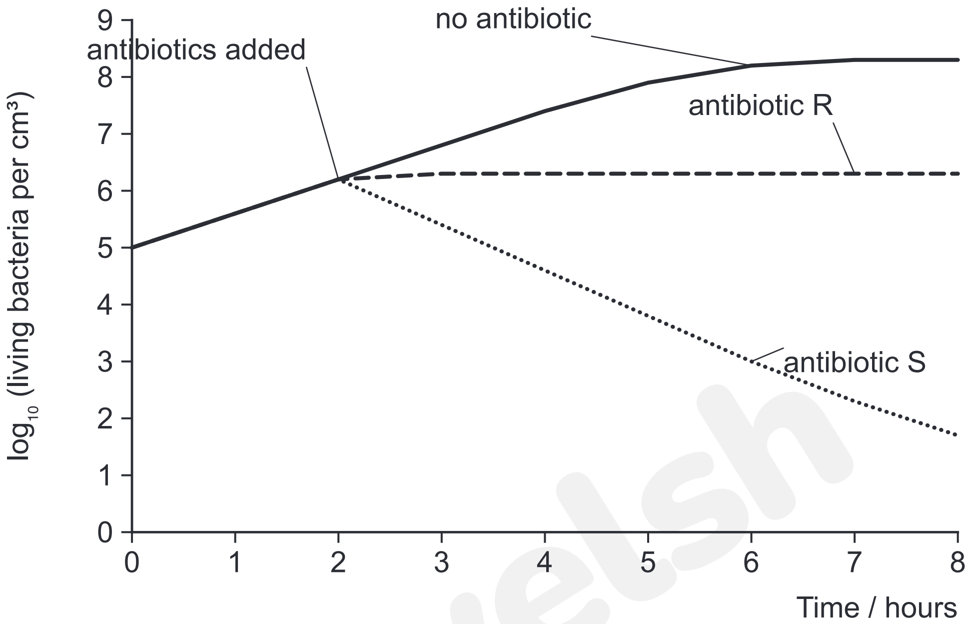
9. Two antibiotics, **R** and **S**, were added to separate cultures of *Staphylococcus aureus* after 2 hours. A third culture received no antibiotic. The number of living bacteria was measured every hour. **Graph 9.1** shows the results.



Graph 9.1

(a) Using **Graph 9.1**, identify which antibiotic is bactericidal. Give a reason for your answer. [2]

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(b) Antibiotic **S** is a type of penicillin. Explain how penicillin kills bacteria. [3]

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(c) Antibiotic **R** binds to the 30S subunit of bacterial ribosomes, like tetracycline. Explain why it stops the bacteria dividing without killing them. [2]

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(d) Antibiotic **S** had very little effect on *Escherichia coli*, a Gram-negative bacterium. Explain why. [2]

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(e) Suggest why neither antibiotic would be prescribed for influenza. [1]

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10. Meticillin-resistant *Staphylococcus aureus* (MRSA) is resistant to penicillin and related antibiotics. **Table 10.1** shows the percentage of *S. aureus* samples from bloodstream infections in the hospitals of one country that were MRSA.

Table 10.1

Year	1995	1998	2001	2004	2008	2012	2016	2020
MRSA / %	3	20	40	42	30	12	7	6

(a) Describe the changes shown in **Table 10.1**. [2]

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(b) Explain how MRSA became so common in hospitals between 1995 and 2004. [3]

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(c) Resistance alleles are often carried on plasmids. Suggest why this allows resistance to spread more quickly. [1]

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(d) Some resistant bacteria secrete an enzyme called beta-lactamase. Suggest how this protects them from penicillin. [2]

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(e) Suggest **two** changes in hospital practice that could explain the fall after 2004. [2]

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11. A student investigated the effect of five antibiotics, **A** to **E**, on *Bacillus subtilis*, a harmless bacterium. The student spread the bacteria evenly over nutrient agar in a Petri dish, placed paper discs soaked in the antibiotics on the agar and incubated the dish at 25 °C for 48 hours. Disc **A** was soaked in sterile water. **Image 11.1** shows the dish after incubation, drawn to scale.

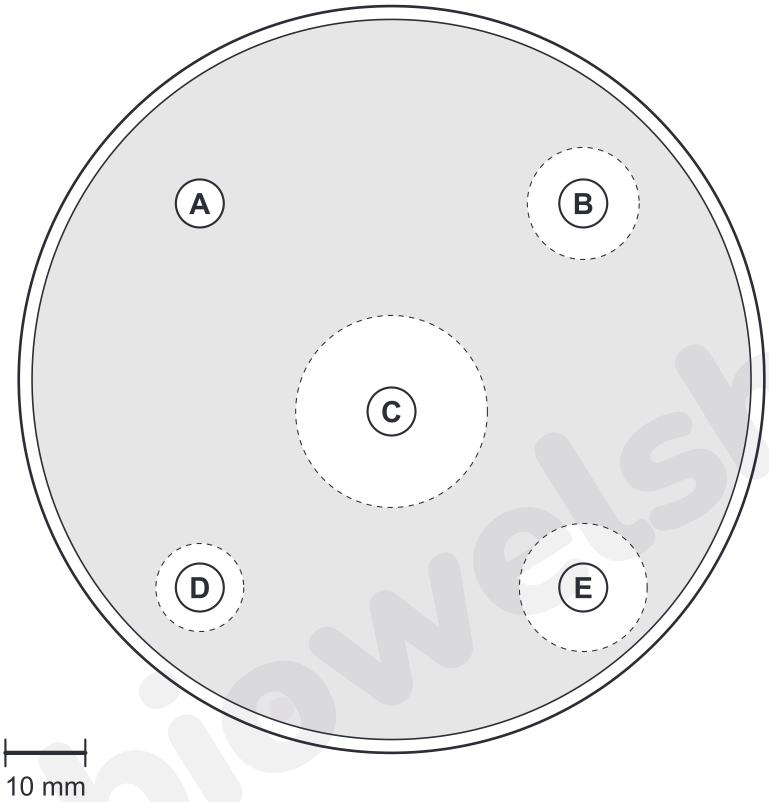

Image 11.1

(a) Describe **three** aseptic techniques the student should use when spreading the bacteria on the agar. [3]

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(b) Explain the purpose of disc **A**. [1]

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Table 11.2 shows the diameter of the clear zone around each disc.

Table 11.2

Disc	A	B	C	D	E
Diameter of clear zone / mm	0	14	24	11	16

(c) Calculate the area of the clear zone around disc **C**. Use the formula area = πr^2, where π = 3.14. Give your answer to **3 significant figures**. [2]

Area = ... mm^2

(d) State **two** conclusions the student can make from these results. [2]

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(e) Suggest **two** variables that should have been controlled so that the antibiotics can be compared fairly. [2]

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(f) Explain why the dish was incubated at 25 °C rather than 37 °C. [1]

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12. A hospital laboratory measured the minimum inhibitory concentration (MIC) of an antibiotic for bacteria from a patient. Eight tubes of sterile broth contained a series of concentrations of the antibiotic. The same volume of the bacterial culture was added to each tube and the tubes were incubated for 24 hours. **Table 12.1** shows the results. A cloudy tube shows that the bacteria have grown.

Table 12.1

Tube	1	2	3	4	5	6	7	8
Antibiotic concentration / μg cm^{-3}	64	32	16	8	4	2	1	0.5
Appearance after 24 hours	clear	clear	clear	clear	clear	cloudy	cloudy	cloudy

(a) Describe how 10 cm^3 of the solution in tube 2 could be made from the solution in tube 1. [2]

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(b) Use **Table 12.1** to state the MIC of the antibiotic for these bacteria. [1]

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(c) Suggest a suitable control tube for this investigation and explain why it is needed. [2]

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(d) The antibiotic is prescribed at 15 mg per kg of body mass per day, given as three equal doses. Calculate the mass of antibiotic in each dose for a child with a mass of 22 kg. [2]

Mass per dose = ... mg

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(e) The antibiotic is supplied as a liquid containing 25 mg per cm^3. Calculate the volume of liquid needed for each dose. [1]

Volume = ... cm^3

(f) For serious infections this antibiotic is injected into a vein rather than taken by mouth. Suggest **two** reasons why. [2]

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13. The body has several barriers that reduce the risk of infection.

(a) Complete **Table 13.1** to show how each barrier reduces the risk of infection. [3]

Table 13.1

Barrier	How it reduces the risk of infection
Skin	a tough layer of dead cells containing keratin that microorganisms cannot pass through
Tears	....
Mucus and cilia in the trachea	....
Hydrochloric acid in the stomach	....

(b) A splinter carried bacteria into a finger. Within a few hours the skin around it became red, warm and swollen. Explain how these changes help to fight the infection. [3]

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Image 13.2 shows a phagocyte from the tissue around the splinter.

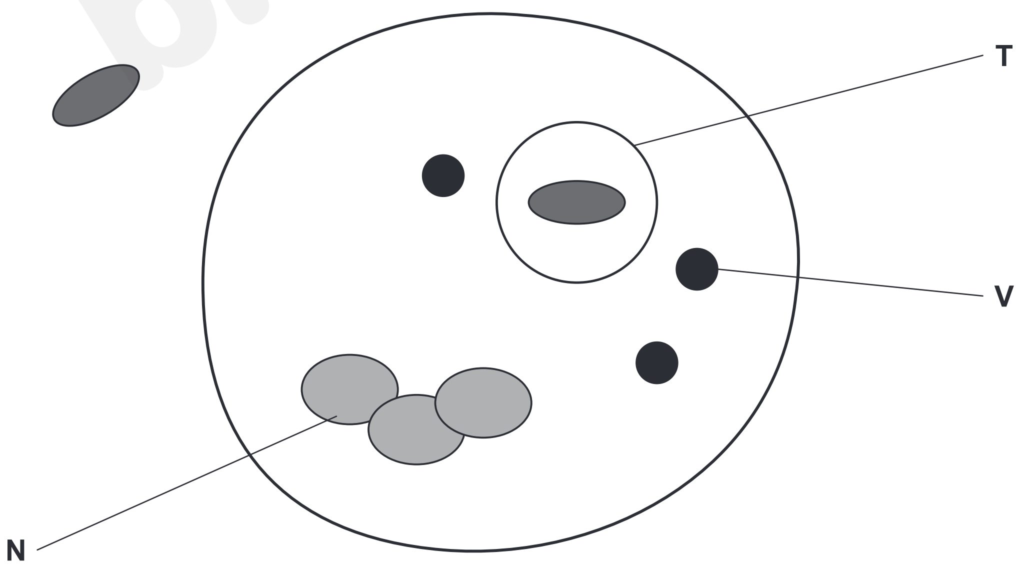

Image 13.2

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(c) (i) Identify the structures labelled **T**, **V** and **N**. [2]

T ....

V ....

N ....

(ii) Describe how structure **V** helps to destroy the bacterium. [2]

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(d) Macrophages are phagocytes that present antigens from the bacteria they digest on their cell surface. Explain why antigen presentation is needed for a specific immune response. [2]

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14. Tetanus is caused by a toxin released by the bacterium *Clostridium tetani*, which can enter the body through a deep wound. The tetanus vaccine contains toxoid, an inactivated form of the toxin. **Image 14.1** shows the structure of an antibody.

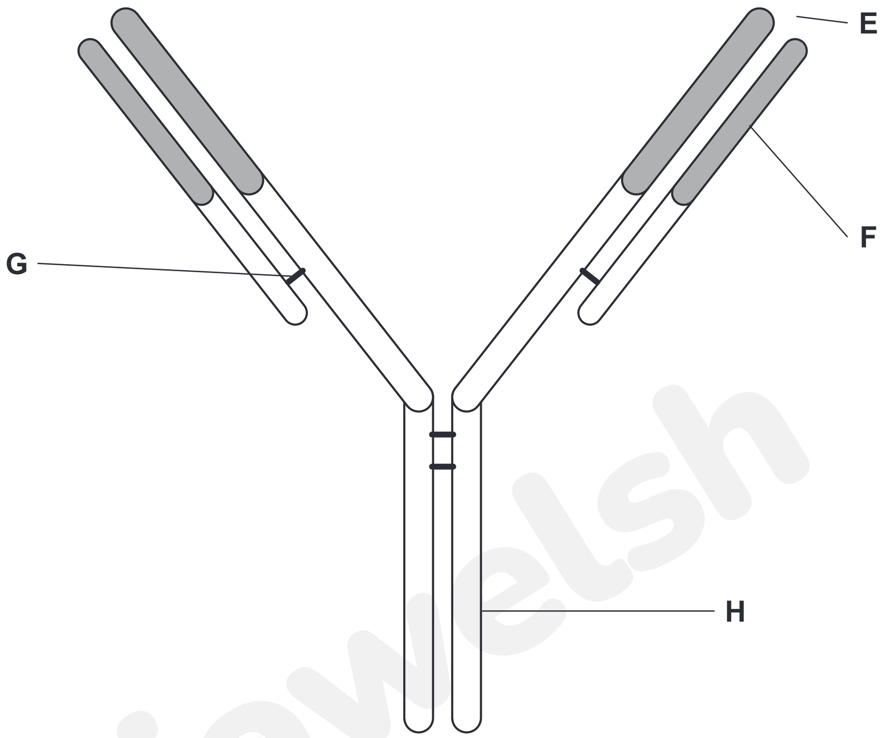

Image 14.1

(a) Identify the parts labelled **E**, **F**, **G** and **H**. [2]

E ....

F ....

G ....

H ....

(b) Explain why the antibodies made after tetanus vaccination bind to tetanus toxin but not to other molecules. [2]

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(c) Describe the events that follow the injection of toxoid and lead to the secretion of antibodies. [3]

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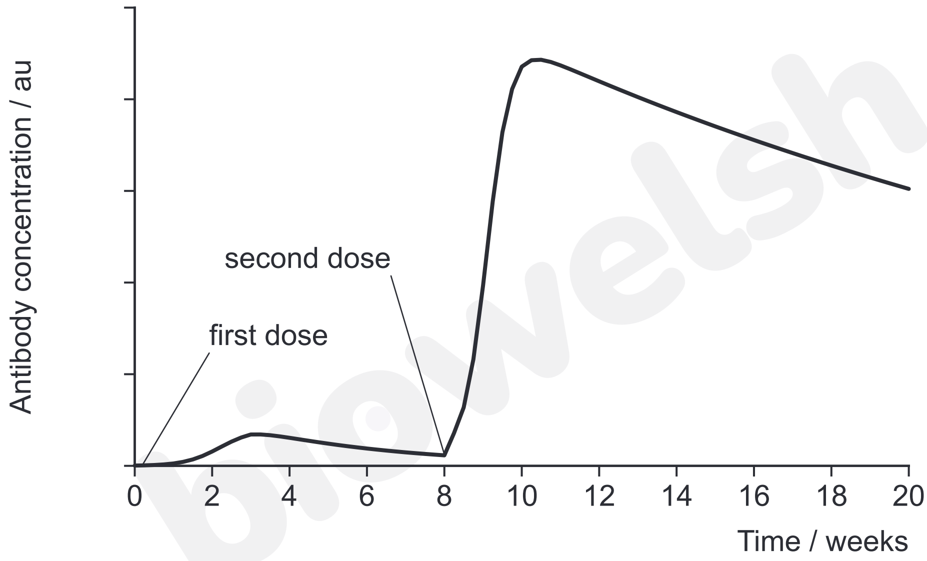
Graph 14.2 shows the concentration of antibody in the blood of a child given two doses of tetanus vaccine.



Graph 14.2

(d) Explain the differences between the responses to the first and second doses shown in **Graph 14.2**. [3]

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(e) A gardener who has never been vaccinated against tetanus gets a deep cut from a rusty fork. A doctor injects tetanus antibodies and gives the first dose of vaccine. Explain why both are given. [2]

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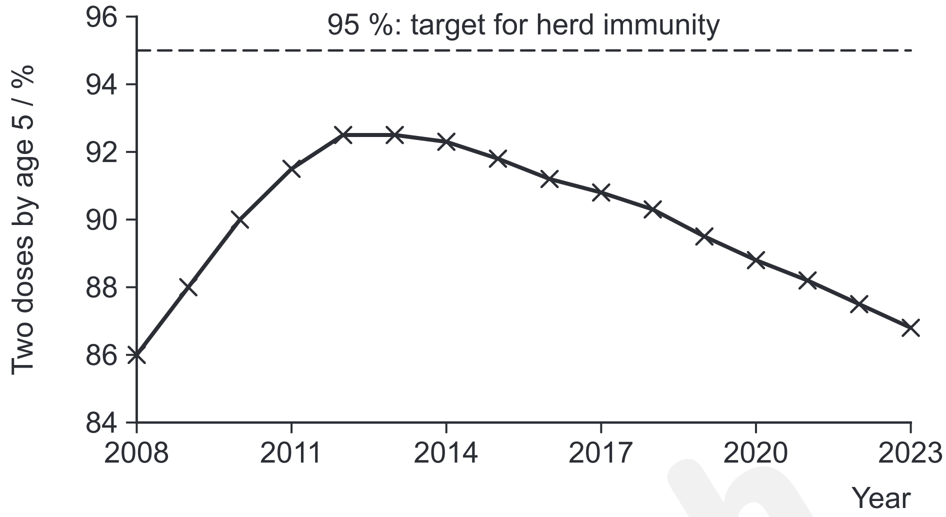
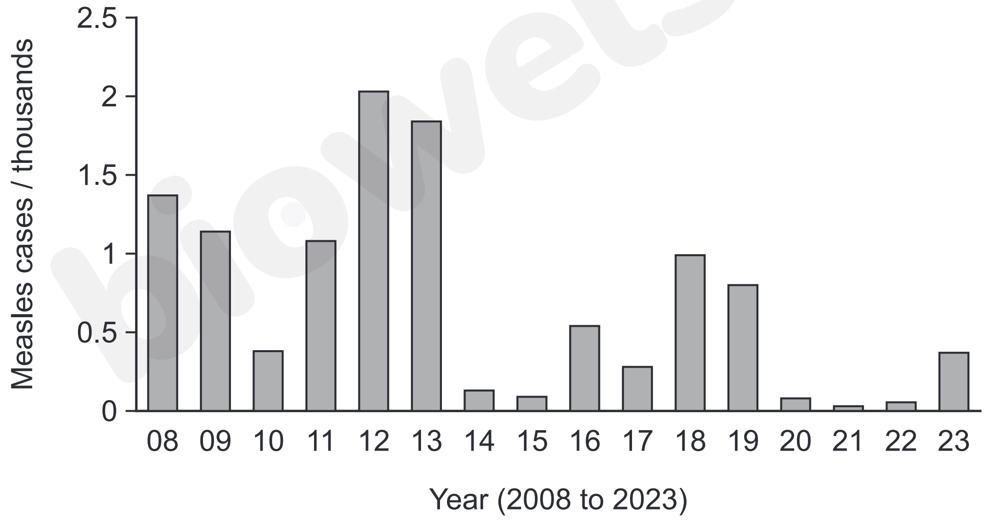
15. The MMR vaccine contains weakened measles, mumps and rubella viruses. In one country it is given at 12 months and at 3 years 4 months of age. Measles is very infectious, and rubella caught during early pregnancy can seriously harm the foetus. Uptake of MMR in this country fell in the early 2000s after a report that wrongly linked the vaccine with autism. **Graph 15.1A** shows the percentage of children who had received both doses by the age of five, and **Graph 15.1B** shows the number of confirmed cases of measles.



Graph 15.1A



Graph 15.1B

Explain how two doses of the MMR vaccine give long-lasting protection against measles and rubella. Use **Graph 15.1A** and **Graph 15.1B** to describe the relationship between vaccine uptake and cases of measles, and explain it using the idea of herd immunity. Discuss the ethical issues a government should consider before making MMR vaccination compulsory.

[9 QER]

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END OF WORKSHEET

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Acknowledgements

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