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SECONDARY 4 · BIOLOGY · INFECTIOUS DISEASES IN HUMANS

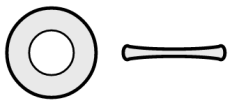
Infectious Diseases in Humans

Theory and worked examples

Recap from Sec 3: cells, white blood cells, osmosis and two calculations

This chapter builds on ideas from Sec 3. You need the parts of a cell to compare bacteria and viruses, the white blood cells to understand vaccines, and osmosis to see how some antibiotics kill bacteria. Exam questions on disease also ask you to work out sizes from micrographs and percentage changes from data, so the two calculations are recapped here too.

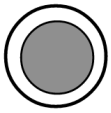
- Animal and plant cells have a cell membrane, cytoplasm, ribosomes (which make proteins) and a nucleus that holds the DNA. Plant cells also have a cell wall.
- Blood contains red blood cells, white blood cells and platelets in plasma. Phagocytes are white blood cells that engulf and digest pathogens. Lymphocytes are white blood cells that make antibodies.
- An antibody is a protein made by white blood cells (lymphocytes). Each kind of antibody acts against one particular pathogen only and helps to destroy it.
- Osmosis: water moves from a dilute solution to a more concentrated solution through a partially permeable membrane. Water enters a cell placed in a dilute solution; a cell wall stops it from bursting.
- Magnification = image size ÷ actual size. Use the same unit for both sizes: 1 mm = 1000 µm (micrometres) and 1 µm = 1000 nm (nanometres).
- Percentage change = (new value − old value) ÷ old value × 100%. A negative answer is a percentage decrease.



red blood cell (flat and edge-on)



phagocyte



lymphocyte



platelets

WORKED EXAMPLE

An electron micrograph shows a bacterium 60 mm long at a magnification of ×20 000. Calculate the actual length of the bacterium in micrometres (μm).

1. Asked: the actual size, so rearrange: actual size = image size ÷ magnification.
2. Actual length = 60 mm ÷ 20 000 = 0.003 mm.
3. Convert to micrometres: 0.003 × 1000 = 3 μm.
4. Check: bacteria are about 1-5 μm long, so 3 μm is sensible.

Actual length = 60 ÷ 20 000 = 0.003 mm = 3 μm.

TRY THIS

In a survey, 40 pupils had a cough in May and 28 in June. Calculate the percentage change.

Answer: (28 – 40) ÷ 40 × 100% = –30%, a 30% decrease.

Infectious and non-infectious diseases

A disease is a condition that stops part of the body from working properly. An infectious disease is caused by a pathogen and can be spread from person to person. Influenza, pneumococcal disease, COVID-19, tuberculosis and the common cold are infectious. A non-infectious disease is not caused by a pathogen and cannot be spread from person to person, however close you are to someone who has it. Coronary heart disease, type 2 diabetes, lung cancer and high blood pressure are non-infectious; they are linked to lifestyle (diet, smoking, exercise), to age or to the genes a person inherits.

WORDS TO KNOW

infectious disease	a disease caused by a pathogen that can be spread from person to person
non-infectious disease	a disease that cannot be spread from person to person
pathogen	a micro-organism that causes disease, e.g. a bacterium or a virus

	Infectious disease	Non-infectious disease
Cause	a pathogen (e.g. a bacterium or a virus)	not a pathogen: lifestyle, age or inherited genes
Spread from person to person?	Yes	No
Examples	influenza, pneumococcal disease, COVID-19, tuberculosis, common cold	coronary heart disease, type 2 diabetes, lung cancer, high blood pressure
Prevented by	hygiene, masks, vaccination	healthy diet, exercise, not smoking

WORKED EXAMPLE

A school nurse at a secondary school in Tampines notes four pupils in one week: Ravi has influenza, Mei Ling has type 2 diabetes, Hafiz has pneumococcal pneumonia and Jia Hui has high blood pressure. Which pupils' diseases could spread to other pupils? Explain your answer.

1. Asked: which diseases are infectious.
2. Idea: only a disease caused by a pathogen can be spread from person to person.
3. Influenza is caused by the influenza virus; pneumococcal pneumonia by the bacterium pneumococcus.
4. Type 2 diabetes and high blood pressure are not caused by pathogens.

Ravi's and Hafiz's. Influenza and pneumococcal pneumonia are infectious diseases: they are caused by pathogens (a virus and a bacterium) that can be passed from person to person. Diabetes and high blood pressure are non-infectious, so they cannot spread.

TRY THIS

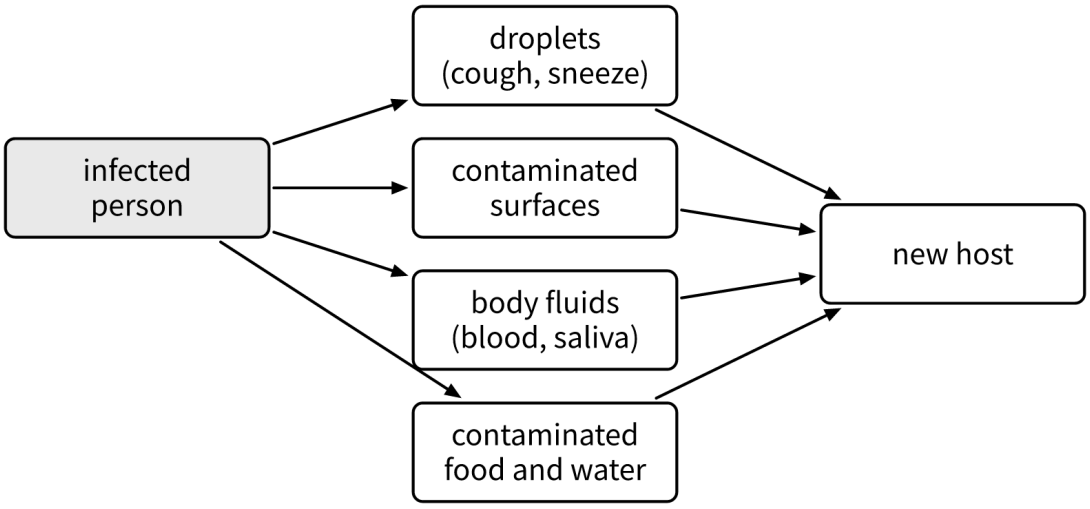
Lung cancer is common in smokers. Is it an infectious disease? Give a reason.

Answer: No. It is not caused by a pathogen and cannot be spread from person to person.

Pathogens and how they spread

Infectious diseases are caused by pathogens such as bacteria and viruses. Inside the body a pathogen multiplies quickly. Bacteria may release poisons (toxins) or damage tissues; viruses enter body cells and damage or destroy them as they reproduce. This harm causes the signs and symptoms of the disease. A pathogen leaves an infected person and reaches a new host by one of a few routes: through body fluids, through food and water, or through droplets and surfaces.

Route	How the pathogen passes on	Example
Droplets in the air	an infected person coughs, sneezes or talks; another person breathes in the droplets	influenza, pneumococcal disease
Contaminated surfaces	droplets land on a door handle or lift button; a person touches it, then the nose or mouth	influenza, pneumococcal disease
Body fluids	blood, saliva, mucus or semen passes from one person to another (sharing needles, kissing, sexual contact)	HIV (chapter 9), pneumococcal disease (saliva, mucus)
Food and water	food or drinking water contaminated with the pathogen, often from faeces	cholera, food poisoning



WORKED EXAMPLE

Three diseases are described. Disease P: a bacterium is found in river water downstream of a village with no toilets. Disease Q: a virus is found in the mucus and saliva sprayed out when patients cough. Disease R: a virus is found in the blood of patients. State the route by which each disease is spread and one way to reduce its spread.

1. Asked: the route of spread and one matching control measure for each.
2. P: the bacterium is in water contaminated with faeces, so it spreads through water.
3. Q: the virus is in droplets from coughs, so it spreads through droplets in the air (and contaminated surfaces).
4. R: the virus is in blood, so it spreads through body fluids.
5. Each measure must break that route.

P: through contaminated water; boil or treat drinking water and build proper toilets. Q: through droplets when patients cough (or surfaces); wear a mask, cover the mouth when coughing and wash hands. R: through body fluids (blood); do not share needles and screen donated blood.

TRY THIS

Why does washing your hands with soap reduce the spread of a disease that is spread by droplets?

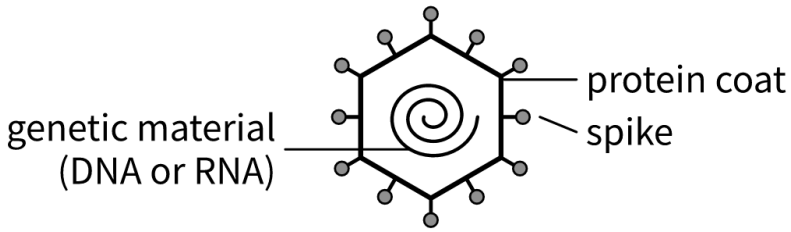
Answer: Droplets land on surfaces and hands; washing removes the pathogens before you touch your nose, mouth or eyes.

Viruses

A virus is much smaller than a bacterium and is not made of a cell. A typical virus has a protein coat enclosing its genetic material (DNA or RNA). It has no cell membrane, no cytoplasm and no ribosomes, so it cannot feed, respire or make proteins on its own. A virus reproduces only inside living host cells: it enters a host cell, and the host cell's ribosomes, enzymes and energy are used to make many new copies of the virus. The new viruses are released, often destroying the host cell, and go on to infect other cells. Outside a host cell a virus does nothing at all.

KEY IDEA

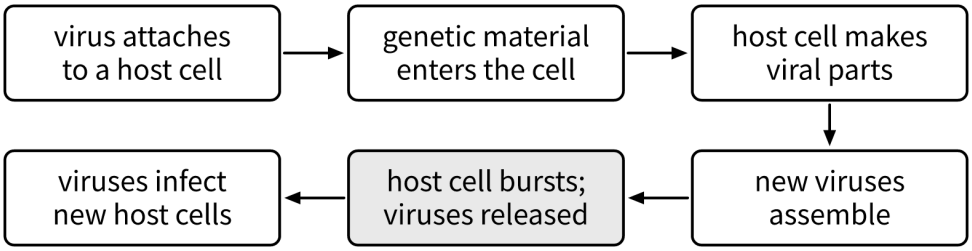
A typical virus has a protein coat enclosing its genetic material and reproduces only in living host cells.



Not drawn to scale: a virus is about 20–300 nm across.

WORKED EXAMPLE

The flow diagram shows how a virus reproduces. Explain why a virus cannot reproduce in a dish of nutrient agar, although many bacteria can.



1. Asked: why there is no reproduction outside a living cell.
2. Diagram: the new viral parts are made by the host cell, not by the virus.
3. Structure: a virus is only a protein coat and genetic material; it has no ribosomes, enzymes or cytoplasm of its own.
4. Agar has nutrients but no living cells to take over.

A virus has only a protein coat and genetic material; it has no ribosomes, enzymes or cytoplasm of its own. It can reproduce only inside living host cells, using the host cell's ribosomes and enzymes to make new viruses. Agar contains no living cells, so the virus cannot reproduce. Bacteria are cells with their own ribosomes and enzymes, so they can grow on agar.

CHAPTER 1

Practice Questions

Part 2: Infectious Diseases in Humans



In the practice questions

23 questions, 75 marks. For each multiple-choice question, write the letter of the correct option (A, B, C or D) in the brackets. Write your other answers on the lines given. The answers are on page 448.

- Section A: Multiple-Choice Questions: 15 questions, 15 marks
- Section B: Structured Questions: 6 questions, 40 marks
- Section C: Free-Response Questions: 2 questions, 20 marks

Name: _____ Class: _____ Date: _____

SECONDARY 4 · BIOLOGY · INFECTIOUS DISEASES IN HUMANS

Infectious Diseases in Humans

INSTRUCTIONS

- 23 questions, 75 marks in total.
- Answer all questions in the spaces provided.
- For MCQs, write the letter (A, B, C or D) in the brackets.
- Write your other answers on the lines given. Show your working in calculations.

Section A: Multiple-Choice Questions

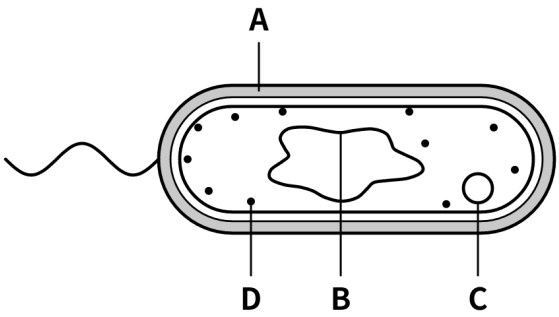
1 Which disease is an infectious disease? ( ) [1]

(A) coronary heart disease
(B) type 2 diabetes
(C) influenza
(D) lung cancer

2 Which row describes a typical virus? ( ) [1]

	Has a cell wall	Has a protein coat	Can reproduce outside living cells
A	No	Yes	No
B	Yes	No	Yes
C	No	Yes	Yes
D	Yes	Yes	No

3 The diagram shows a bacterium. Which labelled part stops the bacterium from bursting when water enters it by osmosis? ( ) [1]



4 In good conditions a bacterium divides into two every 20 minutes. How many bacteria are there after 2 hours, starting from one bacterium? ( ) [1]

Ⓐ 12 Ⓑ 64 Ⓒ 120 Ⓓ 4096

5 Which of these can spread the influenza virus?

1 breathing in droplets from a sneeze
2 touching a contaminated lift button and then rubbing the eyes
3 being bitten by a mosquito

( ) [1]

Ⓐ 1 only Ⓑ 2 and 3 only Ⓒ 1, 2 and 3 Ⓓ 1 and 2 only

6 Which row shows the type of pathogen that causes each disease? ( ) [1]

	Influenza	Pneumococcal disease
A	virus	virus
B	virus	bacterium
C	bacterium	virus
D	bacterium	bacterium

7 Which group of signs and symptoms is typical of pneumococcal pneumonia? ( ) [1]

Ⓐ an itchy rash, swollen ankles and weight gain
Ⓑ great thirst, passing a lot of urine and weight loss
Ⓒ pain in the left arm and jaw during exercise
Ⓓ fever, chills, cough, chest pain and difficulty in breathing

8 What does a vaccine contain? ( ) [1]

(A) antibodies against the pathogen
(B) an antibiotic that kills the pathogen
(C) an agent that resembles the pathogen, such as the killed pathogen
(D) white blood cells that recognise the pathogen

9 The table shows the antibody concentration in a man's blood after he was vaccinated and, months later, after the same pathogen entered his body. How many times higher is the highest concentration after the pathogen entered than after the vaccine? ( ) [1]

	After the vaccine	After the pathogen entered
Highest antibody concentration / arbitrary units	40	600
Days taken to reach the highest concentration	14	5

(A) 15 (B) 9 (C) 2.8 (D) 560

10 In an electron micrograph a virus measures 18 mm across. The magnification is ×150 000. What is the actual diameter of the virus? ( ) [1]

(A) 12 nm (B) 120 nm (C) 1200 nm (D) 2700 nm

11 Why are antibiotics ineffective against viruses? ( ) [1]

(A) Viruses are too small to be seen with a light microscope.
(B) Viruses have a thick cell wall that antibiotics cannot pass through.
(C) Viruses are destroyed by white blood cells before the antibiotic can act.
(D) Viruses have no cell structures for antibiotics to target and reproduce inside host cells.