10. Infectious Diseases

10.1 Infectious Diseases

Paper 2

Question Paper

1 **(a)** A class of students was studying the features of some human pathogens. One of the students constructed a flow chart to identify four different human pathogens. The student used information about the structure and mode of transmission of each of these pathogens.

Fig. 3.1 shows the partially completed flow chart.

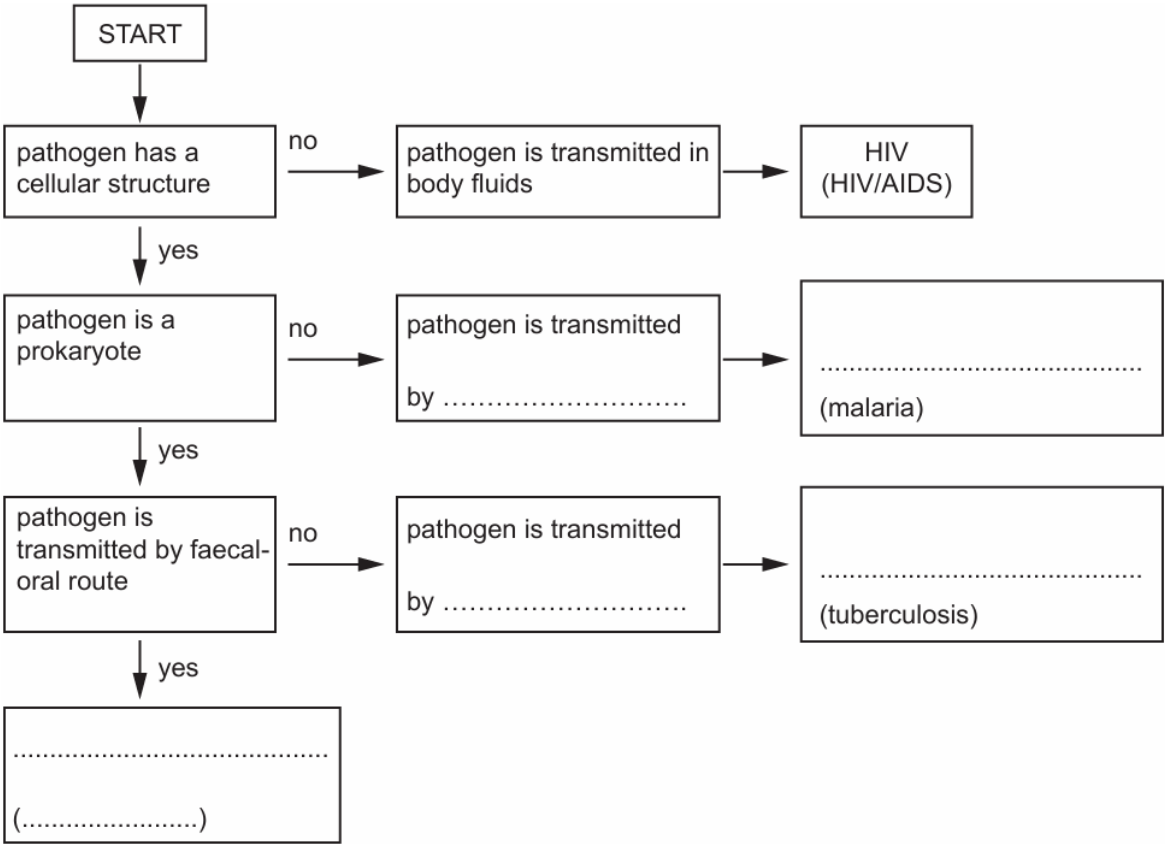


Fig. 3.1

Complete the flow chart in Fig. 3.1 by identifying:

- the modes of transmission
- the scientific names of the pathogens
- the name of one of the diseases.

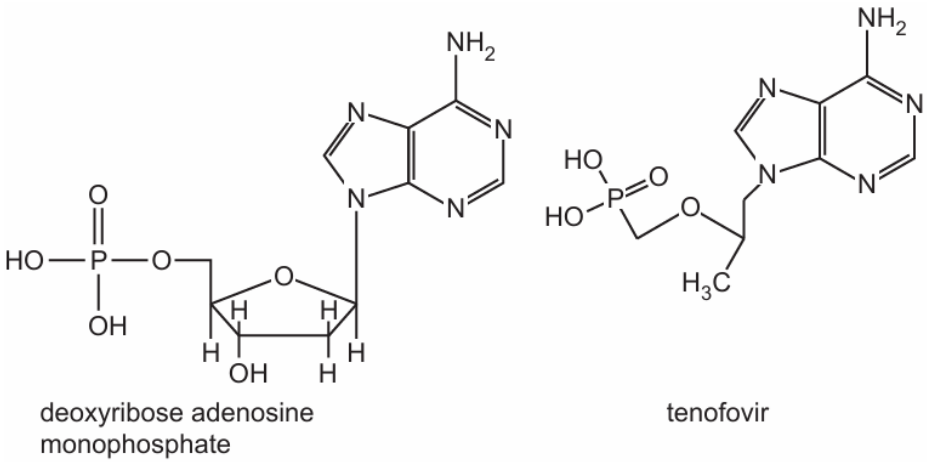
[5]

(b) HIV has a nucleic acid core of RNA. The virus also contains the enzyme reverse transcriptase.

After HIV enters T-lymphocytes, reverse transcriptase catalyses the formation of DNA using activated DNA nucleotides with the viral RNA as a template.

Some drugs, such as tenofovir, have been developed to inhibit the action of reverse transcriptase.

The structure of tenofovir is similar to the structure of deoxyribose adenosine monophosphate, as shown in Fig. 3.2.



deoxyribose adenosine monophosphate

tenofovir

Fig. 3.2

After tenofovir is absorbed into cells it is phosphorylated twice and can be used by reverse transcriptase in the synthesis of DNA.

When a tenofovir molecule is added to the DNA strand being synthesised, the process stops.

Suggest the mechanism of action of tenofovir to prevent the synthesis of DNA by reverse transcriptase. Use the information in Fig. 3.2 in your answer.

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(c) Pre-exposure prophylaxis (PrEP) is the use of therapeutic drugs to prevent the replication of HIV in the body following infection. The drugs are taken by people who are at risk of becoming infected. Tenofovir is one of these therapeutic drugs.

In 2016, the United Nations (UN) set a global target of 3 million PrEP users by 2020.

Table 3.1 shows the number of people across the world who received a therapeutic drug for PrEP in each of the years between 2012 and 2019.

Table 3.1

year	number of people who received PrEP
2012	10 000
2013	15 000
2014	27 500
2015	57 500
2016	95 000
2017	145 000
2018	340 000
2019	605 000

(i) Calculate the percentage of people who received PrEP in 2019 as a percentage of the target set by the UN in 2016.

Give your answer to the nearest whole number.

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(ii) PrEP does not prevent transmission of HIV.

State **and** explain how health authorities can reduce the transmission of HIV.

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2 Some people who are infected with HIV have HIV/AIDS.

(a) State the full term for HIV.

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(b) Following transmission of HIV, early diagnosis of infection and treatment with anti-retroviral therapy (ART) helps to control the spread of the pathogen and prevent HIV/AIDS.

Suggest why treating people who have developed HIV/AIDS with ART may help to reduce the number of overall deaths from infectious diseases, such as cholera, TB and malaria.

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3 People who become infected with human immunodeficiency virus (HIV) are at risk of developing HIV/AIDs, particularly if antiretroviral therapy (ART) is not available.

(a) In people infected with HIV, the use of ART also helps to reduce transmission of the virus to uninfected people.

Outline **two** control methods, other than ART, that can be used to reduce the transmission of HIV.

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4 Malaria is an infectious disease caused by the protoctist, *Plasmodium*.

As part of its lifecycle, *Plasmodium* infects human red blood cells. Researchers can compare haemoglobin from the red blood cells of a healthy person with haemoglobin from a person with malaria.

(a) Throughout the world, most deaths from malaria are caused by *P. vivax* and *P. falciparum*.

Name **one** other species of *Plasmodium* that causes malaria.

Plasmodium ..... [1]

5 **(b)** Tuberculosis (TB) is an infectious disease that affects the human gas exchange system.

The pathogen that causes TB secretes a protein that can be detected in saliva.

Early diagnosis of TB is important in reducing the transmission of the pathogen.

Scientists have developed a test strip for TB that uses monoclonal antibodies. Monoclonal antibodies are specific in their action.

This test strip contains:

- mobile monoclonal antibodies that bind to one part of the protein secreted by the pathogen
- immobilised monoclonal antibodies.

Fig. 3.2 shows a simplified diagram of the test strip.

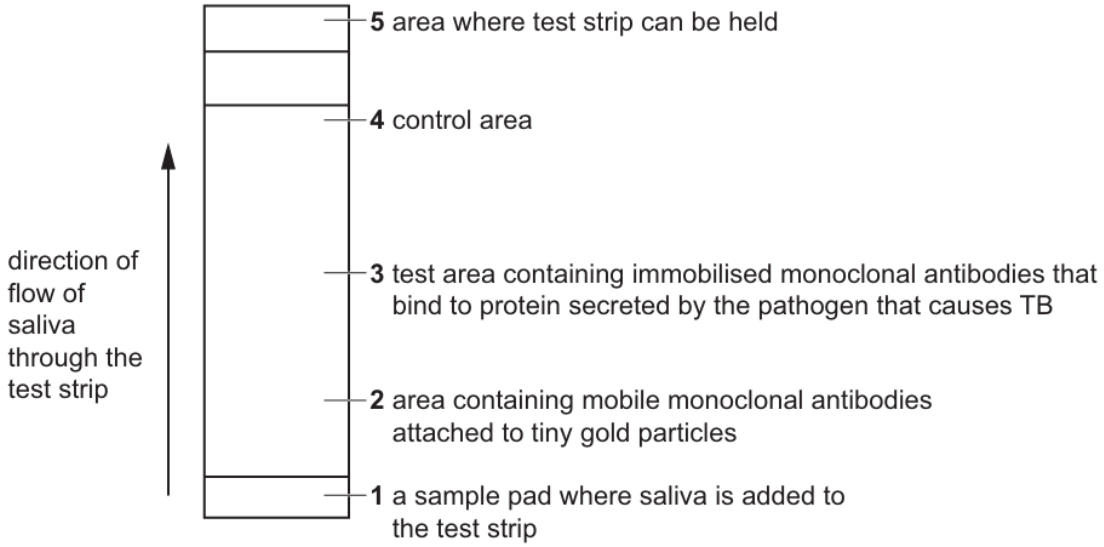


Fig. 3.2

A sample of saliva is collected and put onto the sample pad in the test strip.

The saliva moves up the test strip through area **2**.

The mobile monoclonal antibodies are attached to tiny gold particles. If these antibodies collect in test area **3**, a gold line becomes visible on the test strip.

A gold line that becomes visible in area **4** confirms that the test strip is working and that the results are valid.

(i) State the name of the pathogen that causes TB.

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6 *Trypanosoma brucei* is a unicellular organism that causes the infectious disease known as sleeping sickness. Insects known as tsetse flies pass on the organism from infected people to uninfected people when male and female tsetse flies feed on human blood.

(b) Malaria is an infectious disease caused by organisms belonging to the genus *Plasmodium*.

(i) State the term used to describe an organism that causes disease.

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(ii) Name **one** of the species of *Plasmodium* that causes malaria.

Plasmodium ..... [1]

(c) Outline the similarities **and** differences between the modes of transmission of malaria and sleeping sickness.

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7 Tuberculosis (TB) is an infectious disease caused by a bacterium. In the majority of people, only the lungs are affected.

In most cases, the transmission of TB from an infected person to an uninfected person involves *Mycobacterium tuberculosis*. A different species of bacterium is involved in the transmission of TB from cattle, such as dairy cows, to humans.

(a) Name the species of bacterium causing the transmission of TB from dairy cows to humans.

..... [1]

(b) In some areas, cattle cannot be regularly tested or treated for TB. In these areas, milk and dairy products from infected dairy cattle may enter the human food chain.

Outline a control measure that can be taken to protect people that consume milk and dairy products from these infected cattle.

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(c) Cattle are not usually affected by *M. tuberculosis*, but the pathogen can cause disease in other animals.

A few cases of transmission of TB from people to animals have been reported.

Explain the most likely mode of transmission of TB from an infected person to an animal.

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(d) In most people, the response of the immune system to the infection of lung tissue by *M. tuberculosis* can prevent the spread of the bacterium to other organs of the body. The bacterium is contained in the lungs in a dormant state. This is known as latent TB.

Outline the treatment that is used to kill *M. tuberculosis* in latent TB infections.

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8 Some people who are infected with HIV develop HIV/AIDS.

(a) Fig. 4.1 shows the number of people that have been newly infected with HIV (new infections) in 2018 across the world and the percentage changes in the number of new infections since 2010.

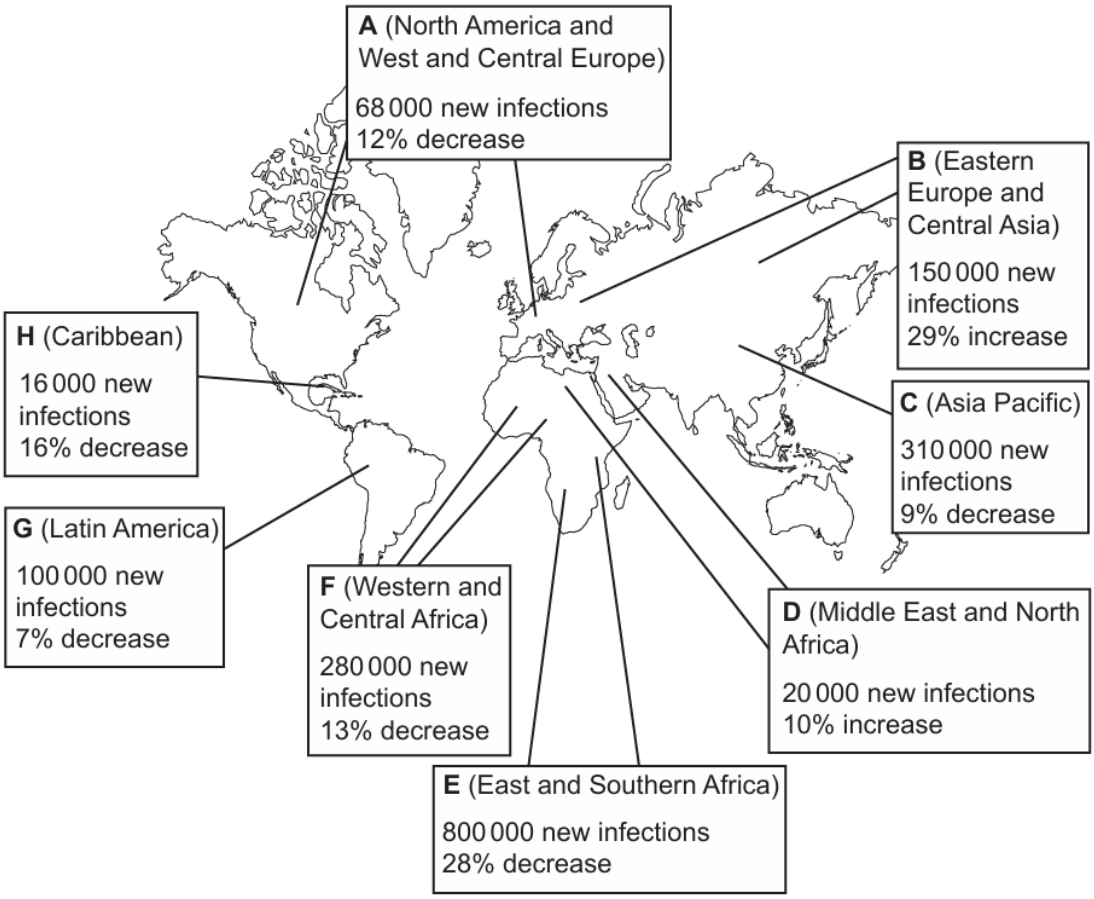


Fig. 4.1

(i) State the full name of the pathogen HIV.

..... [1]

(ii) Using **only** the data in Fig. 4.1, state what can be concluded about the change in number of new HIV infections across the world between 2010 and 2018.

You may use the letters in Fig. 4.1 to identify the regions of the world.

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9 Cholera is a life-threatening and infectious disease caused by the bacterium *Vibrio cholerae*. One of the symptoms of the disease is severe diarrhoea.

V. cholerae O1 and *V. cholerae* O139 are the two forms of the pathogen that are associated with cholera epidemics (large outbreaks). These two forms have different antigens that can be detected.

(a) If an outbreak of cholera is suspected but not confirmed, a standard home treatment for diarrhoeal diseases can be used immediately to help prevent severe illness as a result of dehydration. If cholera is the cause of the disease, this standard treatment also helps to prevent a larger outbreak of the disease.

(i) Outline the standard treatment that can be used for suspected cholera cases.

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(ii) Suggest **and** explain why this treatment can help to prevent a larger outbreak of cholera.

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10 **(a)** Infectious diseases are caused by pathogens and are described as transmissible diseases.

Explain what is meant by the term transmissible.

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(c) Table 5.1 shows data on large outbreaks of cholera that occurred in seven countries in 2019.

The case-fatality rate is the number of deaths as a percentage of the number of cases.

Table 5.1

country	number of cases of cholera	number of deaths from cholera	case-fatality rate /%
Cameroon	1307	55	4.2
DR Congo	29087	501	1.7
Haiti	684	3	0.4
Kenya	5150	39	0.8
Somalia	9968	50	0.5
Sudan	346	11	3.2
Yemen	2260495	3767	

(i) Complete Table 5.1 by calculating the case-fatality rate for Yemen. [1]

(ii) Suggest why large outbreaks of cholera occurred in the countries listed in Table 5.1, but there were very few cases in most other countries.

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11 *Plasmodium falciparum* is one species of *Plasmodium* that causes the life-threatening disease malaria. With early diagnosis and the correct drug treatment, the pathogen can be eliminated from the body, particularly if the disease is not severe.

(a) Name the type of pathogen that causes malaria.

..... [1]

(b) To help prevent the development and spread of drug resistance in *Plasmodium*, the World Health Organization (WHO) recommends using a treatment known as artemisinin-based combination therapy (ACT).

ACT involves two different types of drug:

- a fast-acting drug derived from a compound known as artemisinin, which causes a rapid decrease in the number of *P. falciparum*
- one or more longer-acting, non-artemisinin, drugs that eliminate any remaining pathogens.

(i) Suggest why using ACT with the two different types of drug is more effective in preventing the development of drug resistance in *Plasmodium* than a treatment using only one type of drug.

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(ii) In some areas, partial artemisinin resistance has developed. This means ACT takes a longer time for the pathogen to be eliminated from the body.

Explain why there is an increased risk of transmission of the pathogen to other people if a person is receiving ACT and the pathogen has partial artemisinin resistance.

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(c) ACT can act on the stage of the life cycle of *P. falciparum* that occurs within red blood cells. The cells of *P. falciparum* in this stage are known as trophozoites.

Fig. 3.1 is a photomicrograph of a blood smear (thin layer of cells). Some of the red blood cells contain trophozoites.

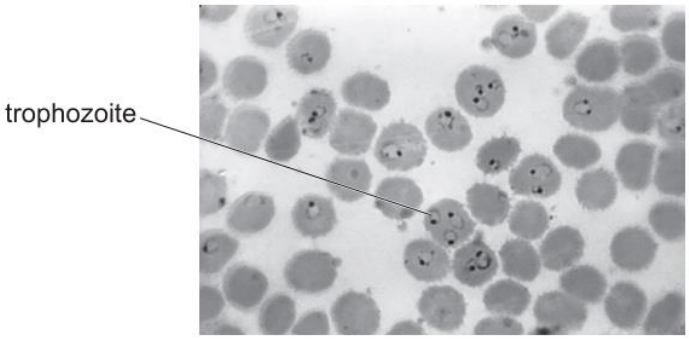


Fig. 3.1

PfK13 is a protein that has an important role in the development of the trophozoite stage of *P. falciparum*. The gene *kelch13* codes for PfK13.

Two different mutations of *kelch13*, known as F446I and C580Y, were investigated to see if they were associated with partial artemisinin resistance. Details of these mutations are summarised in Table 3.1.

Table 3.1

name of mutation	change in DNA		change in protein PfK13	
	nucleotide present in *kelch13*	**nucleotide present after mutation**	**amino acid before mutation**	**amino acid after mutation**
F446I	thymine (T)	adenine (A)	phenylalanine (phe)	isoleucine (ile)
C580Y	guanine (G)	adenine (A)	cysteine (cys)	tyrosine (tyr)

(ii) In the investigation, the survival rate of trophozoites within red blood cells was determined for two different concentrations of an artemisinin-based drug known as DHA.

Two different strains, **A** and **B**, of *P. falciparum* were tested. Three different cultures of each strain were involved:

- no mutation in *kelch13* (control)
- *kelch13* F446I mutation
- *kelch13* C580Y mutation.

Table 3.2 shows the six different cultures tested and the trophozoite survival rate for each culture.

Table 3.2

culture number	culture details	mean percentage survival rate of trophozoite	
		DHA concentration 20 nmol dm^{-3}	DHA concentration 700 nmol dm^{-3}
1	strain **A** no mutation	3.15	0.00
2	strain **A**, F446I mutation	26.00	0.73
3	strain **A**, C580Y mutation	33.08	0.91
4	strain **B** no mutation	2.86	0.00
5	strain **B**, F446I mutation	13.50	0.53
6	strain **B**, C580Y mutation	17.50	0.63

State the main conclusions that can be drawn from the results shown in Table 3.2.

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12 **(d)** Some insects are vectors of disease.

(i) When an insect feeds on the xylem fluid it can act as a vector of plant diseases such as Pierce's disease. This bacterial disease affects many fruit trees causing the leaves to turn brown and drop from the plant, resulting in much less fruit being produced.

Explain why Pierce's disease can be described as an infectious disease.

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(ii) Malaria is another infectious disease that also involves an insect vector.

State the type of organism that causes malaria **and** name **one** organism that causes malaria in humans.

type of organism .....

name .....
[2]

13 The diseases myasthenia gravis (MG) and HIV/AIDS both involve disorders of the immune system.

(d) Fig. 6.1 is a summary of some of the statistics published by UNAIDS (Joint United Nations Programme on HIV and AIDS) about HIV and HIV/AIDS for the year 2017.

The figures shown in Fig. 6.1 for 2017 are estimated.

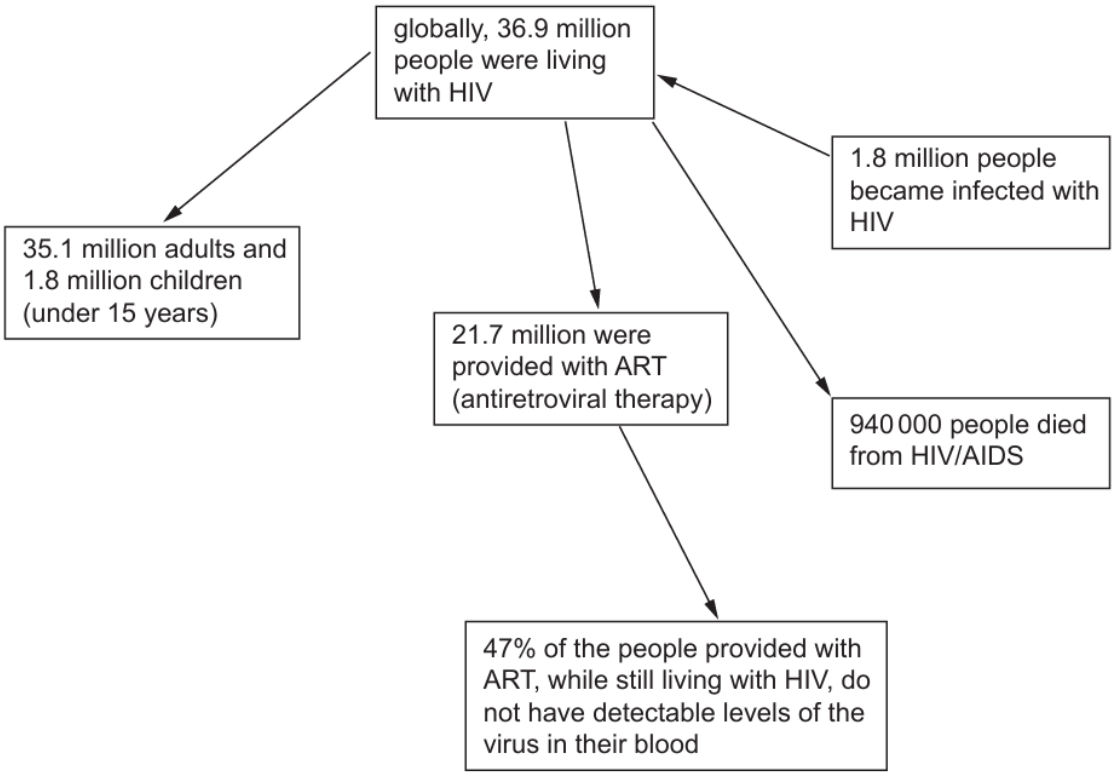


Fig. 6.1

One other statistic published by UNAIDS indicated that, in 2017, only 75% of the estimated 36.9 million people living with HIV knew that they had been infected with the virus.

With reference to the information in Fig. 6.1, discuss the importance of this statistic.

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14 Much success was made in reducing the number of cases of malaria between 2000 and 2015.

(a) Explain how malaria is transmitted.

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15 Much success was made in reducing the number of cases of malaria between 2000 and 2015.

(d) The highest number of cases of malaria occur in sub-Saharan Africa and South-East Asia.

Discuss the factors that determine the global distribution of malaria.

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16 Baculovirus is a virus that kills some of the insect pests of major crops. When the virus is released to the outside of the insect body, it is contained within stable, protective structures known as polyhedrons.

The main component of the polyhedron is a protein molecule, polyhedrin.

Polyhedrons can be sprayed onto plants as a bioinsecticide. They are ingested by feeding insect larvae and once inside the insect gut they break down to release the virus.

(a) Explain why the term infectious disease can be used to describe the effect of baculovirus on insects.

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17 The causative organism of measles is *Morbillivirus*. Young children who have not been vaccinated for measles are at highest risk of becoming ill and of developing complications associated with the disease.

(b) Describe how measles is transmitted.

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(d) Smallpox is a disease that has been eradicated with the help of a global vaccination programme. Measles has not been eradicated, even though there is a global vaccination programme.

Fig. 5.2 is a graph showing the estimates of number of deaths from measles globally, between 2000 and 2017, for people who have **not** been vaccinated.

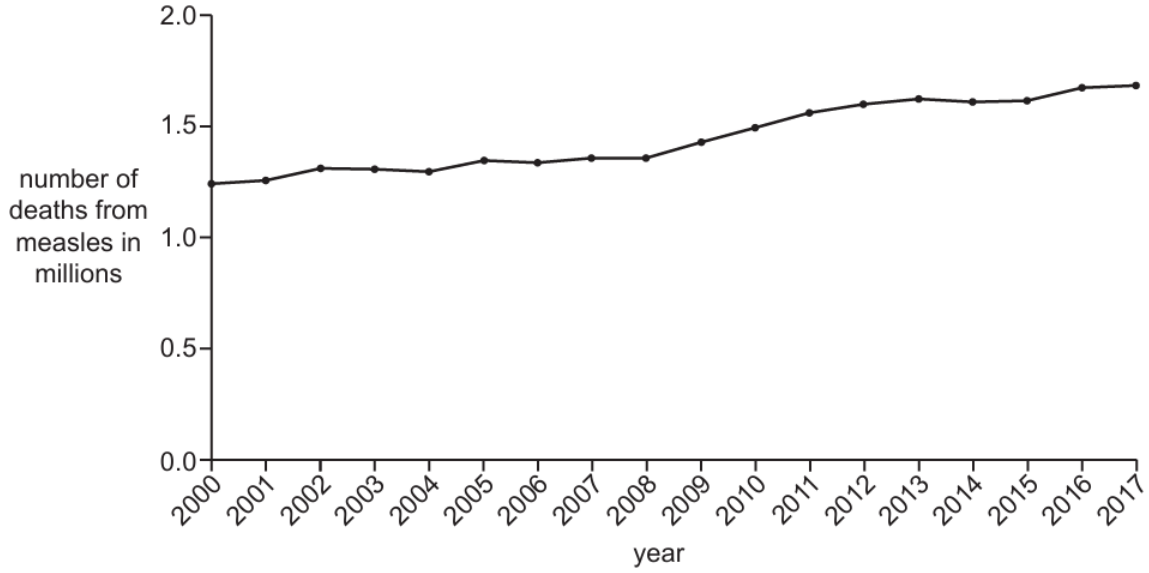


Fig. 5.2

(i) State the trend shown in Fig. 5.2 between 2000 and 2017.

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(ii) Suggest reasons for the trend shown in Fig. 5.2.

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18 Cholera is an infectious disease caused by the bacterial pathogen *Vibrio cholerae*.

(a) Describe how *V. cholerae* is transmitted from an infected person to an uninfected person.

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19 The Bacillus Calmette-Guérin (BCG) vaccine is the only vaccine used to provide protection against the infectious bacterial disease tuberculosis (TB). Most countries of the world have a BCG vaccination programme.

(a) TB is most commonly transmitted from person to person by aerosol infection. The causative organism is present in airborne droplets.

Name the species of causative organism of TB commonly passed from person to person by aerosol infection.

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(b) In general, the countries that do not have a BCG vaccination programme are high-income countries that have a low number of cases of TB. In most of these countries, the vaccine is given only to babies and children at high risk of developing TB.

Suggest **one** reason why a child in a country with a low number of cases of the disease could be at a high risk of developing TB.

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(c) Countries are classified by the World Bank into one of four income groups.

Table 3.1 shows the estimated incidence of TB for 2012 to 2016 for these income groups.

The incidence represents the number of new cases of TB occurring per 100 000 people in one year. The new cases include the number of cases that have occurred again after a period of recovery (relapse TB).

Table 3.1

	incidence per 100 000 people				
year / **income group**	**2012**	**2013**	**2014**	**2015**	**2016**
low	253	244	238	231	224
lower middle	244	240	236	232	227
upper middle	84	81	78	76	74
high	14	13	13	12	12

Describe the patterns and trends shown in Table 3.1.

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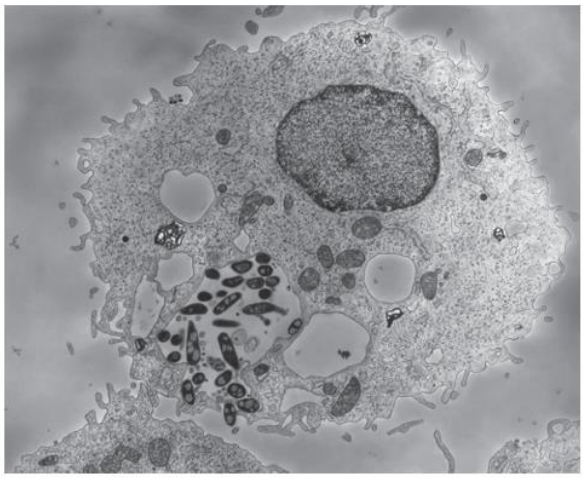
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20 The vaccine used to control tuberculosis (TB) is known as Bacillus Calmette-Guérin (BCG). The vaccine contains live bacteria that have been selected so that they do not cause disease in humans.

Fig. 5.1 shows a macrophage that is in the process of engulfing the bacteria in the vaccine.



magnification ×4400

Fig. 5.1

(a) (i) Name the pathogen that causes TB.

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(ii) Describe how this pathogen is transmitted.

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(d) Suggest why vaccination with BCG has not yet eradicated TB.

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21 Fig. 2.1 is a transmission electron micrograph showing the bacterial pathogen that causes tuberculosis (TB).

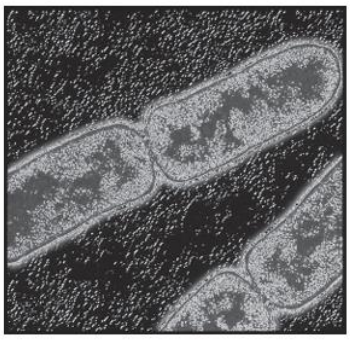


Fig. 2.1

(a) (i) Name the pathogen shown in Fig. 2.1 that causes TB.

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22 Countries that have a high number of cases of malaria also have problems with diseases caused by bacteria. This means that many people in these countries are prescribed antibiotics, such as penicillin, for the treatment of bacterial infections.

The female *Anopheles* mosquito is the vector of the *Plasmodium* pathogen that causes malaria. The insect takes in *Plasmodium* when feeding on blood from an infected person. At a later stage the insect can transmit the pathogen when taking a blood meal from an uninfected person.

(b) Name **one** of the four species of *Plasmodium* that can cause malaria.

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(c) The male *Anopheles* mosquito does not feed on blood and so does not act as a vector.

Suggest why there is a difference in this feeding behaviour between male and female *Anopheles*.

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(d) Research has shown that *Plasmodium* is not always transmitted to uninfected people.

Two main reasons for this have been suggested.

- The immune system of mosquitoes kills *Plasmodium* while it is still in the gut.
- Bacteria living in the gut of mosquitoes compete with *Plasmodium* so it does not survive to continue its life cycle.

A study was carried out to see if taking antibiotics affects the risk of transmission of malaria.

Some observations and results of the study are summarised in Fig. 5.1.

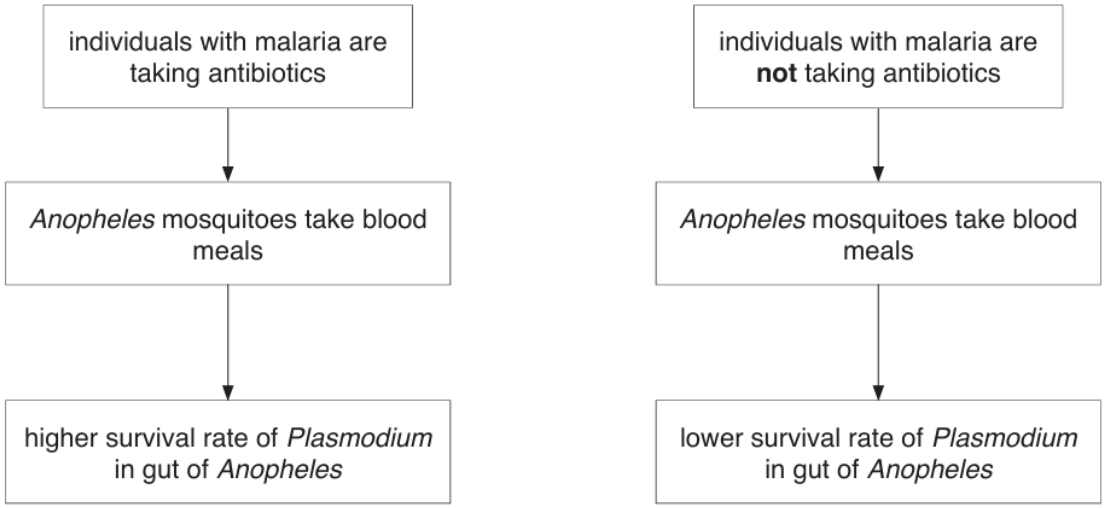


Fig. 5.1

Suggest explanations for the results shown in Fig. 5.1 **and** comment on the importance of these results for doctors working in countries that have malaria and a high number of bacterial infections.

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23 The bacterium *Vibrio cholerae* is the causative organism of the infectious disease cholera.

V. cholerae has structural features typical of all bacterial cells. It also has a flagellum for movement.

(b) The World Health Organization (WHO) collects data about cholera from the 194 countries that are members of the World Health Assembly (WHA).

In 2015:

- there were cases of cholera in 42 of the member countries of the WHA
- the total number of cases of cholera reported was 172 454
- there were deaths as a result of cholera in 23 of these countries
- the total number of deaths from cholera reported was 1304.

The case fatality rate for cholera is the proportion of cases of cholera that results in death within a particular time period.

A country with cases of cholera that are properly treated should have a case fatality rate of less than 1%.

(i) Calculate the case fatality rate for the 42 member countries of the WHA for 2015.

Give your answer to the nearest 0.1%.

case fatality rate = ... % [1]

(ii) Many of the 23 countries reporting deaths from cholera in 2015 had a case fatality rate of less than 1%.

However, two of the 23 countries had case fatality rates greater than 5%.

Suggest **two** explanations for the higher case fatality rate in these two countries.

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(c) In 2010, the country of Haiti experienced a major earthquake. This led to an outbreak of cholera.

(i) Explain why an earthquake may lead to a cholera outbreak.

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(ii) Fig. 4.2 shows data about cholera collected by WHO over a period of 8 years, from 2008 to 2015. These data include:

- the total number of cases of cholera for each year
- the number of countries in each year that had cases of cholera.

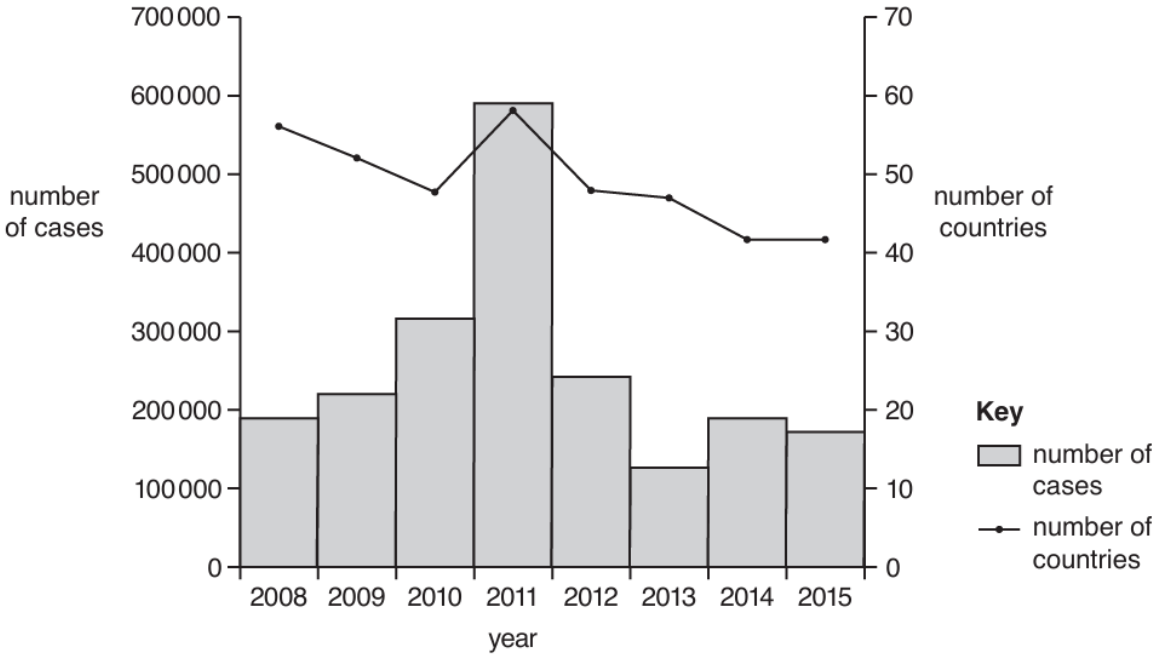


Fig. 4.2

Comment on the trends shown in Fig. 4.2.

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24 When tobacco smoke is inhaled, chemicals such as nicotine and carbon monoxide enter the circulatory system through the gas exchange system. Tar builds up on the lining of the gas exchange system.

Many people decide to give up smoking tobacco in order to improve their health.

(d) A person who gives up smoking decreases their risk of developing lung cancer, a non-infectious disease.

Explain why lung cancer is described as a *non-infectious disease*.

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25 Viruses share common structural features. Some viruses, such as human immunodeficiency virus (HIV), also have an outer envelope as part of their structure.

HIV can remain in a dormant state within infected immune system cells for many years. A person diagnosed as HIV-positive (HIV+) has the virus but does not have symptoms of HIV/AIDS.

The chances of an HIV+ person developing HIV/AIDS can be greatly reduced with a drug treatment programme known as anti-retroviral therapy (ART).

(b) In 2010, the World Health Organization (WHO) published recommendations for the treatment of pregnant women living with HIV. This includes both HIV+ women and women who have developed HIV/AIDS.

The publication recommended that **all** pregnant and breastfeeding women living with HIV should be provided with ART.

Fig. 4.1 shows the number of pregnant women living with HIV, and the number of these receiving ART, between 2005 and 2013, in low and middle income countries.

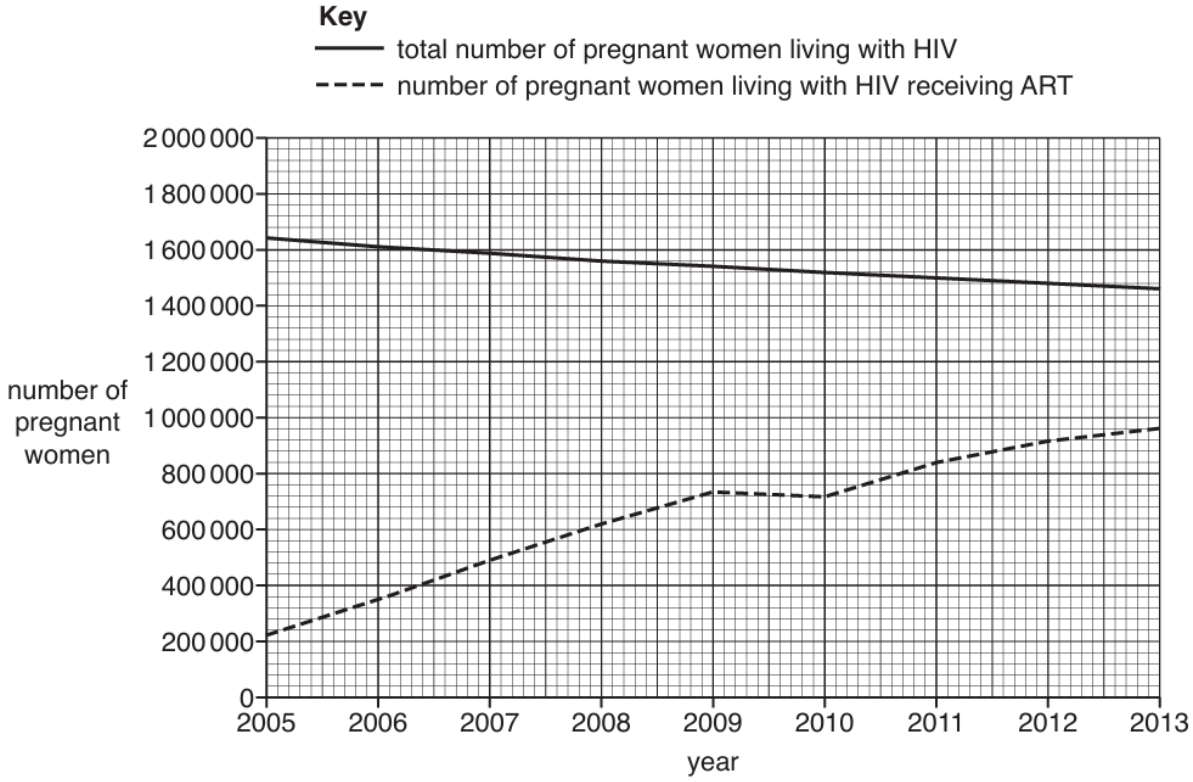


Fig. 4.1

(i) From the data in Fig. 4.1, it can be calculated that 13% of pregnant women living with HIV received ART in 2005.

Calculate the percentage of pregnant women living with HIV that received ART in 2013.

answer = ... % [1]

(ii) Describe the trends shown in Fig. 4.1.

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(iii) Suggest **and** explain the global importance of providing ART to all pregnant and breastfeeding women living with HIV.

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..... [3]

26 Fig. 1.1 shows the human gas exchange system.

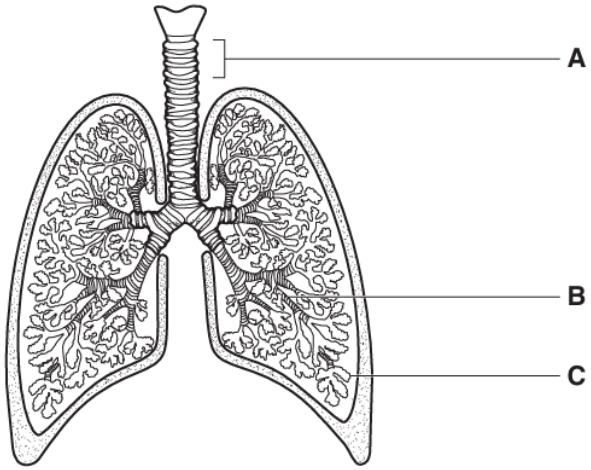


Fig. 1.1

(c) Malaria is an infectious disease.

Name the pathogen that causes malaria.

..... [1]

(d) There are a number of vaccines being developed to help control the spread of malaria.

Explain why vaccination programmes have **not** been able to eradicate malaria.

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..... [3]

(e) Fig. 1.2 shows the distribution of malaria in the Americas in 2012.



Fig. 1.2

Suggest the factors, **other than** lack of vaccines, that could be restricting the distribution of malaria to area **P**.

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..... [4]