HODDER Education

Biological Sciences review

www.hoddereducation.com/biologicalsciencesreview

Volume 37, Number 1, September 2024

Activity

Phages as lifesavers

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Introduction

Use information from Claudia Igler's article, *Phages as lifesavers: promises and challenges*, and your own knowledge to answer the following questions.

Questions

1 The article refers to humans, bacteria and bacteriophages.

a The table below lists these biological entities along with a number of biological features.

Complete the table by placing a tick (✓) in each box that shows a feature of each biological entity. [2 marks]

Biological entity	Contains nucleic acid	Contains mitochondria	Contains 70S ribosomes	May contain circular DNA	May have a protein capsid
Human cell					
Bacterial cell					
Bacteriophage					

b Suggest why the question above refers to 'biological entities', rather than to organisms. [1 mark]

2 Many species of bacteria have become resistant to antibiotics.

a Give **two** processes that can lead to a bacterial cell acquiring antibiotic resistance. [1 mark]
b Suggest and explain **two** features of antibiotic-resistant bacteria that enable them to overcome the effects of an antibiotic. [2 marks]

3 Fluoroquinolones are one type of antibiotic. They are termed 'broad-spectrum antibiotics' and cause damage to bacterial DNA, resulting in the death of the bacterial cells.

a Explain the term 'broad-spectrum antibiotic'. [1 mark]

b Explain why damage to its DNA could cause an affected cell to die. [2 marks]

c DNA damage caused by fluoroquinolones can trigger a process known as the 'SOS response' in the affected bacteria.

The SOS response repairs the damaged DNA in bacteria and increases the rate of genetic mutations.

Suggest how an increase in the rate of genetic mutations could be of benefit to affected bacteria. [2 marks]

d Ciprofloxacin is one type of fluoroquinolone.

A team of scientists tested the ability of different compounds, A, B and C, to increase the effectiveness of different antibiotics, including ciprofloxacin.

Using cultures of methicillin-resistant *Staphylococcus aureus* (MRSA), they measured the minimum inhibitory concentration (MIC) of each antibiotic with, and without, the addition of compounds A, B and C.

The minimum inhibitory concentration (MIC) is defined as the lowest concentration capable of preventing bacterial growth in laboratory cultures.

The table below summarises their results.

Antibiotic	MIC/ mol $dm^{-3} \times 10^{-6}$	MIC-fold decrease		
		With A	With B	With C
Ampicillin	2.7	2	1	1
Cefazoline	2.2	2	1	1
Ciprofloxacin	24.2	1	2	2
Gentamicin	2.1	2	2	4
Linezolid	5.6	1	1	1
Vancomycin	0.6	2	1	2

The MIC-fold decrease is a measure of the reduction of the minimum inhibitory concentration resulting from the addition of compounds A, B or C to the antibiotic. For example, an MIC-fold decrease of 1 shows that the minimum inhibitory concentration was half that of the antibiotic alone.

Give **three** conclusions you can make from the data in the table above. [3 marks]

4 Treatment using bacteriophages has potential advantages over treatment using antibiotics.

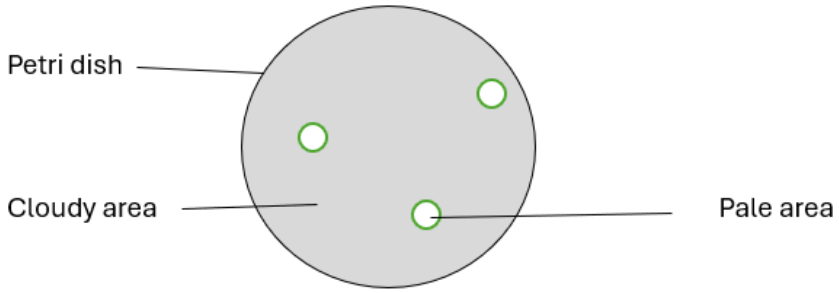
Identify and explain **two** of these advantages. [2 marks]

5 A scientist demonstrated the effects of a bacteriophage on a species of bacterium.

They used the following procedure:

1. Inoculate liquid agar with the bacterial species.
2. Add a dilute sample of the bacteriophage to the liquid agar.
3. Pour the liquid agar into a number of Petri dishes and allow the agar to set.
4. Incubate the Petri dishes at 25°C.

The diagram below shows the appearance of one of the Petri dishes after being incubated for 24 hours.



a Describe and explain **one** precaution that the scientist would have used when pouring the inoculated agar into the Petri dishes. [2 marks]

b Explain the appearance of the cloudy area and pale areas in the agar. [2 marks]

c Suggest how the pale areas would change if the scientist incubated the Petri dishes for a further 12 hours. Explain your answer. [2 marks]

Model answers

1 **a** All rows correct = 2 marks; 2 rows correct = 1 mark; fewer than 2 rows correct = no mark

Biological entity	Contains nucleic acid	Contains mitochondria	Contains 70S ribosomes	May contain circular DNA	May have a protein capsid
Human cell	✓	✓	✓	✓	
Bacterial cell	✓		✓	✓	
Bacteriophage	✓				✓

b Human cells and bacterial cells have an active metabolism, but bacteriophages do not.

OR

Human cells and bacterial cells are alive, but bacteriophages are not.

2 **a** (Gene) mutation and horizontal gene transfer

OR

(Gene) mutation and bacterial conjugation

b Change in tertiary structure of surface protein so phage cannot attach to bacterial cell

Production of protein / anti-enzyme that reduces / prevents activity of (key) phage enzyme

3 **a** Antibiotic is effective against several species of bacteria

b Damaged DNA will result in no / incorrect (DNA) transcription

So vital proteins / enzymes will not be produced

c Some (random) mutation might result in resistance to antibiotic

d Credit any three conclusions, for example:

Ciprofloxacin has the highest MIC / vancomycin has the lowest MIC

A, B and C reduce the MIC of all antibiotics

Linezolid shows the smallest reduction in MIC across all antibiotics

Gentamicin shows the greatest reduction in MIC across all antibiotics

Compound B is the least effective in reducing MIC

4 A phage attaches to a type of surface receptor found only on a specific bacterial cell, so will not infect human cells.

New phage particles / virions are (repeatedly) released by dead bacterial cells, so fewer treatments are needed.

5 **a** Lift lid of Petri dish at a slight angle (or use a laminar flow hood)

To reduced risk of bacteria from air contaminating culture

b Cloudy areas show growth of bacteria

Pale areas show where phage has killed bacteria

c They would be larger OR there would be more of them

(New) virus particles / virions would infect and kill more living bacterial cells