

Antibiotics

Question Paper 3

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Infectious disease
Sub Topic	Antibiotics
Booklet	Theory
Paper Type	Question Paper 3

Time Allowed : 76 minutes

Score : / 63

Percentage : /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Antibiotics are drugs which are very important in the treatment and cure of some diseases.

(a) Underline the disease or diseases in the list below which are treatable with antibiotics.

cholera

malaria

HIV/AIDS

tuberculosis (TB)

[1]

(b) When patients are prescribed a course of antibiotics, they must not stop taking the antibiotics as soon as they start to feel better, or when they feel that the disease symptoms have gone.

Explain the importance of taking a complete course of antibiotics.

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(c) Some antibiotics act as competitive inhibitors of enzymes in pathogens.

(i) Describe what is meant by the term competitive inhibitor.

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Penicillin acts as a competitive inhibitor of one of the enzymes involved in bacterial cell wall synthesis.

(ii) State why penicillin, which is an enzyme inhibitor, can be taken by humans.

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(iii) Suggest the effect which penicillin will have on bacterial cells.

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[Total: 11]

- 2 (a) Penicillin belongs to a group of antibiotics known as β lactams, which all act in the same way on bacteria.

Describe how penicillin kills non-resistant bacteria.

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- (b) One of the ways in which a bacterium may be resistant to an antibiotic, such as a β lactam, is by having protein pumps in its cell surface membrane which expel the antibiotic from the bacterium.

The gene coding for such an efflux pump is carried on a plasmid.

Outline how the bacterium produces an efflux pump from a gene on a plasmid.

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- (c) A strain of the bacterium *Pseudomonas aeruginosa*, strain **R**, has a gene coding for an efflux pump and is resistant to a β lactam antibiotic.

The minimum inhibitory concentration (MIC) of the β lactam for strain **R** was determined. The MIC is the lowest concentration of antibiotic that prevents a colony of the bacterium from growing.

The MICs were also determined for two mutant strains derived from strain **R**, mutant strain **1** and mutant strain **2**. Each of these strains differs from strain **R** in the expression of the gene coding for the efflux pump.

The MICs for the three strains of *P. aeruginosa* are shown in Table 2.1.

Table 2.1

strain of <i>P. aeruginosa</i>	MIC of β lactam / $\mu\text{g cm}^{-3}$
resistant strain R	64
mutant strain 1	0.5
mutant strain 2	256

With reference to Table 2.1, suggest:

- (i) why the MICs for mutant strains **1** and **2** differ from that for strain **R**

mutant strain 1

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mutant strain 2

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3 Penicillin-binding proteins (PBPs) are proteins found in the cell surface membranes of bacteria. PBPs catalyse the final steps in the production of a peptidoglycan cell wall.

(a) From the information given above, describe the likely molecular structure of a PBP.

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(b) Penicillin-resistant mutants of the bacterium, *Staphylococcus aureus*, produce a PBP, PBP2a, that does not bind well with penicillin.

Suggest how the presence of PBP2a in the cell surface membrane provides *S. aureus* with resistance to the effects of penicillin.

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(c) Explain why penicillin does not affect viruses.

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[Total: 7]

- 4 The disease-causing bacterium, *Pseudomonas aeruginosa*, may occur in the form of a 'biofilm'. A biofilm consists of a layer of bacteria, growing on a surface and attached to one another. Such biofilms are difficult to control by antibiotics.

A mutant strain of *P. aeruginosa* has been found which produces biofilms that are indistinguishable from those of the wild-type bacteria. However, the mutant strain differs from the wild-type in its resistance to an antibiotic, **A**.

(a) Antibiotic **A** belongs to a group of antibiotics known as anti-pseudomonal penicillins.

(i) Describe the mode of action of penicillin on bacteria.

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(ii) Explain why penicillin does not affect viruses.

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- (c) The wild-type and mutant strains of this bacterium have different DNA sequences in part of a gene coding for an enzyme which is needed to produce polymers of glucose, called glucans. Glucans are secreted by bacteria and can bind to various molecules, including those of antibiotic **A**.

Explain

- (i) how a mutation of a gene coding for an enzyme may result in an enzyme with reduced activity,

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- (ii) the different effects of antibiotic **A**, shown in Fig. 2.1, on the wild-type and mutant strains of bacteria.

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- (d) Explain the role of natural selection in the evolution of antibiotic resistance in bacteria.

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[Total: 16]

- 5 (a) Cell walls of bacteria contain peptidoglycans. Peptidoglycans are long chains of the sugars N-acetylmuramic acid (NAM) and N-acetylglucosamine (NAG) which alternate along the chain. A short peptide chain of three to five amino acids is attached to each NAM and these form cross-links with similar peptide chains from adjacent strands.

Fig. 3.1 shows a diagram representing part of a peptidoglycan structure.

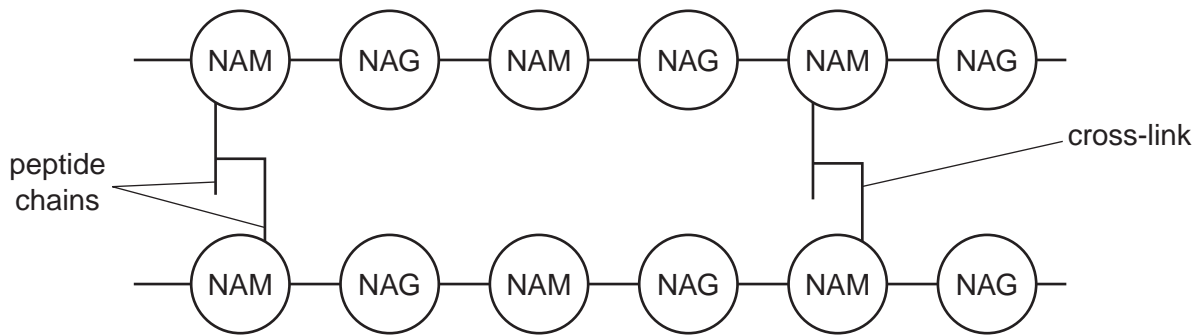


Fig. 3.1

- (i) Name the type of reaction that takes place to assemble the peptide chains that form the cross-links.

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- (ii) Describe the mode of action of antibiotics, such as penicillin, on bacteria.

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- (iii) Suggest the name of the type of enzyme that assembles the peptide chains that form the cross-links in peptidoglycans.

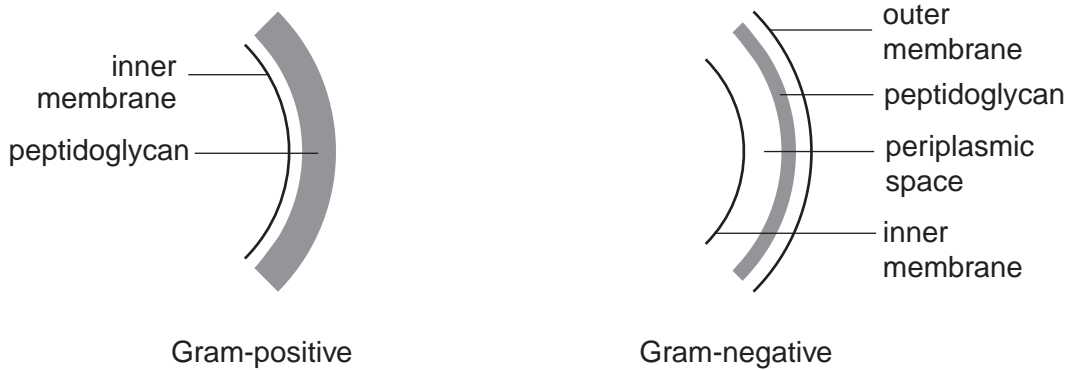
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(b) State why antibiotics, such as penicillin, have no effect on viruses.

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(c) Bacteria may be Gram-positive or Gram-negative.

Fig. 3.2 shows a diagram of part of the cell walls of both Gram-positive and Gram-negative bacteria.



Gram-positive bacteria cell walls have a peptidoglycan content of 50%

Gram-negative bacteria cell walls have a peptidoglycan content of 10 – 20%

Fig. 3.2

Suggest why Gram-positive bacteria are more susceptible to the action of penicillin than Gram-negative bacteria.

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