Unit 1: Antibiotics and antibiotic sensitivity

TEACHER’S BOOK

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Amb el suport de:
Curricular context:

MP06QU0 Why are bacteria becoming resistant to antibiotics?

Família de Química.

Cicle Formatiu de Grau Superior de Laboratori d’Anàlisi i Control de Qualitat.

Mòdul Professional 06: Assajos microbiològics.

Unitat Formativa 1: Preparació d'equips i mostres. Tècniques de sembra.

Unit 1: Antibiotics and antibiotic sensitivity (timing 5h)

1.1. Warm-up activities
1.2. Vocabulary activities
1.3. Activities I
1.4. Activities II
1.5. Revision activities
1.6. Assessment activities

Introduction:

The selection of a proper antibiotic is crucial for the efficient treatment of bacterial related diseases. A classical laboratory test in order to sort out the most suitable antibiotic to fight an infection is the Antibiotic Susceptibility Testing. This unit, entitled “Antibiotic and antibiotic sensitivity” is intended to give the basics of this technique, which is very often performed by microbiologists, and to raise awareness of the common misuse of antibiotics that is leading us to a generalised antibiotic resistance scenario, and so, a global health problem.

Objectives:

– To get acquainted with the lab ware and techniques of Microbiology.
– To incorporate the use of English in professional situations, and to train the students’ language skills and practice, so as to enable them to work in another country.

Keywords:

Antibiotic, bacterial strain, bacterial culture, bacterial sensitivity and resistance
**1.1 Warm-up activities**

Antibiotics are drugs that either occur in nature naturally or are made synthetically. They are used in the treatment and prevention of bacterial infections.

**Activity 1.1** Start writing all the pros and cons of using antibiotics:

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To learn about antibiotics and bacteria becoming resistant to antibiotics, let’s start watching a nice video. Watch from 0:00 till 2:04. That’s enough!  
[Video - What causes antibiotic resistance? - Kevin Wu - TED-Ed](#)

**Activity 1.2** Write the proper caption under each picture according to the former video.

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1- Antibiotic
2 - Harmful (or pathogenic) bacteria
3 - Harmless and beneficial bacteria
4 - Antibiotic fights against a susceptible (or sensitive) bacterium
5 - Antibiotic defeats a susceptible bacterium
6 - Antibiotic fights against a resistant (or non-sensitive) bacterium
7 - Antibiotic can’t defeat a resistant bacterium
8 - Two bacteria before mutation
9 - Two bacteria after mutation

1.2 Vocabulary activities

The following activities will introduce you to some basic vocabulary concerning antibiotics and the lab ware to perform an AST – Antibiotic Susceptibility Testing.

HIGHLIGHTS

AST is a test that is run on a Petri Dish in which a bacterial strain is spread all over the sterile agar plate (with the help of a plate spreader) and some antibiotic discs (i.e. wafers impregnated with different antibiotics) are set separately onto the surface of it. Bacterial growth after a period of incubation is only allowed in those areas where a certain antibiotic won’t affect on the growing of bacteria (these bacteria are called resistant to that antibiotic), whereas no bacteria will grow close to an antibiotic to which they are non resistant (these bacteria are called sensitive or susceptible to that antibiotic.)

Activity 2.1 Only a few of the next sentences are incorrect (6). Can you match the two columns as in the examples in order to get meaningful sentences?

<table>
<thead>
<tr>
<th></th>
<th>Antibiotic sensitivity</th>
<th>a indicates that an organism, e.g. a microbe is susceptible to an antibiotic, meaning that it can cause its death.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Antibiotic resistance</td>
<td>b is a change in the genome (genetic material) of an organism.</td>
</tr>
<tr>
<td>b</td>
<td>Bacterial strain</td>
<td>c stands for Minimum Inhibitory Concentration, i.e. the amount of antibiotic to which a bacterial culture is inhibited from growth.</td>
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<tr>
<td>c</td>
<td>Serotype</td>
<td>d or serovar is a variation within a species, e.g. bacteria, that has slightly different cell surface antigens from another.</td>
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<td>d</td>
<td>Pathogenic bacteria</td>
<td>e can cause infectious diseases.</td>
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<td>e</td>
<td>Beneficial bacteria</td>
<td>f live in our body, e.g. in our bowels, interacting with our body in a non-detrimental way.</td>
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<td>f</td>
<td>Mutation</td>
<td>g is a low level taxonomic rank, infraspecific level.</td>
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<tr>
<td>g</td>
<td>MIC</td>
<td>h is the opposite of antibiotic sensitivity.</td>
</tr>
<tr>
<td>h</td>
<td>IU</td>
<td>i means that kills a bacterium by serious damage of any part of it.</td>
</tr>
<tr>
<td>i</td>
<td>Antimicrobial</td>
<td>j is an agent that kills microorganisms or inhibits the growth of microbes.</td>
</tr>
<tr>
<td>j</td>
<td>Disinfectant</td>
<td>k is an antimicrobial agent that is nonselective, such as bleach.</td>
</tr>
<tr>
<td>k</td>
<td>Bacteriostatic</td>
<td>l means that paralyses the growth, multiplication or metabolism of a bacterium.</td>
</tr>
<tr>
<td>m</td>
<td>Bactericidal stands for <em>International Units</em> and it is commonly used to measure concentration of medications, vaccines, vitamins, etc.</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>Antiseptics are antimicrobial agents which are applied to living tissue, such as <em>Povidone</em> or <em>Iodine</em>.</td>
<td></td>
</tr>
<tr>
<td>o</td>
<td>Antibiotic is an antimicrobial agent that destroys organisms within the body.</td>
<td></td>
</tr>
</tbody>
</table>

**Activity 2.2** Write the proper caption on each picture.
Micropipette | Autoclavable bottle (with its autoclavable cap) | Bacteriological suspension (it is kept frozen in a vial, a flat-bottomed screw capped tube) | Plastic autoclavable tips for micropipette

1.3 Activities I

Activity 3.1 First, students will try to fill in the gaps from texts number 1 and 2. After that, one student will read aloud text number 1 (from the teacher’s book) in front of the class only once. Simultaneously, the rest of students must fill in the missing words from text number 1. Next, another student will read aloud text number 2 (from the teacher’s book) and the rest of students must fill in the gaps from text number 2. Compare results.

Text 1:

Antibiotic Susceptibility Testing I

Antibiotic sensitivity or antibiotic susceptibility is the susceptibility of bacteria to antibiotics. Because susceptibility can vary even within a species (with some strains being more resistant than others), antibiotic susceptibility testing (AST) is usually done to determine which antibiotic will be most effective in treating a bacterial infection in vivo. Testing for antibiotic resistance is often done by the Kirby-Bauer method. The results of the test are shown on the antibiogram.

Text 2:

Antibiotic Susceptibility Testing II

Small wafers containing antibiotics are placed onto a plate upon which bacteria are grown. If the bacteria are sensitive to the antibiotic, a clear ring, or zone of inhibition, is seen around the wafer indicating poor growth. Other methods to test antimicrobial sensitivity include Agar and Broth dilution methods for minimum inhibitory concentration (MIC) determination. The results of the test are shown on the antibiogram. Antibiotics are drugs that either naturally occur in nature or are made synthetically. They are used in the treatment and prevention of bacterial infections.

The two former 75-word passages were both adapted from the Wikipedia: https://en.wikipedia.org/wiki/Antibiotic_sensitivity

Activity 3.2 You will receive a strip of paper with either a definition or a word written on it. You will stand and circulate around the classroom trying to find your mate whose definition or word match with yours.

1.4 Activities II
Activity 4.1 Watch the video again and tick either T or F whether you think the next statements are True or False according to the video, as in the example. Hint: only one is false!

<table>
<thead>
<tr>
<th>T/F</th>
<th>Min:XX</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>T/F</td>
<td>0:37</td>
<td>A. This is not a developing world problem; this is a global world problem.</td>
</tr>
<tr>
<td>T/F</td>
<td>1:11</td>
<td>B. When an antibiotic is ineffective, plan B is to move to other antibiotics.</td>
</tr>
<tr>
<td>T/F</td>
<td>1:30</td>
<td>C. There is the fear we can run out of treatments.</td>
</tr>
<tr>
<td>T/F</td>
<td>2:05</td>
<td>D. Is there a way we can slow it down?</td>
</tr>
<tr>
<td>T/F</td>
<td>2:12</td>
<td>E. Humans are speeding it up by misusing antibiotics.</td>
</tr>
<tr>
<td>T/F</td>
<td>2:40</td>
<td>F. We don’t over use antibiotics: we don’t use antibiotics to treat the common cold, which is a viral infection.</td>
</tr>
</tbody>
</table>

Activity 4.2 Imagine your GP (General Practitioner) prescribes some antibiotic for you because you’ve caught a flu or a cold. Think about what questions you would ask to the doctor and write them down. Three are enough.

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---------------------------------------------------------------------------------------------------------------------

Activity 4.3 In groups of 5, and after asking to your parents at home, debate what antibiotics you have taken. You can mention the most common in the following lines:

---------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------

Activity 4.4 Effective concentration of antibiotics is commonly measured in IU (International Units). We have a flask containing 40000 IU / ml of gentamicin in the lab. We need to prepare 10 ml of 20 µg / ml gentamicin. What dilution do we have to make if 1000 IU is equivalent to 1 mg of active gentamicin? Solve the problem following the next instructions:

A. Write the concentration of the standard gentamicin flask in mg / ml:

B. In regard to the concentration needed, write it down in different units (mg / ml). Bear in mind that 1 mg = 1000 µg:
C. Is the standard gentamicin solution more diluted than the solution we want to prepare?

No  Yes

D. Think about the dilution factor we have to dilute by the standard gentamicin solution in order to achieve a concentration of 20 µg / ml, regardless the volume desired.

E. Compare the dilution factor you obtained with the one obtained from the following calculations:

\[
40000 \text{ IU} = \frac{40 \text{ mg}}{\text{ ml}} \xrightarrow{\text{dilution factor 1:2}} 20 \frac{\text{ mg}}{\text{ ml}} \xrightarrow{\text{dilution factor 1:1000}} 20 \frac{\text{ µg}}{\text{ ml}} \Rightarrow \text{total dilution factor 1:2000}
\]

Consider the dilution factor 1:2, for instance. What does it mean? It means to take 1 volume of the standard and fill up till 2 volumes with distilled water (1 volume of distilled water). Evenly, 1:1000 means to take 1 volume of the standard and fill up till 1000 volumes with distilled water (999 volumes of distilled water). The final dilution factor can be obtained by multiplying the factors of each step all through the series of dilutions made.

F. Consider now the volume desired. How much is it?

G. Apply the following formula to find out the required volume of the standard gentamicin solution to be mixed with water in order to achieve the desired volume at the desired concentration. You might consider \( \text{concentration}_2 \) the concentration needed, and \( \text{volume}_2 \) the desired volume. Thus, the concentration of the standard gentamicin solution is \( \text{concentration}_2 \).

\[
\text{Concentration}_1 \cdot \text{Volume}_1 = \text{Concentration}_2 \cdot \text{Volume}_2
\]
H. Compare your results with the following:

\[ \text{Concentration}_1 \times \text{Volume}_1 = \text{Concentration}_2 \times \text{Volume}_2 \], which is to say

\[ \frac{40 \, \text{mg}}{\text{ml}} \times \text{Volume} = 0.020 \times \frac{\text{mg}}{\text{ml}} \times 10 \, \text{ml} \]

\[ \text{Volume} = 0.005 \, \text{ml} = 5 \, \mu\text{l} \]

I. What will you do with the 5 µl of gentamicin standard solution?

J. Check whether your answer was right!

We have to pipette 5 µl of the standard gentamicin solution and fill to a volume of 10 ml with distilled water.

**Activity 4.5** After searching for some information in the Internet, make a list of the most commonly prescribed antibiotics and describe their biocidal / biostatic effect on the target microorganisms. What do you do at home with the antibiotics that have expired? Do antibiotics contained in the runoff represent any harm for the environment after being collected in the sewage treatment plant?

1.5 Revision activities

**Activity 5.1** Add the following breakthroughs on the science history timeline represented below:

1861: Louis Pasteur provides the final disproof of the theory of spontaneous generation.

1674: Anton van Leeuwenhoek becomes first person to view living microorganisms.

1929: Alexander Fleming discovers the first antibiotic, penicillin. Fleming makes this discovery by accident.

1798: Edward Jenner performs the first vaccinations against smallpox.

1876: Robert Koch, studying the disease, anthrax, validates the Germ Theory of Disease – the idea that diseases are caused by infectious agents.

1857: Louis Pasteur determines that yeast cause fermentation of wine and develops the process of pasteurization.
Activity 5.2 Follow the instructions:

A. Take a look at the following pictures:

B. Now, take a look at the following list:

<table>
<thead>
<tr>
<th>Algae</th>
<th>Plants</th>
<th>Viruses</th>
<th>Animals</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeast</td>
<td>Protozoan</td>
<td>Mould</td>
<td>Bacteria</td>
<td></td>
</tr>
</tbody>
</table>
C. One of the categories listed above produces antibiotics. These microorganisms may occur on fruit that has gone bad, such as the orange in the former picture. What category is that? _________________. Fruit that has gone off is sometimes rotten or mouldy. What do you call these organisms in your language? _________________.

D. Now, fill in the gaps in the following sentences with two other categories from the list above.

Antibiotics might be useful to fight against some infections caused by Protozoa, but they generally kill or inhibit the growth of _________________, such as Salmonella or Streptococcus. Contrary to what most people think, antibiotics are not effective against _________________, such as the common cold or influenza.

E. Make 3 sentences following the example. The following substitution table might help you build the sentences:

<table>
<thead>
<tr>
<th>Mould</th>
<th>microorganisms</th>
<th>produce</th>
<th>antibiotics.</th>
<th>Bacteria</th>
<th>are living beings that live in the sea.</th>
<th>are always parasites.</th>
<th>spoil fruit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses</td>
<td>organisms</td>
<td>belong to the kingdom of</td>
<td>Fungi.</td>
<td>cause infections.</td>
<td>are sensitive to on the land.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Example: Bacteria are living beings that live in the sea.
**Activity 5.3** Write the following words defined below in the diagram:

- **Antimicrobial**: agent that kills microorganisms or inhibits the growth of microbes.
- **Disinfectant**: antimicrobial agent that is nonselective, such as bleach.
- **Antiseptic**: antimicrobial agent which is applied to living tissue, such as Povidone or Iodine.
- **Antibiotic**: antimicrobial agent that destroys organisms within the body.
Activity 5.4 Let’s play bingo! Follow the next instructions:

A. Circle 9 of the following words or groups of words:


B. Write now each one of them on a single blank space of the grid:

```
   |   |   |
---|---|---|---
   |   |   |
   |   |   |
   |   |   |
```

C. Your teacher will give the definitions of all the words in a random order. Whenever you hear a definition that fits to any of the words you’ve filled the grid with, you have to cross the word out.

- Once you have crossed out a whole line of words, you call out: “Line!” Then, you will read the words aloud, to verify the line.
- At the moment your grid is completed, call out: “Full house!” before any other player does, and… you’ve won!!
Activity 5.5 Complete the following Mind Map with the words or groups of words from below:

Why are bacteria becoming resistant to antibiotics?

Antibiotics

Antibiotic Susceptibility Test

Green
- Chemical
- Different effects
- Natural
- Bactericidal
- Kills bacteria
- Blocks bacteria
- Different sorts
- Bacteriostatic

Orange
- Petri dish
- Results
- Ring
- Yes
- No
- Blurry
- Sensitive
- Half-resistance
- Resistant
- Bacterial suspension
- Antibiotic discs
- Agar

Blue
- Don’t worry!
- No
- Pathogenic
- Yes
- Choose the right antibiotic!

Activity 5.6 Follow the next link to practise vocabulary:

Quizlet – Antibiotics Vocabulary Practice

QUD0_Why are bacteria becoming resistant to antibiotics? / Unit 1_Antibiotics...
1.6 Assessment activities

Activity 6.1 Imagine you are a teacher and that you have to assess your students. Students, in pairs, have to describe a picture in front of the class. The picture consists of students working in the lab and holding different antibiograms (AST – Antibiotic Susceptibility Testing).

Instructions:

A. Working in pairs, you have to create an assessment checklist. To do so, you have to write two new questions in order to assess content (Microbiology) and two more to assess language (English). Follow the examples:

**Content:**

A.1 Is the piece of information given by both students correct?
A.2 Do both members of the group participate equally?
A.3 Do students understand the AST principle?

A.4

A.5

**Language:**

B.1 Are the speakers’ explanations convincing?
B.2 Do students speak about different things that appear in the picture?
B.3 Is the speakers’ pronunciation accurate?

B.4

B.5
Activity 6.2 In groups of 2 (with the same partner you did activity 6.1), you have to choose a bubble from the following cartoon. Each bubble contains a question or two and you have to prepare your answer for these questions in 5 minutes. Then, you will give your answer in front of the class and will be assessed by the teacher according to the former 10 criteria you’ve written in activity 6.1. In case you don’t have much to say, you can always swap to another bubble.

Why are there no bacteria in this Petri dish? Didn’t we spread the bacteria correctly on it?

Look now at the slice of the garlic clove we placed on the agar! Does it work like an antibiotic? Awesome!

Why did some colonies grow inside the ring if they weren’t supposed to? Are they mutant and so, resistant to the antibiotic?

What does it mean that bacterial colonies grow around the white antibiotic impregnated disc? And when do they not grow?
Teacher’s guide (includes attachments and solution key):

Note: The green-framed tables show important features of the activities, which are grouped by sections, as in the following example:

<table>
<thead>
<tr>
<th>Section 1</th>
<th>Sort of activities</th>
<th>1st Activity</th>
<th>Task briefing</th>
<th>Important instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2nd Activity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

After each table you will find the attachments (if needed) and solutions for each activity.

1.1 Warm-up activities

<table>
<thead>
<tr>
<th>Activity 1.1</th>
<th>Activity 1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill a T-chart to activate prior knowledge</td>
<td>Match the pictures with the right caption</td>
</tr>
<tr>
<td>Every student performs the activity individually</td>
<td>Every student performs the activity individually after watching the video</td>
</tr>
</tbody>
</table>

Activity 1.1 key:

Open answer.

Activity 1.2 key:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

Transcript of the video from 0:00 to 02:04:

Pen-Pen Chen: What if I told you there were trillions of tiny bacteria all around you? It’s true. Microorganisms called the bacteria were some of first life forms to appear on earth. Though, they consist of only a single cell. Their total biomass is greater than that of all plants and animals combined. And they live virtually everywhere, on the ground, in the water, on your kitchen table, on your skin, even inside you. Don’t reach for the panic button just yet. Although you have 10 times more bacterial cells inside you within your body has human cells, many of these bacteria are harmless or even beneficial, helping digestion and immunity. But there are a few bad apples that can cause harmful infections, from minor inconveniences to deadly epidemics. Fortunately, they were amazing medicines designed to fight bacterial infections. Synthesized from chemicals or occurring naturally in things like mould, these antibiotics kill or neutralize bacteria by interrupting cell wall synthesis or interfering with vital processes like protein synthesis, all while leaving human cells unharmed. The deployment of antibiotics over the course of the 20th century has rendered many previously dangerous diseases easily treatable. But today, more and more of our anabiotics are becoming less effective. Did something go wrong to make them stop working? The problem is not with the anabiotics, but the bacteria they were made to fight and the reason lies in Darwin’s Theory of Natural Selection. Just like any other organisms, individual bacteria can undergo random mutations. Many of these mutations are harmful or useless, but every now and then one comes along that gives its
organism an edge in survival. And for a bacterium a mutation making it resistant to a certain antibiotic gives quite the edge. [...]
## 1.3 Activities I

### Lower Order Thinking Skills activities

<table>
<thead>
<tr>
<th>Activity 3.1</th>
<th>Activity 3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap-fill combined with mutual dictation variation</td>
<td>Question loop variation with specific terms and definition</td>
</tr>
</tbody>
</table>

**Activity 3.1 attachment and key:**

**Text 1:**

**Antibiotic Susceptibility Testing I**

Antibiotic sensitivity or antibiotic susceptibility is the susceptibility of bacteria to antibiotics. Because susceptibility can vary even within a species (with some strains being more resistant than others), antibiotic susceptibility testing (AST) is usually carried out to determine which antibiotic will be most successful in treating a bacterial infection in vivo. Testing for antibiotic sensitivity is often done by the Kirby-Bauer method. The results of the test are reported on the antibiogram.

**Text 2:**

**Antibiotic Susceptibility Testing II**

Small wafers containing antibiotics are placed onto a plate upon which bacteria are growing. If the bacteria are sensitive to the antibiotic, a clear ring, or zone of inhibition, is seen around the wafer indicating poor growth. Other methods to test antimicrobial susceptibility include Agar and Broth dilution methods for minimum inhibitory concentration (MIC) determination. The results of the test are reported on the antibiogram. Antibiotics are drugs that either naturally occur in nature or are made synthetically. They are used in the treatment and prevention of bacterial infections.

**Activity 3.2 attachment and key (cut-out model):**

QUD0_Why are bacteria becoming resistant to antibiotics? / Unit 1_Antibiotics...
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
<th>Abbreviation</th>
<th>Description</th>
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<td>stands for <em>Minimum Inhibitory Concentration</em>, i.e. the amount of antibiotic to which a bacterial culture is inhibited from growth.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 1.4 Activities II

### Higher Order Thinking Skills activities

| Activity 4.1 | Tick either right or false | Every student performs the activity individually after watching the video. The video will be played twice. Proper internet connection is needed to support video streaming or the teacher should previously download the video |
| Activity 4.2 | Writing sentences | Every student performs the activity individually |
| Activity 4.3 | Eliciting information from the parents and writing it down | The students elicit information on antibiotics' prescription from their parents. Then, they gather in groups of 5 to contrast the information. This activity can be performed in L1. This activity is not immediate |
| Activity 4.4 | Scaffolding calculation exercise | Every student performs the activity individually |
| Activity 4.5 | Browse information on internet and report the collected data | The students write individually their own answer after information was searched (preferably in L2) and sorted out from the Internet |

### Activity 4.1 key:

<table>
<thead>
<tr>
<th>T</th>
<th>F</th>
<th>Min</th>
<th>Question</th>
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<tr>
<td>T</td>
<td>F</td>
<td>2:05</td>
<td>D. Is there a way we can slow it down?</td>
</tr>
<tr>
<td>T</td>
<td>F</td>
<td>2:12</td>
<td>E. Humans are speeding it up by misusing antibiotics.</td>
</tr>
</tbody>
</table>
Ms Helen Joyce: In London, this is The Economist. So this week the World Health Organization brought out a report on antibiotic resistance in bacteria and it’s made quite a splash. I’m Helen Joyce and the editor of the international section of the paper and here to discuss this with me it’s Roger McShane our London based health correspondent. So I’ve been aware of this is a growing problem for several years, maybe for longer. What's changed? What’s new?

Mr Roger McShane: Well, I think the collection of data has really sort of imprinted on people this as a serious problem. There’s also the fact that (A.) this is not a developing world problem. This is a global problem, and so is in the WHO data you find that in China, for example, the standard drugs used to treat a bacterium that can cause pneumonia have been found to be ineffective over a third of the time. But also in America they’ve found that the standard dose that's used to treat wound infections is ineffective over a half of the time in hospitals. So it's truly a global problem.

Ms H. J.: So when an antibiotic is ineffective what is the plan B? What do doctors do?

Mr R. M.: Well, they can move on to other antibiotics but then the bacteria eventually develop resistance to those and then if the doctors can move on to much more complex and riskier treatments that usually take place in hospitals, they are also a lot more expensive. (C.) There’s a fear that eventually we’re just gonna run out of treatments and not be able to control infections and this has profound implications for modern medicine. If doctors are unable to control infections then all of a sudden it becomes nearly impossible to do many types of surgeries such as organ transplants, heart surgeries, even things like cataracts surgeries. They become a lot more... a lot riskier if we cannot control infections.

Ms H. J.: So I guess that this is bacteria evolving to counter the antibiotics we use against them and evolution can't be stopped. (D.) Is there a way we can at least slow it down?

Mr R. M.: Absolutely, as you say (E.) this is a natural process but humans are speeding it up and speeding it up by misusing antibiotics. For example, a person with a urinary tract infection: if they’re told to take the antibiotics for two weeks and their symptoms clear up in one they often stop taking the antibiotics and what this does it leaves behind survivors, and they’re finish survivors, and those fit bacteria they can pass on the resistant genes to the friends, to other bacteria. (F.) We also overuse antibiotics. What I mean by that is we use antibiotics to treat things like the common cold which is a viral infection and antibiotics have no effect on them [...]

Activity 4.2 key:

Open answer.

Activity 4.3 key:

Open answer.
Activity 4.4 key:

A. 40 mg / ml
B. 0.02 mg / ml
C. No
D. / E.

\[
\begin{align*}
40000 \text{ IU} & = \frac{40 \text{ mg}}{\text{ ml}} \frac{\text{mg}}{\text{ ml}} \rightarrow 20 \frac{\text{ mg}}{\text{ ml}} \frac{\text{mg}}{\text{ ml}} \rightarrow 20 \frac{\text{ mg}}{\text{ ml}} \frac{\text{mg}}{\text{ ml}} \rightarrow \text{ total dilution factor } 1:2000
\end{align*}
\]

Consider the dilution factor 1:2, for instance. What does it mean? It means to take 1 volume of the standard and fill up till 2 volumes with distilled water (1 volume of distilled water). Evenly, 1:1000 means to take 1 volume of the standard and fill up till 1000 volumes with distilled water (999 volumes of distilled water.) The final dilution factor can be obtained by multiplying the factors of each step all through the series of dilutions made.

F. 10 ml
G. / H.

Concentration₁·Volume₁ = Concentration₂·Volume₂, which is to say

\[
40 \frac{\text{ mg}}{\text{ ml}} \cdot \text{Volume} = 0.020 \frac{\text{ mg}}{\text{ ml}} \cdot 10 \text{ ml}
\]

\[
\text{Volume} = 0.005 \text{ ml} = 5 \mu l
\]

I. / J. We have to pipette 5 µl of the standard gentamicin solution and fill to a volume of 10 ml with distilled water.

Activity 4.5 key:

Open answer. Bear in mind that a sewage treatment plant processes wastewater to avoid polluting the environment. However, antibiotics aren’t normally processed in those plants, so you can imagine what a serious global problem we have to deal with.
<table>
<thead>
<tr>
<th>1.5 Revision activities</th>
<th><strong>Activity 5.1</strong></th>
<th>Locate 6 historical scientific breakthroughs onto a timeline</th>
<th>Every student performs the activity individually</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Activity 5.2</strong></td>
<td>Observe pictures, read specific terms and perform a cloze text. Write sentences using a substitution table</td>
<td>Every student performs the activity individually</td>
</tr>
<tr>
<td></td>
<td><strong>Activity 5.3</strong></td>
<td>Information categorising using a Venn diagram</td>
<td>Every student performs the activity individually</td>
</tr>
<tr>
<td></td>
<td><strong>Activity 5.4</strong></td>
<td>Definition Bingo</td>
<td>Every student performs the activity individually until the moment someone yells “Line!” or even better “Full house!”'. Then, this player must read aloud one by one all his words to check the correctness. Game can be continued. Teacher should write down all the definitions he/she has read, to contrast afterwards the words with those the presumptive winner has marked on his card</td>
</tr>
<tr>
<td></td>
<td><strong>Activity 5.5</strong></td>
<td>Information classification using a Mind Map</td>
<td>Every student performs the activity individually</td>
</tr>
<tr>
<td></td>
<td><strong>Activity 5.6</strong></td>
<td>ICTs and vocabulary L2-L1 training using Quizlet</td>
<td>This activity is linked to the internet. Proper internet connection is needed to perform the activity. Each student needs a computer or any other substitute device. Groups of 2 students are also possible</td>
</tr>
</tbody>
</table>
Activity 5.1 key:

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1674</td>
<td>Views first living microorganism</td>
</tr>
<tr>
<td>1798</td>
<td>First vaccination</td>
</tr>
<tr>
<td>1857</td>
<td>Yeast fermentation</td>
</tr>
<tr>
<td>1861</td>
<td>Disproves spontaneous generation</td>
</tr>
<tr>
<td>1876</td>
<td>Germ theory of disease</td>
</tr>
<tr>
<td>1929</td>
<td>First antibiotic</td>
</tr>
</tbody>
</table>

Activity 5.2 key:

A. / B. –
C. Mould / Floridures (moho).
D. bacteria / viruses.
E. Mould is microorganisms that produce antibiotics. / Mould are living beings that belong to the kingdom of fungi. / Bacteria are organisms that are sensitive to antibiotics. Etc.

Activity 5.3 key:

Antimicrobial

Disinfectant

Antibiotic

Antiseptic

Activity 5.4 attachment:

**Antibiotic sensitivity:** susceptibility of an organism to an antibiotic, meaning that the latter can cause its death.

**Antibiotic resistance:** opposite term to antibiotic sensitivity.

**Bacterial strain:** lower level taxonomic rank, infraspecific level, that is, under species level.
**Serotype**: sort of bacteria that have some biochemical features (different cell surface antigens) slightly different from another sort of the same species. It is also called serovar.

**Pathogenic bacteria**: bacteria that may cause infectious diseases.

**Beneficial bacteria**: bacteria that are living in our body, e.g. in our bowels, interacting with our organism in a non-detrimental way.

**Mutation**: change in the genome (genetic material) of an organism.

**MIC**: *Minimum Inhibitory Concentration*, i.e. the amount of antibiotic to which a bacterial culture is inhibited from growth.

**IU**: *International Units* and it is commonly used to measure concentration of medications, vaccines, vitamins, etc.

**Antimicrobial**: agent that kills microorganisms or inhibits the growth of microbes.

**Disinfectant**: antimicrobial agent that is nonselective, such as bleach.

**Bacteriostatic antibiotic**: antibiotic that paralyses the growth, multiplication or metabolism of bacteria.

**Bactericidal antibiotic**: antibiotic that kills bacteria by serious damage of any part of them.

**Antiseptic**: antimicrobial agent which is applied to living tissue, such as *Povidone or Iodine*.

**Antibiotic**: antimicrobial agent that destroy organisms within the body.

*Activity 5.5 key:*
Activity 5.6 key:

Quizlet automatically gives assessment after performing this activity on the internet.

1.6 Assessment activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 6.1</td>
<td>Checklist creation in order to assess a hypothetical classmate (use of assessment as learning) Students in pairs complete a checklist of criteria to assess both content and language following an example.</td>
</tr>
<tr>
<td>Activity 6.2</td>
<td>Oral presentation in front of the class in groups of 2 Each group of 2 students performing the presentation will be assessed by the teacher using the same criteria they have just written on their checklist. The teacher takes the student’s book to check the criteria and assesses on his own notebook</td>
</tr>
</tbody>
</table>

Activity 6.2 attachment:

Assessment suggestion (scores’ example):

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Content</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A.1</td>
<td>B.1</td>
</tr>
<tr>
<td></td>
<td>A.2</td>
<td>B.2</td>
</tr>
<tr>
<td></td>
<td>A.3</td>
<td>B.3</td>
</tr>
<tr>
<td></td>
<td>A.4</td>
<td>B.4</td>
</tr>
<tr>
<td></td>
<td>A.5</td>
<td>B.5</td>
</tr>
</tbody>
</table>

Criteria  | 0 Criteria is not achieved | 0.25 | 0.50 | 0.75 | 1.00 Criteria is magnificently achieved |
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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<td>X</td>
<td></td>
<td></td>
<td>0.25</td>
<td>X</td>
</tr>
<tr>
<td>A.2</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>A.3</td>
<td>X</td>
<td></td>
<td>0.25</td>
<td>0.50</td>
<td>X</td>
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<tr>
<td>A.4</td>
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<tr>
<td>A.5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<tr>
<td>B.1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
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<td>B.2</td>
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<td>B.4</td>
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<td>X</td>
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<td>B.5</td>
<td>X</td>
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<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Total: 0x0.00 Total: 1x0.25 Total: 4x0.50 Total: 5x0.75 Total: 1x1.00

Total: 7.00

Suggested assessment sheet for each 2-student group (photocopiable):
<table>
<thead>
<tr>
<th>Criteria</th>
<th>0 (Critierium is not achieved)</th>
<th>0.25</th>
<th>0.50</th>
<th>0.75</th>
<th>1.00 (Critierium is magnificently achieved)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A.1</td>
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<td>A.2</td>
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<tr>
<td>A.4</td>
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<td></td>
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<tr>
<td>A.5</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td></td>
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<tr>
<td>B.1</td>
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<td>B.2</td>
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<tr>
<td>Total:</td>
<td>x0.00</td>
<td>Total: x0.25</td>
<td>Total: x0.50</td>
<td>Total: x0.75</td>
<td>Total: x1.00</td>
</tr>
</tbody>
</table>

Teacher notes:

QUD0_Why are bacteria becoming resistant to antibiotics? / Unit 1_Antibiotics...
References:

- The transcription of the video linked on page 17 of the Teacher's guide section in the Teacher's book was taken from:
  - LYBIO.net (http://lybio.net/kevin-wu-what-causes-antibiotic-resistance/education/)

Narration/voice: Pen-Pen Chen  
Educator: Kevin Wu  
Animator: Brett Underhill  
Script Editor: Alex Gendler

The video itself (linked on page 3) can be found in:

- You Tube (https://www.youtube.com/watch?v=znnp-lvj2ek), and
- TED conferences (http://ed.ted.com/lessons/how-antibiotics-become-resistant-over-time-kevin-wu)

- The transcript of the video that appears on page 22 and the video itself, linked on page 7 of the Teacher's guide section in the Teacher's book were taken from:
  - The Economist.com (http://www.economist.com/blogs/babbage/2014/05/drug-resistant-bacteria)

- The Quizlet link on page 14 (https://quizlet.com/205391216/flashcards) refers to material that has been originally made by me through Quizlet.

- The Mind Maps on pages 14 and 26 were done by me with the help of Text2MindMap (https://www.text2mindmap.com/)

I hereby declare that all pictures used in this work are original (even the ones shown in activity 1.2, which are based on a Brett Underhill work, a TED video mentioned above), and that the SmartArt visuals on pages 10, 12 and 25 were created with educational and non-profit objectives and under the scope of the Microsoft Software License Terms for which it refers to section 3 (Additional Licensing Requirements and/or Use Rights), clause c (Media Elements and Templates).