**Cheat Sheet 1: Cell Biology**

Every living thing, or organism, is made of cells. Some only have one cell; others have millions of cells. Every cell is a bag of chemicals that react with each other in very specific ways to keep the cell alive. Interfering with the chemical reactions will affect how well the cell functions.

Some key terms relating to cells are given below.

**DNA**: Deoxyribonucleic Acid (dee-oxy-rye-bow-new-clay-ic). A complex molecule that carries the information for life. The DNA is organised into structures called chromosomes. Every chromosome can be divided into sections of code, known as genes. It can help to think of the DNA as the instruction manual for the organism, where every chromosome is a different chapter. Some organisms only have one or two chapters, whereas others have lots. Humans have 46 chapters in their instruction manual. Bacteria have one chapter.

**Proteins**: Proteins are the workhorses of the cell. They carry out lots of important jobs within the cell, carrying other molecules around, passing on messages and making sure that all the chemical reactions that keep the cell alive happen. Proteins are made by following the instructions in the DNA manual. If there is a mistake in the DNA code, there will be a mistake in the way the protein is made.

**RNA**: Ribonucleic Acid. A molecule that is very similar to DNA but not the same. The machines that make the proteins can’t read DNA directly, so need to have to DNA code translated into a form they can read. This is RNA.

**Ribosomes**: This are the machines that take the RNA code and use it to make proteins.

**Mutations**: A mutation is when there is a spelling mistake in the DNA instruction manual. This can result in mistakes in the protein, and it can’t do its job properly. Sometimes however, the mistake allows the protein to do jobs that it couldn’t do before.

**Cheat Sheet 2: Bacteria (a bacterium)**

Bacteria are single-celled organisms that can live independently. They are microscopic; they can be seen with a light microscope. Bacteria are usually between 1-5µm in length (1µm = 1/1000th of 1mm. µ = micron).

There are many different species of bacteria. Each one has its preferred place to live. Bacteria can live and grow almost anywhere such as:

* under the Arctic ice,
* at the bottom of the sea,
* in hot water springs,
* in soil contaminated with heavy metals (poisons),
* inside your intestines (both ‘good’ and ‘bad’ bacteria)
* on your skin.

Most bacteria fall into one of two categories: Gram positive or Gram negative. This relates to how they react with a certain staining technique that allows them to be seen under a light microscope.

- Gram positive bacteria such as *Streptococcus* have a thick coat or ‘cell wall’ that protects them from the environment. This is made of a special mixture of sugars and proteins that is only found in bacteria. It is called peptidoglycan (pep-tid-o-gly-can).

- Gram negative bacteria, like *E. coli*, only have a thin layer of peptidoglycan, so they have membranes made of fats and sugars to protect them.

Knowing if a bacterium is Gram positive or negative is useful because it can affect the choice of antibiotic used to treat an infection.

Bacteria have a single DNA chromosome (just one chapter in their instruction manual), but some of them have additional small pieces of DNA, that give them extra genes. These small pieces of DNA are in circles called plasmids. The extra genes allow the bacteria to live in extreme conditions or to resist antibiotics.

Plasmids can be shared very easily between bacteria, including bacteria of different species. This means that the genes for antibiotic resistance can be passed around to lots of different bacteria.

Bacteria multiply through a process called binary fission. Everything inside the bacterial cell is doubled, the cell grows to twice it’s normal size, then it divides into two. Some bacteria can do this every 20 minute in the right conditions, although most bacteria take longer. Bacteria will continue to grow and multiply as long as there is enough food for them, and nothing comes to stop them (such as an antibiotic or the immune system).

Because bacteria are constantly growing and dividing, spelling mistakes (mutations) will be made in their DNA, in both the main chromosome and in the plasmids. Sometimes these mutations change the bacterial proteins in such a way that the bacteria are able to live in conditions that would previously have killed them. This is how antibiotic resistance develops.

**Cheat Sheet 3: Viruses**

Viruses are even smaller than bacteria – they can be 1/100th of a bacterium. They can only be seen with very powerful (and big and expensive) electron microscopes.

Viruses are very simple – they consist of short pieces of either DNA or RNA, inside a protective protein box called a capsid. Lots of viruses also have a membrane outer layer, and some will have extra proteins in this membrane (such as the spike protein of SARS-CoV-2).

Because they are so small, viruses cannot live on their own. They do not have the machinery needed to make copies of themselves, so they have to get inside other cells, and use the machinery of the hijacked cell to make viral copies.

Some viruses, like the Rhinovirus that causes colds, start replicating, making new copies of themselves straight away. They make lots of copies until the cell they have taken over is so full, it bursts open and releases new viruses that go off to take over another cell. Every time we cough or sneeze, we release viruses that can infect other people.

Some viruses will hide inside the cell for a long time before they start making copies. The virus that causes cold sores will do this.

Antibiotics do not work for viral infections. Antibiotics are chemicals that interfere with the chemical reactions that keep bacteria alive. Viruses do not have these chemical reactions so there is nothing for the antibiotics to interact with.

**Cheat Sheet 4: Antibiotics**

Antibiotics are chemicals that interact with the chemical processes that keep bacteria alive. Some antibiotics will kill the bacteria (although not immediately) whereas other antibiotics slow down the growth of the bacteria so that the immune system can clear the infection.

Penicillin interferes with the building of the peptidoglycan cell wall. This will eventually kill the bacteria. It is more effective on gram positive bacteria who have the thicker cell walls.

Ciprofloxacin is able to get all the way inside the bacterial cell and stop the DNA from replicating. If the bacteria cannot replicate its DNA, it can’t divide and grow.

Antibiotic resistance means the bacteria have developed ways to stop the antibiotics from working. In some bacteria, proteins will act as chemical scissors and cut up the antibiotics. In other bacteria, the proteins form mini-pumps that pump the antibiotics out of the cell.

If there is not enough antibiotic in an environment to kill the bacteria, or quickly stop it growing, it gives the bacteria more time to develop resistance. Not taking a course of antibiotics properly, or not finishing the course will help the bacteria become resistant.

Antibiotic resistance is a big problem, and it is getting bigger. More and more bacteria are developing resistance. This means that infections will be harder to treat. It also means that a lot of medical procedures will be harder such as cancer operations, organ transplants, or treating people who have been injured in accidents.