Science & Medicine!

TY Science Module

Student Handout

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Introduction.

Medicine is the art and science of healing. It includes a range of practices from conventional to complementary medicine. In the following module, we will examine the history of some medicines, discuss how drugs are made, undertake some experiments on different drugs, and much more. This is an 8-week course consisting of 8 interactive units. The module will also introduce some new laboratory skills. Each unit consists of a single introductory unit, a double lesson, and an optional third lesson. You will most definitely have a greater knowledge about drugs and medicine if you pay attention to this module!

Unit 1: The Action of Antibiotics!

Unit 1: Action of antibiotics!

Lesson one. Antibiotics – what are they? (Single lesson)

Introduction

There has probably been a stage in everybody's lives where you have become ill and may have had to pay a visit to the doctor. You may have been prescribed a course of antibiotics at some stage – but what exactly are antibiotics? Write down your ideas:

_____

_____

What does the word **antibiotic** mean?
(Hint: break it into two words, anti and biotic)

_____

_____

Antibiotics – what are they*?*

Antibiotics, sometimes known, as anti-bacterials are drugs used to treat infections caused by bacteria.

What do we know about bacteria?

Bacteria are tiny organisms too small to see with the naked eye (you would need a microscope to see them), that sometimes cause illnesses in humans. Some illnesses caused by bacteria include salmonella, syphilis, and some forms of meningitis. Also, there are many types of bacteria that live in or on our body, that do not cause us any harm.

Activity: can you think of any names of antibiotics?

_____

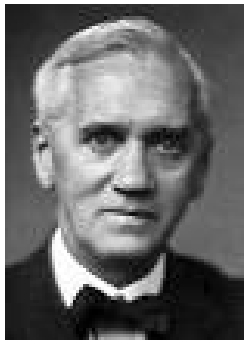
_____

Immune systems are present in our bodies, which contain antibodies and white blood cells. Can you recall the function of white blood cells from the junior cert???

_____

Our immune systems usually kill any harmful bacteria which enter our bodies, before they get a chance to show symptoms. If symptoms do occur, the immune system can often fight the infection. However, sometimes our immune systems are unsuccessful and this is where antibiotics are needed.

The history of antibiotics…



So, how were antibiotics discovered? The discovery of antibiotics began by accident. On the morning of September 3rd, 1928, Professor Alexander Fleming (photo above) was cleaning his cluttered laboratory. Fleming was sorting through a number of glass plates, which had been previously coated with staphylococcus bacteria as part of research Fleming was doing. One of the plates had mould on it, which was in the shape of a ring, and the area around the ring appeared to be free of the bacteria staphylococcus. The mould was ***penicillum notatum***. Fleming concluded that some substance that had come from the mould had killed off the bacteria on the plate around the ring.

Further research was undertaken, and it was found that the mould could kill other bacteria and could be given to small animals without any side effects. It was 10 years later that the bacteria-killing substance was isolated and named **penicillin**. Penicillin was the very first antibiotic to be introduced; and it was nicknamed "the wonder drug". Many more antibiotics have since been introduced and are available on prescription.

How do antibiotics work in the body? ? ?

There are two ways in which antibiotics kill the bad bacteria:

1. **Bacteriostatic:** means that the antibiotics work by stopping bacteria from multiplying.
2. **Bactericidal:** means that the antibiotics work by killing bacteria. They do this by interfering with the formation of the cell walls or cell contents of the bacteria.

Any word which ends with -cidal means to kill – can you think of any other words that end with -cidal???

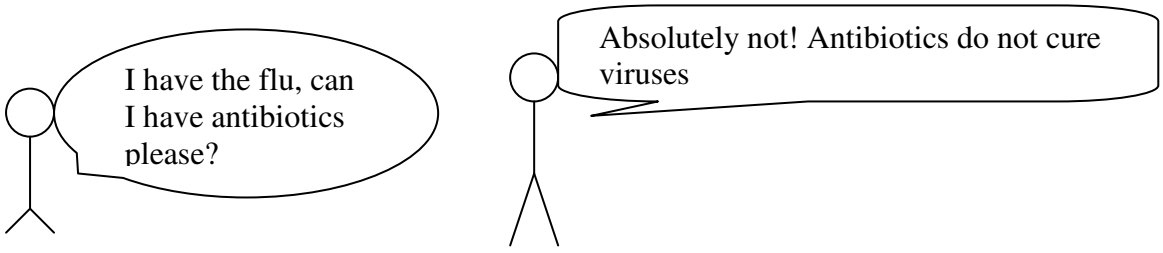
_____

_____

_____

_____

Do antibiotics treat bacterial or viral infections?



It is important to understand that antibiotics **only** treat infections caused by bacteria. They do **NOT** work against viral infections. Viruses cause many common illnesses such as the common cold and sore throats. Overuse of antibiotics can lead to the bacteria becoming resistant so it is important to only take them when necessary. This is currently a big problem at the moment – can you think of a reason why?

_____

_____

Types of antibiotics

Some antibiotics are produced to treat a wide range of infections and are known as *'broad – spectrum'* antibiotics. Others are produced in order to fight against a few types of bacteria, and are called *'narrow – spectrum'* antibiotics. Some antibiotics work against aerobic bacteria, others work against anaerobic bacteria.

Question: what is the difference between aerobic and anaerobic bacteria?

_____

_____

In some cases, antibiotics are given to a patient before an infection occurs, for example, before certain operations. This is known as the **prophylactic** use of antibiotics and is common before orthopaedic (bone) and bowel surgery. Why do you think doctors do this?

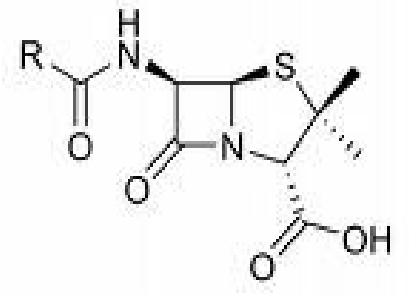
_____

What forms do antibiotics come in?

Oral antibiotics are simply ingested, while intravenous (injection) antibiotics are used in more serious cases such as systemic infections. Antibiotics may also be sometimes administered topically, as with eye drops or ointments. It is vital to take the whole course of antibiotics to prevent reoccurrence of the infection. (This is explained later).

Antibiotics are complex organic molecules, whether they are found in nature (like penicillin) or whether they have been made in a laboratory. Many suynthetic penicillins have been made since Fleming's chance discovery.

The chemical structure of an antibiotic



Do you think you can explain to your mother why you shouldn't have an antibiotic if you have a cold?

Unit 1: Action of antibiotics!
Lesson 2. The superbug (Double lesson)

You have all heard about superbugs, often caught in hospitals, which are resistant to antibiotics. In this lesson we will investigate superbugs.

Side-effects of antibiotics

While taking a course of antibiotics, you may experience some nasty feelings. These are known as side-effects.
What types of side effects can you think of that may occur from taking antibiotics???

_____

_____

There will always be a leaflet included with every course of antibiotics you take. The leaflet will inform the user of any side-effects that may occur while taking the course. We will now examine a label from an antibiotic: Copy down from the label the possible side-effects that are listed.

The most common side effects that occur with antibiotic drugs are diarrhea, feeling sick, and being sick. Fungal infections may also occur when taking antibiotics, as they may destroy the protective 'good' bacteria in the body as well as the targeted bad ones.
More serious side effects are rare occurrences. Hypothetically, some antibiotics may interfere with the efficiency of birth control pills. However, no conclusive studies have proved this fact.
Some people are allergic to antibiotics; particularly the penicillins. This is called an **anaphylactic reaction** and can be very serious.
What types of side-effects may occur if a person is allergic to the antibiotics they are using?

_____

_____

Does anyone know if they are allergic to an antibiotic?

_____

How do you think you would prevent side-effects from occurring?

_____

_____

Some common headlines we have seen in papers recently

"Super bug crisis worse than feared"
"Super bug kills 22 in one hospital in a year"
"MRSA – a bugs rife" (rife = widespread existence)
"MRSA shows little reduction"

What is the MRSA? (superbug)

_____
_____
_____

How has it occurred?

_____
_____
_____

Sometimes bacteria become 'resistant' to an antibiotic, meaning that the drug will no longer work. Even if the symptoms have cleared up **always** finish the full course of antibiotics. Resistance tends to occur when the bacterial infection responsible for the symptoms is not completely cured. Some of the residual bacteria having being exposed to it, but not killed by the antibiotic, are more likely to grow into an infection that can survive that particular antibiotic.
A common example of where antibiotic resistance has caused a problem is the super bug.

More about the super bug.

The growing number of antibiotic- resistant bacteria is putting the golden era of medicine at risk! The world is now already involved in a race to prevent bacterial infections from once again becoming one of humanity's major killers. In the past, bacterial infections could be life threatening. The discovery of antibiotics appeared to be the perfect solution. But the bacteria have fought back! Any population of organisms faced with a challenge to its survival has the potential to adapt via the processes of natural selection.

What is the process of natural selection?

_____
_____
_____
_____
_____

Can you think of any examples?

_____
_____
_____
_____

The work of a superbug!

Read the following story and then answer the questions on it.

Ann loved running. It was her favorite hobby, and she practiced every evening after school for the upcoming marathon. One Monday evening, whilst Ann was running through the park, she slipped on a banana skin. Ann immediately rang her mother who took her straight to the hospital. Ann suffered a broken finger and some severe cuts on her legs. She returned home but soon after, one of the cuts on her leg got very sore and began to throb. Ann decided to take a few antibiotics that she found in the medicine cabinet hoping that it would help the situation!

That night her leg became so sore that she had to return to the hospital, where the doctor prescribed an antibiotic **A**. Ann took the antibiotics as prescribed but by the end of the week, she could hardly walk with the pain and felt ill. She returned to hospital where the doctors administered antibiotic **C** directly into the bloodstream.

By Saturday, the infection had spread and become much worse.

What should the doctors do next?

1. Why do you think the first few antibiotics that Ann took at home did not work?

_____
_____
_____

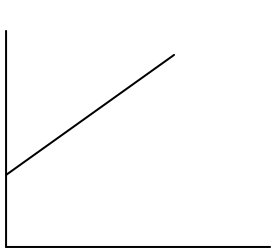
2. Why do you think the antibiotics prescribed by the hospital did not work?

_____
_____
_____

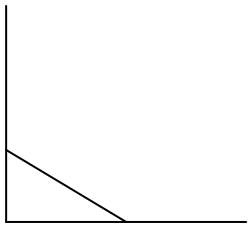
3. What information do the doctors need to find out in order to treat the infection?

_____
_____
_____

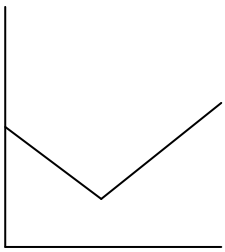
4. The following three graphs show how bacteria are affected in Ann's body over 24 hours.



no antibiotics



antibiotics + susceptible bacteria



antibiotics + resistant bacteria

Explain from the graphs how the number of bacteria changes over 24 hours.
No antibiotics:

_____
_____

Antibiotics and susceptible bacteria:

_____
_____

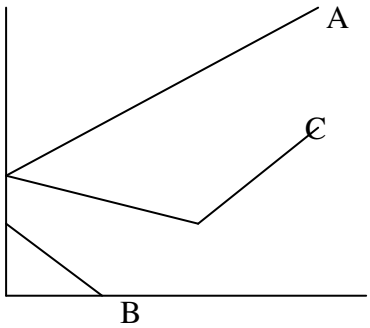
Antibiotics and resistant bacteria:

_____
_____

5. There are 3 antibiotics suggested by the doctors for an infection like Ann's: A, B, and C.

Which antibiotic did Ann first become resistant to? _____
Which antibiotics was she resistant to by Saturday? _____

6.



This shows the bacteria growth by Saturday. What has happened?

_____
_____

7. What should the next antibiotic be that the doctors give Ann?

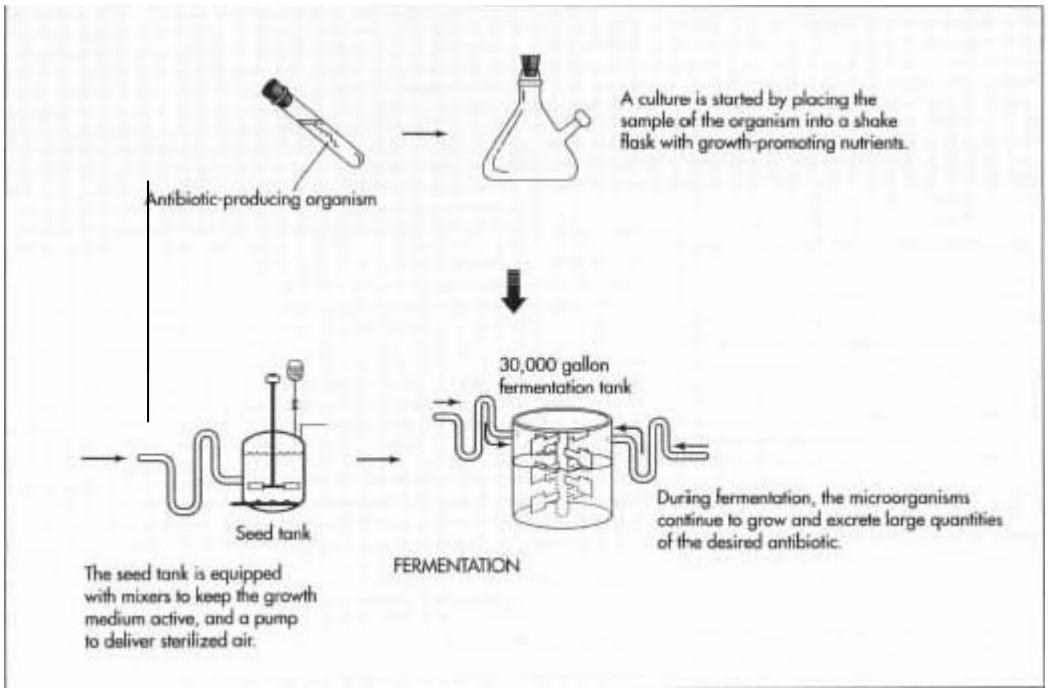
_____

_____

The production process for antibiotics

Antibiotics are derived from special microorganisms or other living systems, and are produced on an industrial scale using a **fermentation** process. Antibiotics represent a multibillion-dollar industry that continues to grow each year!
The commercial development of an antibiotic is a long and costly process.

- Firstly, basic research is undertaken designed to identify organisms, which produce antibiotic compounds. When one is found the species is tested against a variety of known infectious bacteria. If successful, the organism is grown on a large scale so that the compound responsible for the antibiotic effect can be isolated. [Fermentation process]
- The next step involves clinical testing to prove that the antibiotic works in animals and humans and is not harmful to them.
- Finally the Food and Drug Administration (FDA) must give approval to the antibiotic as a new drug. This whole process may take many years.



Understanding the fermentation process.

The diagram above describes how an antibiotic is isolated and then produced. It is essential that sterile conditions be maintained throughout the manufacturing process.

Step 1: Starting the culture
In order to grow the initial culture, a sample of the organism is transferred to an agar plate.
The initial culture is then put into shake flasks, along with food and other necessary nutrients for growth.

It is then transferred to seed tanks for further growth.
After approximately 24 – 28 hours, the material in the seed tanks is transferred to the primary fermentation tanks.

Step 2: Fermentation.
In the fermentation tanks, the microorganisms are allowed to grow and multiply. During this process, they excrete large quantities of the desired antibiotic.

Step 3: Isolation and purification
After 3 –5 days the maximum amount of antibiotic will have been produced.
The fermentation broth is processed by various purification methods. For example, the broth is treated with organic solvents to dissolve the antibiotic.
At the end of this process, the result is a purified powder form of the antibiotic.

Step 4: Refining
The antibiotic can be produced in many forms:

- Solutions: intravenous bags or syringes
- Pill / gel capsule
- Powders: ointments

The product is then transported to packaging stations and is distributed to hospitals, pharmacies, etc.

What other kinds of products can be formed from the process of fermentation?

_____

_____

We will now do an experiment to illustrate the process of fermentation.

Activity: To make yogurt!

With the help of bacteria, milk is turned to yogurt.

What is probiotic yogurt?

_____

Resources:

- Milk
- Yogurt with live culture
- Pot for heating milk
- Thermometer
- Sterile jar

Safety comes first!

Do not make yogurt for consumption in the laboratory. Laboratory equipment or chemicals may contaminate it. It can be made at home or in the domestic science room if you want to eat it.

Care should be taken when handling the container with the hot milk!

Method:

1. Heat some milk (approx 250 ml) to 85 – 90 degrees Celsius in the pot, i.e. just below boiling. **You heat the milk to remove as many bacteria as possible.**
2. Remove from the heat and place the pot in container of water until milk is at 55 degrees Celsius. (You will need a thermometer to check this.)
3. Add one tablespoon of the yogurt to a sterilized jar. (How will you do this?) **Use probiotic yogurt. This is the starter culture.**
4. Carefully pour the milk into the jar and cover with a lid.
5. Place the jar into a cooler with water of 50 degrees Celsius or into a thermos flask to maitnatin the temperature.
6. Leave in the water bath or thermos flask for 3 hours.
7. Refrigerate overnight.

Observations:

_____

_____

Explanation:

The milk was heated to kill any germs. Probiotic yogurt was added to the milk to make a starter culture. By adding this yogurt you added a type of bacteria called **acidophilus.** These bacteria feed on lactose, a sugar found only in milk. They also produce a waste product called **lactic acid**. This acid gives the yogurt its distinctively sour taste and thick, custard-like texture.

Questions:

1. Why was it important to use sterile jars or containers?

_____

2. Why did you need to keep the milk and culture warm?

_____

Unit 1: Action of antibiotics!

Lesson 3. A look further! (Single lesson)

Each group will have been given a task to research for this class, and will present their findings to the class.

Topic 1: The history of antibiotics.

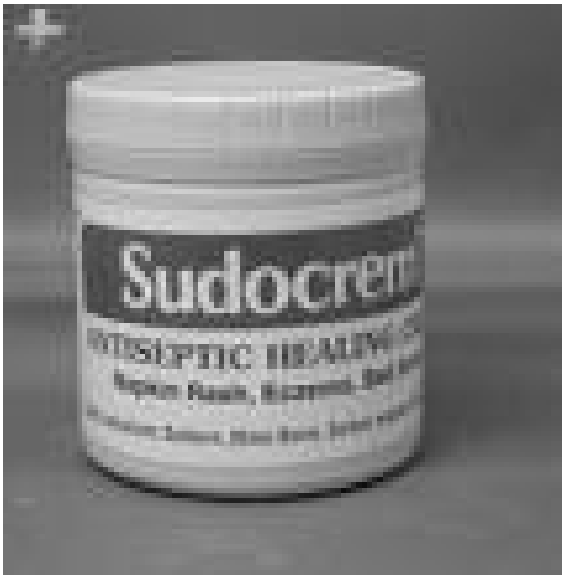
Topic 2: The production process for antibiotics. Research one company that produces antibiotics, preferably an Irish company.

Topic 3: The difference between antibiotics. Compare three antibiotics, their uses, structure and side-effects: augmentin, distaclor, klaricid.

Topic 4: The discovery of new antibiotics.

Topic 5: The fermentation process. Develop what we already have discussed and find out how the antibiotics are separated and purified from the fermentation broth.

Do not repeat material already discussed. Look up new ideas/ information! You can use encyclopedias or the internet.



Unit 2: Antiseptics

Unit 2. Antiseptics

Lesson 1. Why use antiseptics? (Single lesson)

There has more than likely been a stage in all of our lives where we have fallen and cut our skin. What steps would you take if your skin was cut and some dirt could be seen on the cut?

_____
_____
_____

What does the word antiseptic mean?
Anti =
Septic =

What are antiseptics?
Antiseptics have more than one definition:

- Substances with disinfection effects used locally for gargling, dressing wounds, eye drops etc.
- A substance that kills most disease-causing bacteria, viruses, and fungi. It can be used on skin of humans or given internally to prevent or treat infections.
- Helpful chemicals that destroy germs and other contaminants.
- Ingredients that inhibit the growth of bacteria on living tissue or in soap.

Activity: make a list of any antiseptic products you would find at home. Decide amongst the class which product seems to be most / least popular.

_____
_____
_____

How do you think antiseptics work?
Fill in some names of antiseptic products and suggest how you think they may work?

Antiseptics are medicines that slow or stop the growth of germs and help prevent infections in minor cuts, scrapes, and burns. Antiseptics are often applied to the skin to keep bacteria from getting into the wounds and causing infection. However, antiseptics do not usually kill bacteria; they simply slow their growth. Their purpose is to avoid infection, sepsis, or putrefaction.

Antiseptics should be distinguished from antibiotics and disinfectants:
Antiseptics: _____
Antibiotics: _____
Disinfectants: _____

Some antiseptics are true germicides – capable of killing microbes [bacteriocidal], while others only prevent or inhibit their growth [bacteriostatic]. Antibacterials are antiseptics that only act against bacteria.

Examine some labels from antiseptic products and write down the main ingredients!

_____

_____

The history of antiseptics…

It was Ignaz Semmelweis (photo above) who first recognized the importance of hand cleanliness when dealing with patients. He demonstrated that 'childbed fever' was contagious and that enforcing appropriate hand washing behavior by medical caregivers could drastically reduce its incidence. After much research, he found that the number of cases was drastically reduced if the doctors washed their hands carefully before dealing with a pregnant woman. Risk was in fact particularly high if the doctor had been in contact with a corpse before they treated the woman. However, Semmelweis got a poor reception from the medical community. It was after Dr. Semmelweis's death that the germ theory of disease developed. Joesph Lister was the first to adopt the antiseptic chemical phenol in surgery, following the discovery by Louis Pasteur that microorganisms cause infections. Nowadays, surgical techniques are based on ***asepsis*** (the absence of pathogenic organisms) rather than using antiseptics. Sterilization is a method of achieving asepsis.

Florence Nightingale.

Florence Nightingale was born in Italy and devoted her life to nursing. Florence contributed greatly during the Crimean war where medicines were in short supply and hygiene was neglected. Florence began by cleaning the hospital and equipment. She greatly improved sanitary conditions in hospitals. She began to be known as the lady with the lamp.

Cleanliness and washing hands with antiseptic lotions is being used to try and prevent the spread of swine flu.

How to use antiseptics

Some common antiseptics include alcohols, iodine, hydrogen peroxide, and boric acid. These antiseptic products can be purchased without a prescription.
Applying an antiseptic to a wound is not adequate treatment. The wound must first be cleaned, and in most cases, it must be covered / bandaged to keep it clean during the healing process.

Negative effects

As with antibiotics, the overuse of antiseptics and antibacterial agents may lead to an increase in dangerous, resistant strains of bacteria.
How do you think this may occur? (How can this be related to unit 1?)

_____

_____

Our own antiseptics!

The human body produces its own antiseptics, which are apart of the chemical barriers of the immune system. The skin and respiratory tract secrete antimicrobial peptides. Enzymes in saliva, tears, and breast milk are also antiseptic. Semen contains defensins and zinc to kill pathogens. In the stomach, acids and proteases are powerful barriers against ingested pathogens.

Activity: To show that antiseptics are oxidizing agents

What is an oxidizing agent?

_____

_____

_____

Hydrogen peroxide can be used as an antiseptic. This activity will show that hydrogen peroxide is an oxidizing agent. Potassium iodide is added to the hydrogen peroxide solution. The hydrogen peroxide oxidizes the iodide to iodine. When starch is added, a **blue colour** is observed as the starch reacts with iodine; this indicates that it is an **oxidizing** agent. This is known as the potassium iodide starch test.

Iodide $\xrightarrow[\text{agent}]{\text{oxidising}}$ Iodine $\xrightarrow{\text{starch}}$ Blue colour

I^- I_2

Observations:

_____

_____

_____

Unit 2. Antiseptics.

Lesson 2. Effect of antiseptics. (Double lesson)

Antiseptics and disinfectants are widely used in hospitals and households for a variety of uses and for hard-surface applications. A wide variety of active chemical agents (biocides) are found in these products. There is an increase in the use of antiseptics and disinfectants in homes due to concern about the microbial contamination in food. In general, biocides have a broad spectrum. What does this mean?

_____

Experiment: The effect of disinfectants and antiseptics on microbial growth

Background information.

Sterilization: a physical/ chemical process that completely destroys all microbial life, including spores. Sterilization is usually produced by autoclaving with the use of high temperatures and pressures. Chemical sterilization (antiseptics and disinfectants) is therefore necessary for the human body and objects too large to autoclave. Disinfectants and antiseptics do not always sterilize because some of the products only prevent further growth rather than killing all bacteria.

Examples of disinfectants

_____

_____

_____

Examples of antiseptics

_____

_____

_____

Every antiseptic/disinfectant has both advantages and disadvantages. In this experiment you will be comparing the effectiveness of 4 antiseptics or disinfectants on the microbial growth of *E coli* and *Staphylococcus aureus* (both of which can be found in kitchens and hospitals).

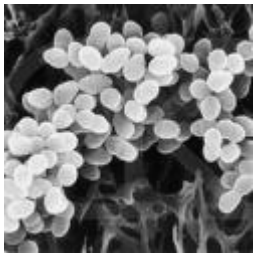
Escherichia coli (E. coli)

There are four recognized classes of E *coli* that cause gastroenteritis in humans. E *coli* are rod-shaped bacteria that affect humans, bovine, and swine (see photo below). A symptom of infection is a watery or bloody diarrhea. Common foods containing E *coli* are raw beef and chicken, although any food exposed to faecal contamination

may be contaminated. (This is why you MUST always wash your hands well after going to the toilet.) It appears that countries with poor sanitation practices have the most frequent outbreaks.

Staphylococcus aureus (staph)

This is also known as golden staph. It is a spherical bacterium (see photo below), frequently living on the skin or in the nose of a person. Approximately 40% of all adults carry this bacterium in their nose and throat and 15% on their skin. Occasionally, *staphyloccus aureus* can get into the body and cause infection. Staph can cause a range of illnesses from minor skin infections to life threatening diseases such as pneumonia, meningitis, septicemia and more. It can be treated using antibiotics. MRSA are staphylococci that are resistant to antibiotics.



Safety tips!

Because an individual microbe is too small to see with the naked eye, they have to be grown as a culture on agar plates.

- Wash your hands before and after this experiment with soap and water.
- No eating or drinking in the laboratory.
- Do not touch your eyes, mouth or face during the experiment.
- Use aseptic techniques to avoid contamination.
- Laboratory coat and goggles must be worn throughout the experiment.
- Open petri dishes as little as possible.

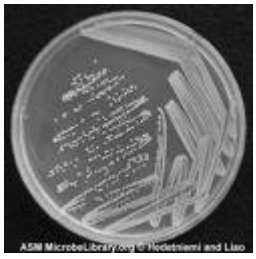
Method:

1. Using a sterile swab dipped into the broth culture of *Escherchia coli*, inoculate the surface of one nutrient agar plate heavily to obtain confluent growth after incubation.
2. Do the same with the other agar plate, using the broth culture of *Staphylococcus aureus* and a second sterile swab.
3. Label the bottom of each plate with the name of the organism.
4. Number the four antiseptic or disinfectant bottles that you will be testing 1, 2, 3, and 4.
5. On the *bottom* of the agar plates, mark four sectors using a marker pen. Label the sectors 1, 2, 3, and 4. These numbered sectors correspond to the numbers you put on the antiseptic or disinfectant containers.

6. Sterilise the tip of your forceps by passing it through the flame of your Bunsen burner two or three times.
7. Aseptically pick up a sterile filter paper disk with your sterile forceps and dip the disk into the disinfectant or antiseptic numbered 1. Ensure that the excess liquid has drained off.
8. Place the disk in the centre of Sector 1 of the *S. aureus*-inoculated plate.
9. Using the same disinfectant, place another disk in Sector 1 of the *E. coli*-inoculated plate. You are comparing the effectiveness of each disinfectant or antiseptic on both organisms.
10. Repeat steps 8 and 9, placing the other disinfectants in the other sectors.
11. Gently press the disks down with the tip of your flamed forceps to ensure contact with the nutrient agar.
12. When all four disinfectant-soaked disks have been placed in all four sectors of both plates, seal them with parafilm, invert the plates and incubate them at 37^{o}C for 48 hours.

You will be required to write a report including title, aim, method, results, discussion and conclusions. You will observe the zone of no growth (the zone of inhibition) around each disk. The discussion/ conclusions will evaluate the effectiveness of each antiseptic/ disinfectant.

E *coli* agar plate



staph agar plate

Mechanisms of action

Firstly, the antiseptic interacts with the cell surface followed by penetration into the cell, and action at the targeted site. The outer layers of microbial cells have a significant effect on their susceptibility to antiseptics.

There are many **biocides** used in antiseptics and disinfectants. There appears to be a great variation in the ability of antiseptics to destroy microorganisms, and a great difference in time required for different antiseptics to work. We will now examine one.

Iodine: is one of the fastest working antiseptics, killing bacteria within thirty seconds. Although aqueous or alcoholic solutions of iodine have been used for 150 years as

antiseptics, they are associated with irritation and excessive staining. The antimicrobial action of iodine is rapid and results in cell death.

Iodine is:

Bactericidal	
Fungicidal	
Virucidal	
Sporicidal	

True or false???

1. Disinfectants always remove all bacteria and fungal spores from an object.

   _____

2. Antiseptic is another term for disinfectant.

   _____

3. The presence of blood serum, skin tissue and other body fluids would interfere with the antimicrobial action of disinfectants.

   _____

4. Disinfectants are used as mouth / throat gargles.

   _____

5. The zone of inhibition is the clear zone around an antimicrobial agent in which no bacteria are growing.

   _____

6. All disinfectants are equally effective against most microbes.

   _____

7. Cutting instruments, thermometers, and plastic materials are best sterilized by autoclaving.

   _____

Unit 2. Antiseptics.

Lesson 3. Writing a report. (Single lesson)

Observe the results and complete the report.

Title:

Aim:

Method:
(Only make bullet points)

Results: (draw a table and also draw your plate. Measure and compare the diameters of the areas of inhibition of growth around each treated disk.)

Discussion / Conclusion:
Compare the effectiveness of each antiseptic or disinfectant.

Activity:

You will be given an envelope containing many questions and answers. Your job is to match the questions with the correct answers!

Unit 3: Blocking sensations!

Unit 3. Blocking sensations.

Lesson 1. Types of anaesthesia (single lesson)

Think about it…..
If you were to twist your ankle and you felt pain – what action would you take?

_____
_____

What is pain?

_____
_____

If you hold some ice to your skin, what feeling would you experience after a few minutes?

_____

What other methods are used to achieve this feeling?

_____

What do you know about anaesthetics? Have you ever had an anaesthetic?

_____

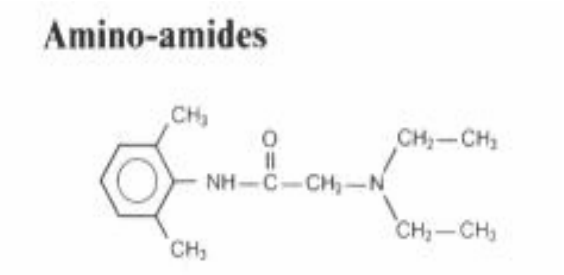
Anesthesia involves the loss of sensation – particularly pain – in all or part of the body.

What does the word anaesthetic mean?

_____
_____

If you are ever faced with having surgery, you will need some type of anaesthetic. There are three main types of anaesthetics – local, general, and regional.

Structure of a local anaesthetic:



Activity: Can you think of some differences between the three types of anaesthetics?

Local	General	Regional

The history of anaesthetics

In the past, there were no anaesthetics available and if a patient was faced with needing surgery they often had to be held down and they suffered much pain. There was also often a priest present, as most patients did not survive major surgery. Patients were often drugged with alcohol.

Opium poppy capsules were collected and used as herbal anaesthetics around 1500 BC. While it produced unconsciousness, it did so unreliably and with significant side effects. Also in America, coca became an important anaesthetic. Doctors chewed coca leaves while performing an operation and would spit into the wounds.

Humprey Davy discovered the qualities of nitrous oxide as an anaesthetic in 1799, and it became known as 'laughing gas'. In 1842, ***diethyl ether*** was used as an anaesthetic and became quickly popular. In 1831, ***chloroform*** was discovered and its use as an anaesthetic spread quickly. However, it caused many deaths, as it was not used properly.

The first effective local anaesthetic was cocaine. Carl Koller first used it in 1884. Nowadays, common local anaesthetics used are cocaine, procaine, lidocaine etc. They are fast acting and reliable. General anaesthetics, which are currently used, are nitrous oxide, halothane and many more. These are reliable methods in common use but no anaesthetic currently in use meets all the requirements of an 'ideal' anaesthetic.

Morphine is an example of an agent that has a longer onset and duration; and it is frequently used for postoperative pain relief.

More about laughing gas!

Nitrous oxide (N_2O) is a colourless, odourless gas. Humprey Davy experimented with the properties of this gas. For forty years, it was used as a means of entertainment, where the public would pay a small price to inhale a minutes worth of the gas. People would laugh and act silly until the effect came to an abrupt end. In the 1840's, nitrous oxide began to be used as an anaesthetic. A man by the name of Dr. Wells discovered that a patient was unaware of his injury after inhaling the gas. This was the birth of N_2O as an anaesthetic. Nitrous oxide is still used nowadays and is a very safe and popular agent.

Have you ever had an anaesthetic?
If yes, write a short account of your experience and what it felt like.

Unit 3: Blocking sensations!

Lesson 2. Blocking the pain (Double lesson)

Methods used to administer anaesthetics to patients are:

- Injection
- Creams
- Sprays
- Inhalation using a gas machine

The most likely place you will have received an anaesthetic is at the dentist. What method does the dentist use to administer an anaesthetic?

_____

FACT!
It is estimated that an average dentist administers between 1500 – 2000 injections of local anaesthetics each year!!
It usually takes about 2-4 minutes for a local anaesthetic to kick in. The time depends on how quick the anaesthetic can penetrate the membrane.

Due to the fact that some people may be allergic to certain types of anaesthetics, you will be required to fill out a form when you first visit the dentist. The form will contain questions such as in the following sample:

Patients name:
Height:
Weight:
Date of birth:
In case of emergency please notify:

1. Have you ever taken illegal drugs?
2. Have you ever been dependant on alcohol?
3. Do you have AIDS or HIV positive?
4. Are you pregnant?
5. Are you taking birth control pills?
6. Are you taking any medication or herbal supplements?
7. Have you ever had an allergic reaction to foods, medication, latex, or rubber?
8. Do you have any heart trouble; ever had a heart attack, angina, a pacemaker?
9. Do you have abnormal blood pressure?
10. Do you have diabetes?
11. Etc.

Signature: _____ Date: _____

Study this picture.

How many people had to hold down the patient?

_____

Why do you think this was necessary?

_____

_____

_____

There was often a priest present when a person was having surgery- why was this necessary?

_____

_____

_____

	In the past	**Today**
How many drugs used to anaesthetize a patient at any one time	1 drug used in large quantities	Many different drugs
How was the amount of drugs controlled?	Hard to control- drops put on a handkerchief	Modern technology controls the amount depending on the persons weight and age
How long did it take for a patient to wake up?	A long time	Controlled by amount of anaesthetic given
Who would administer the anaesthetic?	Anybody	An anesthetist
What were the death rates in operations using anaesthesia?	Many people died after being administered ether or chloroform	Less than 1 in 250,000

How do you think anaesthetics ‘numb’ pain?

What part of our bodies would the anaesthetic have to affect to prevent us from sensing pain?

_____
_____
_____
_____

Can you recall the function of the 2 types of neurons (nerves)?
Sensory neurons:

_____
_____

Motor neurons:

_____
_____

It is these nerves/ neurons that enable us to sense pain. When we receive a local anaesthetic, it is absorbed into the nerves. It blocks the nerves from conducting messages, thus a message cannot be passed to the central nervous system to inform the brain that there is pain occurring. The nerve will regenerate itself after a few hours depending on the dose, and it will begin conducting again. This occurs when we feel the numbness ‘wearing off’, and we start to feel normal sensations again.

The structure of a nerve

Diagram

Functions of the parts of a nerve:

Axon:

Mylin sheath:

Schwann cells:

Nodes of ranvier:

Dendrites:

Axon terminals:

Activity:

Look up the structure of some common general anaesthetics like nitrous oxide, ether and halothane, and their physical and chemical properties. Do they have anything in common that makes them a good anaesthetic?

Unit 3: Blocking sensations!

Lesson 3. More about the nervous system! (Single lesson)

Activity

How do you think the nervous system could be compared to a modern security system?

In groups of 2, you will design a brochure, which will advertise the nervous system as a security system. This involves you explaining the overall purpose and functions of the nervous system. You have to make it sound like a security system, which lets the body know when there is something wrong. You must use your imagination for this task! You may use drawings, magazine cuttings, computer graphics, etc in your brochure.

However, your brochure must contain the following vocabulary: **cell body**, **dendrites**, **neuron**, **axon**, **impulse**, **central nervous system**, **cerebellum**, **spinal cord**, and **peripheral nervous system**. You may need to look up some of the functions of these parts.

Give your brochure a *catchy title*, and you will present this to the class.

Unit 4: Antacids

Unit 4: Antacids
Lesson 1. Indigestion (Single lesson)

Sometimes after a meal you may experience some uncomfortable symptoms such as heartburn, belching, and regurgitation. What do these symptoms indicate?

_____

What would you take to relieve these symptoms?

_____
_____
_____

These products are known as ***antacids.*** What does the word antacid mean?
(hint: break it down into two words)

_____
_____

Can you think of some examples of acids?

_____
_____
_____

We take antacids to help relieve the uncomfortable symptoms of indigestion.
How would you define an antacid?

Antacids are bases, which neutralize the acid in your stomach.

Recall the pH scale, which is used to show if a substance is acidic or basic.
Activity: Draw the pH scale. Mark on it the pH of the stomach.

History of antacids….

Antacids have been used for over 2,000 years for the treatment of heartburn and indigestion. They have mainly been made from calcium carbonate. Where is calcium carbonate found? _____

Back in the sixteenth century, powdered pearls were used. (What are pearls made from?) People also started to use ammonia and potash, both alkalis, but these could be quite dangerous. However, in the last 100 years, there have been major advances and there are now many products available, which give fast relief and are relatively cheap. They can be bought over the counter without a doctor's prescription.

Antacids are usually compounds of calcium, magnesium, or aluminum.

Activity:

Study the labels of some antacid products and compare their active ingredients:

Antacid product.	**Active ingredient.**

Note…

Heartburn is also referred to as acid reflux disease and antacids are reflux suppressants.

Unit 4: Antacids

Lesson 2. Neutralization reactions. (Double lesson)

Antacids perform a neutralization reaction in the stomach:

ACID + BASE = _____ + _____

Since antacids are bases, re- write the equation:

_____

The acid present in our stomach is called:

_____

Antacids differ in how quickly they neutralize acid and how long they provide relief. Those that contain magnesium hydroxide and sodium bicarbonate appear to have the fastest relief. Those that contain calcium carbonate or aluminum hydroxide tend to take longer to begin working. Why do you think this may be the case?

_____

Experiment: to investigate which antacid can neutralize the most stomach acid

Safety!

- **Safety goggles and disposable gloves must be worn throughout this experiment.**
- **A laboratory coat must also be worn and fully buttoned.**
- **Particular care must be taken when using HCL, as it *can* burn your skin.**
- **Wash your hands after the experiment.**

Materials:
4 different antacid tablets
4 beakers
Hot plate
Burette
Hydrochloric acid (HCl) solution
Universal indicator paper or pH meter

Method:

1. Collect four 200 mL beakers.
2. Place 50 mL of hot water in each beaker.
3. Using a bowl and pestle, crush one dosage of each antacid.
4. Put each crushed antacid into a separate beaker of water and label them.
5. Mix the contents of each beaker until the antacids are fully dissolved.
6. Place the beakers in a hot water bath for a few minutes.
7. Test the initial pH of each beaker. You can use a pH meter is available or universal indicator paper.
8. Fill a burette with HCl solution.
9. Allow one drop of HCl into beaker 1 and test the pH. Continue to add drops of HCL until the pH = 7.
10. Count the number of drops needed to bring the solution to pH 7.
11. Repeat this for each beaker.
12. Record the amount of drops used by each beaker.

Results.

Antacid 1 = _____

Antacid 2 = _____

Antacid 3 = _____

Antacid 4 = _____

Antacid	**1**	**2**	**3**	**4**
Initial pH				
No. of drops				

Conclusion:

Which antacid neutralises the most hydrochloric acid?

Question:

Why did we use hydrochloric acid as the acid in this experiment?

Activity:

Make a poster, which depicts the main points of the experiment. Use pictures!
It should include:
Title
Materials
Procedure (short points)
Safety
Results
Graph (bar graph)
Conclusion

Forms of antacids

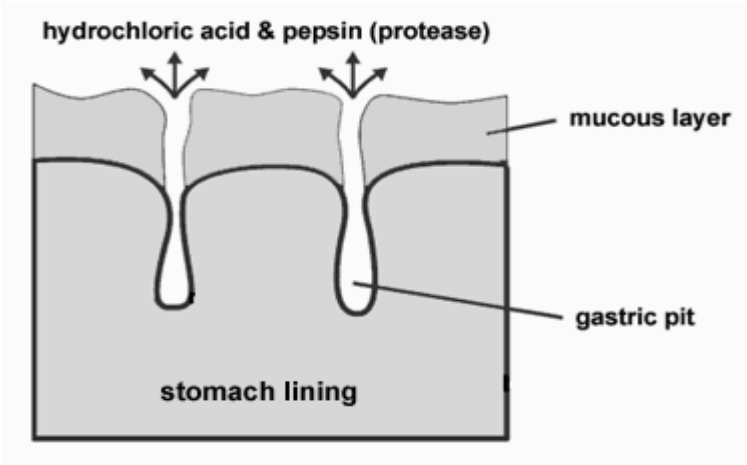
Antacids can be taken as tablets or as suspensions (e.g. Milk of Magnesia).
Note it is very important not to continue taking antacids regularly for over 2 weeks if symptoms persist. This could cause serious side-effects such as vomiting, constipation, ulcer disease etc.

Action of antacids explained further…

What do you think the function is of HCl in the stomach?

_____

Hydrochloric acid is produced in the stomach lining to help in the breakdown of food. However, if there is too much acid, it may travel up the oesophagus and irritate it. The excess acid causes sharp or sore pains. When we swallow the antacid, it neutralizes the acid and soothes the lining. Usually it is rich, fatty, or spicy foods that cause indigestion as the stomach finds these foods difficult to digest so it produces extra acid.



Unit 4: Antacids
Lesson 3. Investigation (Single lesson)

Another way to test the efficiency of antacids is by means of colour change.

Experiment

In this experiment, we will compare the efficiency of 2 antacids _____ and _____ to observe which is the strongest antacid.

Safety!

- **Safety goggles and disposable gloves must be worn throughout the experiment when using ammonia and vinegar.**
- **Laboratory coats must be worn.**
- **Avoid skin contact with ammonia.**
- **Wash your hands after the experiment.**

Materials:
Red cabbage
Two different antacid tablets
2 large beakers (500 mL)
3 small beakers (100 mL)
Funnel
Bottle
Measuring cylinder
3 test tubes
Vinegar
Ammonia solution or sodium bicarbonate

Method:

To make an indicator

1. Place a chunk of red cabbage into a large beaker with approximately 350 mL of water in a large beaker and heat to boiling. Simmer for a few minutes.
2. Pour the cabbage juice through a strainer into a beaker, and then through a funnel into a bottle. Label it 'Red cabbage indicator'.

Test the cabbage juice indicator

3. Get 3 test tubes. Place 10 mL of water and 10 mL indicator solution into each test tube.

4. Add a few drops of vinegar to the 1st test tube, ammonia solution (or sodium bicarbonatesolution) to the 2nd test tube and water to the third. Compare the colour in each test tube.

Observations:
1._____
2._____
3._____

Next…testing the antacids

5. Add 50 mL of indicator to 200 mL of water in a large beaker. Add a few drops of vinegar to obtain a reddish colour.
6. Half fill each of three small beakers with the solution.
7. Crush 2 tablets of each antacid. Place the 1st antacid powder into glass 1 and the 2nd powder into glass 2. Do not put anything into glass 3. This is the _____.
8. Stir each glass every 5 minutes for approximately 20 minutes, and compare the colours.

Results:
Which antacid caused the biggest change in colour?

Conclusion:
What does this experiment tell us about the two antacids?

Unit 5: PAIN

Unit 5: Pain.

Lesson 1. What are analgesics? (Single lesson)

By this stage in your life, you will have experienced some pain. But what is pain and why does it occur? What do you think?

_____
_____
_____

List some examples of pain that you have experienced:

_____
_____

What can people do to relieve pain when it occurs?

_____

List some examples of these products.

_____
_____
_____

These products are known as ***analgesics***. Firstly, what do you think the word means? (Break it down!)

_____
_____

We can define an analgesic as:

_____
_____

The choice of analgesia is dependent on the type of pain (where it occurs, how severe it is etc.)

Let's examine the information leaflets of some common analgesics to help us make more informed choices in the future!
Read the labels and fill in the table below.

Analgesic	Active ingredients	Uses	Production company

Important note! The dangers of paracetamol

You should **never** take more than one product containing paracetamol at a time. For example, if you have the flu, do not take Panadol and Lemsip together. Why do you think this is dangerous?

_____
_____
_____

A trip down pain lane!

Opium is the oldest known painkiller used since 900 BC. In the past, it was known as 'the bringer of sleep and forgetfulness'.

The opium poppy - the source of opium

In 400 BC Hippocrates, the father of medicine, prescribed extract of willow bark to control pain. In 1763 the Rev. Edward Stone began using willow bark to control the ague, however, it was not until the mid-80s that commercial salicylic acid was developed. Salicylic acid is too hard on the stomach and acetylsalicylic acid (ASA) was developed by Felix Hoffmann in 1897 and marketed by the German company Bayer as aspirin. This was made by chemical synthesis not from willow bark. Paracetamol was next developed in 1893 and was initially named acetaminophen. It did not become popular until the 1950s.
By 1917 morphine was produced as a painkiller and it is still the medicine of choice for severe pain.

Activity:

Now that you have knowledge about different analgesics and what they should be used for, this activity requires you to prescribe the correct drug for each pain sufferer.

Pain sufferers	**Recommended analgesic**
A person with a simple headache	
A person who suffers from arthritis	
A pregnant woman with back pain	
A person who is allergic to aspirin	
A child with high fever and body aches	

Unit 5: Pain.

Lesson 2. Aspirin synthesis (Double lesson)

It was _____ who synthesized aspirin from salicylic acid. In this section we will examine how he carried out the synthesis and will then undertake the experiment.

Aspirin is an **ester.** Esters are organic compounds. An organic compound is a carbon-based chemical. To synthesize an ester, you need two other organic compounds – an alcohol and an acid.

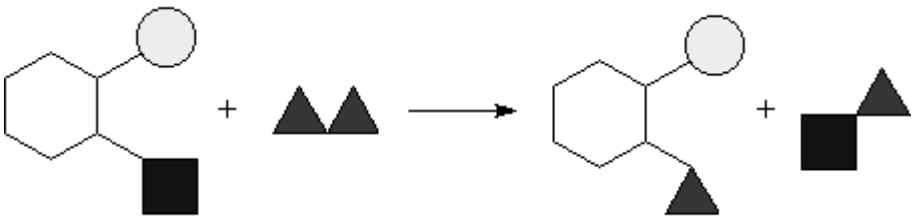
ALCOHOL + ACID = _____

This is known as an **esterification reaction.** In the case of making the ester aspirin we use:

SALICYLIC ACID + ACETIC ANHYDRIDE = ACETYLSALICYLIC ACID + ACETIC ACID

Acetylsalicylic acid = aspirin

The reaction is done in the presence of sulphuric acid, which is the catalyst.
This symbol equation shows clearly how an esterification reaction occurs. One part of the salicyclic acid molecule is replaced by an acetyl group to form the ester.



Salicyclic acid **Acetic anhydride** **Acetylsalicyclic acid** **Acetic acid**

Experiment: To make aspirin

Safety first!

- Laboratory goggles and a laboratory coat (or apron) must be worn at all times throughout this experiment. You should wear plastic gloves when handling the chemicals.
- Particular care should be taken with acetic anhydride to avoid any contact with skin / eyes as it is an irritant.
- Avoid skin contact with sulphuric acid, as it will cause severe burns.
- Do **not** leave the boiling water unattended.
- You may **not** consume the product under any circumstances.
- Wash your hands after the experiment.

Materials:
Hotplate
2 250 mL Beakers
Test tubes (4)
Filter paper
Plastic pipette
Salicyclic acid
Conc. sulphuric acid
Acetic anhydride
Iron (III) (Ferric) chloride solution
Methanol

Procedure:
(You must follow these instructions carefully in order to synthesize aspirin correctly.)

1. Half-fill a 250 mL beaker with water and heat the beaker to boiling point on a hot plate.
2. Fill the second beaker with ice and add water until the beaker is approximately 2/3 full.
3. Measure the mass of a clean, dry test tube. Record this mass.
4. Measure an amount of salicylic acid about the size of a match head into the clean dry test tube.
5. Measure and record the mass of the test tube and salicylic acid.
6. The teacher will place 8 –10 drops of acetic anhydride and 3 –4 drops of conc. sulphuric acid into the test tube.
7. Heat the test tube and its contents in the hot water for approximately 3 minutes.
8. Remove the test tube from the hot water and using a plastic pipette, add 10 drops of water.
9. Stopper and shake the test tube.

10. Place the test tube in the ice bath for at least 5 minutes.
11. Observe and record your observations.
12. Use a pipette to remove any liquid from the crystals.
13. Place the wet crystals on a piece of filter paper and place on a watch glass overnight.

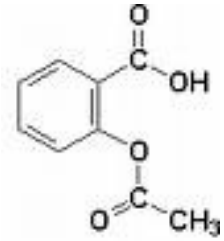
Results:
Mass of test tube: _____
Mass of test tube and salicylic acid: _____

Observations when test tube is placed in ice bath:

_____
_____
_____
_____

After drying for 1 day, weigh the crystals and find the mass of the dry crystals.
Observations:
_____
_____
_____
Mass of dry crystals: _____

You have now made aspirin by means of an esterification reaction.
This is the chemical structure of an aspirin molecule



Identification test for aspirin: The iron(III) (ferric) chloride test!

You are now going to compare your product with some salicylic acid. Salicylic acid contains a phenol (an aromatic ring with -OH). If the salicylic acid has been changed to aspirin successfully, the aspirin should not contain a phenol.
If a phenol group is present the iron(III) chloride will give a purple colour.

Method:

- In separate test tubes, dissolve a few crystals of salicylic acid, a few crystals of your aspirin and some commercial aspirin in 1 mL of methanol. Make up a blank sample with only methanol.
- Add 1-2 drops of ferric chloride solution to each test tube and shake.

Results: Record what you see.

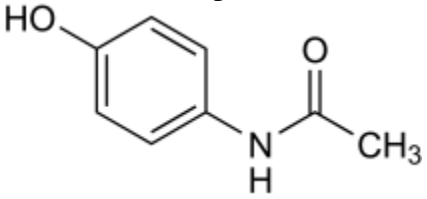
Salicyclic acid	
Aspirin sample	
Commercial aspirin	
Methanol only (blank)	

Activity:

Draw the salicyclic acid and aspirin molecules in colour to represent a 3-D look or better make a molecular models.

Colour code:
Carbon = black
Oxygen = red
Hydrogen = white.
Nitrogen = blue

The structure of paracetamol is shown below:



Make a model of this also and compare it with the aspirin molecule. What are the similarities and differences between the two molecules and that of salicyclic acid?

Unit 5: Pain

Lesson 3. Finding out more about analgesics (Single lesson)

Detective work!

Your job is to research the following topics in your allocated groups and give a short presentation to the class.

1. The history of analgesics. (Extend the information already given)
2. How does aspirin work biologically to reduce the risk of heart attack?
3. Addiction to analgesics (how they affect the liver).
4. What is the 'doctrine of signatures' and what role did it play in the development of aspirin?
5. How do analgesics (for example, aspirin) help to reduce fevers?
6. What is the relationship between aspirin and cancer?
7. How does a migraine differ from a headache? What medicines are used to treat migraines?
8. Research the company that produces Panadol.
9. What is Reye's syndrome? What are the side-effects of taking aspirin?

Unit 6: Importance of medicine

Unit 6. Importance of medicines
Lesson 1. Upcoming new drugs (Single lesson)

Everyday in the media we see stories of new medical findings. For example:

"Drug development costs about $1.7 billion"

"Cannabis the new wonder drug?"

"New vaccine may contain rabies"

"New study of obesity looks for larger test group"

Can you think of any other headlines on new medicines you may have seen recently?

Even though billions of pounds may be put into research and development and then into drug trials, it still happens that drugs are found to have unexpected side-effects and have to be withdrawn from the market. It is also unfortunate that there are still so many illnesses/diseases for which humankind have found no cure.

List some diseases/ illnesses, which have no present cure:

_____
_____
_____

It is _____ companies that make it possible for new drugs to be introduced – they are an extremely important industry to say the least! Ireland is a very important centre for the manufacture of medicinal drugs.

Production of drugs

What do you think would be some of the most important things to consider before developing and introducing a new drug?

Ideas:

_____
_____
_____
_____

The following is the typical sequence of events that occurs when scientists develop a new drug:

1. Will there be a large market?
2. Run many tests to find out how the drug behaves in the body; check the drug in animal studies for signs of toxicity.
3. Scientists assess how the drug is metabolized, how long it stays in the body, and where it goes.
4. Phase I (approx 18 months): Clinical trials. Firstly, the drug must get approval from the Medicines and Healthcare products regulatory agency (MHRA). Six

healthy volunteers are then given doses of the drug much lower than have proved safe in animals; and are monitored carefully.

5. Phase II (approx 12 – 24 months): this stage involves a small group of patients. The drug is tested to ensure that it is safe in people with the disease, and that it does have beneficial effects.
6. Phase III (several years): almost 5000 patient volunteers take part in this stage. The drug is named and gets a license by MHRA. Phase III is the most expensive stage and failure can waste millions of pounds. The company must have great confidence in the drug before proceeding from phase II to phase III.

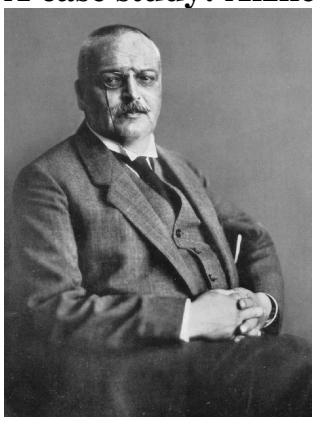
Note! It takes more than 10 years to go from a research lead to a licensed product!

Can you think of any other diseases / illnesses which are currently under research for a cure?

_____

_____

A case study: Alzheimer' disease



Alois Alzheimer

What is Alzheimer's disease?

_____

_____

_____

What do you already know about the function of the brain?

_____

_____

_____

How do you think that damage to the brain may affect a person?

_____

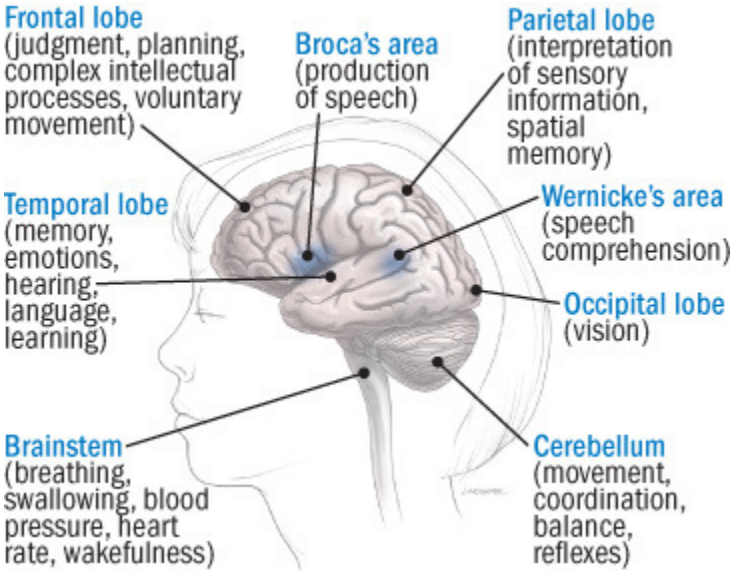
_____

_____

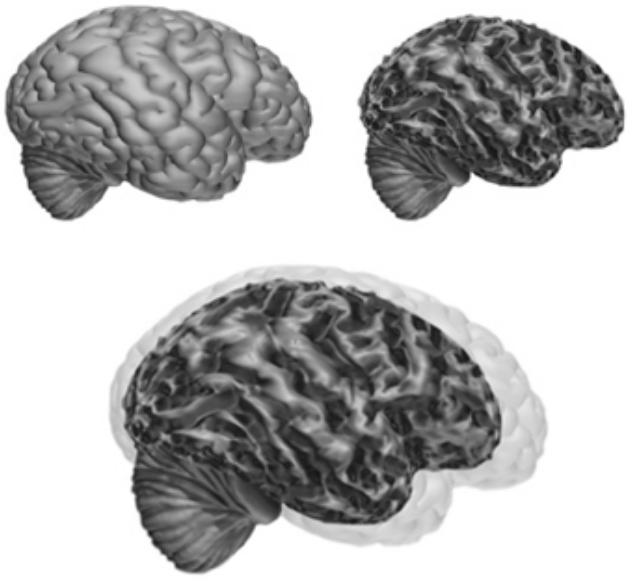
_____

Alzheimer's is a progressive and fatal brain disease. It destroys brain cells, causing problems with memory, thinking and behavior. A healthy brain weighs about _____.

Functions of the brain



The following picture shows the difference between a healthy brain and a brain affected by Alzheimer's disease.



- On the top left is a healthy brain.
- The top right shows a brain affected by the disease.
- The bottom picture shows the difference in size between a healthy brain and a brain affected by Alzheimer's disease.

You may have read in the newspapers recently that scientists are trying to find a cure for this fatal disease. The following is a headline and article, which appeared in a newspaper on April 11th 2008. If you know anyone who has this disease or has died from it, you will understand how important a drug would be that would cure or slow down the disease.

“New hope for Alzheimers sufferers after new treatment restores memory in minutes”

New therapy could hold out hope for Britain's 400,000 Alzheimer's sufferers.
Doctors are calling for a clinical trial of an experimental drug treatment that it is claimed can reverse the symptoms of Alzheimer's disease "in minutes".
U.S. researchers say the treatment allowed an 82-year- old sufferer to recognise his wife for the first time in years.
In the UK, specialists believe the claims should be properly tested as only a few patients have been treated so far.
The treatment involves injecting a drug called Enbrel - which is normally used to treat arthritis - into the spine at the neck.
Patients are then tilted to encourage blood flow into the brain where the drug is designed to block a chemical responsible for inflammation. At least one Alzheimer's patient had his symptoms reversed "in minutes" while others have shown some continuing improvement in problems such as forgetfulness and confusion after weekly injections.
They needed less help from carers during treatment, which appears to reach a plateau at three months.
Around 50 people are being treated by the Institute of Neurological Research, a private clinic in California, with some having had injections for three years.
In one case, the clinic has video evidence of Marvin Miller, 82, which showed he was unable to answer basic questions by a nurse, or identify-everyday objects like a bracelet and a pencil.
Shortly afterwards he is injected with the drug and it is claimed that five minutes later he could greet his shocked wife, who said he had not recognised her for years.
The experiment follows the discovery that levels of TNF (tumour necrosis factor) can be up to 25 times higher in the fluid surrounding the brain in sufferers of Alzheimer's disease.
Enbrel, a biologic treatment licensed for rheumatoid arthritis, binds to excess TNF in the body and makes it inactivate.
When used by arthritis sufferers, the drug is self-administered by injection and researchers had to develop a way of injecting the drug into the spine in order to get an effect in brain cells.
Enbrel is not approved for treating Alzheimer's in the U.S. or in the UK and is regarded at this stage as a highly experimental therapy.
Professor Edward Tobinick, of the University of California Los Angeles and director of the Institute for Neurological Research, is leading the research.
He said the latest report was an in-depth account of one patient's response to treatment.
He said: "It makes practical changes that are significant and perceptible, making a difference to his ability to do activities of daily living such as getting around, accomplishing things and conversing."
He added: "Some patients have been able to start driving again. They don't come back to normal but the change is good enough for patients to want to continue treatment, and some have been doing so for three years.
"We are working with several universities and larger trials are getting under way."
Dr Susanne Sorensen, head of research at the Alzheimer's Society, said: "On the surface these results are exciting but we need to treat the study with caution.
"There are large gaps in the research, which only involved a small pilot group and we cannot draw any conclusions until a controlled trial is carried out."
Rebecca Wood, chief executive of the Alzheimer's Research Trust, said: "It is too early to speak of a miracle cure and we need to do more research into this."

Unit 6. Importance of medicines
Lesson 2. Role of pharmaceutical companies. (Double lesson)

A pharmaceutical company is a commercial business whose focus is to research, develop, market, and distribute drugs. They are subject to a variety of laws and regulations regarding the patenting, testing, and marketing of drugs.

Can you name any pharmaceutical companies based in Ireland?

_____
_____
_____
_____
_____

Now that you understand what in–depth trials are necessary to get a drug on the market, you will undertake an activity, which will require application of this knowledge.

A large pharmaceutical company is now planning their future expenditure. In the past five years, they have had three failures of drugs at phase III that has cost the company millions. The company now has to be very careful about proceeding with the next drug, as they cannot afford to have another failure. The company has three proposed drugs that have all passed phase II. A meeting will now be held with a senior committee of executives to decide which drug A, B, or C should be put forward to phase III.

Roles to play:

- **The Chief Executive Officer:** you are the boss. You would not normally attend this type of meeting, but are making an exception for this difficult decision. You will conduct the meeting. At the beginning welcome everyone, and emphasize the importance of this decision. Call each development head in turn to present their case, and then allow your colleagues to do the questioning. Conduct a voting procedure and announce the result. At the end of the meeting thank everyone for his or her cooperation.

- **Head of Research and Development:** You agree that all 3 drugs have good potential but you need convincing that they will be good in the long term. Ask detailed questions about the long-term effects of the drugs. Argue strongly against the need for cost cutting, as you do not believe in cutting corners.

- **Chief Financial Officer:** you are concerned about income and expenditure. You want to reduce the costs of the trials by planning shorter smaller phase III

trials. You also ask for clear statements of how much each one will cost - do not accept approximations.

- **Head of Commercial Operations:** You feel that the company is falling behind its competitors. Question the development heads on estimated sales figures – how sure are they of these figures? The success of the drug will depend on the price it is sold at.

- **Development leaders:** 3 development leaders will present a case on each of the proposed drugs – A, B, and C. each case will be discussed individually.

- **All members will vote.**

- **Extra roles:** a patient of AIDS/HIV, a representative from the Irish heart foundation etc.

Note: you must read the following information prior to beginning the meeting.

Drug A: treatment for AIDS/HIV

40 million people in the world are affected by AIDS / HIV. There is no known cure. It is a virus, which infects and destroys white blood cells, which are required for our immune system. Each of our cells has receptors to which the virus attaches. In this case scientists have discovered a drug, which will block any virus from attaching to the cell. Cost $500 million.

Phase I: approved.

Phase II: patients affected by HIV took the new drug A, and it proved successful, as their viral count was reduced and no toxic effects observed.

Phase III: 6000 volunteers required.
Benefits – it will sell cheaply for developing countries that may not be able to afford medication. Results appear promising.

Risks – may cause long-term liver damage. Costs will be large. Also many volunteers' from different countries must be recruited to ensure that it suits people worldwide.

Drug B: treatment for heart disease

Heart disease is the leading cause of death in the UK, England, Canada, and Wales. Heart disease is also Irelands No 1 killer! There are many different types of heart disease, the most common when arteries become clogged with fat and cholesterol. Also about 2,000 people die after suffering strokes each year. In this case, scientists developed a drug, which would increase levels of good cholesterol which in turn reduces levels of bad cholesterol. Cost $600 million.

Phase I: approved.

Phase II: Many people were already on medication for this problem so it was difficult to obtain true results of the new drug. However, all patients did have an increase in good cholesterol, but 2 patients also had an increase in blood pressure, which may only be coincidence

Phase III:
Benefits – if this drug were to be successful, it would greatly reduce or even eliminate this deadly disease. It would be a big selling drug for the company, which would make up for the previous losses.
Risks – there is the risk that this drug may cause high blood pressure in patients, in which case millions would be lost for the company.

Drug C: treatment for obesity

Obesity is a disease whereby excess body fat contributes to high blood pressure, high blood fat levels, high cholesterol, diabetes etc. It is the most common nutritional disorder in the world. 1 in 5 Irish adults are obese! In this case, scientists have developed a drug, which will relieve people of cravings for food. It is observed that people who smoke cannabis get cravings for food so the challenge was to do the opposite. Cost $400 million.

Phase I: approved.

Phase II: Obese volunteers, who would be susceptible to the above-mentioned symptoms, were treated with the new drug. Weight was generally lost from the abdomen.

Phase III:
Benefits – side effects minor. This could greatly help patients with a problem that will not respond to diet or exercise. There is also a huge potential market for this drug. Cost lower than other two proposed drugs.
Risks – as this was only a short-term study, there is no guarantee that this is a long-term solution for patients. It may be said that pharmaceutical companies should focus on serious illnesses with no cures; obesity is a lifestyle effect and can be helped with diet and regular exercise.

To do…

The CEO, Head of Research and Development, Chief Financial Officer and Head of Commercial Operations must prepare their speeches, arguments and questions for the meeting.

Each development leader must produce a presentation which will convince their colleagues to vote for their drug.

All other members at the meeting must prepare a list of questions for the committee; and should make notes throughout the meeting to help make the right decision.

Now make your arguments known!

Outcome: record the final decision made by the meeting.

Unit 6. Importance of medicines
Lesson 3. Fieldtrip (single lesson)

If you want to understand how modern medicines are made you need to visit a company that makes pharmaceuticals in bulk and makes the finished medicines. There are many companies to choose from in Ireland. Pharmachemical Ireland has a list of companies in Ireland. Alternatively someone from a pharmaceutical company might visit your school.

Some suggested companies to visit:
Allmarket Ltd (Co Meath)
Clonmel Healthcare (Tipperary)
Roche, Clarecastle, (Co Clare).
Pfizer, (Cork).
Rice Steele, (Dublin)

Or. . .

Working in groups select one of the Irish companies and produce an A4 poster on the company. Find out what they make, how many people they employ, what sort of jobs there are in the company.Use the information to create a large map of Ireland showing the location of the chemical companies and what they make.

Unit 7: Science & Technology in Medicine

Unit 7. Science & technology in Medicine
Lesson 1. Electromagnetic waves (Single lesson)

There are many different types of waves – the waves you see at the beach, the waves the wind may create in a flag, and there are also energy waves.

What is an energy wave?

_____

_____

Waves can transmit electromagnetic energy, which can be used for many medical procedures.

What is electromagnetic energy?
Light, microwaves, X rays, TV, and radio transmissions are all electromagnetic waves. When you cook food in a microwave you are using electromagnetic waves!

What is radiology?

Radiology is the use of electromagnetic radiation to obtain visual images of different parts of the body.

Can you think of any examples that may use electromagnetic energy for medical purposes?

-
-
-
-
-

The electromagnetic spectrum.

Use the following box to draw the electromagnetic spectrum:

The different parts of the electromagnetic spectrum have many using in investigating the structure of matter and some of them are used in medicine.

History…
It was William Conrad Roentgen who first discovered X– radiation on 8 November 1895. It was discovered by accident but the German scientist took an X – ray of his wife's hand, which showed clearly all the bones in her hand. He called it "X" to indicate that it was an unknown (just like you do in Maths). These pictures were studied further, and became known as X – rays.

Nowadays, radiography is used to produce images, which help diagnose and treat diseases. A radiography takes these images and helps to interpret them.
Radiography involves exposing a part of the body to a small dose of ionising radiation, to produce pictures of the inside of the body.
X-rays and gamma-rays can be very dangerous as they can damage human tissue. Gamma-rays and X-Rays can only be stopped by several centimetres of lead. Lead can absorb all types of radiation, which is why this metal is used in radiography equipment to shield medical staff and patients.

Can you remember the chemical symbol for lead? _____

What is an X – ray?

Ideas!

_____
_____
_____

List some uses of X – rays.

- _____
- _____
- _____
- _____

Examine the images below. One hand is healthy and the other has poor circulation. Can you tell which one is which?

_____ _____

Can you recall the three types of blood vessels which circulate blood in the body?

- _____
- _____
- _____

Unit 7. Science & technology in Medicine
Lesson 2. X- rays and Ultrasound (Double lesson)

Share your experiences on X-rays with the class. When did you need to have an X-ray taken?

Bone X-rays.
An X–ray machine produces a small burst of radiation that passes through the body, recording an image on photographic film.

How does an X-ray work? What do you think?

_____
_____
_____
_____

Different parts of the body absorb different amounts of radiation. Dense bone absorbs most radiation.

In the X-ray above: Bone appears white and soft tissue appears in shades of grey.
Air appears black.

What about the patient?
If you have had an X– ray before, you will be familiar with this procedure.
The person receiving the X– ray must hold very still and may be asked to hold their breath for a few seconds to prevent any movement and blurring. At least two images are taken. The process of a bone X– ray usually takes 5 – 10 minutes.

Chest X-rays.

These X – rays make images of the heart, lungs, airways, blood vessels, and the bones of the spine and chest.
Chest X-rays are used to help diagnose patients with symptoms such as:

- Shortness of breath
- Bad / persistent cough
- Chest pain / injury
- Fever

Physicians often use X-rays to diagnose conditions such as

- ✓ Pneumonia
- ✓ Heart problems
- ✓ Emphysema
- ✓ Lung cancer

On a chest X-ray, the ribs and spine will absorb most radiation. Lung tissue absorbs little radiation and will appear dark.

X- rays:

Benefits	Disadvantages

Note.
The denser the material, the more radiation it will absorb. Bones are denser than the rest of the body. Diseased tissue is denser than healthy tissue, so how will they appear different?

_____

_____

Stomach and intestines can also be made visible on an X- ray by getting the patient to drink a suspension of Barium Sulphate (known as a barium meal). Barium is a good absorber of X-rays so as it passes through the intestines it absorbs X-Rays and shows up clearly the structure of the stomach and intestines.

What differences can you see between the two X-ray images below?

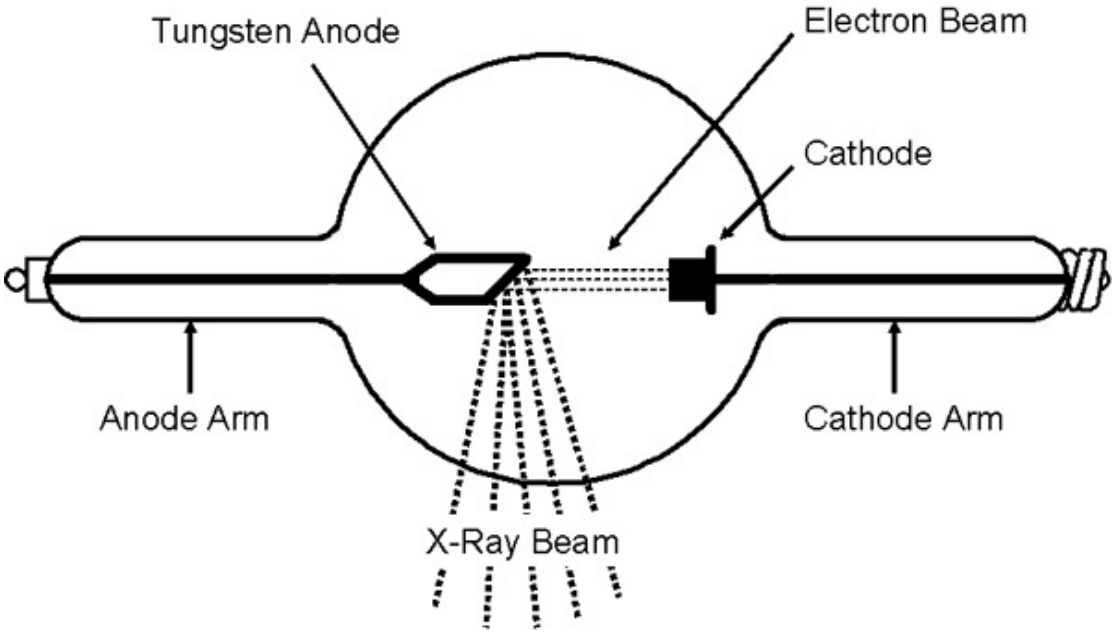
_____
_____
_____

What year was the first X-ray taken?

_____

X-ray equipment

X-rays are very high frequency electromagnetic radiation produced when high-speed electrons in a cathode ray tube strike a metal target. This is shown below.



What is the CATHODE and ANODE?
Cathode:

_____

Anode:

_____

How does it the X-ray machine work?

1. A beam of electrons are produced at the negative cathode.
2. The electrons accelerate at very high speed towards the positive anode.
3. The electrons strike a metal target at the anode, and they are converted into X-rays.
4. The tube is surrounded with a lead shield. X– rays cannot penetrate through lead. It only has a small window for X-rays to escape, which is kept closed with a shutter until needed.

What is a CT (or CAT) scan?

_____

_____

_____

This is another type of non- invasive, painless medical test. **CT stands for computerised tomography.** This type of scan uses special X-ray equipment to produce multiple images, and a computer to join the images in cross-sectional views. It enables the doctor to build up a 3-D image of the body and to look at different layers or depths.

What do you think is the difference between a normal X-ray and a CT scan?

_____

_____

_____

Uses

- ✓ Chest and abdomen
- ✓ Diagnosing cancers. It allows physicians to confirm the presence of a tumour, measure its size, location, and involvement with other nearby tissue.
- ✓ Diagnosing spinal problems. Can clearly show small bones.
- ✓ Often used to plan surgery.

Equipment

Do you know what a CT scanner looks like? You may have seen it on TV.

During a computerized tomography (CT) scan, a thin x-ray beam rotates around an area of the body, generating a 3-D image of the internal structures

A CT scanner is a large machine with a tunnel in the centre. The patient lies on a table, which can slide in and out of this tunnel. The X-ray tube and electronic x – ray detectors rotate around the patient. At the same time, the examination table moves. CT scans provide very detailed images of lungs, bones, and blood vessels.

What is an ultrasound scan? How does it work?

_____

_____

_____

An ultrasound machine involves high frequency sound waves to make images of soft tissue structures in the body. Ultrasounds do not use ionising radiation, thus it is safer than using X-rays. Ultrasound scans are often used to analyse the development of foetal anatomy and will show any abnormalities that the baby may have. An ultrasound procedure is a painless test. Ultrasound travels freely through fluid and soft tissues but is reflected back when it hits a more solid surface.

The operator places a probe on the skin over the part of the body to be examined. Lubricating jelly is put on the skin so that the probe can make good contact with your body. Pulses of ultrasound are sent from the probe through the skin into your body. The ultrasound waves then echo back. It works like an echo-sounder used at sea. Echoes are then detected by the probe and are displayed as a picture. The picture can show movement as well as structure. An ultrasound scan can take from 15 – 45 minutes.

a) 8 weeks

b) 18 weeks

Can you label the head, arms, and legs on the ultrasound scan?
On the 18 week old scan; can you label the skull and spine?

Do you know any other uses of ultrasounds scans?

Unit 7. Science & technology in Medicine
Lesson 3. Using technology to treat disease (Single lesson)

What is radiotherapy?

Radiotherapy is the use of radiation to treat cancer.

The radiotherapy is targeted at the point of your body where the cancer is found. It works by attacking cells that are dividing rapidly, such as cancer cells.
This procedure can be used:

- ✓ To destroy cancer cells
- ✓ To reduce the size of some cancers

To find the exact position of the cancer, your doctor will use X-ray pictures and CT scans.

A machine is used to give a dose of energy, such as X-rays, to attack the cancer cells. The energy beam is directed accurately at the cancer. This is a painless procedure. However, there may be some side-effects such as tiredness, scaring of the skin, hair loss etc. Gamma rays from a radioactive source such as cobalt-60 are also used to kill cancerous cells.

PET scans

Another type of scan used in hospitals is called a PET scan. Research what this is and how it works. What is it used for in medicine? All these scanners are very expensive and are not available in every hospital.

Fill in the gaps! Use the word below to fill in the gaps in the following sentence.

Healthy	dose	dividing	tumour	kill	cancerous	DNA	X-rays
Irradiating							

X – rays and other radiation can damage the _____ in cells and kill them. Cells, which are _____ rapidly, are more likely to be killed, so we use x-rays to _____ the rapidly dividing _____ cells. We must make sure that _____ tissue is undamaged. A special x ray machine generates _____. It rotates around the body, irradiating the tumour from all directions. This means the _____ receives a higher _____ than the healthy tissue.

What is a radiographer and what does the job involve?
Find out what a radiographer does and how they are trained. This is a very skilled job in a hospital and a radiographer needs a good background in science.

Unit 8:
Why not take the alternative route?

Unit 8. Why not take the alternative route?
Lesson 1. Ways to look after our health (Single lesson)

The meaning of health… What is health, how would you define it?

_____
_____
_____

What are alternative medicines? Alternative to what?

_____
_____
_____

The medical community does not generally accept techniques used in alternative medicine because they are not evidence-based or science-based.

Complementary and alternative medicine [known as CAM] can also be referred to as holistic.
Define the three underlined terms:

Alternative:

_____

Complementary:

_____

Holistic:

_____

There is no doubt that you will all have been exposed to some type of CAM at some stage of your life. Alternative medicine includes any home remedy used to make you feel better. For example, when a young child falls and cuts their knee, parents often offer to 'kiss and rub it better'. This actually can ease the child's pain in many cases.

Home remedies! Try and write down some home remedies in the table below

Colds	
Indigestion	
Hiccups	
Sunburn	
Nettle stings	

Can you think of any **examples** of alternative methods used instead of <u>conventional</u> medicine?

-
-
-
-
-

Activity:

CAM shopping!

Each pupil/ group will be allocated a particular alternative therapy. For the next class, your job is to research the therapy and design an eye-catching poster, which makes the therapy sound attractive. Hint! Use pictures and you may include the following:

- Who invented the therapy?
- Where it originates?
- Key principles, how does it work?
- What conditions does it treat [perhaps include a diagram of the human body to highlight where it is effective]?
- Any scientific evidence for or against?
- Any other interesting facts.

Imagine that you are advertising this alternative medicine. This poster should **not** be an essay. Use pictures and colours, which would attract people to use this therapy.

The placebo effect…

Have you heard this term - any ideas?

_____
_____
_____

The following is an example:

> Scientists tricked runners into thinking that they were giving them oxygenated water to drink, which would make them perform better. In reality, the runners were drinking regular tap water. Surprisingly, the runners performed much better because they **thought** they were after drinking something to enhance their performance.

Use this example to define placebo or placebo effect:

_____
_____
_____

This suggests to us that with the use of our minds we can trick our bodies into feeling better or reduce pain etc. What we believe can affect how we feel! The placebo effect is often undertaken in a blind study. This study compares the results after administering an active drug and an inert drug in the same trial. The patients and the doctors do not know who has which pill! Scientists have often discovered that there is no significant difference between drug treatment and placebo treatment!

Unit 8. Why not take the alternative route?
Lesson 2. Alternative therapies (Double lesson)

The posters from the last lesson can be placed around the classroom and each pupil/ group will make a presentation on their alternative therapy. You should take notes on other alternative methods.

Activity:
In groups you will now undertake an activity, which will require the application of information on alternative therapies. You will receive an envelope with alternative therapies and their definitions. Your job is to match the therapy with its correct description.

Your score: _____

Take a look further!

Hypnosis
This is a trance-like state of mind. It can help to manage pain or to kick bad habits like smoking. It is not clear how hypnosis works. While hypnotised you are deeply relaxed, can concentrate on something specific, and become more open to suggestions. Sugestions can be planted in the subsconscious mind which you act on when awake.

Dietary supplements
An example would be the dandelion, a perennial herb. It was commonly used in Native American medicine. They prepared the root and herb to treat kidney disease, upset stomach, and heartburn. Dandelion root and leaf are widely used in Europe for gastrointestinal ailments.

Eucalyptus oil
Commonly used as a decongestant for upper respiratory tract infections / inflammations. It is also often used in mouthwashes.

Echinacea.
Commonly called purple coneflower. Some of these plants are used in herbal medicines. Studies undertaken show that when taken at first signs of a cold, it reduces cold symptoms. People take Echinacea to help the immune system and fight infections.

St Johns Wort (Hypericum)
This is a yellow flowering perennial herb. Most popular use in herbal medicine is for the treatment of major depression. However, a prescription is now required for its use.

Rescue Remedy
Known for its calming effect. This alternative medicine contains 4 flower essentials:

- Rock rose- for terror and panic
- Impatiens – for irritation and impatience
- Clematis – for inattentiveness
- Star of Bethlehem – for shock

It is mostly used in emergency situations to help people cope with stressful situations. It is also good for relaxing students for exams!

What's the evidence?

Modern medicine is evidence-based. What do you think this means?

_____

_____

_____

A remedy like aspirin is used to relieve pain or reduce fever because many clinical trials have shown it to be effective. We also now know how it works in the body, because scientists have investigated its effects on the body. As we saw earlier a new drug is not allowed on the market until it has passed a series of trials and has been shown to have no serious side-effects and has significant benefits over a placebo.

Would you recommend a drug that had no better effect or even a worse effect than a placebo? Why?

_____

Many alternative medicines are not evidence-based - they are based on anecdotal evidence ("My Gran swears by it", "Since I started taking it, I've never felt better!").

Discuss in your group the difference between scientific evidence and anecdotal evidence and summarise your discussion in a table.

Scientific evidence	Anecdotal evidence

Taking cod liver oil is supposed to increase your IQ and make you more intelligent. Discuss how you would design a trial in your school to test whether this claim was true or not. Try to identify the main things you would have to do to provide scientific evidence for or against this claim. Summarise the main points of your discussion below.

Unit 8. Why not take the alternative route?
Lesson 3. Agree or disagree??? (Single lesson)

The popularity of CAM has exploded over the past ten years. Alternative treatments now even have a Center dedicated to it – The National Institutes of Health (NIH). However, the lingering question still remains – do alternative medical treatments actually work? How would we find out?

The Placebo Effect
The following are the views of an alternative medicine practitioner and that of a medical doctor.

Alternative practitioner: the patient is given something that he / she believes will help them and the placebo effect follows. It is just as valuable as other drugs.

Doctor: the placebo is useless. It is a deception to patients. Patients should not be told that they are being given a drug if they are not.

What do you think? Make up your own mind on the placebo effect.
Imagine your teacher gave the class some tablets to help your concentration, and you then undertook an activity faster than you would normally. Your teacher then informs you that the 'drugs' were only Tic Tacs. Would you feel tricked and annoyed or happy that the placebo effect worked?

_____
_____
_____
_____

Since Tic Tacs contain sugar, do you think this was a good choice as a placebo? If not, why not?

_____
_____
_____

Discuss the following questions in small groups and then write down your views.

Do you think public money should be used to fund CAM therapies?

_____
_____
_____

After discussing many alternative therapies – do you think that you would ever use these methods?

_____
_____
_____

If the scientific evidence shows that an alternative remedy does not work, why do so many CAM practitioners reject the evidence and keep on using it?

_____
_____
_____

There have been a number of cases where herbal remedies (which often contain very potent chemicals) have caused serious illness or even death. Do you think that alternative and herbal medicines should be tested and licensed like scientific medicines?

_____
_____
_____

Have you actually tried any alternative remedies? Did they work for you or not?

_____
_____
_____