TEACHING AND LEARNING NOTES

KEY STAGE 5 RESOURCES [TIME REQUIRED = ONE HOUR+]
Starter activity: Case study and questions
Foundation activity: Testing herbs for antimicrobial properties
Higher activity: Antimicrobial molecules
Extension activity: Testing thyme
Plenary activity: Pharming potential

AIMS

Careers education

Pupils should develop an interest in and enthusiasm for science, including developing an interest in further study and careers in science.

How science works

Pupils should develop and demonstrate a deeper appreciation of the skills, knowledge and understanding of How science works.

Cellular control

Pupils will know that gene technologies allow study and alteration of gene function in order to better understand organism function and to design new industrial and medical processes.

KEY VOCABULARY

pharming • bacterial lawn • antibacterial • minimum inhibitory concentration

STARTER ACTIVITY: CAREER CASE STUDY AND QUESTIONS

Ask pupils to read through the career case study in the starter activity worksheet and watch the video. This may be projected to the whole class or students may watch in small groups if PCs are available. They may then discuss the questions in small groups, noting their answers for a brief class discussion. They need not tackle all of the questions, so you may wish to tell them which ones to focus on or give them a strict time limit. Questions may be set for homework, but at least a-c should be discussed to set the scene before pupils tackle the practical. Use the discussion to establish what Julian Ma does and why it is important.

The plenary session uses an article from the Guardian to review the work done by Julian and his team.

A job profile for a research scientist may be found at https://nationalcareers.service.gov.uk/job-profiles/research-scientist

Answers

a) The main area of research is to make vaccines against diseases that harm the poor in developing countries, but work also includes making a barrier agent against HIV.

b) The techniques are cheap and low technology – they do not require large, expensive stainless steel fermentation vats.

c) They extract proteins from plants and use electrophoresis to determine if the target protein is present and in sufficient quantity.

d) Each plant has about 100 flowers, each of which can give rise to around 300-400 seeds. Each seed could become a new plant with the ability to make the medicine.

e) Around 7-8 years.

f) "...because within their lifetime, if successful, this technology could become very important and they could be really intimately involved in some really exciting new developments".

g) Immunologists and molecular biologists, because "working with plants is really fun."

h) In the coffee room.

i) Julian says," ...there is room for many different kinds of people". Julian describes creative individuals who can work on their own and says he would pair them with someone "more meticulous and down to earth to make sure the project gets done."

Transcript of video:

"My name is Julian Ma. I'm a research professor at King George's Hospital Medical School in London and I head up a team of researchers here looking at the prevention and treatment of infectious diseases like HIV, tuberculosis and rabies. I started off at university studying dentistry, but I very quickly became very interested in science and research. At that time was just the moment of discovery that you could genetically modify plants. So I started working with plants and then I realised the potential of plants to address many diseases. So for example we have a plant here that has been genetically modified to make a kind of protein that neutralises the virus that causes HIV, the AIDS virus. The hope here is that we will be able to produce a gel or a cream that could be used to block transmission from an infected patient to a non-infected patient so preventing transmission of HIV. Traditionally, plants have been used for centuries to make medicinal products. The difference here is that these are not natural products. The process of genetic modification allows us to take genes from many other sources and insert them into the plant. And in essence what we are doing is using the plant as a production factory for the medicine itself.

"So this is the first part of the process of making a genetically modified plant. This is Louisa one of our PhD students from Brazil. She's got a tobacco plant here which is not a genetically modified plant and she's just cutting off a leaf and sterilising it. She's going to cut the leaf into small squares and then we use a bacterium in which we've already inserted the gene that we are interested in. And we'll let it then incubate for about 24 hours. And during that time the bacteria will move our gene of interest into the plant nucleus and incorporate the gene into the plant's own DNA. And eventually the plant cell will repair and start to grow again. And once we have a plantlet then we can move it into soil and take it up to the greenhouse to grow into a mature plant.

"And so the next stage of the work is to see if that plant is producing the protein and how much it is producing. Forenda is another student in our group and she is going to go through this process of extracting the protein. I cut the plant, add a little bit of water and then I simply grind the leaves to release now our protein from the cell."

FOUNDATION ACTIVITY: TESTING HERBS FOR ANTIMICROBIAL PROPERTIES

The worksheet introduces the disc diffusion method and the minimum inhibitory concentration (MIC) used by the pharmaceutical industry for testing antimicrobials. Pupils may have seen this used to show the action of antibiotics, but here they can carry out an investigation of the antimicrobial action of herb extracts. If time permits, they could pour and inoculate their own plates.

Pupils can be given slightly different tasks to obtain a range of class results, for example by using a variety of herbs and different bacteria. If a single bacterial species is used, choose a Gram-positive variety, which will be more susceptible than a gram-negative bactrium.

Plates may be stopped (killed) and preserved at any stage (see Technician Notes at end), so follow up lessons do not have to be timed to coincide with the best stage of development.

It would be useful to explain and demonstrate aseptic technique to pupils who have not previously carried out microbiological practical work.

SAFETY: The importance of treating all cultures as potentially pathogenic should be emphasised, whilst explaining that microbiology practicals (as others) are safe if the proper precautions are taken.

Make sure that pupils tape plates with pieces of tape placed diametrically – do not let them seal all around the edge of the dish.

The importance of plants as sources of materials from food (especially as producers) to drugs could be discussed at some stage. The investigation is easily extended to test other materials, for example to make a comparison with antibiotics, antiseptics or disinfectants, or to use pieces of plants such as cloves, or slices of garlic or apple.

HIGHER ACTIVITY: ANTI MICROBIAL MOLECULES

Pupils who complete the practical in good time might be given the higher activity to start. It could also be set in whole or part as homework. Rigorous answers need not be required, the activity can be used to give an appreciation of the range of compounds made by plants that may have pharmaceutical activity.

Answers

a) The usual use of these terms is that they are antimicrobial agents that destroy microorganisms, in the case of i) disinfectants when applied to non-living objects, ii) antiseptics are used on the surface of living tissue, and iii) antibiotics are used inside the body. Originally 'antibiotic' was used to describe natural products produced by some fungi and 'drug' was used for synthetic substances such as sulphonamides. Now synthetic antibiotics like chloramphenicol and semi-synthetic antibiotics such as methicillin are available, 'antibiotic' tends to be used for any antimicrobial drug that can be administered effectively in small doses that do not cause harm to the patient.

b) **i)** Depending on the sources that have been investigated, substances might include phenols or phenolic acids such as thymol, carvacrol, catechol, eugenol and caffeic acid (e.g. chamomile, oregano, sage, thyme), terpenoids such as allicin, menthol, artemesin and capsaicin (e.g. basil, bay, clove, dill, garlic, lemon verbena, peppermint, rosemary, thyme), alkaloids such as berberine and harmane (black pepper, poppy), flavonoids such as catechin and chrysin (e.g. apple), coumarins (e.g. chamomile, caraway)

ii) See **i)**

iii) Mechanisms include membrane disruption, enzyme inactivation, complexing with cell walls.

c) The molecules are generally aromatic compounds (based on benzene rings) of varying degrees of complexity.

See, for example, Peter Snyder's article at http://augmentinforce.50webs.com/ANTIMICROBIAL%20EFFECTS%20OF%20SPICES%20AND%20HERBS.htm

and 'Plant products as antimicrobial agents' by Marjorie Cowan (American Society for Microbiology, Clinical Microbiology Reviews) at https://journals.asm.org/doi/full/10.1128/cmr.12.4.564

EXTENSION ACTIVITY: TESTING THYME

Ask pupils to work in twos or threes to suggest ideas that they can report back.

For fair comparisons to be made factors that should be kept constant or controlled include constituents of the growth medium (gel), depth of the gel (affects concentration of molecules as they diffusion), initial concentration of the herbal extract, length and temperature of incubation,

Peter Snyder (see above) lists factors reported by Zaika (Spices and herbs: Their antimicrobial activity and its determination. J. Food Safety, 1988 9:97-118) which include:

- Microorganisms differ in their resistance to a given spice or herb.
- A given microorganism differs in its resistance to various spices and herbs.
- Gram-negative bacteria are more resistant than gram-positive bacteria.
- The effect of a spice or herb may be inhibitory or germicidal.
- Spices and herbs have microbial contaminants.
- Spices and herbs may serve as substrates for microbial growth and toxin production.
- Nutrients present in spices/herbs may stimulate growth and/or biochemical activities of microorganisms.

Also:

- The age or rate of growth of a plant and the nutrients available to it may affect the concentration of its antimicrobial components.
- The components of spices/herbs may interact synergistically with each other.
- If time and resources allow, pupils could be encouraged to trial their ideas or to conduct a fuller project.

PLENARY ACTIVITY: PHARMING POTENTIAL

Pupils are asked to read a newspaper article about the work of Julian Ma and then work in small groups to explain why his area of work in plant science is potentially so important. Groups can then be asked to feed back one idea at a time until they have exhausted them.
See:
http://www.guardian.co.uk/technology/2011/aug/14/julian-ma-pharming-tobacco-hiv
Alok Jha, The Observer, Sunday 14 August 2011.
There is also an earlier article form the Guardian and a podcast that could be used as alternatives for discussion. See http://www.guardian.co.uk/education/2010/feb/02/tobacco-hiv-research-notes
Louise Tickle, The Guardian, Tuesday 2 February 2010.
http://www.guardian.co.uk/science/audio/2011/aug/08/science-weekly-podcast-juno-jupiter
Alok Jha meets Professor Julian Ma.

TECHNICIAN NOTES

FOUNDATION ACTIVITY: TESTING HERBS FOR ANTIBACTERIAL PROPERTIES

Equipment and materials

For each group:

- Safety goggles
- Permanent marker pen
- Petri dishes containing nutrient agar (one per pupil if possible)
- Cotton wool swabs
- Broth culture(s) of bacteria, for example E. coli and Staphyloccocus albus.
- Herbs (dry or fresh, such as thyme, basil, sage, oregano)
- Discard jar of disinfectant
- Scissors
- Balance (to 0.01 g)
- Weighing boats
- Pestle
- Mortar
- Fine sand (optional)
- Distilled water
- Filter funnel
- Filter paper
- 5 cm^3 graduated syringe
- Three small beakers (25 cm^3 or 50 cm^3)
- Forceps
- Bunsen burner (for flaming the forceps and to create updraught)
- Alcohol (for flaming the forceps)
- Filter paper discs
- Transparent sticky tape
- Incubator at 30 °C

For second lesson:

- autoclavable plastic bag for disposal of used plates

Equipment should be as sterile as possible, though some items such as pestle and mortars may need to be disinfected and stored in plastic bags prior to use rather than autoclaved.

Filter paper discs may be cut using a hole punch, then autoclaved.

Cotton wool swabs may be made from absorbent cotton wool twisted around the ends of cocktail sticks (then autoclaved) – commercial cotton buds may contain antibacterial agents.

Materials (cultures of bacteria, nutrient broth, nutrient agar, antibiotic discs and blank control discs) are readily available from biological suppliers.

Use standard methods to subculture pure strains of bacteria in broth cultures and use them to to prepare pour plates ready for pupils to use to make spread or 'lawn' plates. For example see SGM 'Basic practical microbiology' or The Nuffield Foundation/Society of Biology methods at http://www.nuffieldfoundation.org/practical-biology/making-pour-plate and http://www.nuffieldfoundation.org/practical-biology/making-spread-or-%E2%80%98lawn%E2%80%99-plate.

Science & Plants for Schools

Although the foundation activity sheets instruct pupils to make spread plates (bacterial 'lawn') and prepare impregnated filter paper discs to place into them, the spread plates could be prepared in advance. Alternatively, pour plates could be seeded by inoculation with nutrient broth cultures.

If time permits, pupils could pour their own plates prior to spreading.

Contrasting bacteria which grow on nutrient agar and are likely to show contrasting susceptibilities could be used, for example Gram-positive Staphylococcus albus and Gram-negative Escherichia coli (K12 strain).

After setting up the investigation in the first practical session, the plates should be incubated for 24 hours and then examined as soon as possible. Incubation may be continued until clear zones form and growth may be retarded by storing plates in the refrigerator.

If the second lesson follows much later, further progression can be halted by killing the bacteria. Place filter paper moistened with 40% methanal (formaldehyde) solution [TOXIC: use a fume cupboard] into the lid of the inverted dish. Close, tape and leave the dish overnight, then remove the paper and retape.

Summary of method

Pupils prepare extracts of herbs by grinding up 1 g samples using clean or sterile equipment. Although contamination is possible it is not necessary to use completely sterile materials. The extracts are filtered and used to soak sterile filter paper discs. Pupils are provided with spread plates of bacteria on nutrient agar to which, using aseptic technique, they add their impregnated discs. The inverted plates are incubated at 30 °C for two days (or until zones of inhibition are formed).

Safety

Risk assessments should be carried out for all activities, see your local safety guidance (e.g. CLEAPPS or SSERC).

Methanal methanal (formaldehyde) solution [TOXIC: use a fume cupboard]. Ethanol [Highly Flammable] Refer to, for example, CLEAPSS Hazcard 40A. Aseptic techniques should be adopted for procedures before, during and after the practical sessions. (See for example, http://www.nuffieldfoundation.org/practical-biology/aseptic-techniques). As plant material is being used, there is a risk of allergic reaction. Be alert to this and follow normal local guidelines. Because of the risk of contamination, all cultures should be treated as if they are pathogenic, and must be handled and disposed of safely.

See, for example, CLEAPSS Handbook, sections 15.2 and 15.12. Check for local guidelines for working with bacteria (School Governing Bodies and Local Authority). To discourage growth of pathogens, cultures should not incubated at temperatures above 30 °C.

The Microbiology in Schools Advisory Committee (MISAC), The Society for General Microbiology (SGM) and The National Centre for Biotechnology Education (NCBE) provide advice and help.

See for example:

- MISAC website at http://www.misac.org.uk/, which includes 'Safety guidelines' ,'Suitable and unsuitable micro-organisms' and 'Risk assessment' and a list of resources at https://microbiologysociety.org/careers/career-development/education-resources.html
- Microbiology Society website http://www.microbiologyonline.org.uk/ and publication 'Basic Practical Microbiology: A Manual' which provides an introduction to microbiology, aseptic technique and safety
- NCBE website at https://www.ncbe.reading.ac.uk/safety-working-with-microbes/ and ASE recommended bacteria at https://www.ncbe.reading.ac.uk/safety-working-with-microbes/

PLENARY ACTIVITY: PHARMING POTENTIAL

Pupils are asked to discuss

http://www.guardian.co.uk/technology/2011/aug/14/julian-ma-pharming-tobacco-hiv

Alok Jha, The Observer, Sunday 14 August 2011.

This article could be read online if PCs are available, or copies could be printed.

CAREER CASE STUDY

Julian Ma is Professor of Molecular Immunology and joint head of the Infection and Immunity Research Centre at St George's Hospital Medical School in London. He talked to us about his career in plant science. He specialises in 'pharming' – the production of medicines by plants.

We asked him:

WHAT DO YOU DO?

"At the medical school, all our research is aimed at certain aspects of infections, how we respond to infections and how we might protect against infections. My lab is particularly looking at how we can make vaccines against diseases like HIV and especially those diseases that mainly harm the poor in developing countries.

"We have to make medicines very cheaply and in very large quantities. We don't believe the current technologies are appropriate for that, and so we started many years ago thinking about using genetically modified plants as a manufacturing platform for new medicines. At the moment, I'm growing antibodies in plants to help prevent HIV."

WHAT IS WRONG WITH THE METHODS THAT WE USE TO MAKE MEDICINES AT THE MOMENT?

"They're excellent, but they're very expensive. The way we make medicines like insulin or herceptin relies on genetically modifying bacteria or other cells, and growing those up in large fermentation vats under very sterile conditions. The stainless steel involved in that is horribly expensive, and limits how much medicine you can make. So while that technology is excellent for us in the West, historically we've never been able to make enough medicines to satisfy a global demand, and that's what we need in order to tackle something like HIV or tuberculosis."

HOW DOES YOUR RESEARCH TRY TO OVERCOME THAT?

"Plants are very easy and cheap to grow, and they're also very low technology. So if you can design a plant to make a medicine, you can scale up by standard propagation techniques. Then growing them at agricultural scale is something that could easily be done, perhaps in a developing country. The plant biomass is your crude material. All you have to do is to process that, to extract the medicine, in much the same way that we do now for our conventional medicines."

HOW DO PEOPLE GET INTO YOUR SORT OF ROLE?

"If you look around my lab, you'll see people who have taken many different career routes. Some are like me, clinicians with an interest in research. Others have done basic degrees in science at university. Some of my team studied plant biology and saw the huge potential of plants in medicine. We also have immunologists in our group, and we have molecular biologists, who could work with plant or mammalian cells, but find that working with plants is really fun."

CAN YOU TELL ME ABOUT A TYPICAL DAY IN YOUR LIFE?

"A day in the life of a Professor isn't as much fun as a day in the life of a PhD student! Three years ago, I would have said that a typical day involved going into the lab, starting up some experiments, coming into the office, talking to the people I work with about their projects, maybe working on some applications for funding, and then going back and finishing my experiments. It's not a 9 to 5 job. There were times I'd come in late and work through to midnight, and other times I'd work through the weekend, and other times I'd just have a two hour day. Now, I have more administrative duties associated with organising research at St. George's in general. I still spend a lot of my time talking to PhD students and post-doc scientists in my lab about their projects. I do spend a lot of time trying to raise funding for the Department. I teach, and I also go out to talk to school students about science and research. I'm involved in 3 large European scientific consortia, and a lot of my time is spent trying to direct the work we're trying to do, and collaborating with my international colleagues, which is one of the best things about my job."

IS SCIENCE QUITE A SOLITARY JOB?

"No. Most of the time I'll be talking to someone about the research they've done, and planning for the next two weeks, and that's pretty fun. We do spend quite a lot of time in the coffee room together, and that's an opportunity for more general discussions about work and life. That's where many of our best ideas are formed."

WHAT SORT OF PERSON MAKES A GOOD SCIENTIST?

"I think there is room for many different kinds of people. You have to have creative people, but you also have to have people who are meticulous and well organised. I was interviewing for some new positions yesterday, and for our specific project, we knew we wanted someone who could work by themselves, and someone who's more meticulous and down to earth, to make sure the project gets done."

WHAT'S THE BEST BIT ABOUT YOUR JOB?

"The best bit is the fact that I can think of an idea and go away, work on it, and show whether the idea's a good one or not. It's the freedom for me to act on the ideas I'm having by myself. Of course, at some stage I'll have to find funding, but at the early stages I'll think about something, do the experiment, and see if it works. If it does work, then I have to write a proposal to a funding organisation that will persuade them my idea is worth investing in. And finally, when you're reporting your results, that's a great part of the work, because it's the culmination. You had the idea, you got the funding, and here's the result. Everything is down to you, all the way through."

Julian has made a video about his work. Watch it at:
http://www.youtube.com/watch?v=RBQZBWJgRTo

QUESTIONS

Use the above and the video to answer these questions about Julian's work as a plant scientist:

a) What do Julian and his team do?

b) What advantages do the methods being developed by his team have over the current methods used by biotechnologists for making medicines?

c) How do the team identify which plants are useful?

d) How is it possible to obtain a large number of new plants which make the medicine?

e) In what way are the young scientists "in a very interesting position"?

f) Which people in his team "could work with plant or mammalian cells"? Why do they work with plants?

g) Where does Julian say "many of our best ideas are formed?"

h) What kind of people does Julian think make good scientists?

Julian and his team try to produce new plants that make chemicals to fight or prevent infections. You can't produce new plants yourself, but you can test existing plants to see if they make chemicals which have antimicrobial properties in the investigation: *Testing herbs for antibacterial properties*.

TESTING HERBS FOR ANTIBACTERIAL PROPERTIES

Plants and extracts from them have long been used as medicines. Pharmers like Julian Ma are interested in finding the best medicines and producing them in quantity cheaply and easily from plants. You can investigate the potential therapeutic value of plants by testing herbs for their antibacterial action.

The technique that you will use is called the disc diffusion method. It was introduced over 50 years ago and is still the standard procedure used by the pharmaceutical industry for testing the susceptibility of microbes to inhibitory substances.

A filter paper disc impregnated with the substance under test is placed on agar gel in a Petri dish. The gel has previously been spread with a broth culture of a bacterium to give a "lawn" of growth.

Chemicals will diffuse from the disc into the agar. Concentrations will decrease further away from the disc. If a chemical kills or inhibits the growth of bacteria, they will not be able to grow in an area around the disc. There will be a clear 'zone of inhibition'.

The edge of the zone of inhibition is at the minimum inhibitory concentration (MIC) at which the substance is successful in preventing the growth of the microorganism. So the diameter of the zone is a measure of the effectiveness of the material under test. The wider the zone the more susceptible the bacteria are to the chemical in the disc.

SAFETY

A risk assessment should be carried out before all practical activities. In practical microbiology it is never possible to be certain that pathogens have not been accidentally cultured, so all cultures should be treated as though they are pathogenic.

Aseptic technique is used for procedures before, during and after practical work and is designed to prevent accidental contamination of cultures and the escape of microorganisms from them. Care must be taken to dispose of live cultures safely.

EQUIPMENT

Safety goggles • Permanent marker pen • Petri dishes containing nutrient agar • Cotton wool swabs • Broth culture(s) of bacteria • Herbs (dry or fresh) • Discard jar of disinfectant • Scissors • Balance (to 0.01 g) • Weighing boats • Pestle • Mortar • Fine sand (optional) • Distilled water • Filter funnel • Filter paper • 5 cm^3 graduated syringe • 2 small beakers (25 cm^3 or 50 cm^3) • Discard pot of disinfectant • Forceps • Bunsen burner • Alcohol • Filter paper discs • Transparent sticky tape • Incubator at 30 °C

PROCEDURE

Put on your safety goggles. Work carefully but quickly to maintain aseptic conditions.

01) Use a permanent marker to label the outside of the base of a sterile Petri dish with your name, date, and the name of the bacterium and herb to be used. Do not remove the lid. If using ready-prepared spread plates, go to 05.

Making the spread plate

02) Light a Bunsen burner (medium flame) to create an updraft to carry away airborne microbes.

03) Open a broth culture of a bacterium and dip a swab. Gently squeeze against the inside of the tube or bottle to remove excess fluid. Replace the lid to the culture.

04) Remove the lid of a Petri dish containing nutrient agar. Streak the surface of an agar plate evenly to produce a lawn of growth:

- do not lean over the dish or breathe on it
- wipe the swab gently in a zig-zag over the whole surface of the plate
- streak at right angles to the first streaking
- streak diagonally to the second streaking
- finally streak around the outside edge

Immediately replace the lid. Place the swab into a discard pot of disinfectant.

Preparation of discs

05) Take a dry or fresh herb and (if necessary) cut a sample into small pieces and weigh out 2 g to nearest 0.1 g.

06) Grind up the plant tissue in a pestle and mortar. If available, add a small pinch of fine sand.

07) Use a graduated syringe to add 5 cm^3 of distilled water to the sample and grind it gently to mix it well. If you use dried herbs you may need to add more water to get a filterable extract. Record any further dilution you make.

08) Filter the extract into a small beaker, through filter paper in a filter funnel.

09) Flame sterilise forceps by dipping the tips into alcohol in a beaker and then passing them through a Bunsen flame to ignite the alcohol. Use when the flame has gone out.

Safety: Alcohol is highly flammable – keep the alcohol beaker away from naked flames.

10) Use flame sterilised forceps to add three filter paper discs to the extract in the beaker.

11) Add 5 cm^3 of distilled water to a second beaker. Use sterile forceps to add a filter paper disc.

Diffusion disc technique

12) Use flame sterilised forceps to place the discs gently onto the surface of the agar:

- place the disc with distilled water in the centre
- place the discs with extract, symmetrically and equidistant from the central disc, each other and the edges of the plate.

Gently press the discs down onto the surface of the agar, immediately replace the lid.

13) Use tape placed at the diameter of the plate to hold on the lid. (Do not seal the edge.)

14) Incubate at 30 ^{o}C until the agar appears cloudy and zones of inhibition have formed.

RECORDING AND INTERPRETING YOUR RESULTS

a) Record how long the plates have been incubated for (growth may have been stopped).

b) Use mm graph paper or a ruler to measure the diameters of any zones of inhibition (clear) to the nearest 0.5 mm and record in a table, including any zeroes.

If zones are not circular decide on a method to obtain an average value. Record how your average was obtained.

c) Calculate the average diameter for each herb you tested.

d) Which disc acted as a control? Explain why it was used.

CLASS RESULTS

a) Record your class results in a table.

- **i)** Draw a bar chart to summarise your results.
- **ii)** Was your sample size large enough? Explain.
- **iii)** Suggest possible reasons for any apparent difference in any results obtained for the same herb.

b) What are the possible sources of error in the investigation?

c) Suggest how the investigation might be improved.

ANTIMICROBIAL MOLECULES

Pharmaceuticals - drugs with medicinal properties - can be obtained from the plants that make them. Julian Ma is interested in plants because they can be grown like other crops and therefore useful chemicals can be obtained from them easily and cheaply and on a large scale.

Do some research and try to answer these questions:

a) What are

- **i)** antiseptics
- **ii)** disinfectants
- **iii)** antibiotics?

b) What type or types of molecules in the herb(s) that you have investigated are thought to or likely to have antimicrobial activity?

c) **i)** Find four or five examples of other types of molecules found in plants that can have antimicrobial activity and examples of the plants that make them.

- **ii)** Find how these molecules inhibit the growth of bacteria or kill them.
- **iii)** Make a table to summarise your findings.

d) Do the antimicrobial molecules have anything in common? Describe any similarities that you see.

TESTING THYME

Julian and his team are interested in finding the best molecules that they can. Thyme is reputedly the best antimicrobial herb. Is this true?

Working with one or two others, outline a plan to compare the antimicrobial effectiveness of thyme with other herbs. How can you make a fair comparison?

- In your plan, include a list of the factors which you think should be kept constant or controlled.
- Make another list of other factors which you think might potentially affect the activity of herbal extracts.
- Keep a record of your ideas so that you can report them back to the rest of the class.

PHARMING POTENTIAL

Read the article from the Observer newspaper about Julian Ma's work as a plant scientist:

Julian Ma: I'm growing antibodies in tobacco plants to help prevent HIV

(See http://www.guardian.co.uk/technology/2011/aug/14/julian-ma-pharming-tobacco-hiv)

Working in a small group, discuss:

- Why is the use of plants to produce medicinal drugs potentially so important?
- List your reasons so that you can report them to the rest of the class.