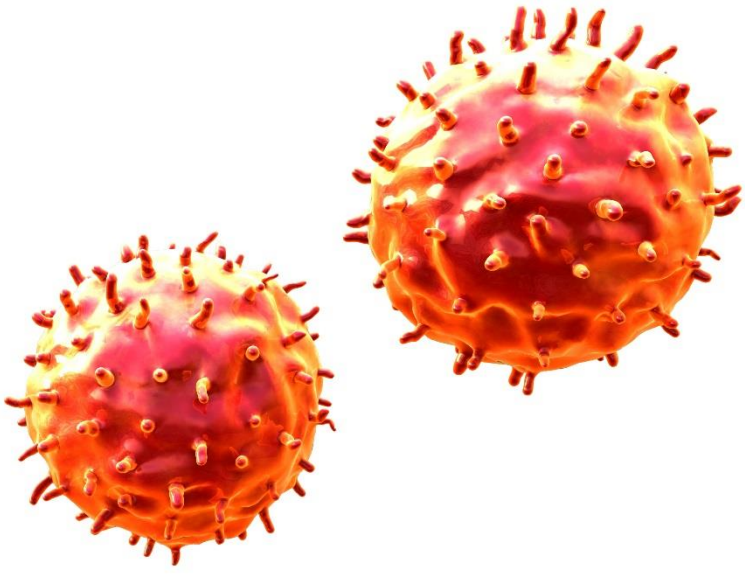
Cambridge Assessment International Education

Teaching Pack

Disease transmission

Cambridge IGCSE™ Biology 0610

This *Teaching Pack* can also be used with the following syllabuses:
- Cambridge IGCSE™ (9–1) Biology **0970**
- Cambridge IGCSE™ Biology (US) **0438**



Version 2.0

Cambridge Pathway

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Introduction

This pack will help you to develop your learners' experimental skills as defined by assessment objective 3 (AO3: Experimental skills and investigations) in the course syllabus.

Important note
Our *Teaching Packs* have been written by **classroom teachers** to help you deliver topics and skills that can be challenging. Use these materials to supplement your teaching and engage your learners. You can also use them to help you create lesson plans for other experiments.

This content is designed to give you and your learners the chance to explore practical skills. It is not intended as specific practice for Paper 5 (Practical Test) or Paper 6 (Alternative to the Practical Test).

There are two options for practising experimental skills. If you have laboratory facilities this pack will support you with the logistics of running the experiment. If you have limited access to experimental equipment and/or chemicals, this pack will help you to deliver a virtual experiment.

This is one of a range of *Teaching Packs*. Each pack is based on one experiment with a focus on specific experimental techniques. The packs can be used in any order to suit your teaching sequence.

The structure is as follows:

Briefing lesson (1 hour*)	
This lesson introduces the focus experimental skills to be developed. It also introduces any content needed for your learners to understand the experiment being carried out in the *Lab lesson*.	
Lab lesson (1 hour*)	
Option 1 – run the experiment	**Option 2 – virtual experiment**
This lesson allows the experiment to be run with your learners, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.	This lesson allows your learners to complete a virtual experiment, providing an opportunity to practise the experiment skills introduced in the *Briefing lesson*.
Debriefing lesson (1 hour*)	
This lesson consolidates and builds on the progress learners have made. In some cases, it will also provide the opportunity to practise extended writing skills.	

** the timings are a guide only; you may need to adapt the lessons to suit your circumstances.*

In this *Teaching Pack* you will find the lesson plans, worksheets for learners and teacher resource sheets you will need to successfully complete this experiment.

Experiment: Disease transmission

This *Teaching Pack* focuses on investigating the importance of hygiene.

Hygienic practices such as hand-washing are essential for reducing the spread of transmissible diseases in hospitals and in the safe production of food. In this experiment, your learners will record the number of bacterial colonies on their hands before and after washing. This will demonstrate that bacteria are present on the skin and can be transferred through touch, and that washing hands reduces the number of bacteria on the skin.

The experiment has links to the following syllabus content:

- 10.1 Diseases and immunity

The experiment covers the following experimental skills, adapted from **AO3: Experimental skills and investigations** (see syllabus for assessment objectives):

- effectively and safely use equipment, materials and techniques
- creating a method based on an aim
- evaluating the suitability of a method and making suggestions to improve this.

Prior knowledge

Knowledge from the following syllabus topics is useful in this experiment.

- 1.1 Characteristics of living organisms
- 1.3 Features of organisms

Going forward

The knowledge and skills gained from this experiment might be useful when you teach learners about transmissible disease.

Briefing lesson: Planning an investigation

Resources	• Worksheet A, ideally printed on A3 paper • Worksheets B and C • Scrap paper
Learning objectives	By the end of the lesson: • ***all*** learners should be able to discuss what makes an effective plan for an experiment. • ***most*** learners should be able to select appropriate equipment and plan a safe investigation. • ***some*** learners will be able to evaluate the effectiveness of an experimental method.

Timings	Activity
10 min	**Starter/introduction** Write '*What should be included in an experiment plan?*' on the board (i.e., at the front of the class) and ask learners to discuss in groups of 2–4. Circulate the room as learners discuss. Ask learners who have mentioned good suggestions, such as a risk assessment / safety; an aim; a method; repeats for more reliable data; and an equipment list, to write their ideas on the board. This can help support other learners in their group discussions and act as a checklist for later tasks. After 5 minutes, stop the discussions and ask learners to explain why the items listed on the board are so important; discussions should focus on the importance of working safely, obtaining valid results and effective time-management.
5 min 10 min	**Main lesson** Give each learner Worksheet A and Worksheet B. Explain that you want them, in their groups, to create a plan to investigate the effectiveness of anti-microbial cleaners such as bleach, witch hazel, antibacterial spray and hand-wash, at killing bacteria. They will use Worksheets B and C to help them complete Worksheet A; each learner should complete their own copy of Worksheet A. Draw their attention to the aim on Worksheet A and remind them that they need to keep this in mind. Before they start, discuss what is meant by the following key words (write them on the board): contamination, sterile and incubate. Following the discussion, write the definitions on the board for support. Learners should refer to these key words throughout the task. Learners use Worksheet B to decide what equipment would be suitable to achieve their aim; you might need to explain what agar is and that bacterial colonies can be grown and counted; and any other unfamiliar equipment. Note that some options are not appropriate. Learners discuss and sort into piles of what they plan to use and what they will not use. Circulate the room to question how they think they could use the equipment in the context of the scenario. Encourage the use of the key ideas discussed at the beginning of the lesson. *Continues on next page …*

Timings	Activity

Main lesson continued …

Once learners have completed the equipment sort, pause the task. As a class, review suggestions. Prompt each group to provide justification of their choices. Once choices are agreed as a class, learners can complete the equipment section of Worksheet A.

Challenge learners to use their equipment list and knowledge of how the equipment could be used, to design a method that investigates the aim. They should start by identifying the variables. You might need to check learners' understanding of dependent, independent and control variables.

Learners should be encouraged to first discuss and draft their method on scrap paper before filling out Worksheet A, because they are likely to change their minds and re-order work as they discuss it; tell them not to write it up until you tell them to do so. Encourage group discussion and make sure learners are describing *how* to use the equipment in their method and how they will avoid cross-contamination that will invalidate their work. If required, learners can use Worksheet C to help them. This gives an idea of one possible approach, to which they then add detail and information using the key words and knowledge of the equipment.

Promote variation within groups. There is no fixed method for this task and variation between methods is a key discussion point in the plenary.

Before learners transfer their method to Worksheet A, have a discussion on risk assessment. Explain that a risk assessment always has to be completed before an experiment can be carried out and that it involves considering all the possible risks involved and how to prevent them. They need to consider the risks for each piece of equipment they plan to use.

Discuss the risks of using bacteria as a class:

Risk	Hazard	Prevention
Bacteria	Concentrated sources of bacteria can be harmful to health if ingested, get on the skin, or in the eyes.	• Wear eye protection and gloves. • Wear lab coats. • Do not put hands in mouth or eyes during the experiment. • Wash hands thoroughly after handling equipment. • Disinfect all surfaces and equipment. • Throw bacteria waste into biohazard bin, or collect in a tray for autoclaving. • Inform teacher immediately if the microbial broth is spilt; teacher should clean it up.
Harmful (disease-causing) anaerobic bacteria	These can grow if the Petri dish is completely sealed.	Do not seal the Petri dish completely with adhesive tape, so that oxygen can get inside the dish and prevent growth of anaerobic bacteria.

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Timings	Activity
	Main lesson continued … Pause the lesson again to review their methods and risk assessments. A group could volunteer to share their method and then other groups describe what they agree with or what they would do differently, and to suggest safety issues. This promotes evaluation of their suggested methods. Once all groups are happy with their choices, they can write out their method on page 2 of Worksheet A.
	**Plenary** All groups should swap their completed Worksheet A with other groups, and peer-assess each other's methods. Ask learners to read through and evaluate the other group's method and equipment selection. Prompt them with suggestions of thinking about what the group has done well and what they could improve. They should write their comments/evaluation on the back of the worksheets. As a class, have a quick feedback session where learners say what they think about the other groups' ideas, and discuss. Learners are then given back their own worksheets to look at the comments from the other group. Challenge learners to think if there is anything that they could take from reviewing their classmates work, and their classmates' review of their work, to improve their method. They amend their method using a different-coloured pen.

Lab lesson: Option 1 – run the experiment (Part 1)

Note that due to an incubation period of 24 hours, this experiment will run over two lessons Part 1 and Part 2.

Resources	• Worksheet D, ideally A3 size • Worksheet E (Part 1) • *Teacher method (Part 1)*, *Teacher notes (Part 1)* • *Teacher walkthrough video* • Equipment listed in the *Teacher method (Part 1)*
Learning objectives	By the end of the lesson: • ***all*** learners should be able to select suitable equipment and follow instructions to use it appropriately and safely. • ***most*** learners should be able to design their own method, with justification for choices made. • ***some*** learners will be able to suggest a safe and accurate method and indicate how potential problems could be avoided.

Timings	Activity
10 min	**Starter/introduction** Explain that you want them to investigate the importance of washing their hands by comparing the bacteria on washed versus unwashed hands. Display the equipment for the practical where all learners can see it. Learners raise their hands to suggest why / how each a piece of equipment might be used in the experiment, and if there are any safety implications. Learners can offer different ideas for the same piece of equipment to generate discussion. By the end of the starter, all pieces of equipment should have been discussed. Learners should use their work from the *Briefing lesson* to inform their choices. Prompt learners in the right direction using the *Teacher method*, so that they have a clear understanding of the equipment they will use in the experiment.
15 min	**Main lesson** Arrange learners into groups of 2–4 and give each learner Worksheet D. Explain that they will plan their experiment before they carry it out, including a suitable risk assessment. They will also need to write a hypothesis, i.e. a prediction of what they think will happen and why. They will have to base this on their content knowledge of how illnesses and diseases are spread, or their knowledge of bacteria. Again, encourage learners to use their work from the *Briefing lesson* to inform their choices. They should write their ideas and justifications on Worksheet D. Learners need to create a method in order to test their hypothesis. They should use their selected equipment and knowledge of how to use it safely. Learners discuss ideas in their groups before recording it on Worksheet D. Review learners' suggested methods as a whole group. *Continues on next page …*

Timings	Activity
10 min	**Main lesson continued …** Discuss with the class if they can think of any possible issues with their methods. Examples might include:

Issue	Why is it a problem?	How to avoid
Opening the Petri dish	Air-borne microbes could contaminate the sample.	Petri dish is opened for a minimal amount of time. Raise the lid a small amount.
Handling the Petri dish	Bacteria from the surroundings could contaminate the sample.	Avoid touching the inside of the Petri dish lid.
Dangerous bacteria	Sealing the Petri dish completely could cause anaerobic bacteria to grow.	Do not seal the dish completely, secure the lid with adhesive tape only on two sides.

These points should be gathered from discussions using knowledge of the equipment. To support learners, you could give them the 'Issues' and ask them to explain why this would be problem and how to reduce or prevent it. Learners complete the appropriate section of Worksheet D.

Explain that you actually want them to follow the method on Worksheet E (Part 1) rather than use their own. Learners will compare the method they use with their plan later, so they should keep in mind the differences, strengths and weaknesses of both methods. Give learners a few minutes to read through the method on Worksheet E. Then, complete a risk assessment for the experiment as a class. The risk assessment is the same as the one in the *Briefing lesson*, except there is an additional 'Prevention' for the 'Bacteria' risk: *do not remove the Petri dish lid when reviewing the growth of samples*.

10 min

Learners now carry out the experiment, following the instructions on Worksheet E.

Safety

Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate.

The method includes key questions for the learners to consider as they progress. Discuss their answers as you circulate the group. The answers will be covered in more detail in the debriefing lesson.

15 min

Plenary

Ask learners how they plan on recording their data when the samples are ready. Give learners two minutes to discuss in their pairs or on their tables.

Review ideas as a class. Direct learners towards counting the number of bacteria colonies present if they haven't already suggested this. They record their ideas on Worksheet D.

Stretch learners to suggest why they cannot immediately review their results; why do the samples have to be left? How long would they recommend leaving the samples? Discuss. Make sure everyone understands that bacteria are microscopic organisms that are normally invisible to the naked eye. The use of agar and an incubation period allows a single bacterium to grow and divide to produce a colony of identical bacteria; the resulting colony is visible with the naked eye. Each colony represents an individual bacterium. End the discussion with learners amending their hypothesis to include more specific detail about what they expect to see.

Teacher notes (Part 1)

Watch the *Teacher walkthrough* video and read these notes before the day of the *Lab lesson*.

Each group will require:

- access to running water
- soap / hand-wash
- sterile agar plates (Petri dishes)
- glassware pen
- incubator (if unavailable, the samples can be stored in a sealed container at a room temperature of around 21°C; temperatures must not exceed 25°C)
- adhesive tape

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

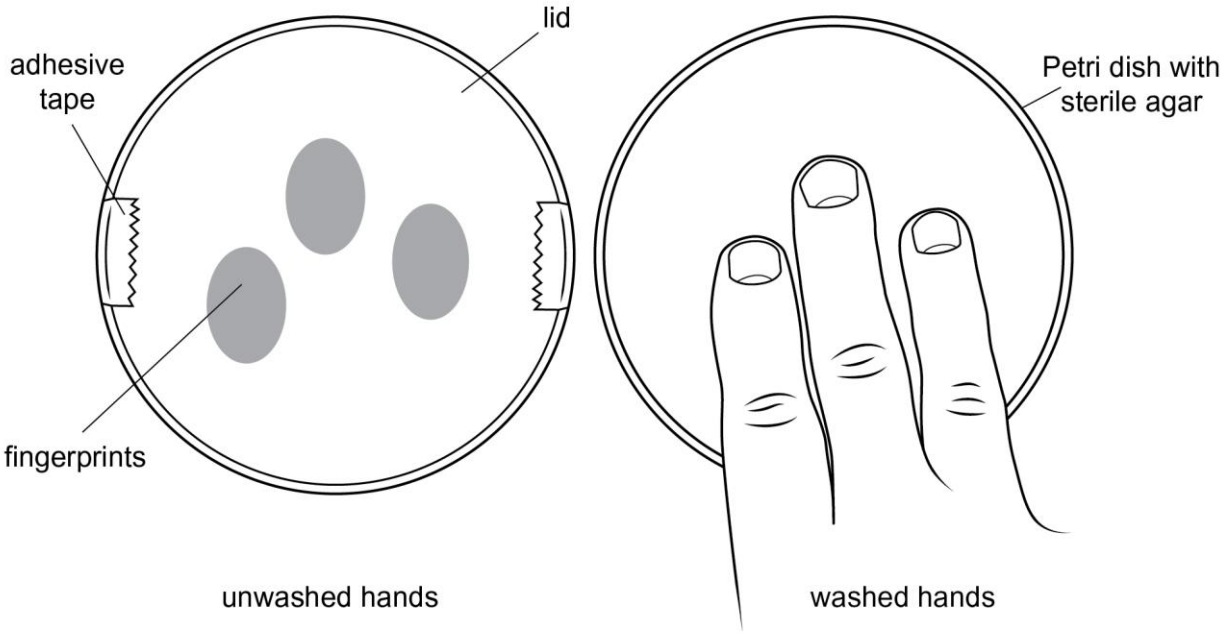
Some associated safety precautions include:

1. The Petri dishes must not be completely sealed so that oxygen can get into the sample; this will prevent toxic anaerobic bacteria from growing.
2. Samples should not be incubated at temperatures greater than 25°C; if this occurs, destroy the plates immediately in an autoclave, or place them into sealable bags and into a biohazard bin.
3. Learners must not put their hands or other items into their mouths.
4. Learners must wash their hands after completing the experiment.

It is **your** responsibility to carry out an appropriate risk assessment for this practical.

Substance	Hazard	First aid
Microorganisms from humans, e.g. finger dabs	BIOHAZARD	**Spilt on the floor, bench, etc.:** for spills of cultures, place paper towels over the spill, pour disinfectant (e.g. Virkon) on top and leave for at least 15 minutes. Bleach is usually suitable in the home. **(You must do a risk assessment for any disinfectant or bleach used.)**
Latex gloves	Allergic reaction	Remove the gloves and wash hands under water. Look out for severe allergic reactions such as difficulty breathing and/or swelling of the face, body or tongue. Seek emergency medical attention immediately.

Experiment set-up (Part 1)



Teacher method (Part 1)

This is your version of the method that accompanies the *Teacher walkthrough video*.

Do not share this method with learners. Give them Worksheet E (Part 1).

Before you begin
Plan how you will group your learners during the experiment session; depending on the availability of Petri dishes, learners could work individually or in pairs.

Think about:
- the number of groups you will need (learners could work independently or in groups of 2–4 as long as the same learner makes the imprint for both samples)
- the amount of equipment required
- how the sample will be incubated.

Experiment
Walk around the learners during the experiment in case they encounter any difficulties.

Step	Notes
1. Learners should collect all the equipment they need from the front of the class.	
2. Learners should carefully open the first Petri dish.	*Make sure learners keep the Petri dish open for minimal time to reduce contamination from air-borne microorganisms.*
3. Learners place three fingers into the agar gently to leave an imprint.	
4. Learners should close the Petri dish.	
5. The Petri dish should then be sealed with adhesive tape on two sides/edges.	*Make sure learners do not seal the Petri dish all the way around in order to prevent the growth of anaerobic bacteria.*
6. The Petri dish is labelled as 'unwashed' using a glassware pen.	*Make sure learners add their labels near the edge of the lid, and not in the centre where it will obscure the visual.*
7. This should be put to one side.	
8. Learners now wash their hands thoroughly using (antibacterial) hand-wash.	*Make sure learners dry their hands properly.*

Steps	Notes
9. Learners should repeat steps 2–5 with the second Petri dish.	*Make sure they limit how long the lid is off; they use the **same three fingers**; and seal the dish on two sides.*
10. The Petri dish is labelled as 'washed hands'.	
11. The samples are incubated for at least 24 hours at 25° C.	*Place the Petri dishes lid down, so that condensation does not form on the lid (which would make it difficult to view colonies later). Ideally you would use an incubator set at 25°C. If an incubator is not available, place the Petri dishes in a transparent box with a lid and leave them at room temperature, which is about 21°C (the box should **not** be air-tight). It is important to keep the temperature around 21–25°C so that any bacteria present can grow but it is not so warm that the bacteria grow uncontrollably. Too much growth would mean that the colonies merge together and it becomes too difficult to count them, and it can also be a health risk. For these reasons, do not exceed 25°C and do not keep the samples longer than 7 days.*

Clean-up

After the experiment learners should:

- wash their hands thoroughly
- tidy up their work space
- return all equipment to you.

Lab lesson: Option 1 – run the experiment (Part 2)

This lesson should follow Part 1 after at least 24 hours, and no longer than 7 days.

Resources	• Learners' completed Worksheet D • Worksheets E (Part 2) and F • *Teacher method (Part 2)*, *Teacher notes (Part 2)* • *Teacher walkthrough video* • Equipment as listed in the *Teacher method (Part 2)*
Learning objectives	By the end of the lesson: • ***all*** learners should be able to collect suitable data by following a set of instructions and enter this into a table. • ***most*** learners should be able to design their own table for data collection, and use an identification chart to identify different types of bacteria present. • ***some*** learners will be able to evaluate the method used to suggest possible improvements.

Timings	Activity
15 min	**Starter/introduction** Ask learners to think about their hypothesis and what that means they are looking for in their samples. Learners should suggest counting how many colonies have grown on each plate. If no one mentions it, explain that different types of bacteria will produce different-looking colonies, so is there anything else they can look for? Challenge learners to design a table to record their results. Support some learners by providing a blank table (Worksheet F), and others by also giving them the headings that they will then need to input into their table. Example headings are indicated below.

Bacteria	Sample tally	
	Washed	Unwashed
Number of colonies		
Total		
Different types and number of each type, e.g. circular …. 𝍸		

Continues on next page …

Timings	Activity
15 min	**Main lesson** Give learners Worksheet E (Part 2), which is the method they should follow; it includes an identification chart to help them identify different types of colony. Ask learners to look at their completed Worksheet D and briefly review the risk assessment as a class. This will reiterate the safety measures of the practical and will remind learners not to remove the Petri dish lid. **Safety** Circulate the classroom at all times during the experiment so that you can make sure that your learners are safe and that the data they are collecting is accurate. Make sure that learners do **not** remove the lids when counting bacteria! Learners collect their plates then use Worksheet E (Part 2) to help them record their observations and data on Worksheet F. Question learners as you circulate the room. A colony in this experiment is taken to be a defined shape with a clear edge that is completely separate from another clearly defined shape. Your questions could include asking if they think there could be smaller colonies that are not yet visible to the naked eye.
15 min	Challenge learners to compare their results with other learners. They could draw more tables on the back of Worksheet F to record the other groups' results. Explain that they could pool this data to calculate a mean. Ask why that's a good idea, they should understand that this is almost like repeating the experiment and makes the results more reliable. Ask why it isn't exactly like doing the repeats themselves and the implications of this on reliability and validly of the results. Agree it's sufficient for the purpose of their investigation. Ask learners to suggest why there will be different types of bacteria on the unwashed and washed plates. Ask why there will be variations between the unwashed plates of different learners, and the washed plates of different learners. Discuss that there are types of bacteria that are found normally on skin or in humans that are essential for healthy functioning. For example, in the gut to aid digestion. This will aid their interpretation of any results and will help them to suggest that any bacteria found on the washed hands could either be from contamination or the healthy bacteria. Abler learners can start to compare the method they used to the method they planned at the start of the previous lesson; what are the strengths and weaknesses of each? Would one be more likely to give more reliable results than the other? Why? *Continues on next page …*

Timings	Activity
	**Plenary** Ask learners to think of the data that they have collected and the method they used. Draw a blank table on the board for learners to copy into their books and fill out. Ask learners to discuss in their pairs or groups any issues there were with the method they used and ask them to make suggestions to improve this in further investigations.

Issue	Solution
It is difficult to count individual colonies because they are so small and / or close together.	Use a magnifying glass to view the samples to make counting the colonies easier.
Some areas are shaded or cloudy and this could be fungi rather than a bacterium.	Do not count or include the cloudy areas in your results. Count circular colonies which are more likely to be bacterial.
Using an identification chart is subjective and so different people may interpret the results differently.	Discuss ideas in pairs or groups to reach a joint conclusion.

Review learners' suggestions as a whole class and promote discussion between groups. Do they agree with each other's suggestions to improve? What else could they do? How does this compare to their initial predictions of what will be an issue?

Teacher notes (Part 2)

Watch the *Teacher walkthrough* video and read these notes before the day of the *Lab lesson*.

Each group will require:
- access to running water
- soap / hand-wash
- their plates from *Lab lesson Part 1*
- a mounting needle

Safety

The information in the table below is a summary of the key points you should consider before undertaking this experiment with your learners.

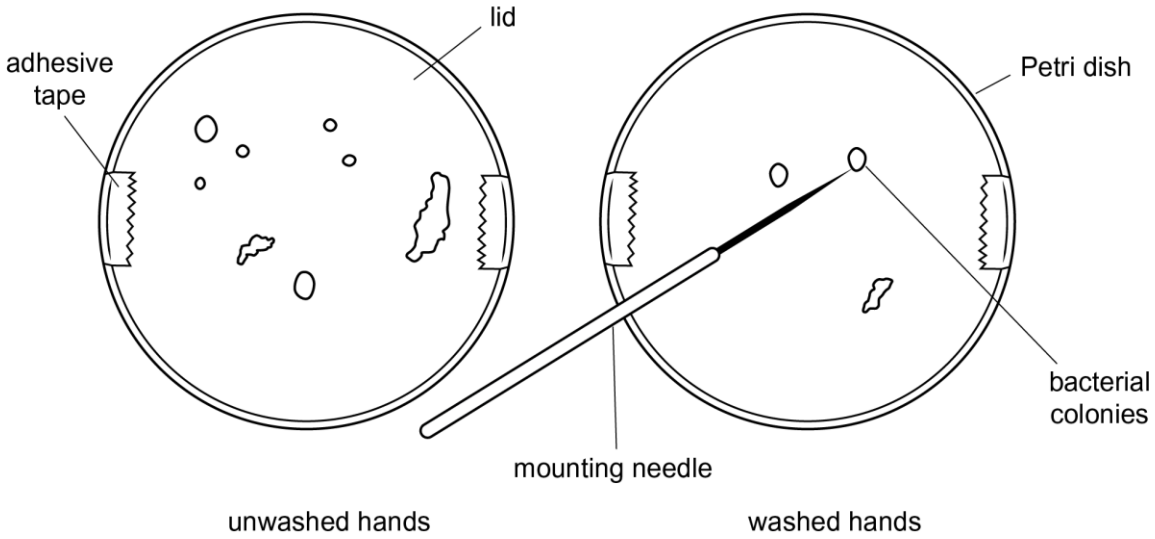
Some associated safety precautions include:

1. Learners must **not** open the Petri dish when reviewing their results.
2. If the Petri dish is opened, then learners should thoroughly wash their hands and you should remove the sample and dispose of it safely.
3. Learners must not put their hands or other items into their mouths.
4. Learners should wash their hands thoroughly after handling the Petri dishes and completing the experiment.
5. All samples should be destroyed within 7 days using an autoclave, or put in sealable bags and disposed of in a biohazard bin.

It is **your** responsibility to carry out an appropriate risk assessment for this practical.

Substance	Hazard	First aid
Microorganisms from humans, e.g. finger dabs	BIOHAZARD	**Skin or clothing:** remove soiled clothing; wash skin thoroughly with soap and running water. **Spilt on the floor, bench, etc.:** for spills of cultures, place paper towels over the spill, pour disinfectant (e.g., Virkon) on top and leave for at least 15 minutes; bleach is usually suitable in the home. **(You must do a risk assessment for any disinfectant or bleach used.)**
Latex gloves	Allergic reaction	Remove the gloves and wash hands under water. Look out for severe allergic reactions such as difficulty breathing and/or swelling of the face, body or tongue. Seek emergency medical attention immediately.

Experiment set-up (Part 2)



Teacher method (Part 2)

This is your version of the method that accompanies the *Teacher walkthrough video*.

Do not share this method with learners. Give them Worksheet E (Part 2).

Before you begin

Plan how you will safely dispose of used Petri dishes.

Think about if:

- learners will collect their samples, or if the samples are already on their work spaces
- you will collect the Petri dishes at the end of the lesson or if learners will move the dishes to a designated location.

Experiment

Walk around the learners during the experiment to make sure learners do not remove the lids.

Step	Notes
1. Learners collect their samples.	*Use judgement of your class' behaviour and maturity to decide if it's better for them to collect the samples or have them laid out on their work space. (Are they likely to open the lids if not supervised suitably?)*
2. Ask learners to look at their samples and record the number of bacteria colonies. Explain that they can use a mounted needle to point at colonies as they count. They can confer with a partner if they're unsure if something is a colony or not.	*Make sure learners do **not** remove the lids to count the colonies! Make sure learners are clear about what they should count as a colony and what not to count, e.g., fungi. Circulate the class to help learners with this task.*
3. Learners should also note the colour and type of bacteria using the identification chart on Worksheet E (Part 2) to help them.	
4. Learners then compare their Petri dishes with other learners.	*It might be safer for learners to move to different tables to view other learners' samples rather than move the samples around the room.*
5. Once finished, decide whether learners will move the Petri dish off their desks for disposal or whether you will do this.	*Is it necessary to minimise the level of contact your learners have with the Petri dishes?*
6. Supervise learners washing their hands and disinfecting their surfaces.	

Clean-up

After the experiment learners should:

- wash their hands thoroughly using soap / hand-wash and running water
- tidy up their work space and clean it with an antibacterial agent (you should carry out a risk assessment for any cleaning products used)
- return all equipment to you.

The samples should be disposed of within 7 days using an autoclave or in a sealed plastic bag within a biohazard bin.

Lab lesson: Option 2 – virtual experiment

Resources	• *Virtual experiment* video • Worksheets D, F, G and H.
Learning objectives	By the end of the lesson: • ***all*** learners should be able to select suitable equipment and follow instructions in order to correctly enter data into a table. • ***most*** learners should be able to design their own method, with justification for choices made; design a results table and collect suitable data to enter into the table; and use an identification chart to identify different types of bacteria present. • ***some*** learners will be able to suggest a safe and accurate method; indicate how potential problems could be avoided; and be able to evaluate the method and suggest improvements.

Timings	Activity
5 min	**Starter/introduction** Explain that you want them to investigate the importance of washing their hands by comparing the bacteria on washed versus unwashed hands. Play the introduction of the video; it will pause automatically on the Equipment screen. Ask learners to raise their hands to suggest why / how each piece of equipment might be used in the experiment, and if there are any safety implications. Learners can offer different ideas for the same piece of equipment to generate discussion. Click on the 'Equipment list' to reveal a written list of all equipment, including access to running water. By the end of the starter, all pieces of equipment should have been discussed. Learners should use their work from the *Briefing lesson* to inform their choices. Prompt learners in the right direction, so that they have a clear understanding of the equipment that will be used in the experiment. The 'Worksheet required' button reminds you of which worksheets learners will need for the virtual experiment.
10 min	**Main lesson** Arrange learners into groups of 2–4 and give each learner Worksheet D. Explain that they will plan their experiment before they carry it out, including a suitable risk assessment. They will also need to write a hypothesis, i.e. a prediction of what they think will happen and why. They will have to base this on their content knowledge of how illnesses and diseases are spread, or their knowledge of bacteria. Again, encourage learners to use their work from the *Briefing lesson* to inform their choices. They should write their ideas and justifications on Worksheet D. Learners need to create a method in order to test their hypothesis. They should use their selected equipment and knowledge of how to use it safely. Learners discuss ideas in their groups before recording it on Worksheet D. Review learners' suggested methods as a whole group. *Continues on next page …*

Timings	Activity
5 min	**Main lesson continued …** Discuss with the class if they can think of any possible issues with their methods. Examples might include:

Issue	Why is it a problem?	How to avoid
Opening the Petri dish	Air-borne microbes could contaminate the sample.	Petri dish is opened for a minimal amount of time. Raise the lid a small amount.
Handling the Petri dish	Bacteria from the surroundings could contaminate the sample.	Avoid touching the inside of the Petri dish lid.
Dangerous bacteria	Sealing the Petri dish completely could cause anaerobic bacteria to grow.	Do not seal the dish completely, secure the lid with adhesive tape only on two sides.

These points should be gathered from discussions using knowledge of the equipment. To support learners, you could give them the 'Issues' and ask them to explain why this would be problem and how to reduce or prevent it. Learners complete the appropriate section of Worksheet D.

5 min

Briefly outline the method that they will see in the video. Complete a risk assessment for the experiment as a class. The risk assessment is the same as the one in the *Briefing lesson*, except there is an additional 'Prevention' for the 'Bacteria' risk: *do not remove the Petri dish lid when reviewing the growth of samples*.

Discuss with learners what they think they can measure and how they will go about this. Learners should suggest counting how many colonies have grown on each Petri dish. If no one mentions it, explain that different types of bacteria will produce different-looking colonies, so is there anything else they can look for? Challenge learners to design a table to record their results. Support some learners by providing a blank table (Worksheet F), and others by also giving them the headings that they will then need to input into their table.

Example headings are indicated below.

Bacteria	Sample tally	
	Unwashed	Washed
Number of colonies		
Total		
Different types and number of each type, e.g. circular 𝍸		

10 min

Resume play on the video for the next activity. Before resuming the video, give learners Worksheet G and Worksheet H. Explain that Worksheet H contains images of samples from the video, they should do their counting from this worksheet.

Once you resume play on the video, it will not stop unless you click on the buttons to 'Pause for discussion', for 'Data collection' or to answer the 'Video questions'. The results are shown and discussed, so make sure you press the 'Data collection' button if you don't want learners to see the results before they've had a chance to collect them using Worksheet H. If you do pause for data collection, you will need to resume play once learners have finished with Worksheet H, so that they can then observe the colours of the different colonies from the video (step 12 on Worksheet G).

Continues on next page …

Timings	Activity
20 min	**Main lesson continued …** (Please note that on page 1 of Worksheet H the images are photographs, these are the ideal source as it forces learners to really observe the plate and can lead to discussions on what is/isn't a colony. However, black and white line drawings of the plates are provided on page 2 if the photos do not print clearly enough on your printer or photocopier.) Learners record their information in their table on Worksheet F. After learners have recorded the results, have a discussion about what they have found. Explain that quite often when this experiment is carried out, there are some colonies growing on the washed sample. Ask why they think that might be. Learners might suggest that bacteria found on the washed hand sample could be from contamination of the sample. If learners do not suggest it, explain that they could also be healthy, naturally occurring bacteria released from our skin after washing. Explain that some bacteria are found on our skin or inside our bodies that are essential for healthy functioning. For example, in the gut to help digestion. When we wash our hands, some of these healthy bacteria are released from our skin, which is why there are often colonies growing on the agar even after hand washing. Abler learners could be challenged to compare their results with other groups and discuss why some might have got different results. As they are all looking at the same samples, any variation is due to a difference of opinion in what constitutes a colony or a different type of colony. This can lead to a discussion on a possible weakness of the method. Explain to the class that if they had each carried out the investigations themselves, it's very likely that they would all get different results for the number of colonies in each sample and the different types of colonies. Ask why there will be variations between the unwashed plates of different learners, and the washed plates of different learners. Ask learners to suggest why there will be different types of bacteria on the unwashed and washed plates. Explain that if they had all done the experiment they could have collected the class data together to calculate a mean. Ask why that's better than just using the results from the video to draw conclusions; they should understand that this is almost like repeating the experiment and makes the results more reliable. Ask why it isn't exactly like doing the repeats themselves and the implications of this on reliability and validly of the results Abler learners can start to compare the method they have just seen to the method they planned at the start of the lesson; what are the strengths and weaknesses of each? Would one be more likely to give more reliable results than the other? Why? *Continues on next page…*

Timings	Activity
	**Plenary** Ask learners to think of the data that they have collected and their given method to achieve this. Draw a blank table on the board for learners to copy into their books and fill out. Ask learners to discuss in their pairs or groups any issues there were with the practical and ask them to make suggestions to improve this in further investigations.

Issue	Solution
It is difficult to count individual colonies because they are so small and / or close together.	Use a magnifying glass to view the samples to make counting the colonies easier.
Some areas are shaded or cloudy and this could be fungi rather than a bacterium.	Do not count or include the cloudy areas in your results. Count circular colonies which are more likely to be bacterial.
Using an identification chart is subjective and so different people may interpret the results differently.	Discuss ideas in pairs or groups to reach a joint conclusion.

Review learners' suggestions as a whole class and promote discussion between groups. Do they agree with each other's suggestions to improve? What else could they do? How does this compare to their original predictions of what would be an issue?

Debriefing lesson: Review and apply

Resources	• Worksheets B, I and J • Learners' completed worksheet D.
Learning objectives	By the end of the lesson: • ***all*** learners should be able to form a conclusion based on collected data. • ***most*** learners should be able to select suitable equipment and plan a method for a new investigation based on their experiences. • ***some*** learners will be able to evaluate the effectiveness of a method in gathering suitable data.

Timings	Activity
15 min	**Starter/introduction** Give learners Worksheet I and ask them to answer questions 1–3. Learners can work in groups of 2–4. They are asked to use their answers to questions 1 and 2 to write up a conclusion. Explain that their conclusion should be a judgement based on their results; they should quote their data as evidence to support their conclusion. Circulate the room and support learners in discussions and writing. For less able learners, you might want to give the following scaffold: My hypothesis of …… was correct / incorrect. In the sample for unwashed hands, …. colonies were counted, compared to …. for the washed sample. There were …. different types of bacteria in the unwashed sample and only …. in the washed sample. The unwashed sample therefore contained …. more colonies than the washed sample, and …. more different types. This shows that there were more bacteria in number and type on unwashed hands compared to washed hands. This suggests that washing hands is an important step in preventing the transmission of bacteria, including those that cause disease.
30 min	**Main lesson** Recap what makes an effective plan. Learners should draw on what they learnt in the *Briefing lesson* and *Lab lessons*: a risk assessment / safety; an aim; a method; repeats for more reliable data; and an equipment list. Explain that you now want the learners to evaluate the method that they used in the experiment / watched in the video. Remind them that the process of evaluation involves considering the appropriateness of the method and data collected as a result, in terms of the aim of the method. They should think about the required degree of accuracy, the time it takes, and how easy it is to do (for example, is it easily repeated?). They should also include the potential improvements, together with justification of their choices. They can use their completed Worksheet D to help them, by comparing the method that was used against their planned method. Learners answer the rest of the questions on Worksheet I to help them write their evaluation. Evaluating data involves deciding if it is suitable for the purpose of your experiment. *Continues on next page …*

Timings	Activity
	Main lesson continued … Give learners a scenario where scientists are developing a new antibiotic to kill a particular bacterium, which they have called BacA. They do so by spotting the bacterium onto different sections of an agar plate, which has been treated with different concentrations of the antibiotic. Discuss why it would be important for them to test the antibiotics on uncontaminated samples in order to study the effect of the antibiotic on the growth of BacA. Ask them to use all the information they have learned so far, particularly their evaluation of the experiment, to plan a sterile test for the scientists. Give them Worksheet J to do this. Learners discuss in groups of 2–4 what equipment and techniques they would need. They complete the worksheet using the techniques and skills obtained from the previous lessons. For support, hand out Worksheet B but explain that this time they do not have an agar plate with bacteria already on it, they have to apply the bacteria to the plate from a bottle. Pause learners to review the equipment suggested. Encourage them to critique each other's ideas. Why have they chosen that piece of equipment? This encourages learners to discuss and evaluate their work. Worksheet J also challenges learners to develop a method. Test learners' ability to design a method by referring to what makes an effective practical plan. Circulate the room and focus learners on how they will avoid contamination of the samples.
	**Plenary** Learners should swap their Worksheet J with other groups to review and evaluate their work. Learners could suggest a 'what works well' (WWW) and 'even better if' (EBI) to structure their suggestions for improvements.

Worksheets and suggested answers

	Worksheets	Suggested answers
For use in the *Briefing lesson:*		
A: Experiment discussion mat	**28–29**	**49**
B: Equipment	**30**	**—**
C: Hint sheet	**31**	**—**
For use in *Lab lesson: Option 1:*		
D: Investigation	**32**	**50**
E: Method (Part 1)	**33–35**	**51–52**
E: Method (Part 2)	**36–39**	**—**
F: Results	**40**	**53**
For use in *Lab lesson: Option 2:*		
D: Investigation	**32**	**50**
F: Results	**40**	**53**
G: Collecting data	**41–43**	**—**
H: Unwashed and washed samples	**44–45**	**—**
For use in the *Debriefing lesson:*		
B: Equipment	**30**	**—**
I: Writing a conclusion and evaluation	**46–47**	**54–55**
J: Making an uncontaminated sample	**48**	**56**

Worksheet A: Experiment discussion mat

Aim: Test the effectiveness of four different antibacterial agents at killing bacteria.

Equipment list (explain each choice)

The independent variable is:……..……

The dependent variable is: ……..……

The control variables and how I will manage them:

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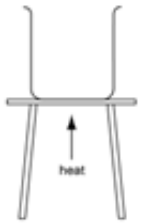
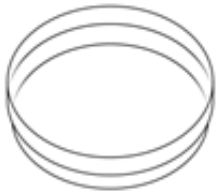
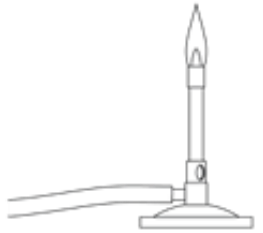
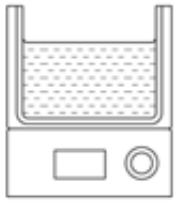
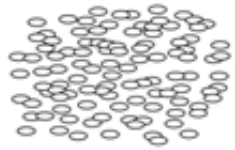
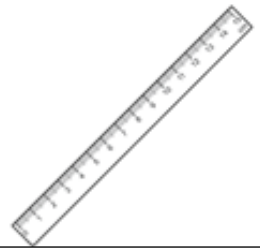
Risk assessment

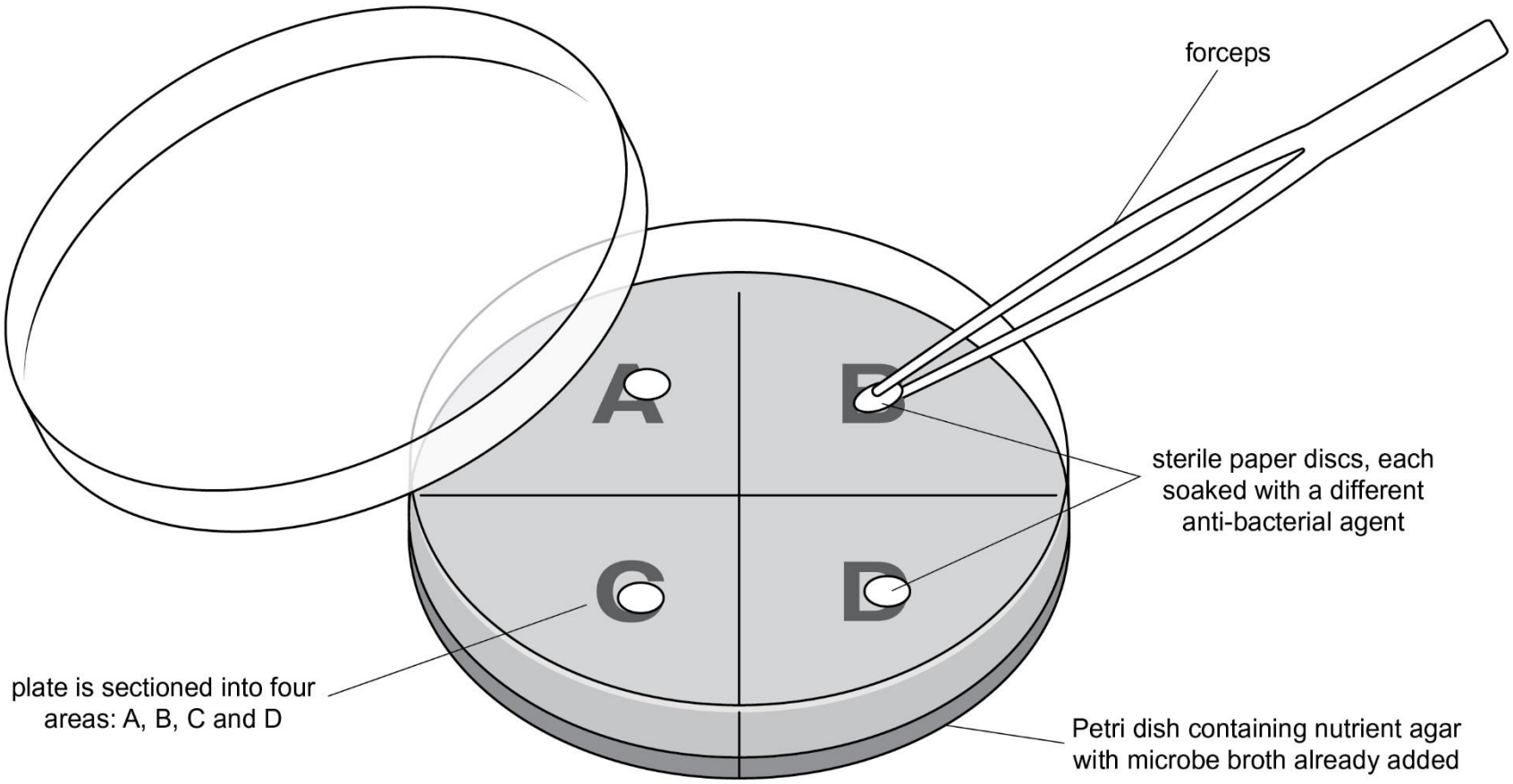
Hazard	Risk	Prevention

Method

Worksheet B: Equipment

						
dropper pipette	distilled water	biohazard bin	Bunsen burner & tripod	boiling tubes / test-tubes	sterile agar	measuring cylinder
						
antibacterial spray	Petri dishes	spatula	forceps	inoculation loop	beakers	Bunsen burner
						
thermometer	agar with microbe broth	water bath	paper discs (antibiotic assay)	glassware pen	microbial broth	hand wash
						
incubator	syringe	adhesive tape	conical flask	Witch hazel	15 cm ruler	ethanol

Worksheet C: Hint sheet



Worksheet D: Investigation

Hypothesis:

……

Equipment and how you will use it:

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Risk	Hazard	Prevention

Issue	Why is it a problem?	How to avoid

How do you plan to measure the results of your investigation?

……

Why does your sample have to be left for 24 hours?

……

Worksheet E: Method (Part 1)

Follow the step-by-step method below.

1. Collect all your equipment.

2. Carefully lift the lid off one of the Petri dishes but do **not** take it off completely; open it just enough to get your fingers inside.

*Do **not** touch the inside of the lid.*

3. Gently press three fingers onto the agar, with just enough pressure to leave behind imprints but not so hard that you break the surface of the agar.

See the experiment set-up sheet to help.

4. Close the Petri dish lid. Seal the lid to the base on two sides using small pieces of adhesive tape.

*Do **not** seal the lid all the way around as it will prevent oxygen from getting into the plate.*

5. Label the Petri dish as 'unwashed' using a glassware pen and / or a sticky label.

Think about how you will collect your results, and decide where the most appropriate place for the label is.
Add your name or initials next to the label so you can identify your plates later.

6. Wash your hands thoroughly using soap and running water. Then dry them thoroughly on an unused clean paper towel.

Be careful not to touch any surfaces with your clean hands.

7. Repeat steps 2, 3 and 4 with the second Petri dish. Use the **same** three fingers as you used for the unwashed sample, when pressing into the agar.

8. Label the sample 'washed'.

9. Incubate your samples according to the instructions given by your teacher. The samples will be incubated at a temperature between 21°C and 25°C.

The samples will be left for at least 24 hours and will be stored where they cannot be tampered with.

After you have cleared away your equipment, cleaned your work space and washed your hands, answer the questions below about the method.

Why was it important not to open the lid completely and to avoid touching the inside of the lid?

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1. Why was it important for oxygen to be able to get in?

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2. Why was the position of the label important? What could it affect?

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3. Why was it important that you dry your hands on a clean paper towel, and were careful not to touch any surfaces with the washed hands?

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4. Why was it important to use the same three fingers?

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5. Why was it necessary for the samples to be incubated at that temperature for at least 24 hours? Why do they need to be stored safely out of reach?

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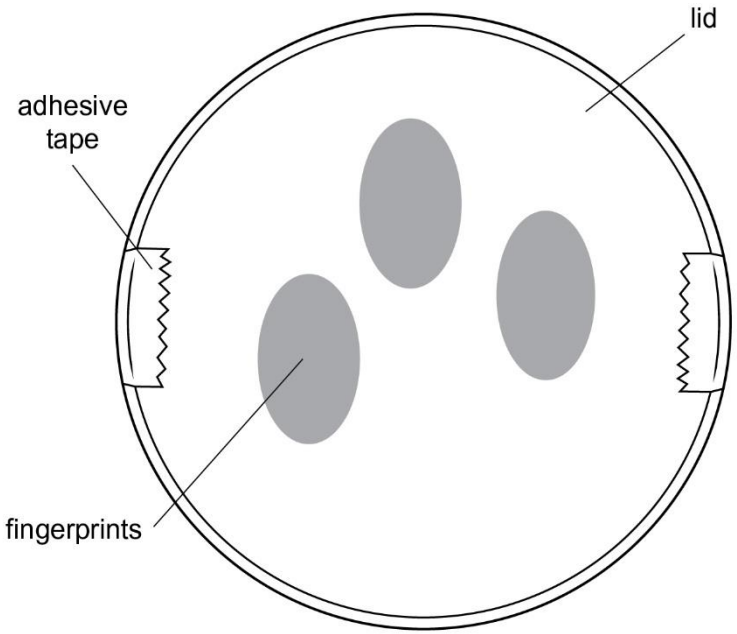
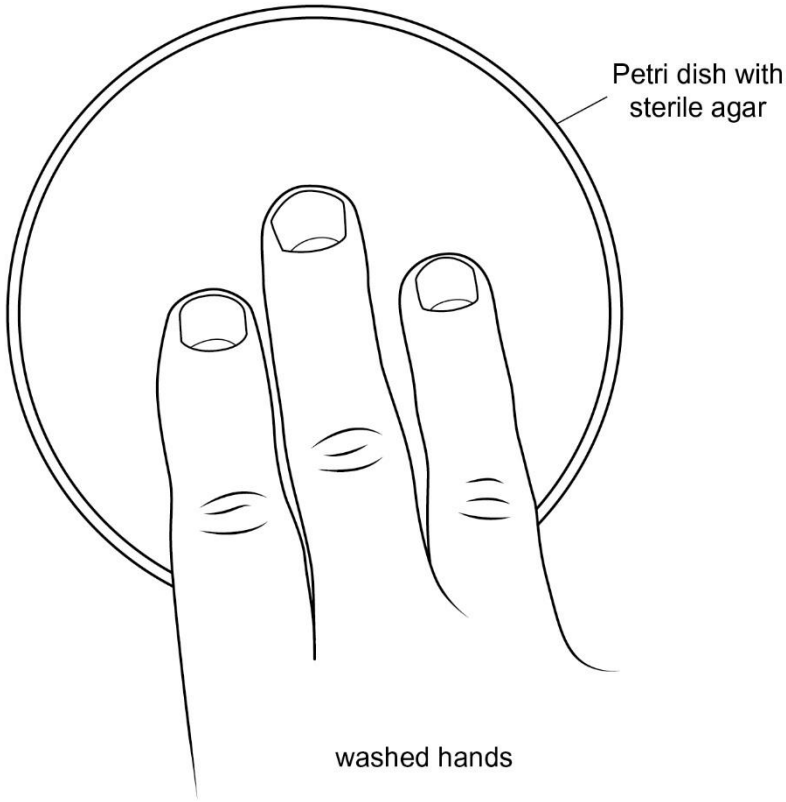
Equipment set-up



unwashed hands



washed hands

Worksheet E: Method (Part 2)

Follow the step-by-step method below.

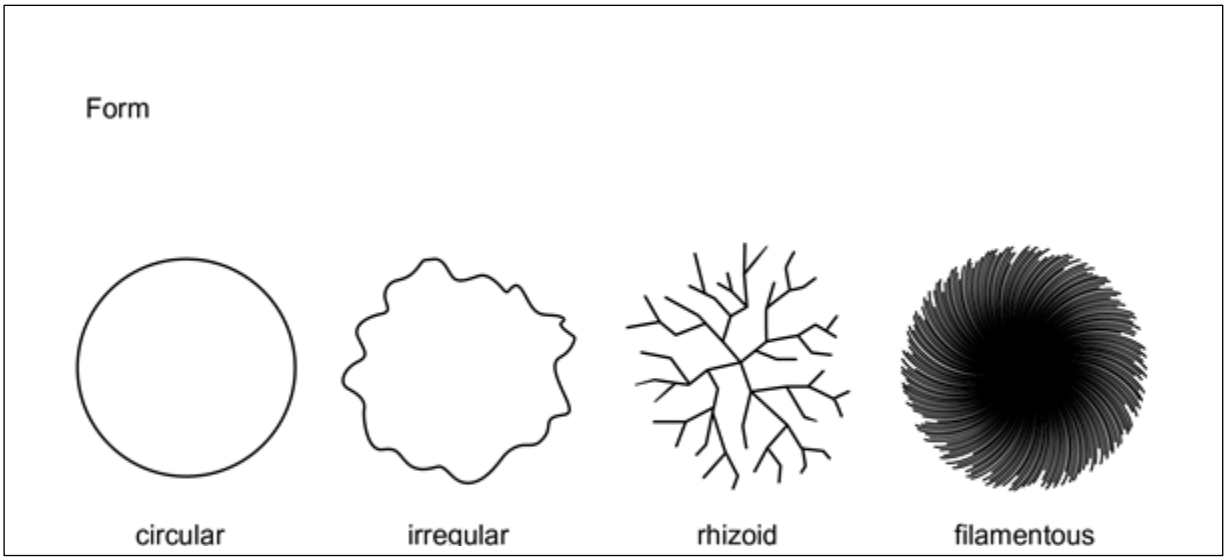
1. Collect your sample.

2. Use a mounted needle to help you count the number of colonies in the **unwashed** sample.

*Do **not** remove the lid for counting. Remember that a colony is any separate shape with a defined edge. Fungal growths have unclear edges and look 'fuzzy' or 'cloudy'; they also tend to be much larger than bacterial colonies. Do not include fungal colonies in your count. Record your data as a tally as you count, then calculate the total when you have finished.*

3. Observe the colours of the colonies, describe what you see. Write down your observations on a piece of paper or on Worksheet F.

Different bacterial colonies can have a different shape (form).



4. Observe the form of the colonies, describe what you see. Write your observations on a piece of paper or on Worksheet F.

5. Use the identification chart and your observations to help you identify the different types of colony present.

6. Record the different types and how many there are of each type in your table.

7. Use a mounted needle to help you count the number of colonies in the **washed** sample.

*Do **not** remove the lid for counting.*
Remember that a colony is any separate shape with a defined edge. Record your data as a tally as you count, then calculate the total when you have finished.

8. Observe the colours of the colonies, describe what you see. Write down your observations on a piece of paper or on Worksheet F.

9. Observe the form of the colonies, describe what you see. Write your observations on a piece of paper or on Worksheet F.

10. Use the identification chart and your observations to help you identify the different types of colony present.

11. Record the different types and how many there are of each type in your table.

12. Look at the samples from another learner. Draw a new table and use someone else's samples to collect more data. Repeat for as many other samples as you can.

13. Calculate a mean total number of colonies in the unwashed sample, and calculate the mean number of colonies in the washed sample, using the formula below. Record the means.

$$\text{mean number of colonies} = \frac{\text{sum of number in each sample}}{\text{total number of samples}}$$

After you have cleared away your equipment, cleaned your work space and washed your hands, answer the questions below.

1. Why was it important that you did **not** remove the lids of the Petri dishes?

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2. Do your samples contain any fungal growths?

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3. Was there any difference in the types of bacteria present in the different samples?

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4. Are there any issues with the way you have collected the data? How could they be solved?

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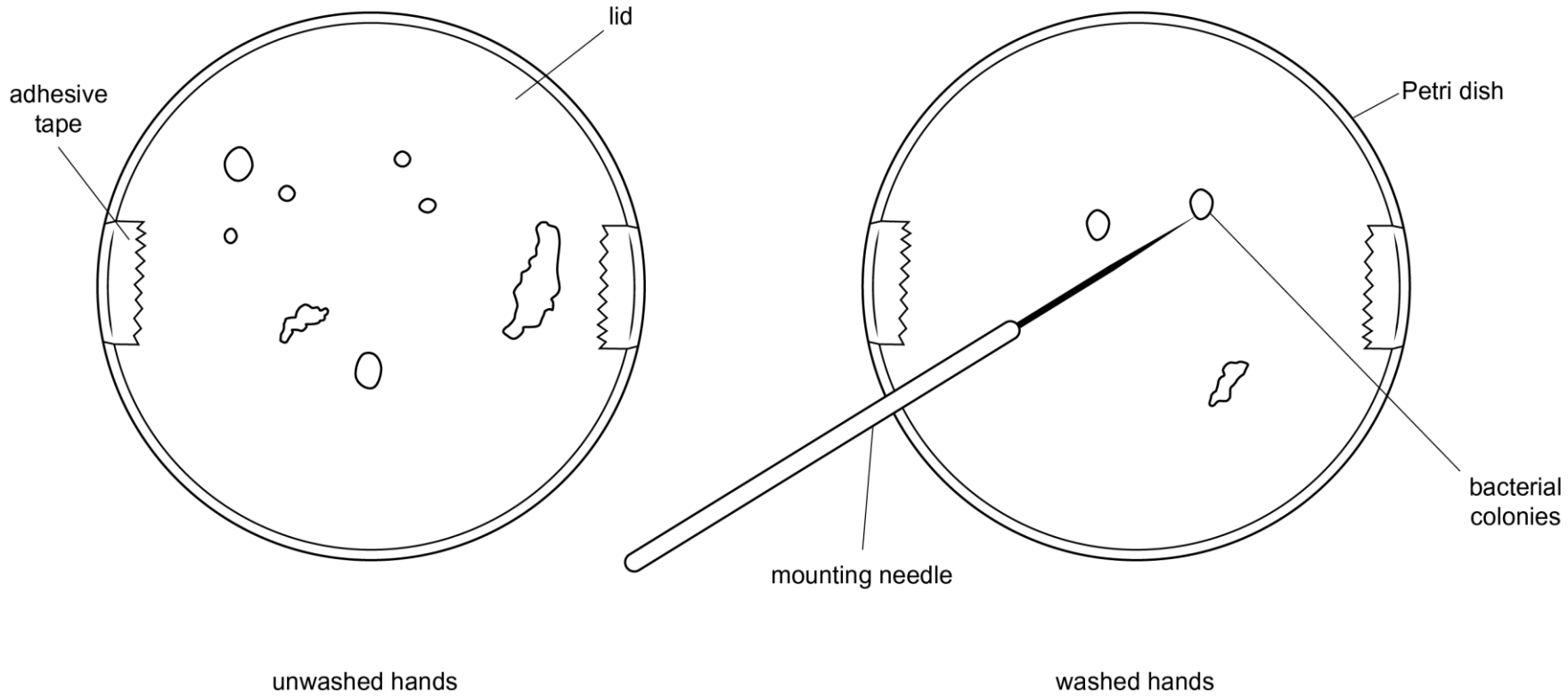
Equipment set-up



Worksheet F: Results

Add headers to the table below to create your results table.

Note down your observations here, on a separate piece of paper or in your notebook.

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Worksheet G: Collecting data

Follow the step-by-step method below.

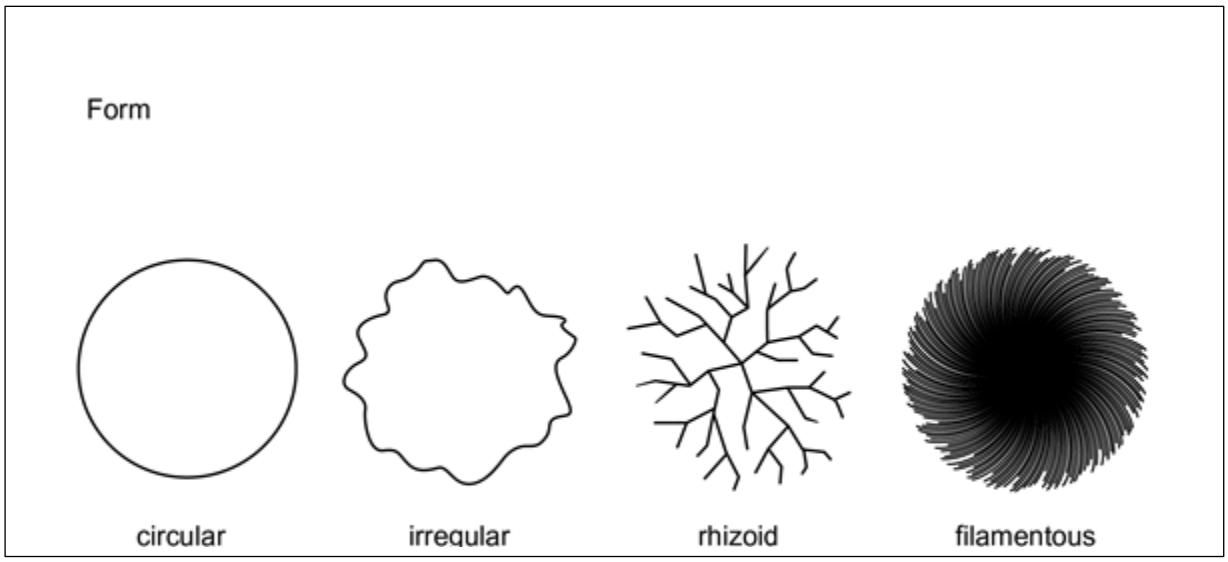
1. Look at the samples on Worksheet H.

2. If these samples were real, the lids could **not** be removed for counting.

3. Use a pen to help you count the number of colonies in the **unwashed** sample. Record the data on Worksheet F.

> *Remember that a colony is any separate shape with a defined edge. Fungal growths have unclear edges and look 'fuzzy' or 'cloudy'; they also tend to be much larger than bacterial colonies. Do not include fungal colonies in your count. Record your data as a tally as you count, then calculate the total when you have finished.*

4. Different bacterial colonies can have a different shape (form).



5. Observe the form of the colonies using the identification chart above. Describe what you see. Write your observations on Worksheet F.

6. Use the identification chart and your observations to help you identify the different types of colony present.

7. Record the different types and how many there are of each type in your table on Worksheet F.

8. Use a pen to help you count the number of colonies in the **washed** sample as per step 3.

9. Observe the form of the colonies, describe what you see. Write your observations on Worksheet F.

10. Use the identification chart and your observations to help you identify the different types of colony present.

11. Record the different types and how many there are of each type in your table.

12. Your teacher will resume the video. Observe the colour of the colonies in each sample from the video; add notes to your observations on Worksheet F.

How do your results compare to those given in the video?
Did you get the same count? If not, why might that be?

When you have finished collecting your data, answer the questions below:

1. Why is it important when pressing the fingers on the agar plate, not to open the lid completely and to avoid touching the inside of the lid?

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2. Why was it important for oxygen to be able to get in?

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3. Why was the position of the label important? What could it affect?

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4. Why is it important to dry hands on a clean paper towel, and to be careful not to touch any surfaces with the washed hands?

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5. Why was it important to use the same three fingers?

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6. Why was it necessary for the samples to be incubated at that temperature for at least 24 hours? Why do they need to be stored safely out of reach?

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7. Why is it important **not** remove the lids of the Petri dishes when counting colonies?

.....

8. Do your samples contain any fungal growths?

.....

9. Was there any difference in the types of bacteria present in the different samples?

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10. Are there any issues with the way you have collected the data? How could they be solved?

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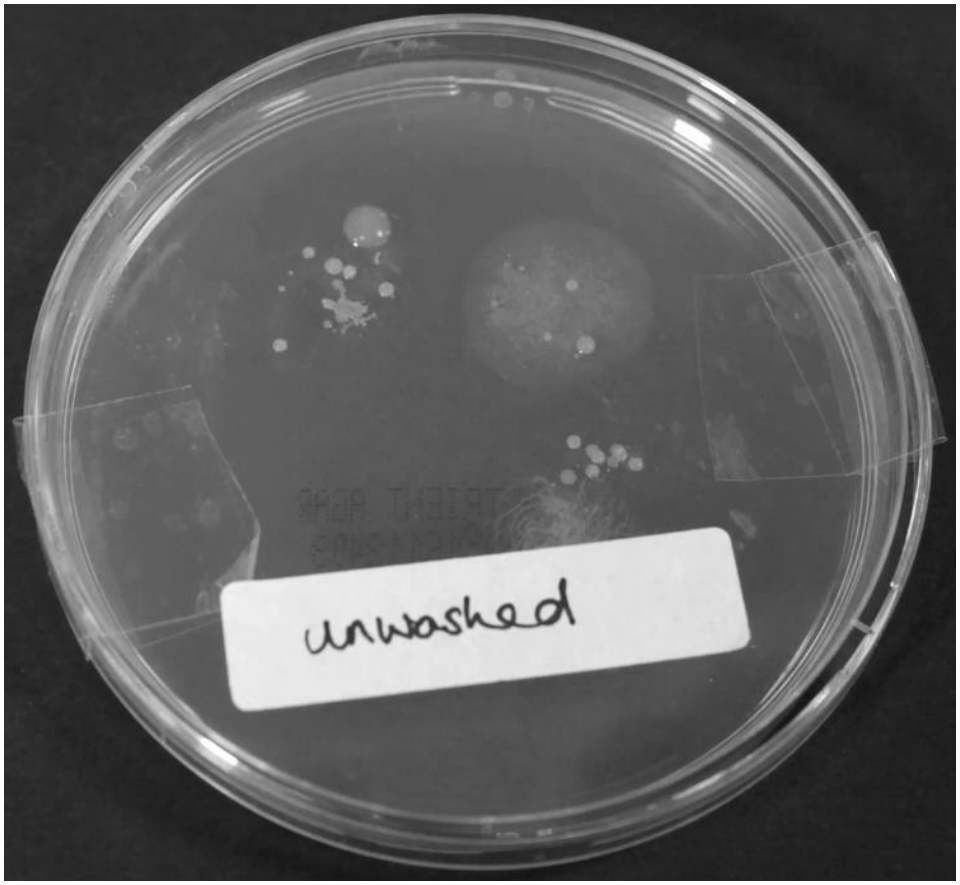
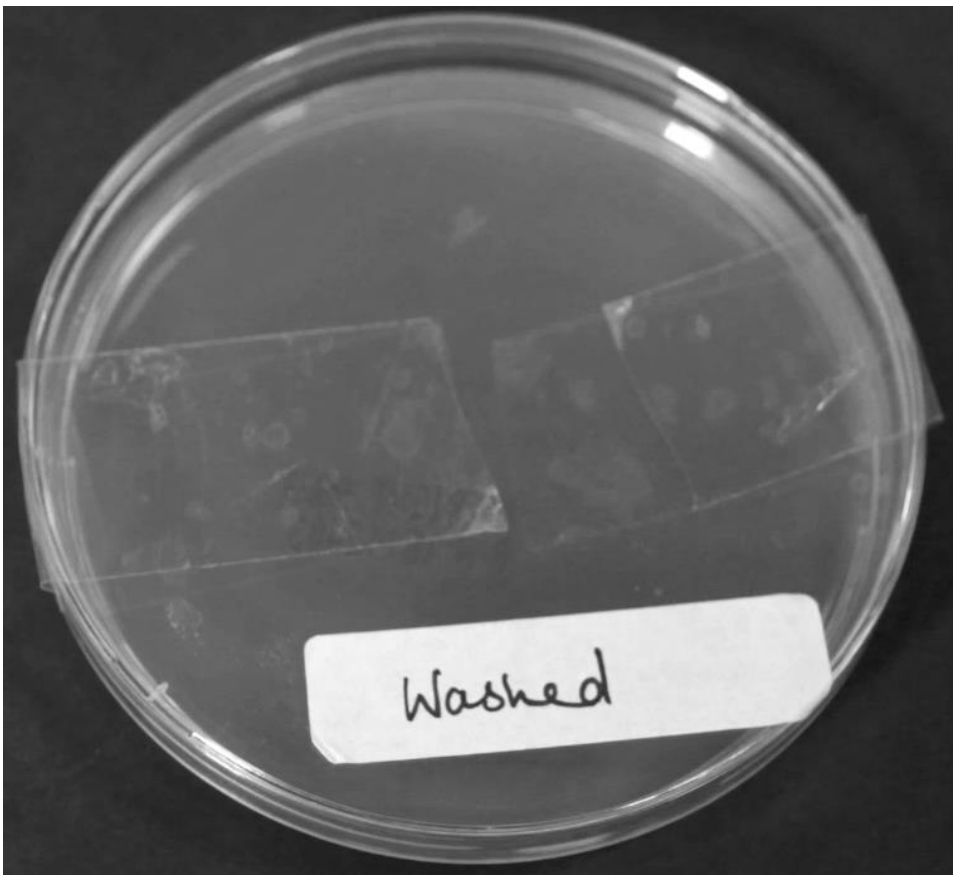
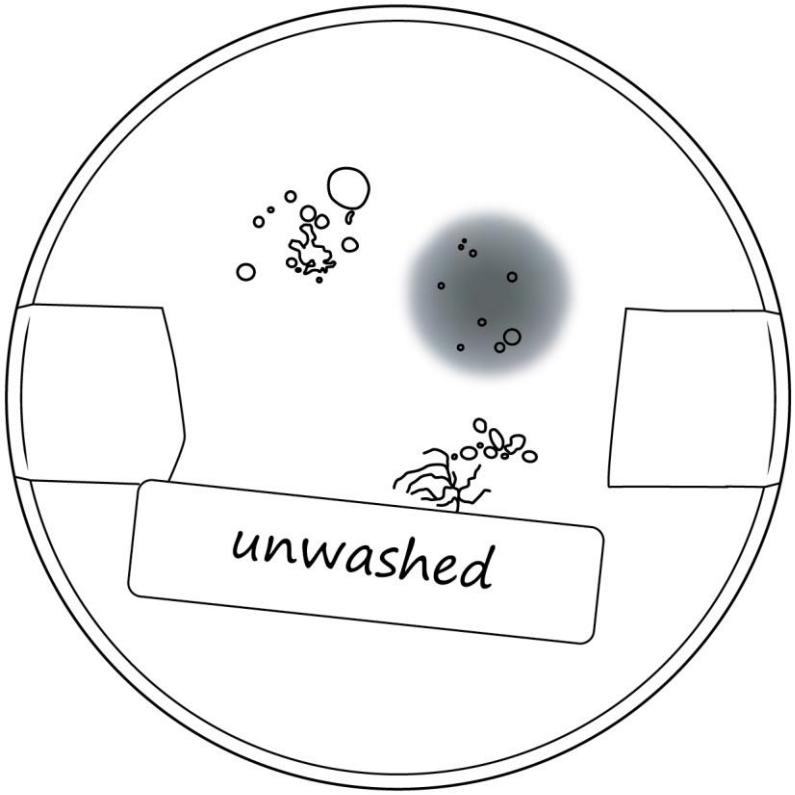
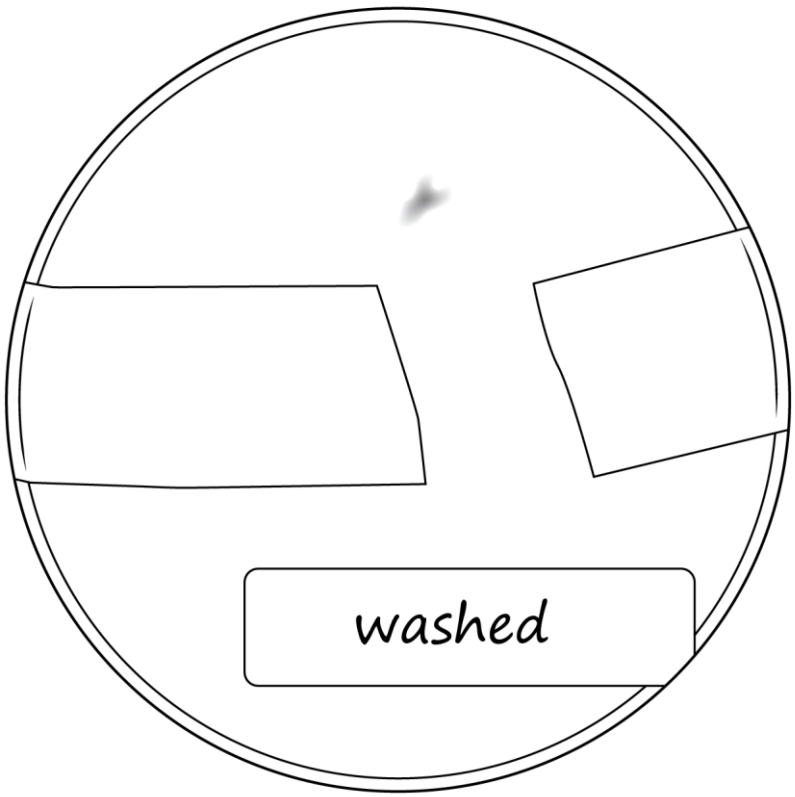
Worksheet H: Unwashed and washed samples









Worksheet I: Writing a conclusion and evaluation

Answer the questions using your data and experiences to help you.

1. Use your results from the investigation to summarise the difference between washed and unwashed hands.

2. What do your results suggest about the importance of good hygiene in hospitals or kitchens?

3. Use your answers to questions 1 and 2 to write a conclusion to your investigation.

4. Describe any issues in completing the method (or the method you watched) or collecting data.

5. Compare the method used with your plan on Worksheet D. What are the strengths and weaknesses of the method used? How could you improve the method?

Worksheet J: Making an uncontaminated sample

Aim: Creating an uncontaminated sample to test the efficiency of a new antibiotic at killing BacA.

Equipment list (justify your choices)

Points to consider

1. How can you avoid your sample from becoming contaminated?
2. Why is it essential to wash your hands?
3. What temperature should the sample be stored at and why?

Method (justify your choices)

Risk assessment

Risk	Hazard	Prevention

Worksheet A: Suggested answers

Learners will provide their own suggestions. Use your discretion to determine if they're suitable and the justifications are valid. Below is just one example of possible answers.

Equipment list (explain each choice)

- Antibacterial hand-wash to wash hands thoroughly
- Petri dish containing agar and bacteria; if the agar is already impregnated with the bacteria then there's less risk to safety as you don't have to pour or apply the bacteria from a bottle; also reduces the risk of cross-contaminating with other bacteria when transferring the bacteria to the agar.
- Different antibacterial agents to test (antimicrobial hand-wash, witch hazel, ethanol); these are the dependent variable that needs to be tested.
- Distilled water (control); the control allows you to determine if the results seen are due to the dependent variable or not.
- Paper discs (to dip into the antimicrobial agents to test); provides a discrete area to look at to see if bacterial colonies grow or not; can compare the agar that is under the disc to that which is not.
- Forceps to handle paper discs to avoid contaminating them with bacteria from the skin.
- Adhesive tape to seal the Petri dishes to avoid the lids getting knocked off and to avoid air-borne bacteria getting in.
- Glassware pen to label the samples; important to know which part of the plate each antibacterial agent is added to.
- Incubator to store the sample; warmth sufficient to allow bacteria to grow.

Independent variable: **type of antimicrobial agents**

The dependent variable is: **area cleared by antimicrobial agent**

Control variables:

- apply same volume of each antimicrobial agent
- leave each antimicrobial agent for the same length of time
- use sterile forceps and plates to avoid contamination
- use sterile paper discs to avoid contamination

Risk assessment

Hazard	Risk	Prevention
Bleach	Could irritate skin	Wash hands thoroughly
Harmful bacteria grown	Could make you ill if ingested or comes into contact with skin/eyes.	Make sure the dish is sealed and that the lid is not removed. Do not touch agar directly and do not put fingers in mouth. Wash hands thoroughly.
Bacteria on plate	As above	As above

Worksheet D: Suggested answers

Hypothesis: There will be a greater number of bacteria in the unwashed hand sample than the washed hands sample.

Equipment:

Petri dish × 2 with agar jelly to grow the bacteria
Antibacterial hand-wash
Adhesive tape
Glassware pen

Risk	Hazard	Prevention
As per briefing lesson, e.g. Harmful bacteria	Could cause illness if ingested or gets onto the skin or in the eyes	Wear eye protection and a lab coat; don't put hands in mouth or in eyes; wear gloves. Do not open the Petri dish. Wash hands thoroughly after handling the Petri dish. Do not seal the dish completely.

Issue	Why is it a problem?	How to avoid
Bacteria from another source (i.e. not the fingers) could get into the Petri dish.	This will make the results invalid as the bacteria are not just from the hand.	Keep the specimen covered with the lid; only open the lid enough to put fingers inside; don't keep the lid open too long.
The adhesive tape could cover the Petri dish.	This could make seeing the results difficult.	Seal the sides using small pieces of tape.
Harmful bacteria could grow.	This could be dangerous.	Do not seal the Petri dish completely. Dispose of samples within 7 days.
Bacterial colonies are difficult to see as they are so small & deciding if something is a colony is subjective.	Increases the chance of human error in counting; variations in count of same sample measured by different people.	Use a magnifying glass to view the samples as clearly as possible; get a second opinion on the count from someone else.
Other microorganisms could be growing such as fungi.	Other organisms other than bacteria could be counted and included in the results.	Discount any cloudy areas. Work in groups to discuss opinions.

Plan for measuring results: counting the number of bacteria that grow; recording what the bacteria look like and how many different types there are.

Sample has to be left for 24 hours to give time for bacteria to reproduce and multiply to form a colony. Gives time for the colonies to grow large enough to be seen by the naked eye.

Worksheet E (Part 1) and G: Suggested answers

Why is it important not to open the lid completely and to avoid touching the inside of the lid?

Not opening the lid completely will prevent any other microorganisms in the air from entering the Petri dish and contaminating the results and limit the learners breathing on the agar. The inside of the lid should not be touched to prevent the transfer of any other bacteria from the surroundings into the Petri dish, which might contaminate the results.

Why is it important for oxygen to be able to get in?

Bacteria require oxygen present in the air to be able to respire and grow. Restricting oxygen could cause harmful anaerobic bacteria to develop which would be a safety issue.

Why is the position of the label important? What could it affect?

The label position could affect how easy it is to view the sample and count the colonies. The lid of the Petri dish cannot be removed, in order to prevent any harmful bacteria from being released, and so you need to make sure the top of the Petri dish remains clear.

Why is it important that you dry your hands on a clean paper towel, and are careful not to touch any surfaces with the washed hands?

It is important to dry washed hands on a clean paper towel and avoid touching any other surfaces to reduce the chance of any other bacteria from a used paper towel / surfaces being transferred onto the washed hands. This could affect the results of the investigation.

Why is it important to use the same three fingers for both the washed and unwashed samples?

This is so that valid comparisons can be made between the samples. The fingers are used to transfer any bacteria from the skin onto the agar. Different fingers have different sizes and so using different fingers with the samples would cause a different surface area of skin to come into contact with the agar. This could affect the number of bacteria counted rather than the independent variable of washed versus unwashed.

Why is it necessary for the samples to be incubated at that temperature for at least 24 hours?

This allows time for the bacteria to reproduce and multiply so that they become visible to the naked human eye and can be counted. If temperatures exceed 25°C, the bacteria could grow too much which could be a health hazard and will also make it difficult to count separate colonies since as they get bigger they will start to overlap in the same space.

Why do they need to be stored safely out of reach?

This is to prevent any other conditions affecting the results, such as the Petri dish lid being knocked or dislodged. This also reduces the chance of the bacteria being released and possibly causing harm.

Are there any issues with the way you have collected the data? How could they be solved?

It is difficult to determine whether the colonies are all bacterial. Other microorganisms could have contaminated the results. Any regions that are not typical colonies (small with defined edges) such as having a cloudy / fuzzy appearance are discounted as they are more likely to be other microorganisms such as fungi. It is often subjective as to whether a colony is an irregular colony or two circular colonies that have overlapped; the counting in general can also be subjective and very small colonies could be missed. It will help to get a second opinion of the count and to discuss the differences of opinion in order to agree a result.

Worksheet F: Suggested answers

The results below are from the *Virtual experiment video.*

Bacteria	Sample tally	
	Unwashed	Washed
Number of colonies	𝍸 𝍸 𝍸 𝍸 𝍸 𝍸 |	
Total	31	0
Different types and number of each type, e.g. circular .. 𝍸	circular 𝍸 𝍸 𝍸 𝍸 𝍸 | irregular |||| rhizoid |	N/A

Worksheet I: Suggested answers

1. Washed hands have less bacteria present than unwashed hands, as shown by a greater number of bacterial colonies in the unwashed sample. There are some bacteria cultures on the washed hands.

2. Washing hands is essential to prevent the transmission of diseases. Harmful bacteria could be present on the hands and then transmitted between patients or from food to customers.

3. The following is an exemplar answer only:

   The results show that there are more bacterial colonies present on the agar of the unwashed hands sample than the washed hands sample. After 24 hours, 32 colonies of bacteria were found on the unwashed sample compared to 0 colonies of bacteria on the washed sample.

   On the unwashed sample, three different types of bacteria were identified based on the different visual appearance of the colonies: circular (27), irregular (4) and rhizoid (1). This suggests that there might also be more variety of bacteria in the unwashed sample, though it's not possible to conclude that from the data collected as there are no bacterial colonies on the washed sample to compare to.

   Pressing fingers on the agar led to the growth of bacterial colonies, suggesting that bacteria can be transferred by touch. Given that there were 32 colonies on the unwashed sample compared to 0 on the washed sample, it suggests that washing hands is important to reduce the transmission of bacteria through touch. This is especially important in hospitals or in the kitchen where there are people who are susceptible to disease or where food is being prepared.

   The results show that washing hands regularly will reduce the number of potentially harmful bacteria on the hands being transferred through direct contact to other people, food items or surfaces.

   For learners' own results where there might be some colonies on the washed sample, something along the lines of the following should also be included:

   The presence of bacteria in the washed sample could mean that the hand was accidentally contaminated before pressing the agar, or that this is healthy and natural bacteria, which is secreted from the skin.

   Depending on the results collected, learners might also be able to conclude that unwashed hands contain more different types of bacteria than washed hands, suggesting there's a higher chance of unwashed hands containing harmful bacteria.

4. Adhesive tape could have been positioned incorrectly making viewing the Petri dish difficult.

   Learners might have forgotten to use the same fingers; they might have touched other surfaces before the agar; they might have touched the inside of the lid; they might have breathed onto the agar; they might have opened the lid too far or for too long.

   The method for collecting results is very subjective; can be a difference of opinion over what is a colony and what is a different type of colony.

   Colonies could be miscounted.

   Fungi could erroneously be counted as bacteria.

   Better to have repeats by using the same hands each time; pooled class data isn't the most accurate way to calculate a mean.

5. The following is an exemplar answer only:

   We cannot be certain that the samples were not contaminated by outside sources as bacteria are too small to see. It may have been that the lid was left open too wide or for too long when positioning the fingers or that the hands may not have been washed thoroughly. The agar could have been breathed on.

   Allowing the colonies to grow for 48 hours would increase the size of the colony as bacteria reproduce. This would make identifying and counting the colonies easier.

   It may also have been difficult to come to an agreement about the number, type or whether the growing microorganism is a bacterium or fungi. This is because the results are subjective and based on observations and so different people will have different results.

   This practical could be improved by repeating the experiment several times in order to calculate a mean. This would eliminate any anomalies, reduce the effect of any contamination and so make the data more reliable and reduce the effect of subjective observations. Also, using a light microscope to view the samples would make counting and describing the colonies easier as the colonies would be easier to see.

Worksheet J: Suggested answers

Equipment with suitable justification from learner:

inoculating loop	Bunsen burner
Petri dish	adhesive tape
bacteria	incubator
agar	distilled water
antibiotic	paper discs

Points to consider

1. Do not completely open the Petri dish. Close the Petri dish lid. Do not touch the inside of the Petri dish lid. Flame the Inoculating loop in the Bunsen burner to kill any bacteria. Flame the bottle to kill any bacteria on the surface (only if it's a glass bottle!).
2. To prevent transmission of bacteria.
3. 25°C so that bacteria grows but not too much. Too high and it could also kill bacteria, or cause a hazardous level of growth.

Risk assessment

Risk	Hazard	Prevention
As per *Briefing lesson* and *Lab lesson*.		
With the addition of an open flame of the Bunsen burner. This could cause a fire or burns if it comes into contact with flammable substances or the skin. Keep it on an orange flame when not in use. Do not touch objects with the flame directly (except the inoculating loop). Keep flammable substances out of reach. Keep long hair tied back.		

Method

- On underside of Petri dish draw a line to split it in half; label one half 'C' for control and the other 'A' for antibiotic.
- Open the bacteria bottle.
- Flame the bottle and an inoculation loop using a Bunsen burner.
- Take an inoculating loop and insert this into the bacteria bottle.
- Remove the inoculating loop.
- Open the lid of the Petri dish enough to insert the inoculating loop.
- Make a zigzag pattern with the inoculating loop across the whole plate.
- Flame the inoculating loop.
- Soak a paper disc in 1 cm^3 of antibiotic, and another disc in 1 cm^3 of distilled water.
- Place each disc on the correct side of the plate according to the labels.
- Seal the Petri dish partially with adhesive tape.
- Incubate at 25°C for at least 24 hours.
- Wash hands thoroughly with antibacterial wash.
- Inspect the sample after 24 hours and record the results.

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