Yeast Bead Catalase Investigation

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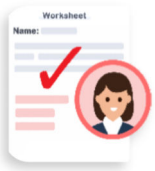


Notes for teachers

- Scan the QR code to get the electronic files.
- Teachers are strongly encouraged to adapt and modify these resources as necessary.

Innovations in Biology Investigations

Yeast Bead Catalase Investigation

Overview

- The *Yeast Bead Catalase Investigation* is about the industrial application of immobilised yeasts to remove hydrogen peroxide from factory effluents.
- Immobilised yeasts, known as yeast beads, contain catalase (Bryer, 2016a, b).
- Students collect quantitative data (i.e., the time for the yeast beads to rise to the surface of the hydrogen peroxide solution) to determine the catalase activity for compare the inhibitory effects of different types of heavy metal ions under different concentrations.
- Students have the opportunity to design and carry out experiments in which they set up replicates, consider the importance of a larger sample size, identify significant assumptions in their experimental designs.
- Students also analyse data, construct graphical representations to compare data sets, and use the information to inform decisions in the application of effluent treatment.

Teaching Plan

Prerequisite knowledge (scientific ideas)

- The properties, actions and roles of enzymes
- Factors affecting the actions of enzymes
- The action of catalase on hydrogen peroxide

Lesson	Lesson sequence	Duration (mins)	Resources
Stage ❶ Preparing for the investigation • It is situated in an authentic context related to the industrial application of yeast beads in removing hydrogen peroxide from factory effluents (**Contextualisation**). • Students read information to familiarise themselves with the background of the investigation (*Reading Materials*).			
Before Lesson 1	• The teacher distributes *Worksheet 1* for students to complete at home so that they can be familiar with the background of the investigation.		*Worksheet 1*
1	• The teacher discusses the investigation context with students. • The teacher provides feedback on students' responses in *Worksheet 1.* • Students complete *Worksheet 2* to design an investigation. • Students perform mini-trial run.	40	*Worksheet 2*
Stage ❷ Designing the investigation • Students perform mini-trial run (*Trial Run*). • Students interact with a virtual laboratory to familiarise themselves with the materials and apparatuses they use in the investigation (*Virtual Laboratory*). • Students use a template to design their own experimental set-ups (*Investigation Planning Template*). • Students have the chance to evaluate their own and their peers' experimental set-ups (*Self & Peer Evaluation*). • Students' experimental designs of a similar investigation are collected and discussed in class (*Diagnostic Assessment*).			
2	• The teacher provides feedback on students' experimental designs in *Worksheet 2.*	40	Student Samples 1
3	• The teacher presents the main investigation context and discusses with students questions related to their experimental designs. • The teacher provides students with the laboratory manual for preparation at home.	40	Teacher Notes 1

Stage ❸ Carrying out the investigation • Students use microscale instrumentation that reduces the time of the experiments (**Microscale Instrumentation**). • Students collect more complex data sets by setting up replicates (**Complex Data Set**).			
3	• Teacher asks questions to help students connect their lab experience and related ideas/scientific inquiry skills. • Students carry out the investigation.	40	Laboratory Manual
Stage ❹ Explaining and evaluating data • Students record and share data using *Google Spreadsheet*. (*Digital Tool*) • Students use data to make claims about the inhibitory effects of different types of heavy metal ions under different concentrations and make decisions (**Decision-making Task**).			
Before Lesson 4	• Students complete data reporting and analysis at home. • The teacher collects and marks student responses.		Teacher Notes 2
4	• The teacher provides feedback on students' performance related to data reporting and analysis**.**	40	Teacher Notes 2

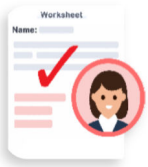
Important Notes

- Students should wear safety goggles and lab coats during the experiment.
- Students should avoid contact with hydrogen peroxide, as it can discolour clothing.

Instructional Materials

Stage 1 Preparing for the investigation

Student Worksheet 1



Notes for teachers

- Teachers can distribute *Worksheet 1* and ask students to read the background information related to the investigation at home.
- Students' responses can be collected using a *Google Form*.
- Scan the QR code to get a copy of the *Google Form*.

Task 1

- Read the following information and the source materials in the data file.
- Answer the questions that follow.

Scenario

Hydrogen peroxide (H_2O_2) is widely used as a bleaching agent in textile industries. Hydrogen peroxide residues should be broken down to harmless substances before discharge to the environment.

Yeast (*Saccharomyces cerevisiae*) is a rich source of catalase, which is an enzyme that catalyses the breakdown of hydrogen peroxide into oxygen and water. Scientists make use of yeasts to remove hydrogen peroxide residues in wastewater. Yet, industrial liquid waste often contains heavy metal ions that can inhibit catalase activity of yeast beads.

Yeast beads

Read the information in the *Data File* to familiarise yourself with the background of this investigation.

Data file

Your biology teacher asks you to read the following source materials to prepare yourself for designing an investigation related to studying catalase.

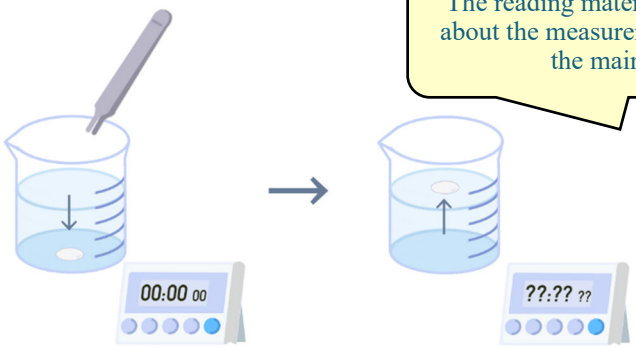
Source 1: Measuring the activity of catalase

Almost all organisms contain catalase. Catalase speeds up the breakdown of hydrogen peroxide, a toxic by-product of some metabolic reactions, into oxygen and water.

The activity of catalase in different tissues can be studied using a simple method involving the following procedures:

- Put filter paper discs into extract of different tissues
- The filter paper discs are then put into plastic vials containing equal volumes of hydrogen peroxide
- Start timing when the filter paper disc reaches the solution
- Note the time (t) required for the filter paper disc to rise to the surface of the solution

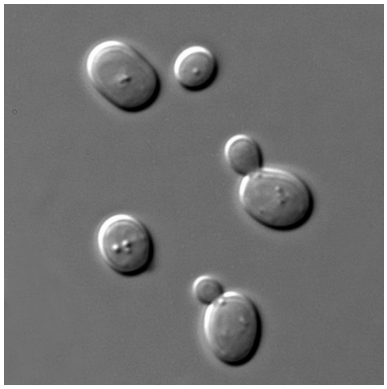
The reading materials provide information about the measurement methods relevant to the main investigation.



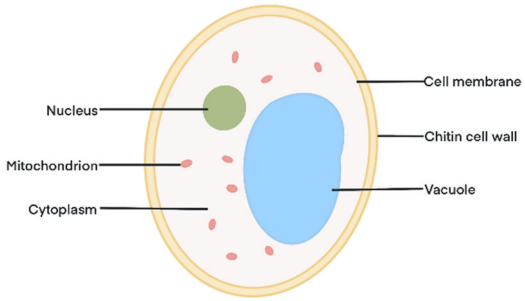
Scan the QR code to see what happens to a filter paper disc with fresh potato juice.

Source 2: What are yeast and yeast beads?

Yeast (*Saccharomyces cerevisiae*) is a eukaryotic organism. A eukaryotic cell has a true nucleus and membrane-bound organelle. Although yeast cells have cell wall, the chemical composition of cell wall of yeast cells is different from that of plant cells. The following diagrams show yeast cells under a light microscope and a drawing of yeast cell respectively.



Yeast cells under microscope



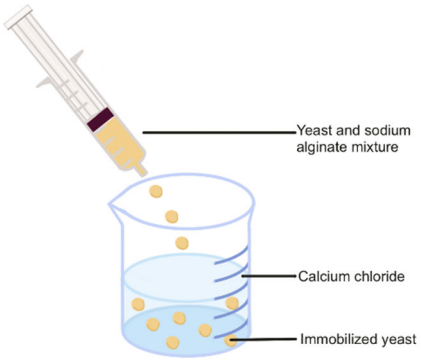
Drawing of a yeast cell

Yeast cells contain catalases. The catalase can break down hydrogen peroxide into oxygen and water.

Scan the QR code to see what happens when a dialysis bag containing yeast solution is put into a beaker of hydrogen peroxide solution.

Scientists make use of yeast for many industrial applications including brewing of beer, making of bread and etc. In some applications, scientists immobilise whole yeast cells to form yeast beads using sodium alginate and calcium chloride.

The reading materials provide information about yeast beads, which may be unfamiliar to the students.



Yeast in alginate solution + Calcium chloride ⟶ Yeast beads

(Yeast immobilised in insoluble calcium alginate)

Immobilised yeasts are also active. The yeast beads can be collected and reused after reaction.

Answer the questions below *after* reading the source materials.

(a) Write a word equation for the action of catalase on hydrogen peroxide.

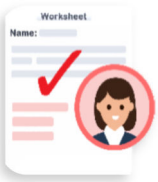
(b) Suggest an animal organ in which catalase is present in great abundance and from which the enzyme can be obtained. Explain why this organ has so much catalase.

(c) With reference to *Source 1*, explain why the paper discs rise to the surface of the hydrogen peroxide solution.

(d) How is the time taken for the paper disc to rise to the surface of the solution related to the activity of catalase?

(e) With reference to *Source 2*, state *two* observations when a dialysis bag containing yeast solution is put into a beaker of hydrogen peroxide solution.

Student Worksheet 2



Notes for teachers

- Teachers distribute *Worksheet 2* and ask students to design the investigation at home.
- Teachers may ask students to perform a trial run before their design. See *Supplementary Resource* section for the material list.
- Students can see the materials and apparatuses in the *Virtual Laboratory*.
- Some student work samples are shown below to illustrate possible student thinking.

Task 2

- Answer the questions that follow.

1. Briefly describe how you would use the following materials to design an experiment to achieve the above aim. You can draw your experimental design.

1M Zinc sulphate solution	Timer	Distilled water
1M Nickel chloride solution	Forceps	0.1% Hydrogen peroxide
1M Copper sulphate solution	Yeast beads	Plastic vials
Autopipette	Autopipette tips	10 ml measuring cylinder
Petri dish		

Scan the QR code to see these materials.

The virtual laboratory provides students with opportunities to get familiar with materials used in the investigation.

Brief explanation of my design:

The mini trial run provides opportunities for students to see how the dependent variable can be measured (i.e., the time for the yeast beads to rise).

Mini trial run procedures

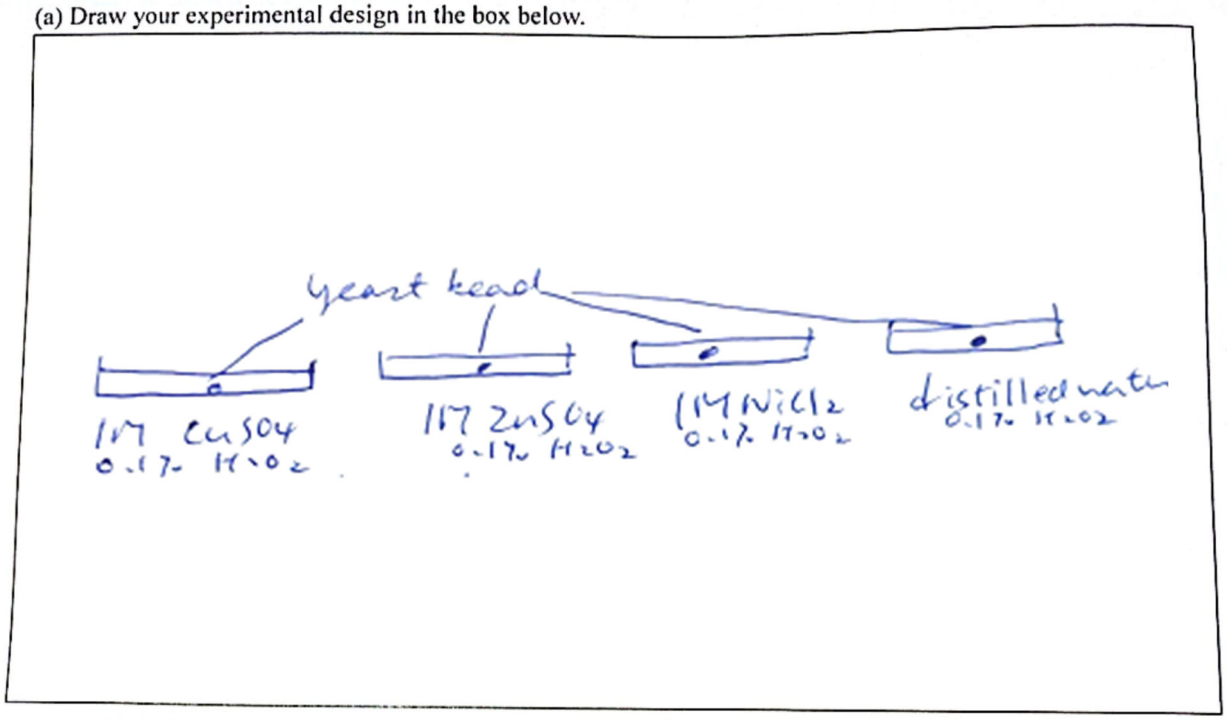
You may want to perform the following trial run before you design the investigations.

- Pour some hydrogen peroxide (H_2O_2) into a plastic vial.
- Use the forceps to transfer several yeast beads into the H_2O_2 solution.
- Observe what happens.

Examples of students' initial experimental designs

Sample 1

(a) Draw your experimental design in the box below.



(b) Briefly explain your design:

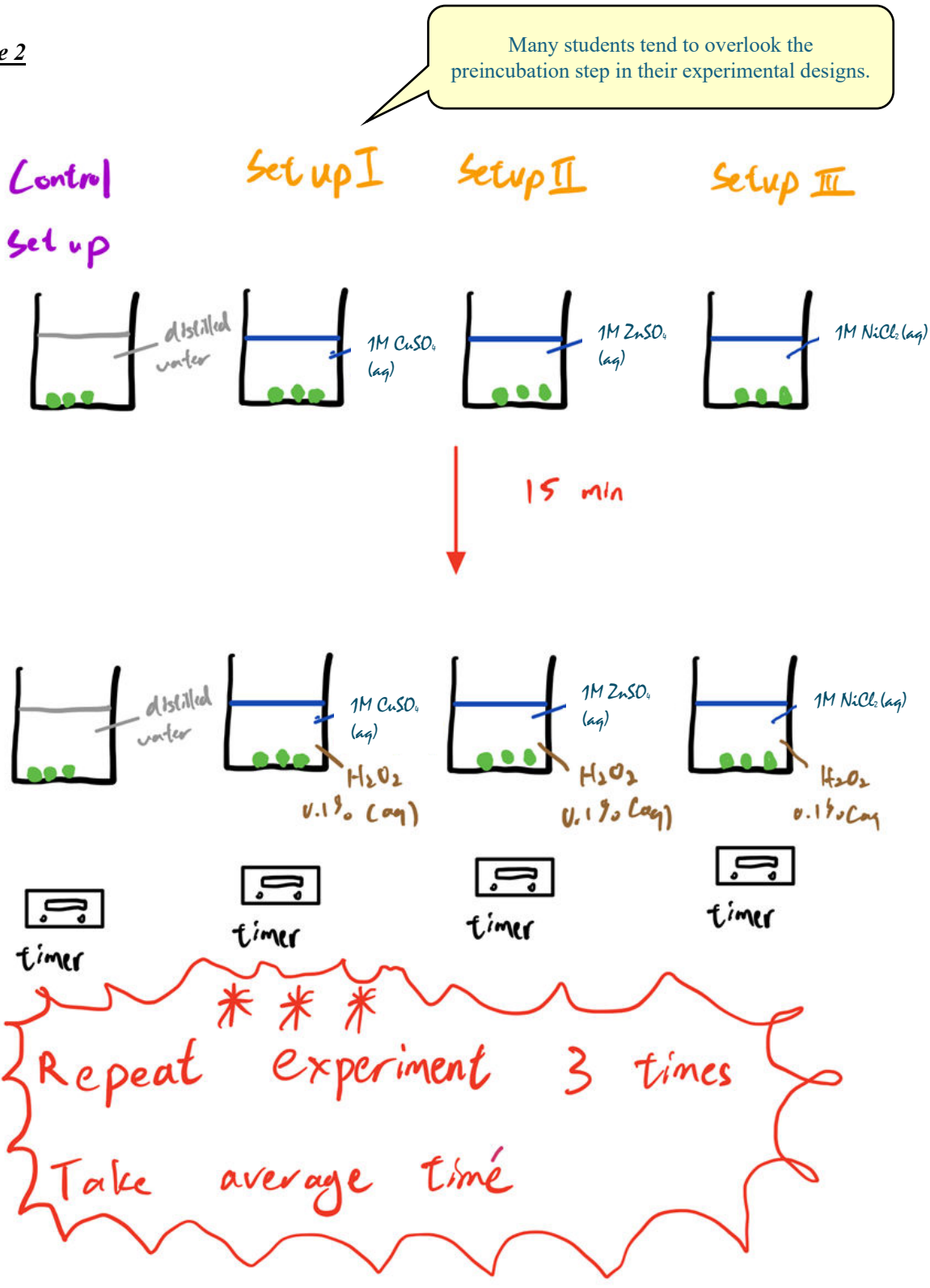
1) Set 4 set ups : 1M CuSO4, 1M ZnSO4 1M NiCl2 , distilled water
All set ups with 0.1% hydrogen peroxide

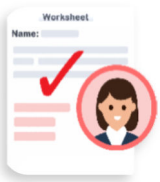
2) Put the yeast heads into the mixture solution

3) use timer to time when the yeast heads reach the top of the petri dish

Students evaluate their own and their peers' designs on a similar experiment. Teachers provide feedback on important scientific thinking skills.

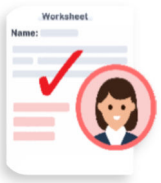
Sample 2





Notes for teachers

- Teachers can choose some students' diagrams (anonymised) of experimental setups for students to evaluate.
- Teachers can discuss the following scientific inquiry skills: (1) the importance of precautionary step; (2) the number of yeast beads in each vial; (3) the number of replicates they would set up.



Notes to teachers

- After receiving feedback on their experimental designs, the following shows the main investigation context for students to design another investigation that involves continuous independent variable.
- There are some questions that teachers may use to guide students in thinking about or assessing the scientific inquiry skills related to experimental designs.
- Some student work samples are shown below to illustrate possible student thinking to some questions.

Task 3

Scenario

Hydrogen peroxide (H_2O_2) is widely used as a bleaching agent in textile industries. Hydrogen peroxide residues should be broken down to harmless substances before discharge to the environment.

Baker's yeast (*Saccharomyces cerevisiae*) is a rich source of catalase. Catalase is an enzyme that catalyses the breakdown of hydrogen peroxide into oxygen and water. Scientists make use of yeasts to remove hydrogen peroxide residues in wastewater. However, industrial liquid waste often contains heavy metal ions that can inhibit catalase activity of yeast beads. More yeast beads need to be used to achieve the same efficiency.

Yeast beads

Your biology teacher has asked you to design an investigation *to investigate the effect of different types of heavy metal ions on the activity of yeast bead catalase under different concentrations*. This information is important for determining the catalase activity of yeast beads in removing hydrogen peroxide in water with heavy metal.

Design of investigation

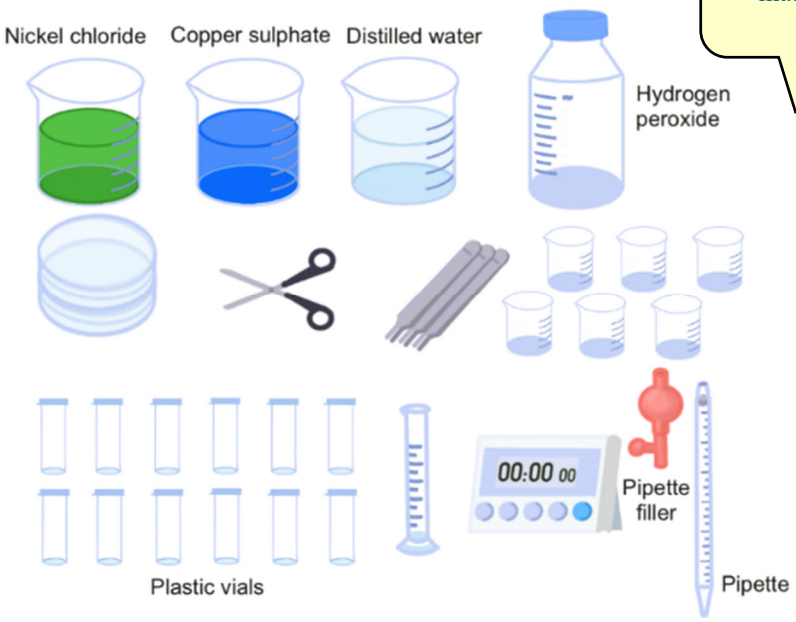
Aim of the investigation

- To investigate the effect of different types of heavy metal ions on the activity of yeast bead catalase under different concentrations

Materials and apparatus:

- You have been given the following materials and apparatus:

1M Nickel chloride solution	Forceps	Plastic vial
1M Copper sulphate solution	Petri dish	Timer
0.1% Hydrogen peroxide solution	1 mL Pipette	10 mL Measuring cylinder
Distilled water	Pipette filler	25 mL Beaker
Yeast beads	Scissors	



The diagrams provide visual scaffolds to help students understand the materials and apparatuses for the investigation.

Scan this QR code to see the materials.

Possible questions:

1. State how the dependent variable can be measured using the above materials and apparatus.

   Hints: Make sure that you include the following parts in your answers:

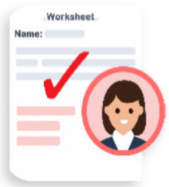
   ☐ the measurement tools and the methods of measurement.

   ☐ the relationship between the measurement and the dependent variable

The checklist serves to scaffold students' responses.

2. Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?

3. Your teacher advised you not to use hydrogen peroxide solution that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide solution in relation to the overall validity of the investigation.

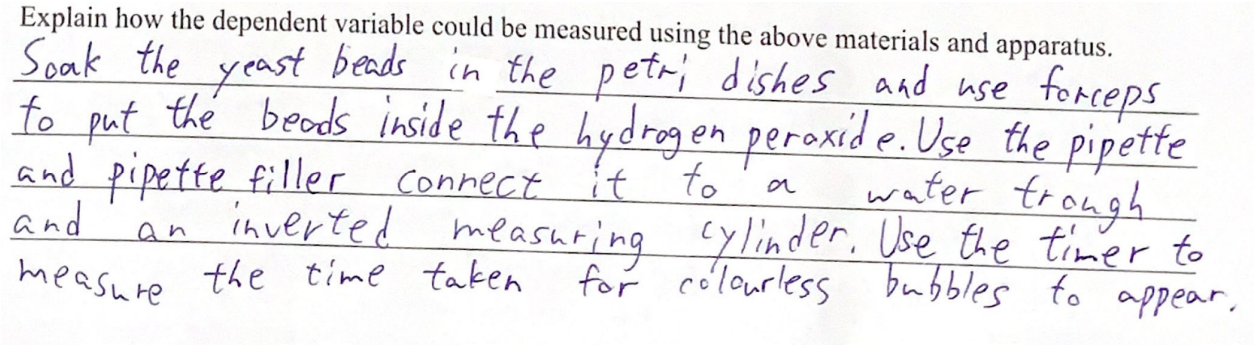


Notes for teachers

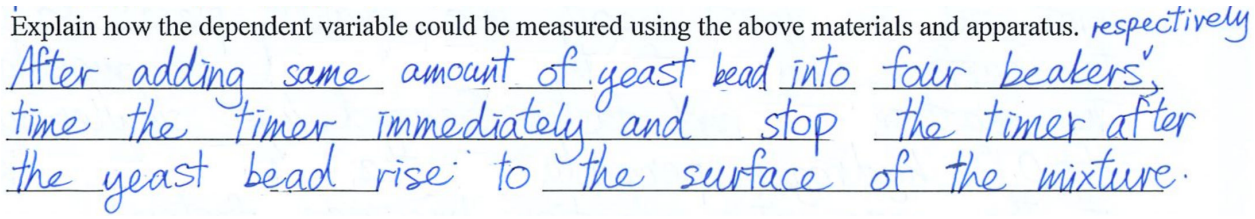
- Q.1 assesses students' ability to connect the measurement to the dependent variable.
- Q.2 assesses students' ability to explain how increasing the sample size can help reduce the impact of individual differences inherent in biological samples on the quality of the data.
- Q.3 assesses students' ability to explain design that relates to the validity of the design.

The following are some examples of students' responses to Q.1:

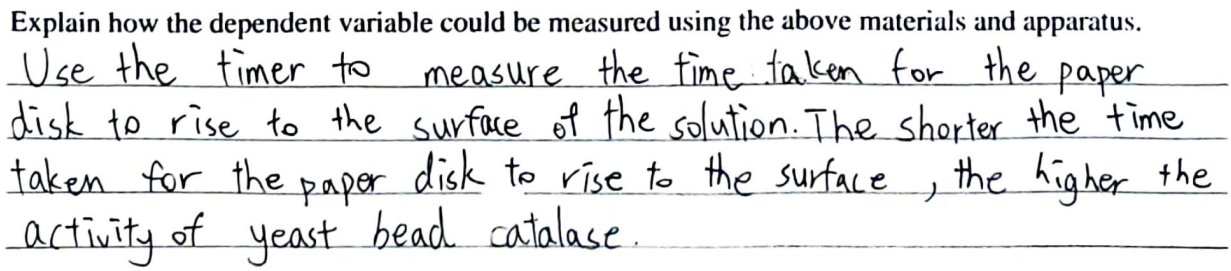
Sample 1


Explain how the dependent variable could be measured using the above materials and apparatus.
Soak the yeast beads in the petri dishes and use forceps to put the beads inside the hydrogen peroxide. Use the pipette and pipette filler connect it to a water trough and an inverted measuring cylinder. Use the timer to measure the time taken for colourless bubbles to appear.

Sample 2


Explain how the dependent variable could be measured using the above materials and apparatus.
After adding same amount of yeast bead into four beakers respectively, time the timer immediately and stop the timer after the yeast bead rise to the surface of the mixture.

Sample 3

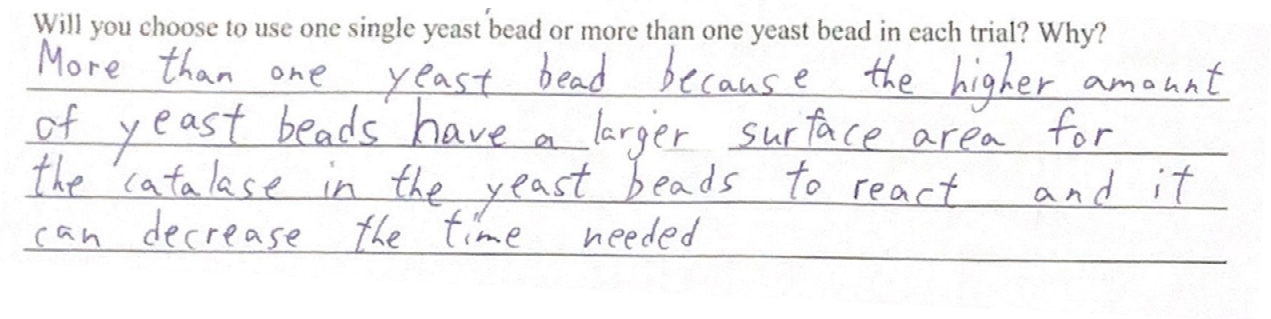

Explain how the dependent variable could be measured using the above materials and apparatus.
Use the timer to measure the time taken for the paper disk to rise to the surface of the solution. The shorter the time taken for the paper disk to rise to the surface, the higher the activity of yeast bead catalase.

About the samples

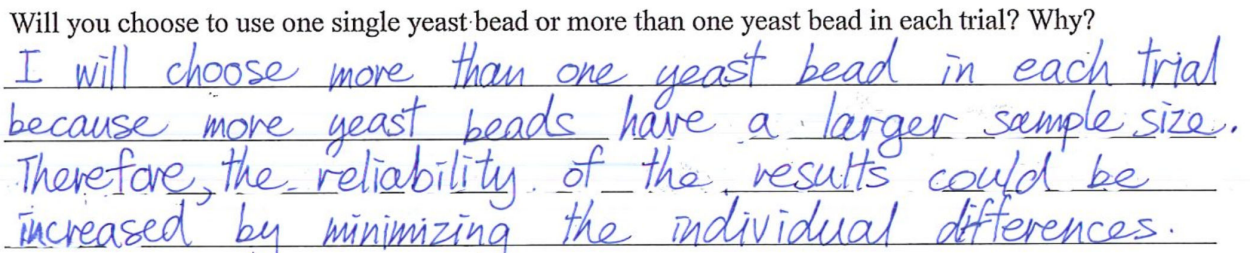
- Sample 1 proposed a set-up that required additional materials and apparatus not provided in the list. It is also not feasible to measure the time it takes for the colourless gas bubbles to appear.
- Sample 2 described the measurement (i.e., time for the yeast beads to rise to the surface of the solution) but did not state the relationship between the measurement and the relative rate of catalase activity.
- Sample 3 confused yeast beads with paper discs (information in the *Data File*.)

The following are some examples of students' responses to Q.2:

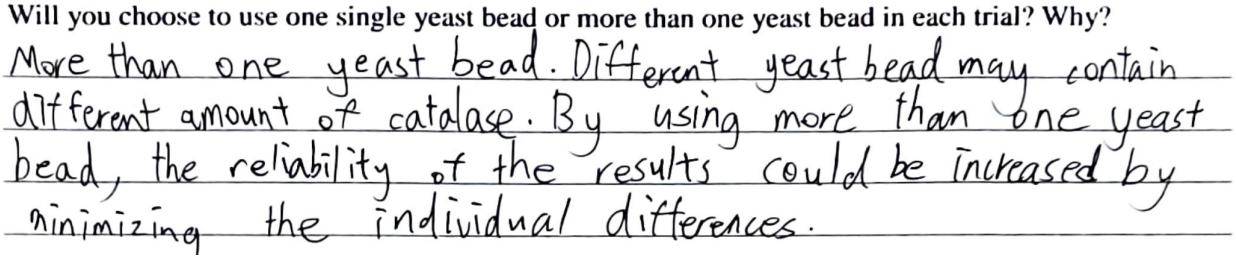
Sample 1


Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?
More than one yeast bead because the higher amount of yeast beads have a larger surface area for the catalase in the yeast beads to react and it can decrease the time needed

Sample 2


Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?
I will choose more than one yeast bead in each trial because more yeast beads have a larger sample size. Therefore, the reliability of the results could be increased by minimizing the individual differences.

Sample 3


Will you choose to use one single yeast bead or more than one yeast bead in each trial? Why?
More than one yeast bead. Different yeast bead may contain different amount of catalase. By using more than one yeast bead, the reliability of the results could be increased by minimizing the individual differences.

About the samples

- Sample 1 wrongly believed using more than one yeast can lead to a shortening of the duration of the experiment. The surface area to volume ratio of each yeast does not change when more than one yeast bead is used.
- Sample 2 and Sample 3 related to the reliability of the data. Sample 2 described the differences between the yeast beads in terms of the differences in the amount of catalase. Increasing the number of yeast beads in each trial can reduce the impact of the inherent variations in catalase in the yeast beads.

The following are some examples of students' responses to Q.3:

Sample 1

Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

As hydrogen peroxide is acidic, a too concentrated hydrogen peroxide will affect the action of catalase by denaturing it. A suitable concentration of hydrogen peroxide ensures the catalase in the yeast beads are able to work in a suitable pH.

Sample 2

(h) Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

Catalase works best in a certain concentration of hydrogen peroxide. Too concentrated hydrogen peroxide will affect the rate of catalase activity and affect the overall validity of the investigation.

Sample 3

Your teacher advised you not to use hydrogen peroxide that is too concentrated (>5% hydrogen peroxide). Discuss the importance of using a suitable concentration of hydrogen peroxide in relation to the overall validity of the investigation.

Because too concentrated hydrogen peroxide will lead to higher rate of catalase reaction. So, the rate of yeast bead to reach the surface will be too fast and ~~the~~ it will be too hard to measure the difference of rate of reaction between different solutions. Suitable concentration can ensure the result is obvious to compare.

About the samples

- Sample 1 wrongly stated that more concentrated hydrogen peroxide solution is more acidic.
- Sample 2 did not pinpoint what the changes in the rate of catalase activity would be when too concentrated hydrogen peroxide is used and its effect on the measurement.
- Sample 3 was able to relate the difficulty of discerning the differences if the rate is too high for both treatments.

Laboratory Manual

Notes to teachers

- Teachers can distribute the manual for students to read and prepare before the investigation.
- It is suggested that half of the class investigate the effect of copper ions while the other half study the effect of nickel ions.
- Teachers can ask questions to check if students fully understand the procedures (e.g., how many yeast beads will you need in this experiment? Why?).
- The *Supplementary Resource* section contains the material list.
- Scan the QR code to view the process of the experiment.

Task 4

- Read the following procedures to carry out the investigation.

Procedure

Preparation of yeast beads

1. Add 10 mL of 10% yeast (in a vial) to 10 mL of 2% sodium alginate solution in a 50 ml tube.
2. Mix the solution well by inverting the 50 mL tube to make a yeast–sodium alginate solution.
3. Hold the plastic dropper (without cap) with a stand and clamp.
4. Pour 50 mL 2% $CaCl_2$ (calcium chloride) into a plastic cup/100 mL beaker.
5. Assemble the set up shown in *Figure 1*.
6. Add the yeast-sodium alginate solution to the plastic dropper (a bead should form when the drop comes into contact with the $CaCl_2$ solution and falls to the bottom of the beaker).
7. Wait 5 minutes until the beads have hardened.
8. Discard any floating yeast beads with a plastic spoon.
9. Collect the beads with a sieve.
10. Wash the beads several times with distilled water from a wash bottle over a plastic cup.

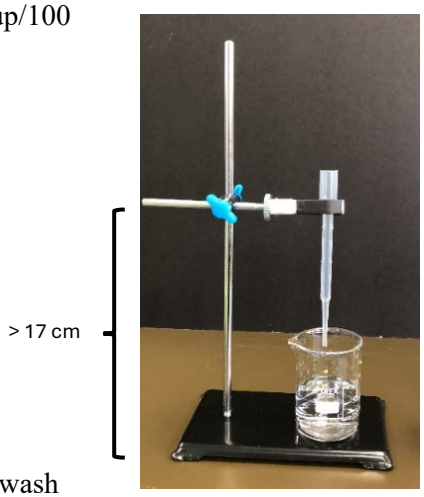


Figure 1

Inhibition of catalase activity

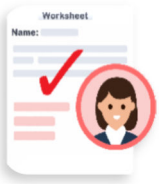
1. Add the heavy metal solution (e.g., 5 mL depending on the size of the petri dish) with different concentrations (1M, 0.5 M, 0.25M) and distilled water to four different petri dishes.
2. Use forceps to gently move at least 15 yeast beads into each labelled petri dish for at least 5 minutes.

Testing the catalase activity

1. Measure 10 mL of 0.1% hydrogen peroxide solution with a measuring cylinder and pour the solution into a plastic vial. (You can use the dropper to transfer the solution).
2. Repeat *Step 1* three times.
3. Use the forceps to carefully transfer five yeast beads from each petri dish into each plastic vial.
4. Start the timer as soon as the yeast beads touch the surface of the hydrogen peroxide solution or as soon as they touch the bottom of the vial.
5. Record the time when all the beads have reached the surface of the hydrogen peroxide solution.
6. Repeat your measurements at least two more times.
7. Report your group data in this *Google Sheet* by scanning the QR code.

Scan the QR code to get a copy of the *Google Sheet*.

Teacher Notes 2



Notes for teachers

- The following are some possible questions that teachers can use to guide students in thinking about or assessing their scientific inquiry skills related to data analysis and interpretation.
- Some student work samples are shown below to illustrate possible student thinking.

Task 5

Possible questions

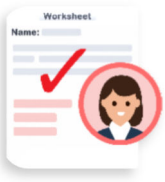
1. Based on the class data, which data set concerning the effect of 0.5 M of the two heavy metal ions on the yeast bead catalase activity is more variable? Explain your answer.

2. Plot a graph to show the class data.
   - Which type of graph would you choose to show the effect of different types of heavy metals on the activity of catalase under different concentrations? Why?
   - Which axis, the x-axis or the y-axis, should be the independent and dependent variables respectively?
   - What should be a suitable title for your graph?

Some reminders are added to guide students in constructing graphical representations appropriately.

3. Describe and compare the effect of different concentrations of the two heavy metal ions on the activity of catalase in the yeast beads.

4. If 1,000 yeast beads are typically used to remove hydrogen peroxide from industrial effluents without heavy metals, how many yeast beads would be needed to achieve the same removal efficiency in effluents containing 0.1 M nickel chloride and 0.1 M copper sulphate, respectively?

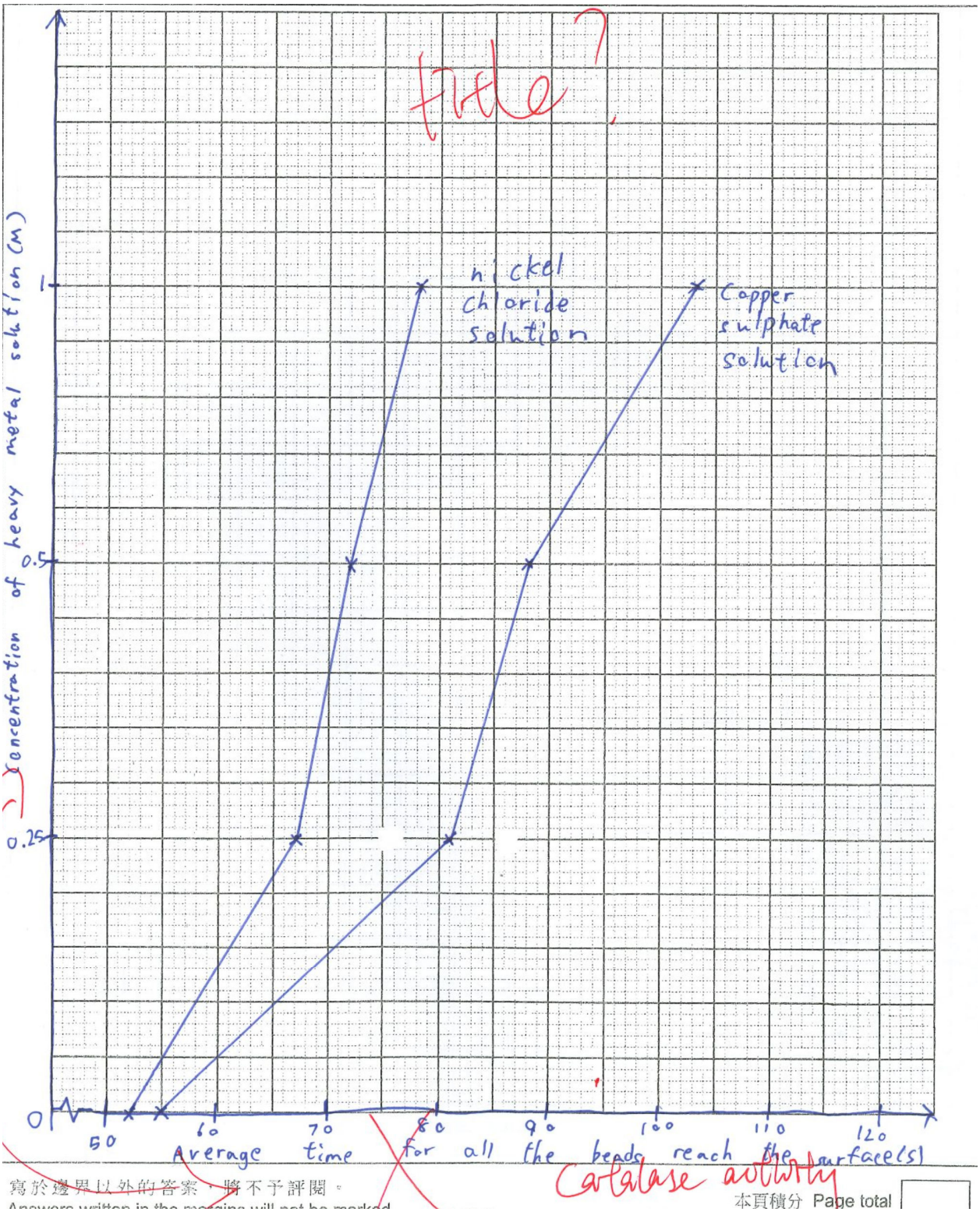


Notes for teachers

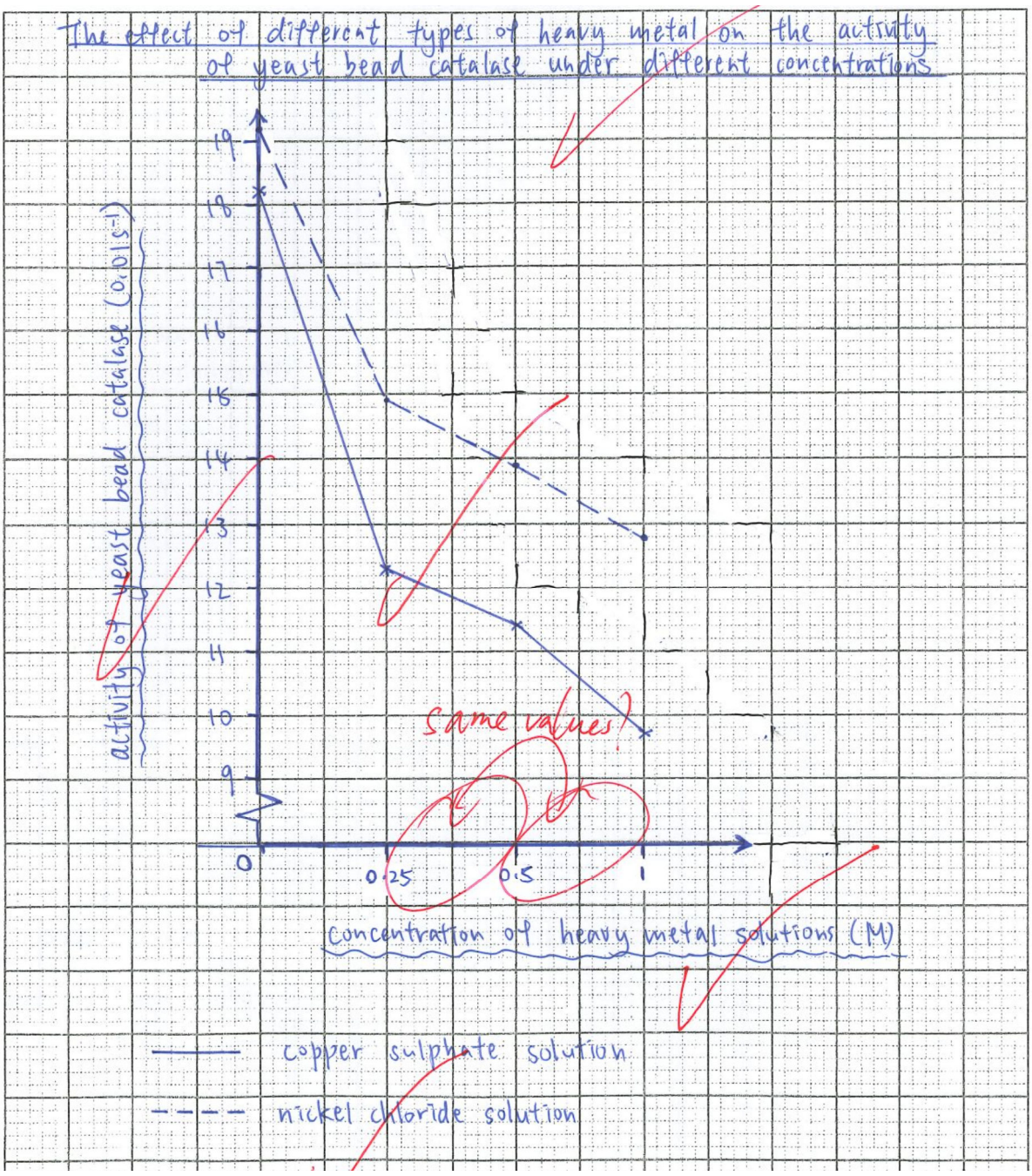
- Q.1 assesses students' ability to apply basic statistics to compare the variability of datasets.
- Q.2 assesses students' ability to construct appropriate graphical representations.
- Q.3 assesses students' ability to describe and compare more complex data sets involving more than one independent variable.
- Q.4 assesses students' ability to read data from the graph and perform simple calculation based on their data.

The following are some examples of students' responses to Q.2:

Sample 1



Sample 2

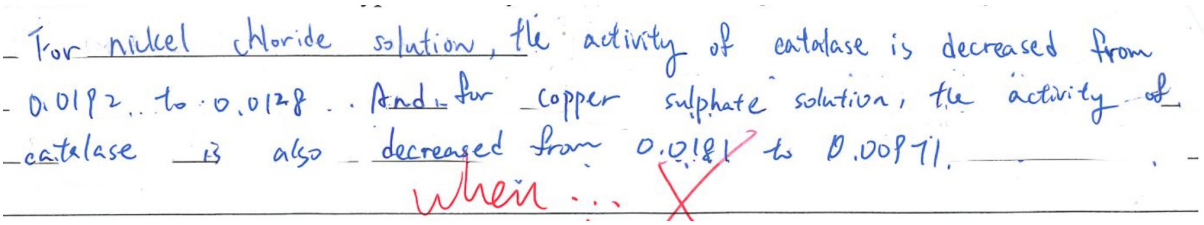


About the samples

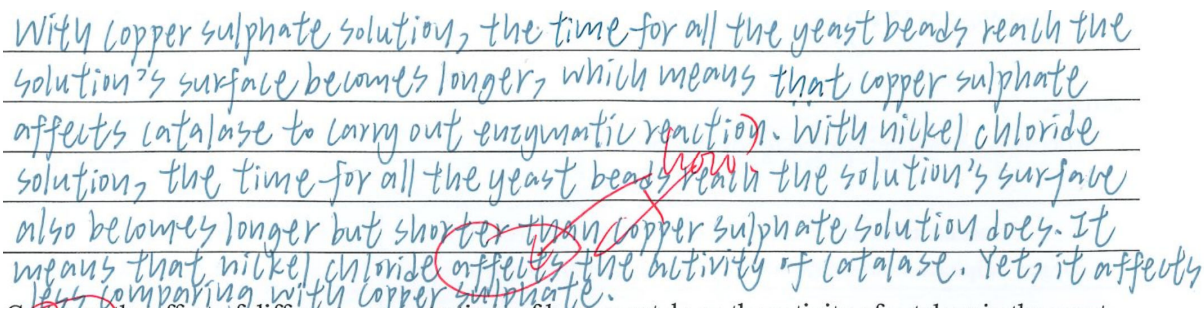
- Sample 1 has various mistakes in the graph plotting. These include: (1) missing a title for the graph; (2) reversing the x-axis and y-axis; (3) using a measurement parameter rather than the dependent variable on the axis.
- Sample 2 shows a scaling issue in the graph. The interval between 0.25 M and 0.5 M is the same as the interval between 0.5 M and 1.0 M, which is not an appropriate scaling.

The following are some examples of students' responses to Q.3:

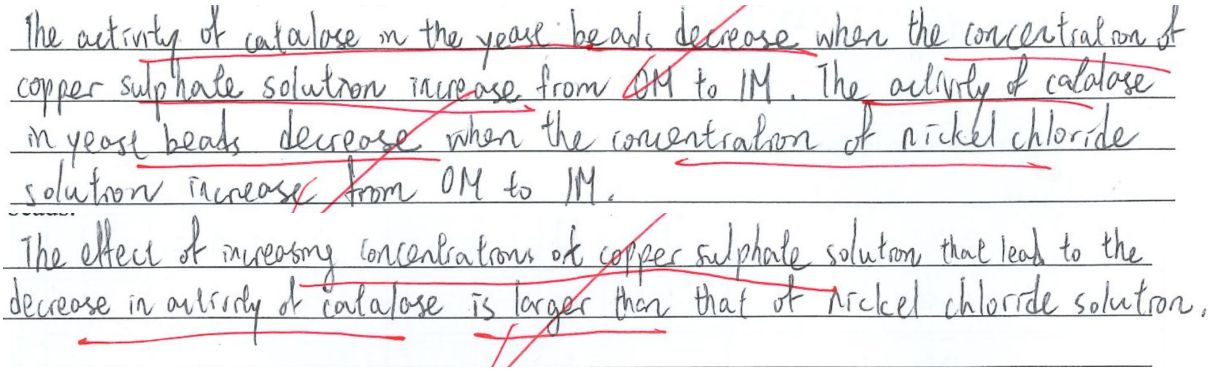
Sample 1



Sample 2



Sample 3



About the samples

- Sample 1 did not clearly identify how the different concentrations of copper/nickel ions influenced the yeast bead catalase activity.
- Sample 2 did not specify the range of heavy metal ion concentrations over which there was a decrease in yeast bead catalase activities. There was also no explicit comparison of the effects of the two different heavy metal ions.
- Sample 3 showed that as the concentration of heavy metal ions increased, there was a decrease in yeast bead catalase activity. It also identified that the copper ions caused a greater decrease in activity compared to the nickel ions. However, the description of the differential effects between the two heavy metal ions could be more nuanced.

Supplementary Resources

Possible Modifications

1. Studying plant material beads

- Catalase can be found in many different tissues of plants and animals. Crude extract from plant materials can also be used to make alginate beads (Andrews et al., 2019). Potato, banana and cucumber beads can be prepared using the following protocol:

Procedure

Preparation of alginate beads using crude extract from plant materials

1. Weigh 20 g of potato/cucumber.
2. Cut the potato/cucumber into small pieces.
3. Add 20 mL of distilled water to the potato/cucumber.
4. Blend the potato/cucumber and the distilled water with a blender.
5. Filter the potato/cucumber juice with a muslin bag.
6. Add 10 mL of 3% or 4% sodium alginate solution to 10 mL of filtered potato/cucumber juice.
7. Mix the mixture well.
8. Store at 4°C to remove air bubbles.
9. Add the potato/cucumber juice-sodium alginate solution to the plastic dropper (a bead should form when the drop comes into contact with the $CaCl_2$ solution and falls to the bottom of the beaker) above a beaker of 2% calcium chloride.

Scan the QR code to watch a video on how to prepare plant material alginate beads.

Important notes

- It is important to make sure that the plant extract is dense enough for the beads to sink to the bottom.
- Storing the plant extract–alginate mixture overnight at 4°C can effectively remove the air bubbles (the beads will float if they contain many air bubbles).

Technician Notes

1. Materials for Task 2

Materials to for each group

- 1% H_2O_2 (50 ml) in 100 mL beakers
- 3% H_2O_2 (50 ml) in 100 mL beakers (Handle with care!)
- 5 plastic vials
- Forceps X2
- Irregular yeast beads in a petri dish

2. Materials for Task 4

Chemicals to be prepared

- 10% yeast extract (1 mL in 1.5 mL tube) (to be prepared on that day) (Add 15 g yeast in 150 mL distilled water. Add a spoonful of sugar. Stir on a magnetic stirrer. Wait for 30 minutes to activate the yeast. Keep stirring. Aliquot just before the experiment.)
- 2% sodium alginate (food grade). Add 200 mL of distilled or deionised water and a stir bar. Heat the solution. Slowly add some sodium alginate to dissolve it. Add more powder slowly (5 g in total). Make up volume to 250 mL. Store the solution at 4°C.
- 0.1% hydrogen peroxide (150 mL per group) You may perform a trial run with 0.2% H_2O_2 as the catalase activity depends on the quality of the yeast. It is desirable if the yeast beads rise within 1 minute in the control (i.e., without metal ion treatment).

Scan the QR code to watch a video on how to prepare 2% sodium alginate.

Materials for each group

• 10 mL 2% Sodium alginate in 50 mL tube	• Plastic forceps X 4	• Plastic vials X 12
• 10 mL 10% Yeast in a plastic vial X 1	• 3 mL Plastic disposable pipette (with part of the head cut)	• 10 mL Measuring cylinder
• 100 mL Beaker X 2	• Mini-petri dish X 4	• 5 mL 1 M $CuSO_4$/$NiCl_2$ solution in 15 mL tube
• Spoon (for removing floating yeast bead)	• 3 mL Disposable dropper (for measuring H_2O_2)	• 5 mL 0.75 M $CuSO_4$/$NiCl_2$ solution in 15 mL tube
• Sieve	• Stand and clamp	• 5 mL 0.25 M $CuSO_4$/$NiCl_2$ solution in 15 mL tube
• 50 mL 2% Calcium chloride	• Wash bottle (with distilled water) X 1	• 5 mL Distilled water in 15 mL tube
• Timer	• 0.1% Hydrogen peroxide (>120 mL)	• Rubbish bin

Notes

- Do *not* use tap water to prepare heavy metal solutions.

Scan the QR codes to watch the videos.

References

Andrews, K., Beaumont, P., & Louis, M. (2019). Catalase activity in immobilised yeast. *School Science Review*, *100*(373), 13–16.

Bryer, P. J. (2016a). A twist on measuring catalase. *Science Teacher*, *83*(6), 69–73.

Bryer, P. J. (2016b). Exploring catalase and invertase activity using sodium alginate–encapsulated yeast (yeast spheres). *Journal of Microbiology & Biology Education*, *17*(3), 490–491.

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