27. Scientific Method

General Aims

To develop competence in the:

- **Process skills of science associated with designing and performing controlled experiments, collecting, recording, presenting and interpreting data**
- **Measurement of length, volume and mass, and in the calculation of magnifications, field diameters and estimations of dimension of structures in light**

General Objectives

- Demonstrate competence in measurement of length, volume and mass, and in calculations of magnifications, field diameters and estimations of dimension of structures in light microscopy.
- Retrieve information from a variety of sources, collate information into succinct reports, communicate accurately and clearly, both orally and in writing
- Analyse and interpret data presented in graphical and tabular form

The next two questions refer to the table below.

Consider the table below showing data recorded for a person viewing a frightening horror movie.

Time (minutes)	1	2	3	4
Cardiac Output (L / minute)	5	7	20	10

1. 2003 / 26

Concerning these data, which of the statements below is most correct?

(a) The sympathetic nervous system appears to be most active between 2 and 3 minutes.
(b) The parasympathetic nervous system is most active at 3 minutes.
(c) Adrenalin is secreted in response to increased cardiac output at 4 minutes.
(d) Between 2 and 3 minutes the hypothalamus adjusts the heart rate to meet a need for greater oxygen.

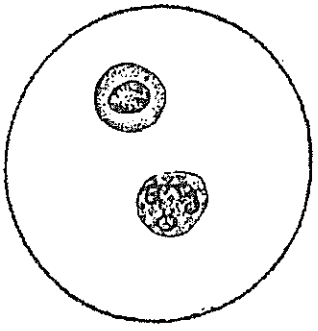
2. 2003 / 27

The changes noted in the person's body are

(a) a result of the hormone thyroxine.
(b) a homeostatic response.
(c) designed to maximise oxygen delivery to the skeletal muscles.
(d) designed to ensure that carbon dioxide levels do not increase.

3. 2003 / 32

Cells shown in the diagram below were observed using a microscope fitted with a 40X objective lens and a 10X ocular (eyepiece) lens. Given that the field of view for this microscope at a magnification of 100X is 200 micrometres, what is the approximate size of these cells?



(a) 10 micrometres
(b) 20 micrometres
(c) 30 micrometres
(d) 50 micrometres

4. **2003 / 33**

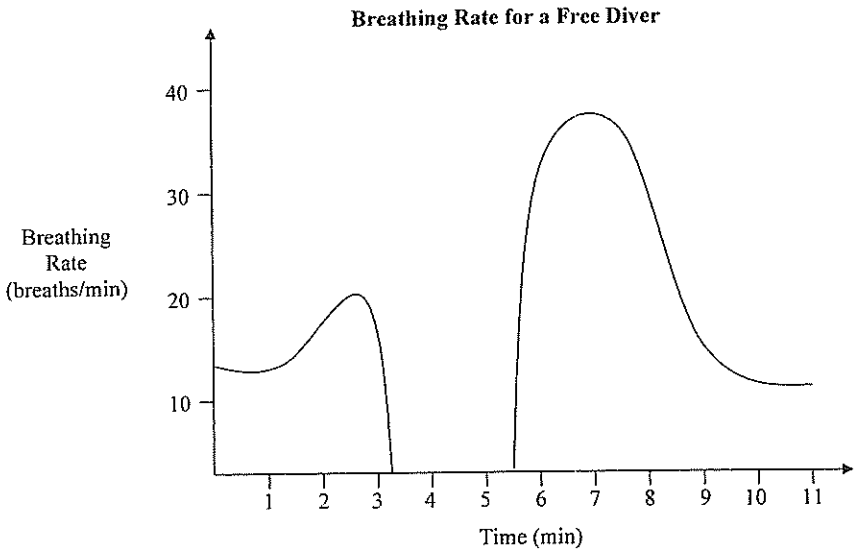
If human cells were given essential nutrients and allowed to grow and reproduce in a closed test tube, what changes would you expect to measure in the test tube?

(a) An increase in temperature, as well as increased levels of oxygen and carbon dioxide.
(b) An increase in temperature, carbon dioxide levels and glucose but decreased oxygen levels.
(c) An increase in temperature and carbon dioxide levels but decreased levels of oxygen and glucose.
(d) A decrease in temperature as well as a decrease in levels of oxygen, carbon dioxide and glucose.

5. **2004 / 25**

Free-diving is an Extreme sport in which divers hold their breath for long periods of time and dive to great depths. An investigation into the effect that such a dive has on breathing rate was performed.

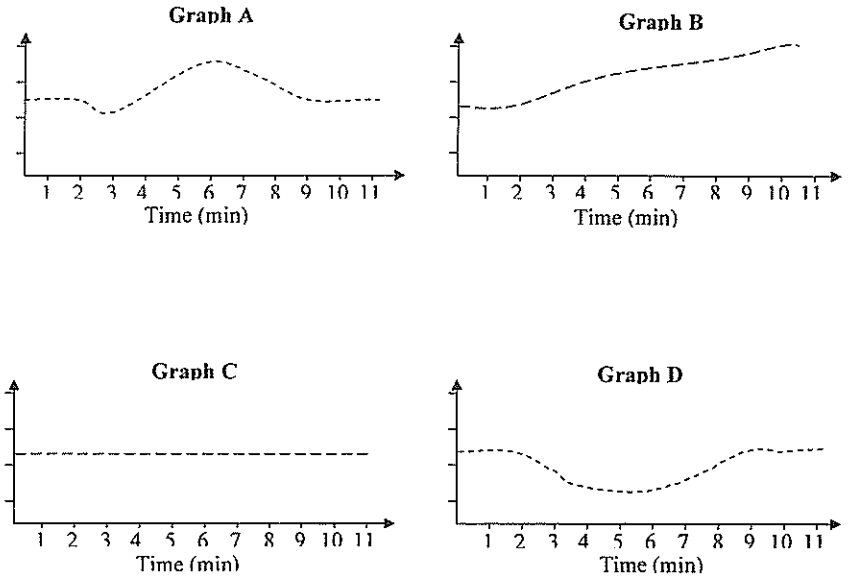
The data collected for breathing rate are shown below.



Examine the graphs drawn below. Which of the graphs best represents the change in carbon dioxide levels in the blood during the free dive investigation?

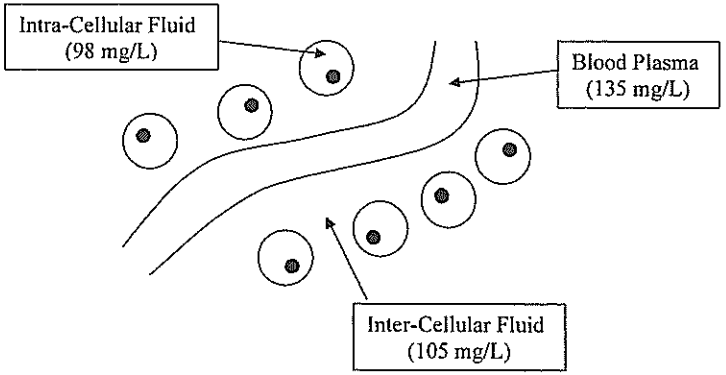
(a) Graph A
(b) Graph B
(c) Graph C
(d) Graph D

Note: The Y-axis represents levels of Carbon Dioxide in the blood.



6. **2004 / 35**

The diagram below indicates part of an image viewed down a microscope. Three different fluid compartments within a small sample of human tissue are shown. Also provided are data on the concentration of total dissolved substances within these compartments.



If you were asked to measure the size of these cells, which piece of information would be most useful?

(a) The field of view.
(b) The magnification of the image.
(c) The number and size of lenses in place.
(d) The type of cells being viewed.

Amylase is an enzyme that hydrolyses starch into sugars in humans. An experiment was performed to determine the effect of temperature on amylase activity. The data collected are given in the following table.

Refer to this table for the next 2 questions

Temperature (°C)	Rate of production of sugar (g/min)
0	0.0
10	0.4
20	0.6
30	0.8
40	1.0
50	0.4
60	0.2
70	0.0

7. 2005 / 21
The independent variable in this experiment is

(a) the rate of hydrolysis of starch into sugars.
(b) the rate of amylase activity.
(c) the incubation temperature.
(d) the concentration of amylase.

8. 2005 / 22
What factors need to be controlled in this experiment?

(a) amylase activity and incubation temperature
(b) concentration of amylase and amount of starch
(c) concentration of amylase and amount of sugar
(d) amylase activity and amount of starch

For the next 2 questions refer to the information and table below.

Four disinfectants were diluted and tested on cultures of a micro-organism (at standard temperature and pressure). The results are shown in the table below where:

\+ indicates that bacteria grew, and
\- indicates no growth.

	Disinfectant			
Dilution	**A**	**B**	**C**	**D**
1:2	+	-	-	-
1:4	+	-	+	-
1:8	+	+	+	-
1:16	+	+	+	+

9. 2005 / 37
Of the four disinfectants tested, which was most effective?

(a) disinfectant A
(b) disinfectant B
(c) disinfectant C
(d) disinfectant D

10. 2005 / 38
Why are you led to this conclusion?

(a) Bacteria showed growth at all dilutions.
(b) Bacteria showed growth only in the most dilute solution.
(c) Bacteria showed growth in the less dilute solutions.
(d) Bacteria showed no growth in the less dilute solutions.

11. 2006 / 15
A student is using a microscope with a 10x ocular lens. His high power objective lens is 40x and the field of view is 325µm. He then changes to a low power objective lens of 10x.
What is the 'field of view' at low power?

(a) 0.65 mm
(b) 0.82mm
(c) 1.30mm
(d) 1.64mm

12. 2002 / 45
A scientist was investigating the effectiveness of a newly developed drug, "Neurogen", and its ability to improve recovery from nerve cell injury. The experiment was performed as described below:

Nerve cells were placed into culture medium (a solution containing nutrients to keep the cells alive and help them grow). An equal number of nerve cells (in culture medium) were transferred into nine test tubes and maintained under constant temperature and oxygen levels. Three of the test tubes received no further treatment. Of the remaining six test tubes, three tubes received a large, single dose of Neurogen whilst the remaining three tubes had a series of smaller doses of Neurogen added over a one week period.

After one month the growth of nerve axons in the test tubes was measured and the results are shown in the table below.

TREATMENT	Tube number	GROWTH OF NERVE AXONS AFTER ONE MONTH (mm)
NEUROGEN (Large, single dose)	1	0.50
	2	0.42
	3	0.45
NEUROGEN (Series of small doses)	4	0.80
	5	0.98
	6	0.90
NO TREATMENT	7	0.25
	8	0.27
	9	0.19

For the experiment described above:

(a) Identify **ONE** hypothesis being tested. (2)

_____

_____

(b) What is the Dependent Variable? (1)

_____

(c) Based on the information given, list **three** variables that were controlled in this experiment.

(i) _____

(ii) _____

(iii) _____ (3)

(d) What is the purpose of having the three test tubes that did not receive any treatment with Neurogen? (2)

_____

_____

(e) What **two** major conclusions could be drawn from these results? (2)

(i) _____

(ii) _____

(f) After this experiment, the scientist repeated the procedure three more times. Why would the scientist repeat the experiment so many times? (2)

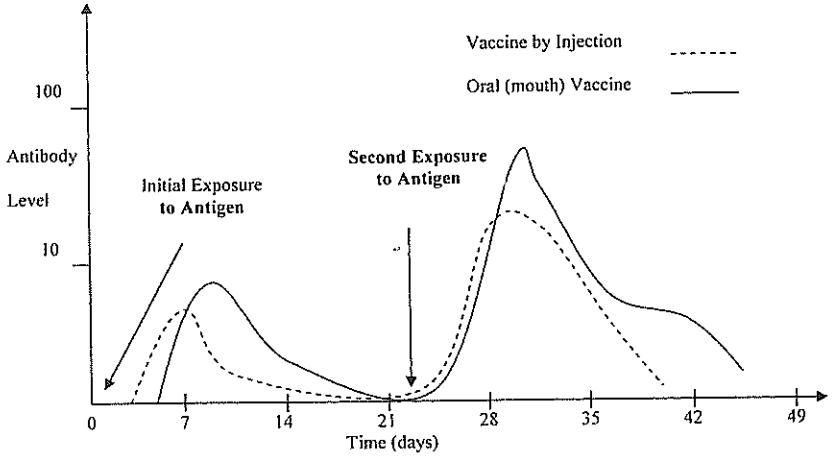
_____

_____

13. 2003 / 42

In 1968 a new variety of influenza appeared in Hong Kong. Named the " Hong Kong Flu", it began to spread around the world quickly. In many laboratories around the world potential vaccines were investigated and trials performed to assess their effectiveness. The data recorded from one such trial are shown below.

Examine these data and answer the questions that follow:



(a) For this experiment, identify the:

Experimetal Variable : _____

Dependent Variable : _____ (2)

(b) Compare the primary responses shown by the two groups of subjects in the experiment.

_____

_____ (2)

(c) Identify **four** factors that would need to be controlled in the selection of subjects for this experiment.

_____

_____ (2)

(d) Identify one method by which the vaccines used in the experiment could have been prepared. (1)

_____

_____

(e) Explain clearly, why the secondary response is quicker and larger than the primary response. (3)

_____

_____

_____

(f) Given that an antibody level of 10 is effective at combating the disease, which vaccine would be more successful at controlling the spread of this flu? Explain your answer. (2)

_____

_____

_____

(g) Apart from antibody levels, what other blood measurement could be taken to assess the effectiveness of the secondary responses? (1)

_____

14. 2004 / 43

As the scientist on duty in a regional hospital you receive a sample of Cerebrospinal Fluid (CSF). You are asked to test the sample for a bacterial infection, which you find, and then you are asked to determine the best form of treatment.

As a young scientist you are keen to investigate a drug company's hypothesis that:

"Our new drug 44-Maxophage improves the action of antibiotics."

(a) When designing an experiment to test this hypothesis, what would be

(i) the independent variable?

_____

(ii) the dependent variable?

_____

(iii) two control variables?

(1) _____

(2) _____

(4)

In order to test the hypothesis, you grow the bacteria cells in a series of petri-dishes containing essential nutrients. The results of your experiment are shown in the table below.

- A negative (–) indicates that the antibiotic had no effect.
- A positive (+) indicates that the antibiotic destroyed the bacterium.

Note: At higher concentrations, antibiotics can harm the cells of the body.

Antibiotic Concentrate	Petri Dish 1	Petri Dish 2	Petri Dish 3	Petri Dish 4
	Antibiotic A only	Antibiotic A and 44–Maxophage	Antibiotic B only	Antibiotic B and 44–Maxophage
100 mg/ml	(+)	(+)	(+)	(+)
50 mg/ml	(+)	(–)	(+)	(+)
25 mg/ml	(–)	(–)	(+)	(–)
10 mg/ml	(–)	(–)	(–)	(–)

(b) Do the results presented in the table support the drug company's hypothesis? Use data from the table to support your answer.

_____

_____

(2)

(c) Of the four treatments, which would you **MOST LIKELY** recommend to treat the bacterial infection? Why?

_____

_____

(2)

(d) What was the purpose of setting up Petri Dishes 1 and 3?

_____

_____

(2)

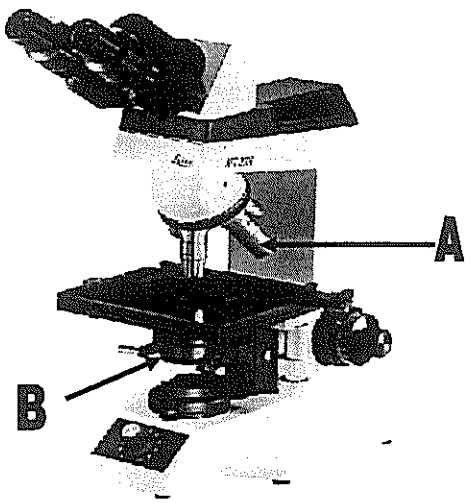
(e) Identify another hypothesis that these data could be used to evaluate.

_____

_____

(1)

15. 2005 / 43



Refer to the microscope pictured above.

(a) On the diagram of a microscope, what is the part of the microscope labelled A called?

_____

(1)

(b) What is the function of the part of the microscope labelled B?

_____

(1)

(c) You are given a slide and told that it contains bacteria and viruses which are to be observed under a light microscope. Indicate what you will see through this microscope, and explain why.

_____

_____

(2)

(d) You have focused on some cells on a slide and are given the following information:

Magnification on microscope:	1000X
Field of view at this magnification:	100μm
Length of cell in your drawing:	2cm
Estimate of length of cell in microscope:	10μm

Use this information to answer the following questions. Show all working.

(i) How many cells would fit across the field of vision of this microscope?

_____

(1)

(ii) What is the magnification of the drawing compared to the cells on the slide?

_____

_____

_____

(2)

OR

- Heavy Metals (1)
- From a variety of industrial/manufacturing processes (1)
- Accumulate in food chains (1)
- Affect humans in a number of ways: nausea, birth defects, nervous disorders etc. (1)

OR

- Increase in salinity of fresh water (1)
- Due to large scale land clearing (1)
- Rising water table increases soil salinity (1)
- and thus run-off into streams (1) (any three points = 3 marks - first example only marked)

27 Scientific Method

1	**A**	2	**D**	3	**A**	4	**C**	5	**A**	6	**A**
7	**C**	8	**B**	9	**D**	10	B	11	**C**		

Scientific Method questions are often very difficult. The following comments are an attempt to explain why each answer for the multichoice is correct.

1. A Sympathetic system increased heart rate. Other answers not related to information.
2. D Increased activity of heart requires reduced CO_2 as primary response.
3. A Magnification is 40 x 10 = 400X. FOV is 200µm at 100X so is 50µm at 400X.
   Cells occupy approx 1/5 of FOV circle = 10µm.
4. C All parameters fit the process of respiration for the cells. Others have at least one error.
5. A When diver holds breath the level of CO_2 increases as unable to expel from blood until breathing restarts.
6. A FOV is essential to all measurements as it define the size of the cells within.
7. C Amylase production depends on temperature
8. B Concentration of amylase and amount of starch determine amount of sugar produced.
9. D Only growth at weakest dilution (also more -ve signs)
10. B All others have growth at higher concentrations (also more iv signs)
11. C Orig Mag : 40 x 10 = 400. New Mag : 10 x 10 which increases FOV by 4x : 325 x 4 = 1300µm = 1.30mm

12. (a) Neurogen increases / decreases / affects (1) nerve regeneration (1)
    OR a series of small doses of Neurogen is more effective than a single dose on nerve regeneration (2).
    Note: Must link dependent and independent variables. (If / Then style acceptable of link variables)
    (b) Growth / length of nerve axons (1)
    (c) Number of cells (1), oxygen level (1), temperature (1), nutrients (1), time (1) culture medium (1)
    (Any three : 1 mark each)
    (d) Control group (1) that provides a comparison for the experimental group (1)
    Or eliminates some other factor causing the result (1) (2)
    (e) Neurogen promotes growth of nerve axons (1);
    A series of Neurogen treatments is more effective than one large dose (1) (2)
    (f) Increased reliability / validity / confidence (1);avoid results being due to error / chance (1) (2)

13. (a) Experimental variable : mode of vaccine delivery (1)
    Dependent variable : antibody count/level/titre / speed of response (1)
    (b) Oral vaccine is slower to cause response (1) or vica verca
    Oral vaccine remains at higher level for longer (1) or vica verca
    Oral vaccine has a larger response (1) (any two for 2 marks)
    (c) age, sex, health, exposure to flu, dosage etc. (any four for 2 marks; three or two is 1 mark)
    (d) Deactivated virus / modified virus / weakened virus / dead virus / attenuated virus / viral antigen / genetically-modified microorganism (1)
    (e) Vaccine has stimulated production of **memory** cells (1) Antigen recognition quicker (1) Antibody production is quicker (1)
    (f) Injection quicker response (1) means that there is **less chance to pass it on** (1)
    (g) Level of T-cells or level of B-cells or lymphocytes or WBC count or monocytes or granulocytes or neutrophils or viral antigen (1)

14. (a) (i) 44-Maxophage /drug (1)
(ii) Action of antibiotics or cell death or survival rate (1)
(iii) Antibiotic **OR** type of bacteria **OR** concentrations **OR** Temperature (any two = 2 marks)
If use patient line ie sex, age, fitness (max of 1 mark)
(b) No (1) Petri dishes with 44 Maxophage require higher concentrations of antibiotic (1)
(c) Petri dish 3 i.e. Antibiotic B only (1)
Requires lowest concentration of antibiotic (1)
(d) Act as control/comparison (1) for 44 Maxophage/drug action (1)
(e) Antibiotic concentration increases/decreases survival of bacteria (1)
OR High levels of antibiotic increases/decreases survival of bacteria (1)
OR Antibiotic A is more effective than antibiotic B at killing bacteria (1)
OR Maxophage works better with antibiotic A rather than antibiotic B (1)

15. (a) objective (lens) (1)
(b) controls amount of light / equalizes illumination / focuses light on object (1)
(c) Will see ONLY BACTERIA (1) Viruses too small to see with light microscope (1)
(d) (i) 100 um view/ 10 um cells = 10 cells will fit (1)
(ii) 10,000 um = 1 cm : 2cm = 20,000 um = 20000 um in microscope cell = 10 um
so magnification of drawing relative to cell = 20000 um /10 um (1) = **2000** (1)

16. (a) If an individual took **Vitamin C** at the first sign of a cold then they would **recover more rapidly.**
Does not have to be an if/then statement (1)
(b) Time it took the person to recover/ length of illness. (1)
Time taken from the first sign of a cold until there were no symptoms. (1)
(c) Same number of tablets taken : **NOT** amount of Vitamin C taken (which is the indep var) (1)
All take orange flavoured tablets (1)
Tablets taken at the same time (first sign of a cold) (1)
Individuals were unaware of placebo/Vitamin C (1)
(d) General health of subjects – less fit people are more susceptible/time to recover from colds (1)
Age of subjects – all old people would be more susceptible/time to recover from colds (1)
Living conditions – heating/ diet / medication etc affect / susceptible to colds (1)
(Note: 1 mark for two listed factors without explanation)
(e) An inactive substance/used as a control in experiments (1)
overcomes any psychological effects tablets may have on subjects (1)

17. (c) A suitable hypothesis for this experiment is that "buprenorphine reduces heroin dependence / addiction"
(accept any valid hypothesis that is a STATEMENT not a question
(must have *variable : cause : variable* relating to the variables in the question)
(if / then format acceptable) (1)
Independent variable : buprenorphine treatment (1)
Dependent variable : heroin dependence / craving for drug (1)
Experimental group must be heroin addicts (1)
Control group receives a placebo (1)
The treatment group receives buprenorphine treatment (1)
(Total 6 marks)
Controlled variables would be : number in group (100) / even group size / dosage / time of day dose is given / age / sex / body weight / diet / length of heroin addiction / no other drugs / etc (Any three : 1 mark each)
Experimental error can be reduced by careful attention to controlled variables / repeating the experiment / increasing sample size etc (anything reasonable) (Any three : 1 mark each)
(Total of controlled and error reduction points : max 4 marks)