GRAPHS IN BIOLOGY

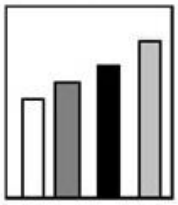
How do I know which type of graph to use? Follow this key…

1. Is the data a percent that sums to 100% or a total amount of time?
   a. If yes ……Pie chart
   b. If no……...Go to #2
2. Are <u>both</u> your manipulated and responding variables quantitative?
   a. If no…….. Bar graph
   b. If yes …….. Go to #3
3. Is your manipulated variable levels <u>continuous</u> (i.e. time in years) or <u>clumped</u> into groups (i.e. 0-5 years, 6-10 years)?
   a. Continuous…….. Scatter plot/line
   b. Clumped……..Histogram

Pie Chart

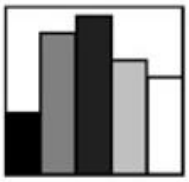
Designed to show a percent of a whole, where the whole equals 100%. Pie charts are used to compare data, but cannot be used to see how a manipulated variable affects a responding variable. Pie charts do not show change with respect to another variable.
Ex: Percent of time the cell spends in each phase of the cell cycle

Bar Graph



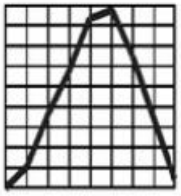
Designed to make comparisons of data. The data represented in bar graphs are not necessarily dependent on any other variables and the groupings are usually qualitative (i.e. grouped into categories, like blood types or color). The bars do NOT touch.
Ex: Comparison of the mean reaction rate for five different enzymes

Histogram



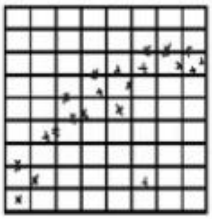
Histograms are similar to bar graphs except the data represented in histogram is usually in groups of continuous numerical (quantitative) data. In this case, the bars do touch. Histograms are often used to show frequency data.
Ex: Minimum Decibels (dBA) of sound heard by 20 people

Line Graph



A line graph consists of a series of points plotted on the grid and then connected together point to point by a line. Line graphs are only used when both variables are quantitative. Line graphs show trends, such as how things change over time.
Ex: Average mean temperature between the years 1900 and 2000

Scatter Plot



The points are plotted on the grid, but they are not joined point to point. A best fit line may be added to a scatter plot to show a trend. Line graphs are only used when both variables are quantitative. These graphs are useful for showing if a correlation exists between two variables, especially when it is not possible to alter either of the variables (i.e. in descriptive studies).
Ex: Reaction rate at various enzyme concentrations

How to Graph:

Determine the manipulated and responding variables (Independent and Dependent). In an experiment the experimenter will set up a set of conditions, it may be a range of temperatures or pH values, or, more common, the experimenter may choose to observe the experiment proceeding at set intervals of time (seconds, days or even years). These are the manipulated variables (Independent) and always go on the horizontal axis (x—axis). The effect of the experimenter varying the manipulated variable is measured as the responding variable (the part of the experiment under observation) or the dependent variable, this is always plotted on the vertical axis (y—axis or ordinate).

Note the units of measurement for each of the variables. Non- metric units such as Fahrenheit (°F) should be avoided in science. It is important to indicate to your audience in what unit you are actually measuring your variables. The units of measurement are presented behind the label of the axis, e.g. Temperature (°C)

The proportions of the axes. The area enclosed by the axes should be roughly square and not disproportionately exaggerated
Mark the quantities on both axes and number them at regular intervals. Your axis intervals do not have to be the same on the x and y axis and they do not have to always start at the origin with a value of 0.

Giving the graph a title. The graph must have a title which should contain a brief description of what is being investigated. Other information which may go in the title, if available, includes: the date, place and name of experimenter or collector of the data. If there is more than one graph a reference number or letter is required.

Graph Element Checklist

___The correct type of graph is made for the type of data presented (i.e. bar, line, histogram, pie, etc…)
___Graph is neatly constructed, organized, and makes good use of space. If used, colors make the graph more readable.
___Y axis is labelled with the RV (Dependent Variable), X axis is labelled with the MV (Independent variable)
___Units are clearly and correctly identified along the X and Y axis
___The graph axes are proportional to the data (meaning the data is spread over the span of the axis, not clumped)
___ X and Y axis intervals are consistent and correct
___Specific title is included. The title indicates what data is presented, including scientific name if relevant.
___All points are plotted clearly and correctly. In most cases, the mean of the data is graphed (not each individual trial).
___When the mean is graphed, the standard deviation of each mean in included and labelled
___If needed, best fit lines or curves are added to the graph to show trends or relationships

CIE graph advice O Level Biology

Drawing line graphs

If you're asked to draw a graph:

- Choose a scale which uses most of the grid provided on the exam paper.
- Choose a simple scale, e.g. one large square is equal to 1, 2, 5 or 10 units in the data. Don't make it difficult to plot the data by using a scale such as one large square = 3 or 6.
- Write the name of each axis and the correct unit, e.g. rate of water loss/g per h, temperature/°C, time/s.
- Plot the points exactly using a sharp pencil. Draw the points lightly so that you can rub them out if you need to. Make them more definite when you're sure they are right.
- Use a cross (x) or a dot in a circle (0) for your plot points. Don't use a single dot as it may not be seen after you have drawn your line.
- If you have to plot two lines on a graph, use two different symbols for the plot points. You can use a cross, a dot in a circle or a plus sign (+). Label each line carefully or use a key. Use a pencil for both lines; don't use a blue or black pen or different colours as these don't show up on scanned scripts.
- Read the question carefully before you put a line in the graph. Look carefully at the points. You have to decide whether to use a straight line of best fit, a smooth curve of best fit or join the points by straight lines. Always use a sharp pencil.

- Remember that lines of best fit don't have to pass through the point where the two axes meet (the origin). If you're sure that 0, 0 is a point then you can include it. For example, in an investigation of the effect of the concentration of enzyme on enzyme activity 0, 0 means that there is no enzyme present. If there is no enzyme there can be no activity, so 0, 0 could be included.
- Don't extend your line graph beyond the last plotted point.

Bar charts have separate columns that don't touch – there are gaps in between; histograms have columns that do touch each other. Bar charts are used to show data on discontinuous variables, for example blood groups, eye colour, etc.; histograms are used to show data on continuous variables, e.g. length, mass, speed, volume, etc.

Drawing bar charts

You may have to draw a bar chart (Paper 6) or add some data to a bar chart (Paper 2).
You draw a bar chart when you have different categories, such as the numbers of six different species in a habitat.

- Choose a scale which uses most of the grid provided on the exam paper; don't make the chart too small.
- Draw the chart in pencil.
- Rule the columns evenly so that they are all the same width.
- Take care to rule the top of each block in the correct place – double check with the table of data each time.
- The spaces between the columns on the x-axis should be identical; they should be the same length, e.g. one large square on graph paper.
- The y-axis should be properly scaled with equal intervals just as in a line graph.
- The y-axis should be labelled with units.
- The lines or blocks can be arranged in any order, but to make comparisons it helps if they are arranged in descending or ascending order of size.
- You should identify each block by putting a label directly underneath each block. Don't shade the blocks or colour code them.

Drawing histograms

Histograms are ways of displaying the variation in a particular feature, for example the lengths of leaves on a tree. If you measure the lengths of leaves you would have to divide the data into classes, such as 50–54 mm, 55–59 mm, 60–64 mm, etc. The numbers would be recorded in a tally table.

- Choose a scale which uses most of the grid provided on the exam paper; don't make the histogram too small.
- Draw the histogram in pencil. The x-axis represents the independent variable and is continuous. It should be properly scaled and labelled with appropriate units.
- The blocks should be drawn touching.
- The area of each block is proportional to the size of the class. It is usual to have similar-sized classes (as in the example above) so the widths of the blocks are the same.
- The blocks should be labelled either by putting the class ranges (e.g. 60–64, 65–69 etc.) underneath each block or by putting the lowest number in each range (e.g. 60, 65, 70, etc.) under the left-hand side of the relevant block.
- The y-axis represents the number or frequency and should be properly scaled with equal intervals. It should be labelled with appropriate units.

Graphing Practice #1: Ethylene is a plant hormone that causes fruit to mature. The data above concerns the amount of time it takes for fruit to mature from the time of the first application of ethylene by spraying a field of trees.

Amount of ethylene in ml/m^2	Wine sap Apples: Days to Maturity	Golden Apples: Days to Maturity	Gala Apples: Days to Maturity
10	14	14	15
15	12	12	13
20	11	9	10

25	10	7	9
30	8	7	8
35	8	7	7

A. Make a line graph of the data.
B. What is the dependent variable?
C. What is the independent variable?

Graphing Practice #2: A clam farmer has been keeping records concerning the water temperature and the number of clams developing from fertilized eggs. The data is recorded below.

Water Temperature in °C	Number of developing clams
15	75
20	90
25	120
30	140
35	75
40	40
45	15
50	0

A. Make a line graph of the data.
B. What is the dependent variable?
C. What is the independent variable?
D. What is the optimum (best) temperature for clam development?

Graphing Practice #3

A student investigated the effects of two newly developed stimulant drinks (A and B) on the heart rate of water fleas (*Daphnia*). *Daphnia* were incubated in either water or a sample of the drink for 5 minutes. They were then mounted onto a microscope slide, from which the heart of a water flea is visible through its transparent body, and the heartbeats were counted for 30 seconds. The table below shows the heart rates following exposure to the samples.

Heart rate (beats per 30 seconds)									
Drink	**Test 1**	**Test 2**	**Test 3**	**Test 4**	**Test 5**	**Test 6**	**Test 7**	**Mean**	**Range**
Water	35	40	34	29	36	56	51		
A	42	30	34	32	55	49	33		
B	58	64	62	38	37	71	66		

(a) Calculate the mean and range for the results, rounded to one decimal place. Complete the table. **[1]**

(b) Plot a graph of the results. **[4]**

(c) Provide a conclusion from the means calculated.

..... **[1]**

(d) Suggest which set of results is least reliable and why.

.....

..... **[2]**

(e) Explain why the *Daphnia* were always incubated in their test solution for 5 minutes.

..... **[1]**

(f) What term is given to the water sample in this investigation? Tick the correct box.

negative control		comparison	
calibrator		positive control	

[1]

(g) (i) Name the independent variable of the investigation.

..... **[1]**

(ii) Tick the box that corresponds to the dependent variable.

caffeine concentration		number of seconds	
heart rate		drink type	

[1]

(iii) Other than incubation time, suggest a control variable for the investigation.

..... **[1]**

Graphing Practice #4:

pH of water	Number of tadpoles
8.0	**45**
7.5	**69**
7.0	**78**
6.5	**88**
6.0	**43**
5.5	**23**

A. Make a line graph of the data.
B. What is the dependent variable?
C. What is the independent variable?
D. What is the average pH in this experiment?
E. What is the average number of tadpoles per sample?
F. What is the optimum water pH for tadpole development?
G. Between what two pH readings is there the greatest change in tadpole number?
H. How many tadpoles would we expect to find in water with a pH reading of 5.0?