3 Working with formulae

It is often necessary to use a mathematical formula to calculate quantities. You may be tested on your ability to substitute numbers into formulae or to rearrange formulae to find specific values.

3.1 Substituting into formulae

Think about the data you are given in the question. Write down the equation and then think about how to get the data to substitute into the equation. Look at this worked example.

A cheek cell has a 0.06 mm diameter. Under a microscope it has a diameter 12 mm. What is the magnification?

$$\text{magnification} = \text{image size (mm)} \div \text{object size (mm)} \quad \text{or} \quad M = \frac{I}{O}$$

Substitute the values and calculate the answer:

$$M = 12\ \text{mm}/0.06\ \text{mm} = 12/0.06 = 200$$

Answer: magnification = ×200 (magnification has no units)

Sometimes an equation is more complicated and the steps need to be carried out in a certain order to succeed. A general principle applies here, usually known by the mnemonic BIDMAS. This stands for **B**rackets, **I**ndices (functions such as squaring or powers), **D**ivision, **M**ultiplication, **A**ddition, **S**ubtraction.

Practice questions

1 Calculate the magnification of a hair that has a width of 6.6 mm on a photograph. The hair is 165 µm wide.

2 Estimate the area of a leaf by treating it as a triangle with base 2 cm and height 9 cm.

3 Estimate the area of a cell by treating it as a circle with a diameter of 0.7 µm. Give your answer in μm^2.

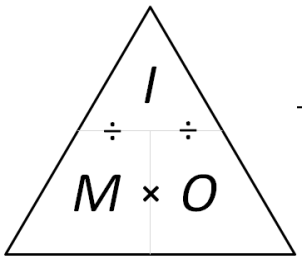
4 An *Amoeba* population starts with 24 cells. Calculate how many *Amoeba* cells would be present in the culture after 7 days if each cell divides once every 20 hours. Use the equation $N_t = N_0 \times 2^n$ where N_t = number after time t, N_0 = initial population, n = number of divisions in the given time t.

5 In a quadrat sample, an area was found to contain 96 aphids, 4 ladybirds, 22 grasshoppers, and 3 ground beetles. Calculate the diversity of the site using the equation $D = 1 - \Sigma\left(\frac{n}{N}\right)^2$ *where* n = number of each species, N = grand total of all species, and D = diversity.

Remember: In this equation there is a part that needs to be done several times then summed, shown by the symbol Σ.

3.2 Rearranging formulae

Sometimes you will need to rearrange an equation to calculate the answer to a question. For example, the relationship between magnification, image size, and actual size of specimens in micrographs usually uses the equation $M = \frac{I}{O}$, where M is magnification, I is size of the image, and O = actual size of the object.



You can use the algebra you have learnt in Maths to rearrange equations, or you can use a triangle like the one shown.

Cover the quantity you want to find. This leaves you with either a fraction or a multiplication:

$M = I \div O$ $O = I \div M$ $I = M \times O$

Practice questions

6 A fat cell is 0.1 mm in diameter. Calculate the size of the diameter seen through a microscope with a magnification of ×50.

7 A Petri dish shows a circular colony of bacteria with a cross-sectional area of 5.3 cm^2. Calculate the radius of this area.

8 In a photograph, a red blood cell is 14.5 mm in diameter. The magnification stated on the image is ×2000. Calculate the real diameter of the red blood cell.

9 Rearrange the equation $34 = 2a/135 \times 100$ and find the value of a.

10 The cardiac output of a patient was found to be 2.5 $dm^3\,min^{-1}$ and their heart rate was 77 bpm. Calculate the stroke volume of the patient.

Use the equation: cardiac output = stroke volume × heart rate.

11 In a food chain, efficiency = $\frac{\text{biomass transferred}}{\text{biomass taken in}} \times 100$

A farmer fed 25 kg of grain to his chicken. The chicken gained weight with an efficiency of 0.84. Calculate the weight gained by the chicken.