# Maths skills – M2 Algebra

### M2.1 – Understand and use the symbols =, ‹, ‹‹, ››, ›, α, ~

You need to understand and be able to use the following symbols in lots of different biological contexts.

|  |  |
| --- | --- |
| = | Equals |
| ~ | Approximately equal to |
| < | Less than |
| > | Greater than |
| << | Much less than |
| >> | Much greater than |
| α | Proportional to |

### M2.2 – Change the subject of an equation

It is essential that you are able to rearrange the formulas to make the ‘unknown’ the subject of the equation. Most of the time this will involve multiplying or dividing each side by one of the ‘knowns’.

For example, three quantities *a*, *b* and *c* are linked by the simple relationship *ab* = *c.* To make *a* the subject of the equation we divide both sides by *b* giving *a =* *c*/*b*.

To get the formula for *b* from the original equation *ab* = *c* we need to divide both sides by *a*, giving *b* = *c*/*a.*

### M2.3 – Substitute numerical values into algebraic equations using appropriate units for physical quantities

After you rearrange an equation you need to substitute in numerical values before you can solve it. These might be given in the question or else you may have already calculated them. There are a few rules that you need to remember. When you multiply or divide) two negative numbers, the answer is always a positive number. For example,. On the other hand, if only one of the numbers is negative then the answer is negative: .

This rule does not apply with addition and subtraction. For addition and subtraction you need to look at the signs in the ‘middle’ of the sum. If the two signs in the ‘middle’ of the sum are different signs they make an overall sign of a minus. For example . However if the signs in the ‘middle’ of the sum are both the same the overall sign is a plus. For example

Substituting numerical values into an equation is very important in biology, for example when using Simpson’s index of diversity. This gives a measure of diversity by taking into account the total number of organisms (N) and the number of individuals of each particular species (n). It is calculated using the following equation:

To calculate the index of diversity you first need to find . For each species you need to work out the number of that particular species (*n*) divided by the total number of organisms (N), and square the answer. Then you need to add the answers for all of the species together.

By substituting in this value in place of in the equation you can work out the value of *D*. By comparing the diversity values of different areas you can conclude which has the highest level of diversity (the highest value for *D)*.

### M2.4 – Solve algebraic equations

Solving an equation involves rearranging equations and substituting values into a formula to calculate an unknown. For example, cardiac output is the volume of blood pumped by the left ventricle of the heart in one minute. This is calculated by multiplying the volume of blood pumped in one beat (stroke volume) by the number of beats in a minute (heart rate).

cardiac output = stroke volume x heart rate

### M2.5 – Use logarithms in relation to quantities that range over several orders of magnitude

Logarithms are basically powers. For example, the calculation ‘102 = 100’ can also be expressed as the ‘power of 10 that gives 100 is 2’, or in formal notation ‘log 100 = 2’.

Logarithms are really useful for providing a better scale when dealing with quantities that vary exponentially (get big/small very quickly). For example, sketching a graph where the scale goes from 10, 100, 1000, 10 000, 100 000 etc. would be very difficult using a standard scale. However, taking the logarithms of these quantities gives 1, 2, 3, 4 and 5, which is much easier to use and spot trends in.

The natural logarithm is denoted by *l*n *x*, which is shorthand for loge *x*. Here e is the mathematical constant approximately equal to 2.7182818, an irrational number. It is important in situations where quantities change exponentially over time.

Logarithms are particularly useful in microbiology, such as when studying the growth rates of microorganisms.

### Questions:

1. Consolidate your learning on recognising and using symbols by filling the blanks in the following statements with the most appropriate symbol.

| 1. In a study on penguins it was found that survival rate of chicks increased as populations of fish increased, so that survival rate fish population. |
| --- |
| 1. There were 10,000 chicks in 2006 but only 2,000 in 2007, so the number in 2007 was the number of chicks in 2006. |
| 1. Fish stocks were 300,000 fish in 2006 and 290,000 in 2007 so for the fish, the population in 2006 was the population in 2007. |

1. You have a culture of *Salmonella* *typhimurium* which is dividing every 20 minutes under standard conditions. You start off with 50 bacteria in the culture and you want to plot the bacterial growth rate over a period of 3 hours.

Work out the sequence of numbers and plot two graphs, one of which should be a logarithmic graph.

1. By recalling and, where necessary, rearranging equations work out the formula for each of these situations:
   1. If I told you how big a specimen really is and you measured the size of the image I’m showing you, how would you work out the magnification?

|  |
| --- |

* 1. If you are told the volume of a cube, how would you work out the length of the edges?

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| --- |

* 1. If you know the percentage change in the mass of my dog and the original mass how would you work out its current mass?

|  |
| --- |

* 1. Given the surface area of a circular pond how would you work out the diameter?

|  |
| --- |

1. Water potential is an important equation in osmosis and is represented by the symbol (the Greek letter ‘psi’).

The cytoplasm of a plant cell contains dissolved solute which gives it a solute potential,

Solute potential tends to **cause water to enter the plant cell**.

The wall of the cell exerts a pressure on the cell contents giving a pressure potential,

The pressure potential tends to **oppose water entering the cell**.

The overall ψ of the cell is calculated using the equation:

The water from the cell with the highest water potential (closer to zero) will diffuse into the other cell by osmosis. For example for the following two adjacent cells:

|  |  |
| --- | --- |
| **Cell A**  -250  200 | **Cell B**  -300  150 |

Cell A = -250 + 200 = -50 kPa

Cell B = -300 + 150 = -150 kPa

So **Cell A** has the higher water potential (closer to zero) and water from **Cell A** will diffuse into **Cell B** via osmosis.

Try these examples (all units in kPa)

Cell A: = -400 = 150 Cell B: = -300 = 100

|  |
| --- |

Cell A: = -500 = 300 Cell B: = - 250 = 150

|  |
| --- |

Cell A: = -250 = 100 Cell B: = -350 = 200

|  |
| --- |

1. Two areas of chalk grassland were sampled giving the following results. Calculate which area has the higher diversity.

|  |  |  |
| --- | --- | --- |
|  | **Number of individuals** | |
| **Plant species** | **Area A** | **Area B** |
| Kidney vetch | 10 | 0 |
| Bird’s foot trefoil | 55 | 75 |
| Carline thistle | 5 | 5 |
| St John’s wort | 20 | 30 |
| Thyme | 10 | 20 |
| Total |  |  |

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|  |

1. During exercise Jack’s cardiac output is 12 dm3 min -1 and he has a stroke volume of 0.060 dm3. What is his heart rate?

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| --- |
|  |

1. Once Jack has rested his heart rate goes down to 100bpm. His stroke volume is now 0.050. What is Jack’s cardiac output now?

|  |
| --- |
|  |

### Answers:

1. Consolidate your learning on recognising and using symbols by filling the blanks in the following statements with the most appropriate symbol. (M2.1)

| 1. In a study on penguins it was found that survival rate of chicks increased as populations of fish increased, so that survival rate α fish population. |
| --- |
| 1. There were 10,000 chicks in 2006 but only 2,000 in 2007, so the number in 2007 was << the number of chicks in 2006. |
| 1. Fish stocks were 300,000 fish in 2006 and 290,000 in 2007 so for the fish, the population in 2006 was ~ the population in 2007. |

1. You have a culture of *Salmonella* *typhimurium* which is dividing every 20 minutes under standard conditions. You start off with 50 bacteria in the culture and you want to plot the bacterial growth rate over a period of 3 hours.

Work out the sequence of numbers and plot two graphs, one of which should be a logarithmic graph. (M2.5)

50, 100, 200, 400, 800, 1600, 3200, 6400, 12800, 25600...

1. By recalling and, where necessary, rearranging equations work out the formula for each of these situations: (M2.2)
   1. If I told you how big a specimen really is and you measured the size of the image I’m showing you, how would you work out the magnification?

| Size of specimen S Size of image I  Magnification M  S = I / M  so  MS = I  so  M = I / S |
| --- |

* 1. If you are told the volume of a cube, how would you work out the length of the edges?

| Volume V  Length of edge L  V = L3  so take the cube root of both sides  and swap the sides so the subject is on the left |
| --- |

* 1. If you know the percentage change in the mass of my dog and the original mass how would you work out its current mass?

| Percentage change P  Original mass O  New mass N  P = 100 x (N – O) / O  P/ 100 = (N – O) / O  OP / 100 = N – O  (OP / 100) + O = N  N = (OP / 100) + O |
| --- |

* 1. Given the surface area of a circular pond how would you work out the diameter?

| Surface area A Radius R Diameter D |
| --- |

1. Water potential is an important equation in osmosis and is represented by the symbol (the Greek letter ‘psi’).

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Solute potential tend to **cause water to enter the plant cell**.

The wall of the cell exerts a pressure on the cell contents giving a pressure potential,

The pressure potential tends to **oppose water entering the cell**.

The overall ψ of the cell is calculated using the equation:

The water from the cell with the highest water potential (closer to zero) will diffuse into the other cell by osmosis. For example for the following two adjacent cells:

|  |  |
| --- | --- |
| **Cell A**  -250  200 | **Cell B**  -300  150 |

Cell A = -250 + 200 = -50 kPa

Cell B = -300 + 150 = -150 kPa

So **Cell A** has the higher water potential (closer to zero) and water from **Cell A** will diffuse into **Cell B** via osmosis.

Try these examples (all units in kPa) (M2.3 M2.4)

Cell A: = -400 = 150 Cell B: = -300 = 100

| Cell A = -400 + 150 = -250 kPa Cell B = -300 + 100 = -200 kPa  **Cell B** has the higher water potential (closer to zero) and water from **Cell B** will diffuse into **Cell A** via osmosis. |
| --- |

Cell A: = -500 = 300 Cell B: = - 250 = 150

| Cell A = -500 + 300 = -200 kPa Cell B = -250 + 150 = -100 kPa  **Cell B** has the higher water potential (closer to zero) and water from **Cell B** will diffuse into **Cell A** via osmosis. |
| --- |

Cell A: = -250 = 100 Cell B: = -350 = 200

| Cell A = -250 + 100 = -150 kPa Cell B = -350 + 2000 = -150 kPa  **Cell B** and **Cell A** have equal water potential so there will be no movement of water between them by osmosis. |
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1. Two areas of chalk grassland were sampled giving the following results. Calculate which area has the higher diversity. (M2.3 M2.4)

|  |  |  |
| --- | --- | --- |
|  | **Number of individuals** | |
| **Plant species** | **Area A** | **Area B** |
| Kidney vetch | 10 | 0 |
| Bird’s foot trefoil | 48 | 75 |
| Carline thistle | 12 | 12 |
| St John’s wort | 20 | 30 |
| Thyme | 10 | 13 |
| Total | 100 | 130 |

|  |
| --- |
| Area 1  D = 1 – = 0.6952 = 0.70 (to 2 significant figures)  Area 2  D = 1 – = 0.5954 = 0.60 (to 2 significant figures)  Area 1 has a higher diversity |

1. During exercise Jack’s cardiac output is 12 dm3 min -1 and he has a stroke volume of 0.060 dm3. What is his heart rate?

|  |
| --- |
| Heart rate = cardiac output/stroke volume  = 12/0.065  = 184.615...  = 180 bpm (to 2 significant figures) |

1. Once Jack has rested his heart rate goes down to 100bpm. His stroke volume is now 0.050. What is Jack’s cardiac output now?

|  |
| --- |
| cardiac output = stroke volume x heart rate  Cardiac output = 0.050 x 100  = 5 dm3 min -1 |

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