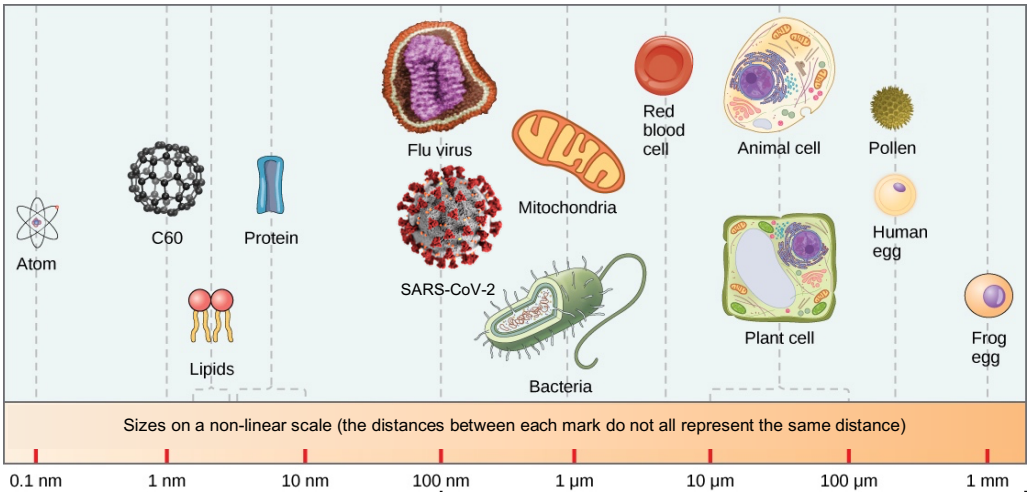
19 Measuring & COVID-19

Links:
- *Exploring Science* 7Kd, 8Da, 9Hd
- *Edexcel 9-1* CB1a, CB1d

SI System

All scientists use an agreed system of units - SI (Système International).

Each quantity has a unit. For example, metres (m) for length and grams (g) for mass. However, it is inconvenient to measure tiny or huge things using these units. So we add prefixes to multiply or divide a unit by a certain amount. 1 kilometre is 1000 m (1 m × 1000). 1 µm is 0.000001 m (1 m × 1/1 000 000).



Prefix	Symbol	Effect on the unit
mega-	M	× 1 000 000
kilo-	k	× 1000
deci-	d	× 1/10 (÷ 10)
centi-	c	× 1/100 (÷ 100)
milli-	m	× 1/1000 (÷ 1000)
micro-	µ	× 1/1 000 000 (÷ 1 000 000)
nano	n	× 1/1 000 000 000 (÷ 1 000 000 000)

Standard form

The SARS-CoV-2 virus is about 120 nm wide. An average human adult is about 1.65 m tall. It is difficult to imagine how these compare because they have different units. We could convert them into the same unit. So, in nanometres an average human is 1 650 000 000 nm tall. That is a large number and difficult to imagine. Numbers with lots of 0s are also hard to write and put into calculators without making mistakes. To solve these problems, scientists use **standard form** or **scientific notation**.

Numbers are written as $A \times 10^n$. A is a number between 1 and 10 and n is how many times A is multiplied by 10. The speed of light is 3×10^8 m/s or 3 × 10 × 10 × 10 × 10 × 10 × 10 × 10 × 10 m/s. We call n the **index** number.

The diagram shows how to convert numbers into standard form. For numbers between 0 and 1, n is the number of times A is multiplied by $\frac{1}{10}$ (or 10^{-1}). 1.2×10^{-7} is $1.2 \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10} \times \frac{1}{10}$.

To find the index number for numbers more than 1:
Count the number of times you need to move the unit to the right to form a number between 1 and 10.

1 2 3 4 5 6 7 8 9

$1650000000 = 1.65 \times 10^9$

To find the index number for numbers 0 - 1:
Count to the left (in the negative direction) to form a number between 1 and 10.

-7 -6 -5 -4 -3 -2 -1

$0.00000012 = 1.2 \times 10^{-7}$

The *difference* between index numbers gives an approximate size comparison. A human is 1.65×10^0 m tall and the SARS-CoV-2 virus is 1.2×10^{-7} m wide. The difference = 0 - (-7) = 7. This gives us 7 zeros. So, a human is 10 000 000 times bigger than the virus. We also refer to this as seven **orders of magnitude** bigger.

Find out

1. Complete the table of units.
2. Find out the distance between the Earth and the Andromeda galaxy in km.

   _____

3. Find out how the metre was first calculated.

   _____

Quantity	SI unit name	Symbol
electrical current		
force		
frequency		
power		
pressure		
speed		
temperature		
time		

_____

_____

Test yourself

4. a. How many centimetres are there in 1 m? _____

   b. How many millimetres are there in 1 m? _____

   c. What fraction of a 1 m is 1 mm? _____

5. The spike protein that sticks out of SARS-CoV-2 is 23 nm long and its head is 7 nm wide.

   a. How long is 23 nm in metres? (Remember that 1 nm is 1 m ÷ 1 000 000 000.)

   _____

   b. Write your answer to a in standard form/scientific notation. _____

   c. Write 7 nm in m in standard form.

   _____

6. A common bacterium, *E. coli*, is 2 μm long.

   a. Write this length in m in standard form. _____

   b. How many orders of magnitude bigger is *E. coli* compared with SARS-CoV-2?

   _____

Check-up

I. Check your answers.

II. Draw a table to compare your height with some different things (e.g. the diameter of the Sun, a bacterium, an atom). Show all measurements in metres in standard form and state the orders of magnitude. (Remember that if you are 1.5 m high, this is 1.5×10^0 m in standard form, which means 1.5 multiplied by 10 zero times, i.e. not multiplied.)

Answers

Note to home educators

This worksheet is designed to support understanding of the SI system of units and standard form/scientific notation. You may wish to share these objectives with students:

- Record numbers using appropriate SI units for common measurements. (KS3)
- Recognise the need to use the same units to make comparisons. (KS3)
- Interpret SI prefixes (centi-, milli-, kilo- & micro-, nano-). (KS3 & GCSE)
- Change numbers to and from standard form. (GCSE)

It is suggested that students complete the worksheet independently, using the internet for questions 1 - 3. Questions 4 - 6 should be completed without help from additional sources.

This sheet draws on material from the UK National Curriculum for Science for Key Stage 3 and Key Stage 4 (GCSE) (Years 7 - 11). Other sheets in the series are available: https://shwca.se/covid19science

If you wish to check the answers, keep this part of the sheet away from the questions!

I. 1. See table.

Quantity	SI unit name	Symbol
electrical current	ampere or amp	A
force	newton	N
frequency	hertz	Hz
power	watt	W
pressure	pascal	Pa
speed	metres per second	m/s
temperature	kelvin	K
time	seconds	s

2. 2.4×10^{19} km

3. In 1793 the metre was originally defined as one ten-millionth of the distance from the equator to the North Pole.

4. a. 100

   b. 1000

   c. 1/1000th

5. a 23 ÷ 1 000 000 000 = 0.000000023 m

   b. 2.3×10^{-8} m

   c. 7×10^{-9} m

6. a 2 ÷ 1 000 000 = 0.000002 m = 7×10^{-6} m

   b. Difference = -9 - (-6) = 3. The bacterium is three orders of magnitude bigger than the virus. (Remember that when subtracting a negative number from a negative number (a minus sign followed by a negative sign), it turns the two signs into a plus.)

II. A table along these lines.

My height (1.9 m or 1.9×10^0 m) compared with …	**Measurement (m)**	**Orders of magnitude**
diameter of the Sun	1.392×10^9 m	The Sun is nine orders of magnitude bigger than me.
diameter of a C60 carbon ball	7.1×10^{-10} m	A C60 carbon ball is 10 orders of magnitude smaller than me.