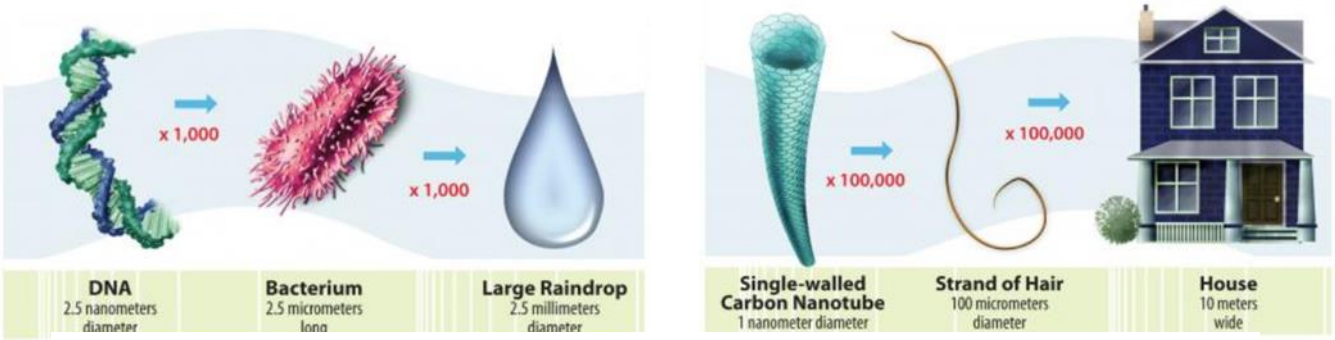
Nanophysics and Nanotechnology

How small is ‘nano’?

There are a lot of technologies that are so small they are described as being “nano” scale. Just how small is “nano”?
In the International System of Units, the prefix "nano" means one-billionth of a metre. That means a ‘nano’metre is one-billionth of a metre, a ‘nano’second is one-billionth of a second, and a ‘nano’litre is one-billionth of a litre. It’s difficult to imagine just how small that is, so here are some examples:

- A sheet of paper is about 100,000 nanometres thick.
- A human hair is approximately 80,000- 100,000 nanometres wide.
- A strand of human DNA is 2.5 nanometres in diameter.
- On a comparative scale, if the diameter of a marble was one nanometre, then diameter of the Earth would be about one metre.
- One nanometre is about as long as your fingernail grows in one second.



https://www.nano.gov/nanotech-101/what/nano-size#:~:text=Just%20how%20small%20is%20%E2%80%9Cnano,is%20about%20100%2C000%20nanometers%20thick

Activity:
You are going to measure some objects and convert the measurements into nanometres using the steps below:

- Use a ruler or tape measure to find out the size in millimetres.
- Convert the measurement in millimetres into metres by dividing the number by 1000.
- Convert the value in metres into nanometres by multiplying the number by 1,000,000,000.
- There are some empty rows at the bottom of the table for you to choose some objects to measure.

Observation Table

Object	Size in millimetres (mm)	Size in metres (m)	Size in nanometres (nm)
		÷1000	×1,000,000,000
Length of your pencil			
Length of your hair			
Width of your table			
Length of your index finger			
Diameter of a button on your clothes			

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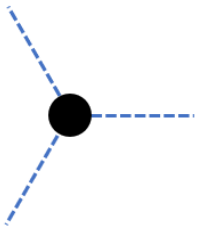
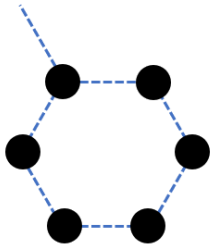
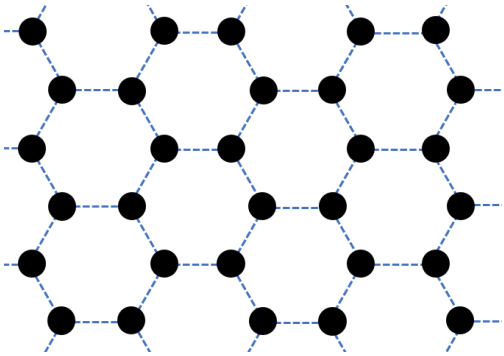
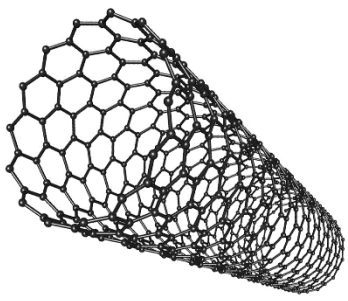
Build a 'Giant' Carbon Nanotube

Carbon is one of the elements that is a building block of everything we see around us. A carbon atom can make bonds with other carbon atoms in different ways. This gives the material that is made different properties. You may know some of the materials that are only made of carbon atoms, like diamonds and graphite (the grey part in the middle of a pencil is graphite). Another material that is made of carbon atoms is graphene. A sheet of graphene is only one atom thick and can be rolled up in to tubes – a carbon nanotube. It is called a 'nanotube' because it is only one nanometre in diameter. The structure of carbon nanotubes mean that they have lots of properties that are useful to us – they can form ultra-high strength, low weight materials that conduct electricity and heat energy.

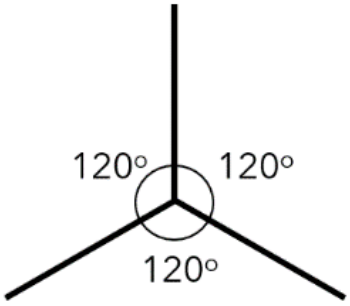
The strength and light-weight properties of carbon nanotubes are down to the structure of how the carbon atoms are arranged.

● This is a carbon atom. They are the small particles that graphite, diamond, and graphene are made up of.

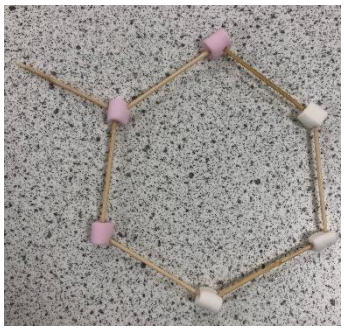
1) In graphene each carbon atom forms a bond with three other atoms. 	2) These then link together to form hexagons. 
3) The hexagons form a repeating pattern. This is a sheet of graphene. 	4) The Sheet of hexagons can then be formed into a cylinder. This is a carbon nanotube. 

You are going to build a “giant” carbon nanotube. In the model mini marshmallows are used to represent the carbon atoms and toothpicks are used to represent the bonds between them.

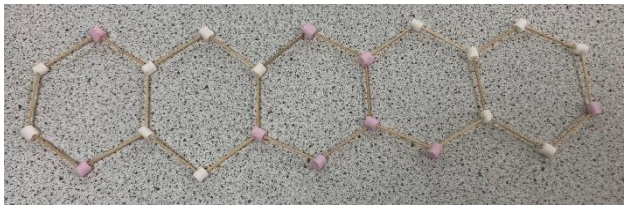
1) Take one mini marshmallow and stick three toothpicks into it. The angle between each toothpick should be as close to 120° as possible. Use the template to help with the angles.



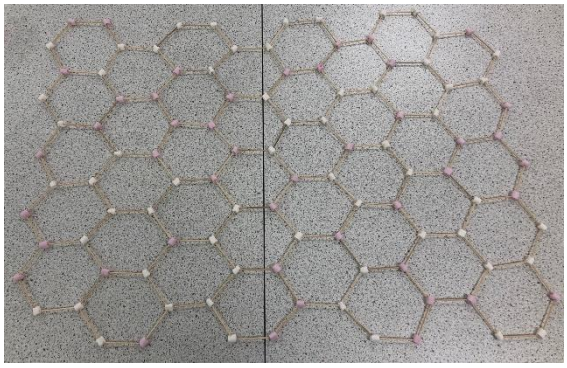
2) Using five more mini marshmallows, link them together with toothpicks to make a hexagon.



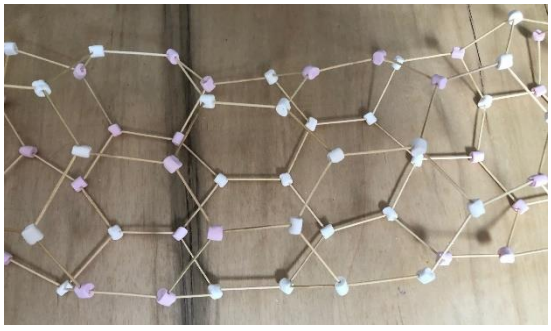
3) Keep adding mini marshmallows and toothpicks until you have a row of five hexagons linked together.



4) Add another row of five hexagons underneath. Keep adding on rows until you have eight rows of five hexagons. This represents a sheet of graphene which is one atom of carbon thick.



5) The next step is to wrap the sheet around to form a cylinder. At this point your model will be unstable if you try and move it around. You should leave it on a flat surface in a safe place for at least 24 hours. This will allow the mini marshmallows to dry out slightly and stick to the toothpick ‘bonds’ more firmly.
After drying out, pick up the ‘graphene sheet’ and curve it around to form a cylinder. Use extra toothpicks to join up the marshmallow ‘carbon atoms’.



Congratulations! You have built a “giant” carbon nanotube model!

You can build a model of a carbon nanotube from paper.

In the model black circles are used to represent the carbon atoms and dotted lines are used to represent the bonds between them.

1) Cut around the template.

2) Glue along the solid blue lines.

3) Wrap the template around in a cylinder shape and line up the carbon atoms to attach to the bonds. Press the edges together to form our carbon nanotube.