**ACTIVITY: Investigating size and scale**

**Activity idea**

This activity introduces students to size and scale. These concepts are important in forming the necessary cognitive framework for making sense of nanoscience. Size and scale are important in understanding the ‘big science ideas’ in nanoscale science.

By the end of this activity, students should be able to:

* describe, using appropriate language, the size of a range of different objects
* make size comparisons of objects with other objects
* explain that there are enormous scale differences in our universe
* understand that there are worlds that are too small to be seen with the naked eye.

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**Introduction/background**

Size and scale are important concepts when introducing students to nanoscience. They underpin the [big science ideas](http://www.mcrel.org/NanoTeach/pdfs/big_ideas.pdf) in this field and are particularly important for understanding that:

* factors relating to size help describe matter and predict its behaviour
* the properties of matter can change with scale.

When talking about objects at the nanoscale, size is often the first term we use to describe them, for example, nanofibre, nanoparticle, nanotube. Size relates to how big or small an object is. To define the sizes of various objects, we must use some form of measurement or a tool of measurement, such as a scale. A scale links the size of an object to a numerical representation of that size in conventionally defined units (for example, metre, kilogram). Think here of a school ruler that will measure an object in mm and cm.

Scale, however, has several more meanings – all of which are relevant in the context of nanoscience. Scale can define the size of an object compared to a model or representation of the object (for example, the scale on a map where 1 cm on the map may represent 1 km in actual distance). Scale can also be considered the ratio of two measurements. In this use, scale is linked to proportionality, for example, when you scale an image on your computer up or down. Scale is also used to define large changes in magnitude of properties like size, for example, the size of materials may be described as reducing from the macroscale to microscale to nanoscale.

When it is used to define large changes in magnitude, scale is a way to categorise objects. They are part of the macro, micro, nano or atomic scale. Classifying objects into these scales (also called worlds) is important as it defines the rules that are used to describe the behaviour of matter at each scale. As an object reduces in size from macroscale to microscale to nanoscale, the physical laws that predict the material’s behaviour change. This leads to materials having novel properties at the nanoscale, so not only do the size of objects change with scale, but also the way in which they function or behave changes too!

In this activity, students are introduced to size and scale using a scale ladder. The activity focuses on the scale from macro to atomic and size 1 m down to 10-10 m.

This activity can be run as a quick introduction. It can help students recognise the order of magnitude of objects by correctly arranging illustrations of objects according to scale and size.

It can also be used to increase familiarity with the metric system, scientific notation and common SI prefixes.

Finally, it can be used to introduce students to the idea that the rules of physics change as the scale and size of an object changes and that this leads to materials with novel properties at the nanoscale.

**What you need**

* [Image cards](#cards) – printed out or use on digital whiteboard
* Access to the [teaching version of the scale ladder](#scaleladder) – printed out or use on digital whiteboard
* Access to the image [Scale ladder – from macro to atomic](http://link.sciencelearn.org.nz/images/2063-scale-ladder-from-macro-to-atomic) – printed out or use on digital whiteboard

**What to do**

1. Begin by exploring with your class what are the largest objects and smallest objects they can think of anywhere/in your school/in your classroom and list these objects on the board.
2. Organise students into groups and give each group a set of [image cards](#cards). Ask them to group the objects into those that you can see and those that can’t. (You might want to include images of the objects your class listed in step 1 as well.)
3. Introduce the class to the [teaching version of the scale ladder](#scaleladder). Explain how objects can be grouped into scales – macro, micro, nano, atomic – and while you are able to see some objects with your eyes, many objects are too small and you need to use special tools (light microscope, electron microscope, atomic probe microscope).
4. Ask students to group the objects on the cards into macro, micro, nano and atomic scales. Check with each group that their cards are grouped correctly. Use the image image [Scale ladder – from macro to atomic](http://link.sciencelearn.org.nz/images/2063-scale-ladder-from-macro-to-atomic) as a reference.
5. Ask each group to order the cards from largest to smallest.
6. Investigate relative scale by asking how large objects are in relation to each other. For example, which is bigger: an atom, a molecule or a virus?
7. Allocate each group a scale – macro, micro or nano – and ask them to research to find 3–5 other objects that are examples for their scale. Students may like to use an online scale interactive or scale app for some of this research (see the Science Learning Hub’s Pinterest board [Investigating size and scale](http://www.pinterest.com/nzsciencelearn/slh-investigating-size-and-scale/)).
8. Create a record of these objects (for example, draw, list, print out image, copy image into PowerPoint or whatever is appropriate for your class).
9. Bring the groups together to hear what objects each group has found. Discuss how each object could be described (for example, as part of the microscale, as x mm diameter, only seen with a microscope, 10 times bigger than x, bigger than z, smaller than y and so on).

**Extension idea**

***Novel properties at nanoscale***

Researchers and scientists are interested in nanoscale materials because, as materials are reduced to nano size, they start to behave differently and novel properties emerge. As objects reduce in size, the physical laws that predict the material’s behaviour change – moving from classical mechanics to quantum mechanics.

The unexplored potential of these new properties and how they lead to new and different uses makes nanomaterials exciting to work with. You might like to explore this in more detail with your class:

* Read the article [Novel properties emerge at the nanoscale](http://link.sciencelearn.org.nz/resources/1676-novel-properties-emerge-at-the-nanoscale) and discuss the examples of novel properties in nanoscale materials and how new applications are being found for these materials.
* Research online to find out other examples of how the properties and behaviours of materials change at the nanoscale, for example:
  + gold – at the macroscale, gold is easily recognisable for its colour, but at the nanoscale, gold particles appear red or purple; at the macroscale, gold has a melting point of 1064°C, but at the nanoscale, the melting point of gold reduces by about 100°C
  + aluminium – at the macroscale, aluminium is an inert, shiny pliable metal used to make cans, but at the nanoscale, aluminium particles are extremely reactive and will explode
  + zinc oxide – at the macroscale, this is an ingredient in some sunblocks that gives it a white colour, but at the nanoscale, zinc oxide particles appear transparent and the sunblock is clear.

