Factors of Ten

This activity involves:

- reading tables of data
- re-ordering data into a more visual form
- considering impact of data
- use of internet to improve impact of data

Introduction

This activity gives students an opportunity to consider the scale of the universe as described by modern science. It is useful to tackle this in order for students to be able to discuss the consequences of such a picture in later activities. It can be used as a more extended piece of work if students are encouraged to find illustrations for the timelines. There are many such images available on the internet.

http://www.powersof10.com/

http://www.wordwizz.com/pwrsof10.htm

http://visav.phys.uvic.ca/~babul/AstroCourses/P303/Module1_p5.htm

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

References

Textbook
Chapter 16

Specification
10.6 The move away from an Earth-Centred View of the Universe

13.6 The scale, origin and future of the Universe

Resources needed

Student book
student sheet
internet access an advantage

Answers to questions 3 and 4

3. The main point is that a log scale is the only one in which such a huge range of values can be represented. If decimal notation is used rather than standard notation the sheer number of zeros can impress.

4. The problem with log scales is that most people are not used to them. We tend to read such diagrams as if they are linear and thus misinterpret them.

Factors of Ten

The modern picture of the Universe is one of such scale that it is difficult to comprehend. We all know that a proton is very small and the Universe is very big but the range of scales is mind-boggling. The Universe is one hundred million, million, million, million times the size of a human (approximately!). A human is a thousand million, million times the size of a proton, approximately.

To represent this range of scales needs a special sort of diagram. This is commonly called a 'log' scale. It looks like this:

Factor of ten scale (log scale)

A 'linear scale' goes up in equal intervals such as: 0 10 20 30 40 .

A log scale goes up in equal multiples. In the example above the equal multiples are factors of ten (1, 10, 100, 1000, 10000, etc).

This can be a useful way of representing the history of the universe and the range of scales of the universe.

1. Look at the two tables of data shown in table 1 and table 2. Represent these data on factor of ten timelines. You can use 'standard notation' if you want to.

   These can fit onto an A4 sheet but you may want to use A3 paper or even bigger.

Time after Big Bang	**Event**
0.000000 s	Big Bang
0.00001s	formation of protons and neutrons
222 s	helium nuclei formed. Universe now composed of 20 % helium and 80 % hydrogen nuclei.
3 000 000 s	Temperature of the Universe about that of the centre of a star.
10 000 000 000 00 s	Universe cool enough to allow electrons to combine with the nuclei forming stable atoms. This is the origin of the cosmic background radiation. Beyond this time matter begins to gather into stars and galaxies.
3 000 000 000 000 000 0 s	globular clusters begin forming. Quasars formed.
3 000 000 000 000 000 00 s	Formation of Solar System

Table 1

Time Before Present	Event
4 500 000 000 years	formation of Solar System
3 800 000 000 years	age of oldest dated rock on Earth
1 300 000 000 years	first plants appear
700 000 000 years	first animals – jellyfish and flatworms
500 000 000 years	first vertebrates
425 000 000 years	life colonises land
395 000 000 years	first insects
200 000 000 years	first mammals
1 800 000 years	homo erectus – first true man
600 000 years	homo sapiens
360 000 years	use of fire by homo sapiens
40 000 years	invention of complex language
14 000 years	invention of fishhooks
10 000 years	cultivation of wheat and rice
6 700 years	Babylonian calendar in use
6 500 years	copper smelted
4 500 years	Stonehenge built

Table 2

2. Look at the table of data about the relative sizes of objects. Represent this on a factor of ten scale on a sheet of A2 sugar paper. If you have access to the internet you can download images of objects to add to your diagram.

Scale	**Typical Object**	**Scale in Standard Notation**
1000 000 000 000 000 000 000 000 00 m	Observable universe	10^{26} m
1000 000 000 000 000 000 000 00 m	Clusters of galaxies	10^{23} m
1000 000 000 000 000 000 000 m	Our galaxy	10^{21} m
1000 000 000 00 m	Solar system	10^{12} m
1000 000 000 m	Sun	10^{9} m
1000 000 0 m	Earth	10^{7} m
1000 0 m	Neutron stars	10^{4} m
1 m	humans	10^{1} m
0.00001 m	living cells	10^{-5} m
0.000 000 000 1 m	atoms	10^{-10} m
0.000 000 000 000 01 m	nuclei	10^{-14} m
0.000 000 000 000 001 m	protons	10^{-15} m

Table 3

3. Write down the features of the diagrams that you think may help people grasp the huge range of scales of the universe.

4. In what ways might this way of representing data be unhelpful to non-scientists?