

Activity 1: Climate timeline

Background information

This activity underpins the students' knowledge of key climate concepts and provides a visual representation of the changes that have occurred in the Earth's climate.

The daily variations that we call weather tend towards certain average values, and it is the combination of these long-term conditions that defines climate. Climate also changes, but much more slowly and (mostly) predictably. For example, we cannot say with any certainty what the temperature will be in Melbourne on the 30 June this year, but we can be fairly confident that it will be colder than the 30 December.

When we look at the way the climate has changed throughout the history of the Earth, it can be very difficult to get our heads around the numbers involved. For example:

- Dinosaurs became extinct 65 million years ago.
- *Homo sapiens* (humans) appeared only 100,000 years ago.

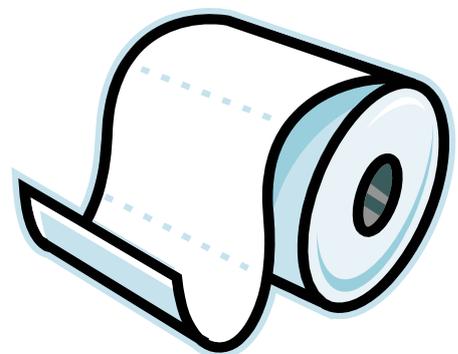
In this activity, students will watch then discuss short interviews with scientists. Transcripts of these are provided on pages 13-14.

They will then construct a 'toilet paper timeline' to help visualise and understand how the climate has changed over time. The 'Key dates in Earth's history' list gives you some key dates, and pre-calculated distances along the timeline. You can choose to give younger students a selection of dates from the list. You may wish to include a scale calculation for more advanced students (see below).

What you need

This task may be done as a class activity, or in smaller groups. Each group will need:

- Several toilet paper rolls (to make a total length of at least 50 metres)
- Post-it notes
- Coloured markers
- Ruler
- Tape measure
- Access to a long space to lay out the toilet roll (eg. a hall, gym or long hallway)



What to do

Part A: Introduction and discussion

1. Ask the students to discuss what they understand by the word *climate*.
2. Show the students the interviews, which deal with
 - a. One particular mass extinction event, driven by climate
 - b. Why we believe the climate is currently changing
 - c. How scientists measure changes in the climate over time
3. Use the interviews to prompt discussion on the topic of climate. The following questions may be a guide:

Has the climate always changed?
How do we know the climate is changing?
Can you name any big climate events in history?
4. Inform students that they will be creating their own timeline of climate change.

Part B: The toilet paper timeline

1. Before you begin, choose some dates from the *Key dates in Earth's history* list (see p 10). The number will depend on the year level of your students.
2. Give students a copy of the list you have chosen, and explain that they are going to use it to form a timeline of Earth's history.
3. Explain that each centimetre of toilet paper represents 1 million years of Earth's history. Therefore, if the sheets of your toilet paper are 11 cm long, each sheet will represent 11 million years. If your sheets are 10.5 cm long, they will represent 10.5 million years – the scale in the table on pages 10-11.

For older students: Rather than using the pre-scaled values, you may wish your students to use the *Calculating Scale Worksheet* (see page 12) to calculate their own scale for the timeline.

For younger students: Calculations may be simpler if you use a toilet roll and tape measure (scale 1cm to 1 million years) rather than counting toilet paper sheets as units.

4. Move students to the area you will use to construct the timeline.
5. Have students unroll the toilet paper a few metres and place a post-it note marked 'NOW' on the end. All the other events will be measured from here.
6. Have students unroll the toilet paper, marking other events with the post-it notes as they go. Use tape to join a second roll to the end if necessary.

For events over a long period of time, note the start and end points.
7. At the end of the exercise, the toilet roll should be completely unrolled and students should be able to see a few key things:
 - a. Most of human history has taken place in a very short time.
 - b. The Earth's climate has changed over time.
 - c. The Earth has experienced a number of major events, including mass extinctions, changes in continent positions and ice ages.

Key dates in Earth's history

This table lists key events in the Earth's climate history, and records how many years ago the events happened. The last two columns are the scaled values of time, based on one 10.5 cm toilet paper sheet = 10.5 million years. Be sure to check the length of a sheet on your own toilet paper and adjust the figures accordingly! (Alternatively, use a tape measure instead of counting sheets).

Note that precise calculations for additional centimetres of toilet paper (last column) should only be used for 'recent' events, as the exact dates for many events in the distant past are not known.

Example using toilet paper with sheets that are 10.5 cm long: If we mark the end of the roll as 'Now', then to place a marker for 'Ice forms on Antarctica' we need to count three sheets and measure 4cm along the next sheet.

Time of event:	Description of event:	Measuring from the 'now' marker, how many sheets ago did the event happen?	How many additional millimetres or centimetres along the next sheet?
0 years ago	Current time.	0	0
10,000 years ago:	Recorded human history begins.	0	0.1mm
18,000 years ago:	Peak of last glacial period.	0	0.2mm
65,000 years ago:	Evidence of humans living in Australia	0	0.6mm
100,000 years ago:	First <i>Homo sapiens</i> appears.	0	1mm
1.7 million years ago:	The ancestors to <i>Homo sapiens</i> develop the ability to use controlled fire.	0	2cm
3.5 million years ago:	First human-like creatures appear, in Africa.	0	3cm
27.8 million years ago:	Fish Canyon Tuff Eruption. Volcanic winter lasting several years.	2	7cm
35.5 million years ago:	Ice forms on Antarctica.	3	4cm
65 million years ago:	Age of Dinosaurs ends, with mass extinction of 70% of all living things, probably because of climate changes caused by a meteorite collision.	6	2cm
70 million years ago:	The Himalayas begin forming. They are responsible for increased global rainfall.	6	7cm

Time of event:	Description of event:	Sheets of toilet paper
150 million years ago:	Supercontinent Pangaea broken up; modern oceans formed; continents drifting apart	14
245 million years ago:	Age of Dinosaurs begins.	23
250 million years ago:	Mass extinction of 90% of life in the oceans and 70% of life on land.	24
350-250 million years ago:	Large parts of the Earth's land surface are covered with glaciers.	33 - 24
0.5 billion years ago:	First land plants with inner vessels.	48
0.6 billion years ago:	Ozone layer starts offering protection, allowing land-based organisms to develop.	57
0.65 billion years ago:	First living things with more than one cell appear	62
0.85-0.65 billion years ago:	Cryogenian Ice-Age	81 - 62
1 billion years ago:	Iron formations in the earth that collect oxygen become 'saturated' and can hold no more, so free oxygen can now stay in the atmosphere.	95
1.9 billion years ago:	First cells with nuclei appear in oceans.	181
2 billion years ago:	Eukaryotic photosynthesis begins, much more efficient than Prokaryotic	190
2.7-2.3 billion years ago:	Huronian Ice Age (hypothesised)	257 - 219
2.4 billion years ago:	Oceans contain significant amounts of oxygen.	229
2.72 billion years ago:	First fossil record of a Stromatolite.	259
3.25 billion years ago:	Photosynthesis begins in oceans.	310
3.5 billion years ago:	First life appears in oceans.	333
3.7 billion years ago:	Earth's crust solidified.	352
5 billion years ago:	Earth is formed, along with the other planets	476

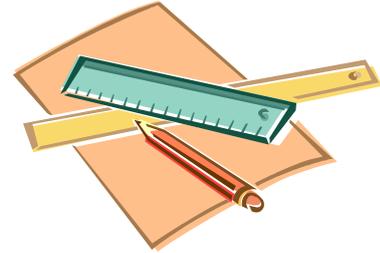
Calculating scale worksheet

Introduction

To calculate where to place the event on the timeline, you need to convert the number of years ago the event happened to a distance that you can plot on the toilet-paper timeline. This worksheet takes you through the steps to do this, using the following scale:

$$1\text{ cm} = 1\text{ million years}$$

This means that if your toilet paper sheets are 10 cm long, each one represents 10 million years of Earth's history. If the sheets are 15 cm long, each one represents 15 million years of Earth's history.



What to do:

1. Measure the length of one sheet of toilet paper. Write down how many centimetres it is:

Length of one sheet of toilet paper = _____ cm

2. Calculate how many million years one sheet represents:

_____ cm x 1 million years = _____ years per sheet
(*length of one sheet*)

3. For each event calculate how many 'sheets ago' it took place and write on the list of events. Use this calculation:

$$\frac{\text{Number of years ago}}{\text{Number of years per sheet}} = \text{Number of sheets}$$

An Example: If your sheets are 10.5 cm long, representing 10.5 million years, then the extinction of the dinosaurs can be represented as follows

$$\begin{aligned} \frac{65\text{ million years}}{10.5\text{ million years per sheet}} &= 6.2\text{ sheets ago} \\ &= 6\text{ sheets} + 0.2 \times 10.5\text{cm} \\ &= 6\text{ sheets} + 2.1\text{ cm ago} \end{aligned}$$

Interview Transcripts

Interview 1: Prof. Guang Shi talking about the Permian extinction - [Video file 1](#)

Question	Answer
Who are you?	I'm Professor Guang Shi, Professor of Earth Sciences at Deakin University. My interest has been in biodiversity and in how biodiversity evolved and particularly the end-Permian mass extinction 250 million years ago.
What was the biggest mass extinction in Earth's history?	This mass extinction is the largest in Earth's history. It actually wiped out about over 90% of animal species in the oceans and more than 70% of species on land.
What caused this extinction?	For over three decades now scientists have been puzzled by the mechanism behind this Great Dying in the Earth's history. There has now been increasing evidence pointing towards climate change. It appears to be that if you trace and link up all the geological evidence, climate change appears to be the ultimate mechanism but may have been triggered by severe volcanism in Siberia. So you actually have climate change, volcanism and some other environmental factors working together in a process of linked environmental change. This led to the development of very hostile and stressful conditions for life.
What can we learn from this event?	Climate change played a major role. From that perspective, this analogy from the end-Permian mass extinction could be used as a very important lesson and perspective for understanding how our modern ecosystem will change in the face of global climate change.

Interview 2: Tas Van Ommen talking about Ice Cores - [Video file 2](#)

Question	Answer
Who are you?	I'm Tas Van Ommen. I work for the Australian Antarctic Division and I lead the Ice Cores Project there.
What is an Ice Core?	Ice cores are valuable sources of past climate information. They're basically cylinders of ice that we drill out of the Antarctic ice sheet. They contain information on the climate that gets deposited with the layers of snow that fall on the continent year by year. These layers carry with them all sorts of information about the atmosphere and its contaminants over time By analysing ice cores, we learn a great deal about the processes that control the climate. We learn how it's changed in the past and how ice ages have come and gone.

<p>What do Ice cores tell us about past atmospheres?</p>	<p>One of the most valuable indicators we get from ice cores comes in the form of tiny bubbles of past atmosphere that get trapped between the snow flakes as the ice builds up on the continent. We can bring the ice cores back to the laboratory, crack open the bubbles which are like tiny time capsules of past atmosphere and analyse them to determine past levels of greenhouse gases. What we find is really startling. The carbon dioxide levels over the past 800,000 years track the temperature record incredibly closely, showing that there is a tight link between CO₂ and climate.</p>
<p>How do we date Ice cores?</p>	<p>If you look at an ice core you can not visibly see the layers of annual snow. However, in almost all of the measurements we make, you can actually detect and count these layers to date the ice core in much the same way that you can count tree rings.</p>

Interview 3: Prof. David Karoly discussing recent climate change - [Video file 3](#)

Question	Answer
<p>Who are you?</p>	<p>My name is David Karoly. I'm a professor here in the School of Earth Sciences at the University of Melbourne. I do a lot of work on climate change research and was heavily involved in the fourth assessment report of the Intergovernmental Panel on Climate Change that was released in 2007.</p>
<p>What has been observed in the climate in the 20th century?</p>	<p>There is ample evidence that temperatures have increased substantially globally and regionally in the twentieth century and the magnitude of that – about seven or eight tenths of a degree over the last hundred years – is very large compared with any other century-time scale change.</p>
<p>How do we get evidence for past temperatures?</p>	<p>When we compare that to temperature changes over the last 1000 years or 2000 years we can't get direct thermometer evidence. We have to look at other evidence like changes in temperatures that we can infer from tree rings, from ice cores, from coral records or other evidence of temperature changes – even documentary records from people living in different areas around the world.</p>
<p>What do we learn from this evidence?</p>	<p>What we find is that the magnitude of temperature variations in the 20th century – seven or eight tenths of a degree – is more than double the temperature changes in any period over the last 1000 or 2000 years and the rate of warming is much greater.</p> <p>There is evidence of a cool period called the 'Little Ice Age' primarily in Europe around the 18th century and also of a mediaeval warm period, but the temperature variations in those periods were much smaller than we've seen in the twentieth century – smaller by at least a factor of two.</p>