primary | PR02

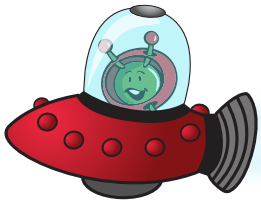
teach with space

→ HISTORY OF THE UNIVERSE

Creating timelines

→ INTRODUCTION

The vast age of the Universe can be difficult to comprehend and put into perspective. This creative and mathematical research activity allows pupils to gain an insight into the main events in the history of the Universe and scale them to a recognisable timescale of one year.



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FAST FACTS

Age range: 10 – 12 years old

Type: pupil (group) activity

Complexity: medium to difficult

Teacher preparation time: 30 to 60 minutes

Lesson time required: 2 hours

Cost per kit: low (less than 10 euro)

Location: indoor (any classroom)

Includes the use of: reference books, internet (optional), art and craft materials, calculators

Outline

In these activities pupils will work in groups to create timelines: first, one of their own lives and then one of the main events in the history of the Universe. Pupils next calculate the events in the history of the Universe to a scale of one year. Pupils will also research the events and produce artwork to accompany the information. Finally, pupils present their work to the class.

Pupils will learn

1. That the Universe is very old.
2. That the Earth was created relatively recently.
3. That humans have been on Earth for a relatively short time.
4. How to construct a timeline of events from the beginning of the Universe to the present day.
5. The influence of impacts on the evolution of the Earth.

Curriculum relevance

Science

- Exploring ideas
- Research using secondary sources of information
- Reporting on findings from enquiries, including oral explanations

Mathematics

- Read, write, order and compare numbers to at least 10 000 000 and determine the value of each digit
- Round numbers to the nearest 10, 100, 1000, 10 000 and 100 000
- Solve number problems
- Use rounding to check answers to calculations
- Add and subtract whole numbers with more than 4 digits
- Multiply and divide whole numbers with more than four digits
- Solve problems involving converting between units of time
- Understand and use place value for decimals, measures and integers of any size

Literacy

- Read and discuss non-fiction and reference books or textbooks
- Distinguish between statements of fact and opinion
- Formal presentations and debates

Art & design

- Produce creative work, exploring their ideas and recording their experiences

→ BACKGROUND

A brief history of the Universe

Beginning of the Universe

Astronomers believe that the Universe began with a 'Big Bang' 13.8 billion years ago. In the beginning, the Universe was unimaginably hot and dense; concentrated into a volume smaller than a pinhead. Suddenly, it expanded rapidly as a hot explosion. In just a tiny fraction (far less than one millionth) of a second the Universe was bigger than a grapefruit and is still expanding today. After the Big Bang the Universe continued to expand and cool. In the first seconds particles formed. Then, in the first few minutes neutrons and protons combined to form the first atomic nuclei, such as deuterium, helium and lithium. Once the Universe had expanded and cooled further, after about 380 000 years, atoms formed. The Universe was then filled with clouds of mostly hydrogen and helium gas, and light could travel freely for the first time. This 'first light' can be detected today as the Cosmic Microwave Background.

Birth of galaxies

A few hundred million years after the Big Bang, in denser areas of gas clouds, the first stars and galaxies formed (Figure 1). The first stars were much bigger and mightier than those we see now, while the first galaxies were much smaller and closer together than they are today.

Birth of the Sun, planets and comets

Our Solar System formed about 4.6 billion years ago from a large cloud of gas and dust called a nebula (Figure 1). The densest area of the nebula slowly began to collapse. The surrounding gas and dust, flowing at high speeds, formed a swirling disc. At the centre of the disc the gas and dust were squeezed together, becoming hotter and denser until the Sun, our nearest star, formed. Most of the dust in the disc surrounding the newly born Sun began to collide and stick together, eventually forming the planets. Today, orbiting around the Sun are eight planets, their moons and many smaller objects known as asteroids and comets.

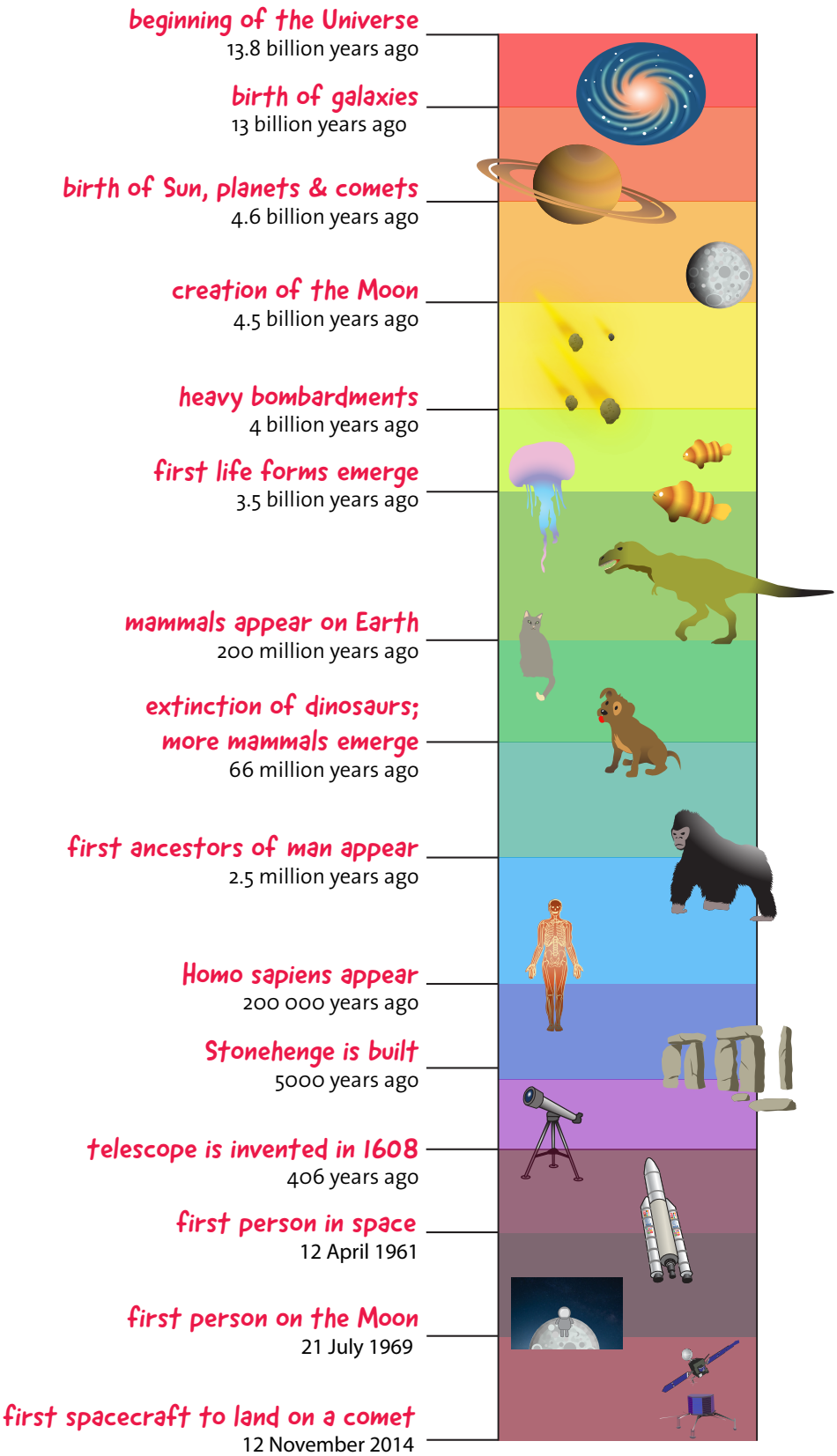
History of the Earth

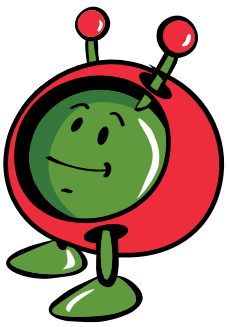
The early Solar System was a turbulent place with frequent collisions between objects trying to develop into planets. This time is often referred to as a period of heavy bombardment. The Earth survived one such large collision about 100 million years after its formation. The debris from this collision is thought to have formed the Moon (Figure 1). The young Earth was bombarded by impacts from asteroids and comets, objects left over from the formation of the planets. After the Earth formed it began to cool down from its original molten state, developing a solid crust and oceans.

To begin with there was no water on Earth. It is thought that impacts from comets and asteroids brought water to our planet. Evidence of these frequent impacts on Earth isn't obvious because the surface of our planet has changed over time, due to the presence of water, tectonic plate activity (such as earthquakes and volcanic eruptions), weathering and erosion. However, evidence can be seen on the surface of the Moon which is heavily scared with craters from past impacts. The surface of the Moon has changed very little since it was formed and therefore preserves a record of the past.

Figure 1

timeline of the Universe





The earliest life forms emerged when the Earth was roughly 1 billion years old (3.5 billion years ago). The early life forms on Earth were microscopic bacteria. As this life developed and harnessed the power of the Sun (by photosynthesis) simple plants evolved.

Around 200 million years ago the first mammals appeared on Earth. But they remained fairly small and inconspicuous until the dinosaurs died out around 66 million years ago (Figure 1). Around this time it is thought that a large asteroid or comet impacted Earth in an area now known as Yucatán, Mexico. It was the global climate change that occurred afterwards that contributed to the extinction of the dinosaurs.

With the dinosaurs extinct, small mammals thrived, quickly diversifying and growing in size. It was around 2.5 million years ago that the first ancestors of man appeared on Earth, followed by the Homo sapiens, our own species, around 200 000 years ago (Figure 1). Around 5000 years ago, our ancestors built giant structures such as Stonehenge and just over 400 years ago the telescope was invented and then turned towards the night sky.

The Space Age

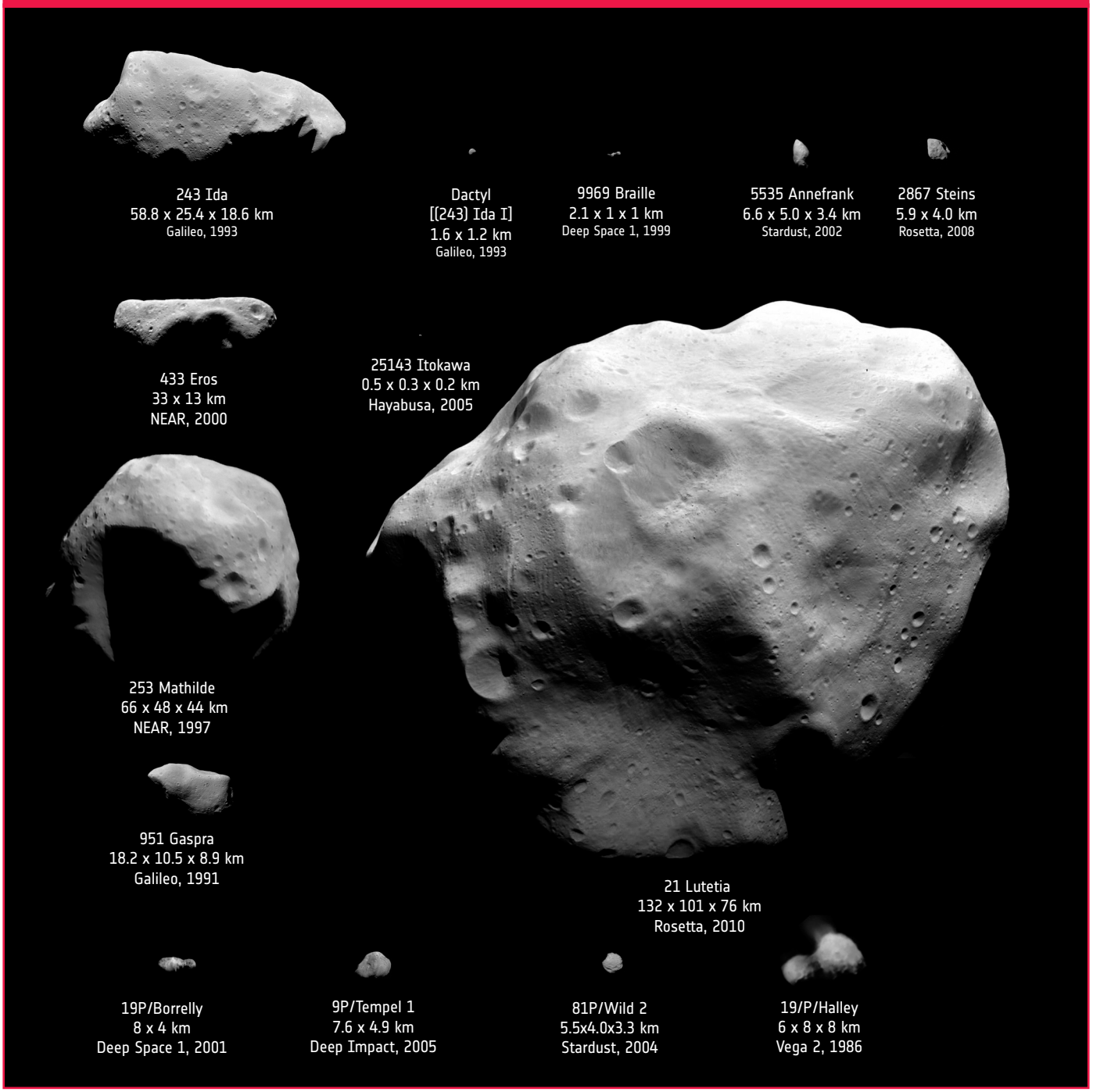
With the advent of the Space Age in the twentieth century, humankind set its sights on exploring beyond Earth. On 12 April 1961 cosmonaut Yuri Gagarin become the first person to journey into space (Figure 1). Yuri Gagarin's adventure in space lasted for just over 100 minutes. Just a few years later, on 21 July 1969, Neil Armstrong became the first person ever to walk on another celestial body as he took his first step onto the Moon. Today there are 6 people living in orbit around the Earth on the International Space Station. Over the last half of the twentieth century humankind has utilised space in many different ways: to study our own planet; to communicate across the globe; to look out into the Universe and to study our local celestial neighbourhood, the Sun, planets, moons, asteroids and comets. Over the limited lifetime of our species on Earth, we have evolved and explored to develop life as we know it today.

Asteroids

Asteroids are a group of small, irregular-shaped bodies located in the inner Solar System. They are made of rocky and metallic material, such as iron. There are millions of asteroids in the Solar System. The majority of asteroids orbit the Sun in the Asteroid Belt between the orbits of Mars and Jupiter. Asteroids are thought to be material left over from the formation of the Solar System.

The European Space Agency's Rosetta mission passed by and studied two asteroids, asteroid 21 Lutetia, and 2867 Steins, on its long journey to a comet. Figure 2 shows a montage of images of asteroids and comets to show the large variation in size and shape.

Figure 2



↑ A composite showing the different shapes and sizes of asteroids and comets. The comets are the four objects at the bottom of the figure. The text accompanying each image is:
Line 1 - number and name of the object,
Line 2 - dimensions in kilometres,
Line 3 - name of the mission that studied the object and the year in which the image was taken.

Created from a montage by Emily Lakdawalla. Ida, Dactyl, Braille, Annefrank, Gaspra, Borrelly: NASA / JPL / Ted Stryk. Steins: ESA/ OSIRIS team. Eros: NASA / JHUAPL. Itokawa: ISAS / JAXA / Emily Lakdawalla. Mathilde: NASA / JHUAPL / Ted Stryk. Lutetia: ESA / OSIRIS team / Emily Lakdawalla. Halley: Russian Academy of Sciences / Ted Stryk. Tempel 1: NASA / JPL / UMD. Wild 2: NASA / JPL

Comets

Comets are small, icy worlds that originate from regions of the outer Solar System, beyond the planet Neptune, known as the Kuiper Belt and the Oort Cloud. Comets are mostly made out of ice, but also contain dust and rocky material. Just like asteroids, they are material left over from the formation of the Solar System and have an irregular shape (Figure 2). The majority of comets take hundreds or thousands of years to orbit the Sun. Compare that to just one year for the Earth! Occasionally, the orbit of a comet can be changed sending it racing towards the inner Solar System. As comets approach the Sun, they begin to heat up and sometimes produce spectacular tails of gas and dust (Figure 3).

Figure 3

↑ Photo of the comet Hale-Bopp taken in Croatia.

Many comets have very elongated orbits, which means that they are close to the Sun, and therefore visible, for only a short period of time. The orbits of some comets have changed so significantly that they now orbit the Sun on much shorter timescales. Comet 1P/Halley orbits the Sun about every 75 years and has been observed from Earth (with the naked eye) on a regular basis over the last thousand years or so. One famous record of comet 1P/Halley's visibility from Earth was made on the Bayeux Tapestry that depicts the Battle of Hastings in 1066 (Figure 4).

Figure 4

↑ Comet 1P/Halley depicted on the Bayeux tapestry (top centre).

Millions, billions and powers of 10

The timescales of the Universe are immense. In this activity, pupils will need to become familiar with large numbers (up to 13.8 billion!) and converting between them. Below is a quick overview of the scientific number conventions:

One million is a thousand thousands:

$$1 \text{ million} = 1000 \times 1000 = 1\,000\,000$$

One billion is a thousand million:

$$1 \text{ billion} = 1000 \times 1\,000\,000 = 1\,000\,000\,000$$

Instead of using/writing many zeros, large numbers can be written in a mathematical shorthand which is clearer and easier to read. For example:

$100 = 10 \times 10 = 10^2$ (this reads '10 to the power 2', or in this case, '10 squared')

Similarly,

$1000 = 10 \times 10 \times 10 = 10^3$ ('10 to the power 3', or in this case, '10 cubed')

Following through to larger numbers:

1 million = 1 000 000 = $1000 \times 1000 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^6$ ('10 to the power 6')

1 billion = 1 000 000 000 = $1000 \times 1\,000\,000 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^9$ ('10 to the power 9')

Making timelines

In this activity, pupils will work in groups to create a timeline of their own lives and a timeline of the main events in the history of the Universe. The timeline of events in the history of the Universe is then set to a scale of one year and pupils calculate on what month, day and hour each event takes place. In addition, pupils will conduct research to find out more about the main events in the history of the Universe and make a picture/piece of artwork to accompany the information. At the end of each task pupils present their work to the class. An example Timeline of the Universe for class display and a set of cards for the events of the Universe are provided in the Appendix.

Equipment

- Large Timeline of the Universe for class display – made in advance (for example, see Appendix)
- Set of cards for the events of the Universe – see Appendix
- Worksheet – My timeline (1 for each pupil)
- Worksheet – A timeline of the Universe (at least one copy per pair of pupils)
- Craft paper – various colours
- Scissors
- Glue sticks
- Colouring pens and pencils
- Calculators
- Pencils

Creating a personal timeline (20 minutes)

Discuss with pupils their memories of events in their lives. What is their earliest memory? How far back can they remember? Can they think of something that is old? Do they know of an event that happened a long time ago? Most of the information we have about times gone by have come from written sources. Everything we know about time before human beings existed has come from scientists' research. Explain to pupils that they are going to construct a timeline to show key events in their own lives, from birth to the present. They may design their own or they may prefer to use the timeline provided in the Worksheet – My timeline.

The pupils plan and complete their individual timelines. Ask for volunteers to describe their life stories and share key events with the class. What are the earliest memories they have? The timelines may be used later as part of a class display.

A timeline for the Universe (1 hour 40 minutes)

Explain to pupils that the timelines they created in the previous activity show events that happened in sequence from when they were young to the present day. Then show a video that tells another story: the story of the Universe from its beginning to the time when humans first appeared (for an example video, see Links section). The example video has spectacular graphics. It starts at the beginning of the Universe and includes key events such as the formation of the Solar System and the emergence of people.

Show pupils the Timeline of the Universe displayed on a whiteboard or classroom wall and explain that this represents the entire history of the Universe from the beginning to the present day, a total of 13.8 billion years. On the display 13.8 billion years are scaled and displayed as one year. The last ten minutes of the year, on 31 December, are highlighted in the final section. Pupils are now going to calculate the number of years (in the history of the Universe) represented by one month, one week, one day, or one minute on this timeline of one year.

Calculating timescales

First ask the pupils to calculate the units of time that make up a year on planet Earth (Task 1 on the Worksheet - A timeline of the Universe). Ask the groups to share their results with the class. Next, go through the calculation in Task 2 on the Worksheet - A timeline of the Universe. In this task pupils must work out the number of years on the actual timeline of the Universe, that are represented by each fraction of a year in the scaled timeline. You may like to support the groups during this task by working through the calculations on the board or by inviting individuals to show the class how they solved each problem. The answers to these calculations can be found in Table A1 and Table A2.

Table A1

time frame	in months	in weeks	in days	in hours	in minutes	in seconds
1 second		-	-	-	-	1
1 minute		-	-	-	1	60
1 hour		-	-	1	60	60 x 60 = 3 600
1 day		-	1	24	24 x 60 = 1 440	24 x 60 x 60 = 86 400
1 week		1	7	7 x 24 = 168	7 x 24 x 60 = 10 080	7 x 24 x 60 x 60 = 604 800
1 month*	1	52 / 12 = 4.3	365 / 12 = 30.4	(365 / 12) x 24 = 730	(365 / 12) x 24 x 60 = 43 800	(365 / 12) x 24 x 60 x 60 = 2 628 000
1 year	12	52	365	365 x 24 = 8 760	365 x 24 x 60 = 525 600	365 x 24 x 60 x 60 = 31 536 000

↑ Converting the timescales of a year into various units.
*Assuming 12 equal months.

Table A2

time on timeline	fraction of a year	time in the history of the Universe (years)
1 year	1	13.8 billion = 13 800 million
1 month (if all months were equal)	1 / 12	13.8 / 12 = 1.15 billion = 1150 million
1 week	1 / 52	13.8 / 52 = 0.265 billion = 265 million
1 day	1 / 365	13.8 / 365 = 0.378 billion = 37.8 million
1 hour	1 / (365 x 24)	13.8 / (365 x 24) = 0.00158 billion = 1.58 million
1 minute	1 / (365 x 24 x 60)	13.8 / (365 x 24 x 60) = 26 300
1 second	1 / (365 x 24 x 60 x 60)	13.8 / (365 x 24 x 60 x 60) = 438

↑ Converting the timescales of a year into the fractions of a year (second column) and converting these to the timescales of the Universe (third column).

Key events in the history of the Universe

Provide each group with one or two cards from Appendix - Cards for the events of the Universe. Ask them to use the Internet or books to research information about their events. Pupils should also design and make a piece of artwork to accompany their information. Explain to pupils that before matching all the events to the correct places on the timeline they must calculate how long after the beginning of the Universe their event occurred. Go through Task 3 on the Worksheet - A timeline of the Universe, showing how to subtract how long ago the event happened from the age of the Universe. If pupils are sufficiently confident, they may complete the calculation for their assigned event(s). Display the results for all of the groups. The answers can be found in Table A3 (third column).

Placing the events on the timescale of one year

Now that pupils are familiar with key events in the history of the Universe, they can convert the times onto the scale of one year and complete Task 4 on the Worksheet - A timeline of the Universe. By using the familiar timescale of one year, pupils will get a better understanding of when events occurred.

This calculation can be challenging and, depending on the ability of the pupils, the task can be amended accordingly. More able pupils may relish the opportunity to demonstrate their mathematical understanding.

The task can also be extended to calculate not just the day of the year, but also the time of day at which the events occur. For pupils who find the mathematics more challenging, you may choose to demonstrate the calculations on the board or provide the data for each group to add the events to the timeline. A worked example calculation is given below and the dates for all events are given in Table A4 (fourth column).

Example calculation

All dates are given in Table A3 (fourth column).

Event: Mammals appeared on Earth.
When did it happen? 200 million years ago.

How many years after the birth of the Universe?
The beginning of the Universe was: 13.8 billion years ago = 13 800 million years ago.
Mammals appeared: 200 million years ago.
Mammals appeared: 13 800 million – 200 million = 13 600 million = 13.6 billion years after the beginning of the Universe.

How many days is this in a year?
If the timescale of the Universe is converted to the scale of one year: 13.8 billion years is equal to 365 days.

Mammals emerged 13.6 billion years after the beginning of the Universe. To calculate the number of days the event occurred after the beginning of the Universe in the timescale of one year:

$$\frac{\text{13.6 billion years}}{\text{13.8 billion years}} = \frac{\text{number of days since the beginning of the year}}{\text{365 days}}$$

And so,

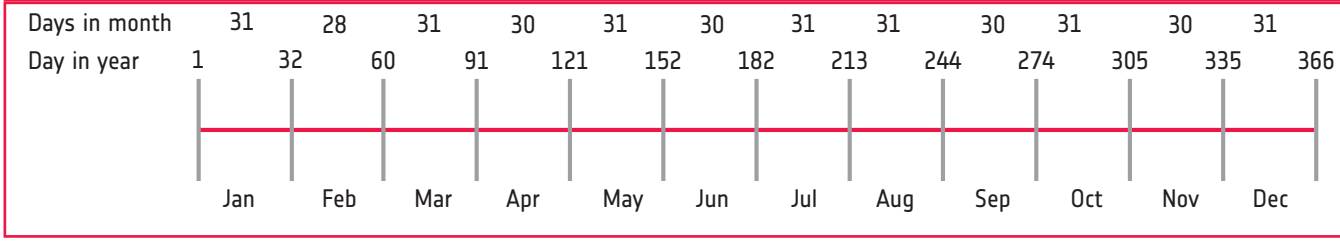
$$\text{number of days since the beginning of the year} = 365 \text{ days} \times \frac{\text{13.6 billion years}}{\text{13.8 billion years}} = 359.71 \text{ days}$$

This is 359 full days and 0.71 days (to 2 decimal places). So, the day we are looking for is day 360.

Once pupils have calculated which day they are looking for, they can identify the exact date and month using the timeline in Figure A1. You will noticed that 1 January is the first day in the year, 1 February is day 32 in the year and 1 March is day 60 and so on.

In the worked example, we are looking for day 360. This is 26 December on the timeline (Figure A1).

Figure A1



↑ Timeline conversion. Remember, 1 January is the first day in the year, 1 February is day 32 and 1 March is day 60 and so on.

Very able pupils may be able to take the calculation further and calculate the time on the day at which the event occured as follows:

Mammals emerged after 359.71 days. This is 359 full days and 0.71 days.

One day has 24 hours so:

$$\frac{0.71 \text{ days}}{1 \text{ day}} = \frac{\text{number of hours in the day}}{24 \text{ hours}}$$

And so,

$$\text{number of hours in the day} = 24 \text{ hours} \times \frac{0.71 \text{ days}}{1 \text{ day}} = 17.04 \text{ hours}$$

i.e. 17 full hours and 0.04 hours (to 2 decimal places).

The event therefore occurred on 26 December between 17.00 and 18.00 (between 5pm and 6pm). Following the same method further to calculate the minutes and seconds of the hour at which the event happened. The time on 26 December is after 17 full hours and 0.04 hours.

One hour has 60 minutes so:

$$\frac{0.04 \text{ hours}}{1 \text{ hour}} = \frac{\text{number of minutes in the hour}}{60 \text{ minutes}}$$

And so,

$$\text{number of minutes in the hour} = 60 \text{ minutes} \times \frac{0.04 \text{ hours}}{1 \text{ hour}} = 2.608 \text{ minutes}$$

And into seconds:

$$\frac{0.608 \text{ minutes}}{1 \text{ minute}} = \frac{\text{number of seconds}}{60 \text{ seconds}}$$

And so,

$$\text{number of seconds} = 0.608 \text{ minutes} \times 60 \text{ seconds} = 36.5 \text{ seconds}$$

Bringing all of the numbers together, we see that the event occurred on:
26 December at 17:02:36.5 (5.02 pm and 36.5 seconds).

After completing the tasks, each group then shares the information and artwork related to their assigned event with the class.

Discuss the pupil's research and calculations. Ask questions such as:

- How old is the Universe?
- When was the Earth formed?
- When did the first humans appear?

Re-emphasise that the timeline covers a span of 13.8 billion years and that one second represents 438 years. Set within this enormous time frame, Earth came into existence relatively recently and humans have lived on the planet for a relatively short time. Finally, pupils attach their events at the appropriate places on the timeline.

Table A3

event	time since the event (years)	years after the beginning of the Universe (Task 3)	time on timeline of the Universe (Task 4)
beginning of the Universe	13.8 billion	0	1 January
birth of galaxies	13 billion	0.8 billion	22 January 03:49:33.9
birth of Sun, planets and comets	4.6 billion	9.2 billion	1 September 08:00:00
creation of the Moon	4.5 billion	9.3 billion	3 September 23:28:41.7
heavy bombardment	4 billion	9.8 billion	17 September 04:52:10.4
first life forms emerge	3.5 billion	10.3 bilion	30 September 10:15:39.1
mammals appear on Earth	200 million	13.6 billion	26 December 17:02:36.5
extinction of dinosaurs; more mammals emerge	66 million	13.734 billion	30 December 06:06:15.7
first ancestors of man appear	2.5 million	13.7975 billion	31 December 22:24:47.0
Homo sapiens appear	200 000	13.7998 billion	31 December 23:52:23.0
Stonehenge is built	5000	13 799 995 000 (13.799 995 billion)	31 December 23:59:48.6
telescope is invented in 1608	406	13 799 999 594 (13.799 999 billion)	31 December 23:59:59.1
first person in space, 12 April 1961	53	13 799 999 947 (13.799 999 billion)	31 December 23:59:59.88 121 ms before midnight
first person on the Moon, 21 July 1969	45	13 799 999 955 (13.799 999 billion)	31 December 23:59:59.90 103 ms before midnight
first spacecraft to land on a comet, 12 November 2014*	293 days = 0.8 years	13 799 999 999.2 (13.799 999 billion)	31 December 23:59:59.99 less than a millisecond before midnight

↑ Some key events in the history of the Universe and the times at which they occured. Note that rounding off numbers to a different number of decimal places may affect some of the calculations and give slightly different answers.
*Calculated from 1st of September 2015

→ CONCLUSION

In this set of related activities, pupils will become familiar with the idea of timelines using the exciting topic of the history of the Universe as a context. In order to complete the activities, pupils will use a variety of skills, including group work, research, calculations and finally presenting their findings to the class.

My timeline

A timeline of the Universe

Task 1: Calculate the units of time that make up one year on planet Earth

A day = ... hours

An hour = ... minutes

A minute = ... seconds

A year = ... months

..... weeks

..... days

..... hours

..... minutes

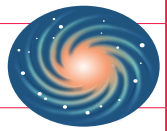
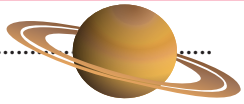
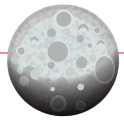
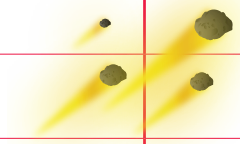
..... seconds

Task 2: Calculate how many years these units represent on the timeline. Round off to three significant figures.

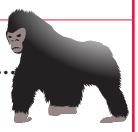
time on timeline	fraction of a year	fraction of a year converted into time in the history of the Universe (years)
1 year	1	13.8 billion
1 month	1/12	13.8/12= 1.15 billion
1 week	1/.....	.....
1 day	1/.....	.....
1 hour	1/.....	.....
1 minute	1/.....	.....
1 second	1/.....	.....

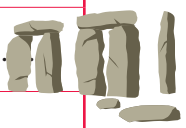
Task 3: How long after the beginning of the Universe did your event take place? Use your calculators to find out.

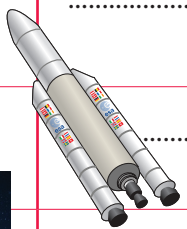
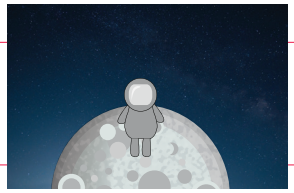
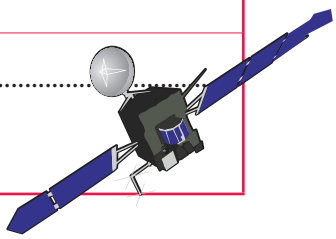
event	time since the event (years)	how many years after the beginning of the Universe?
beginning of the Universe	13.8 billion	0
birth of galaxies	13 billion	0.8 billion
birth of Sun, planets and comets	4.6 billion	.....
creation of the Moon	4.5 billion	
heavy bombardment	4 billion	
first life forms emerge	3.5 billion	.....
mammals appear on Earth	200 million	13.6 billion
extinction of dinosaurs; more mammals emerge	66 million	.....
first ancestors of man appear	2.5 million	.....
Homo sapien appears	200 000	.....
Stonehenge is built	5000	.....
telescope is invented in 1608	406	.....
first person in space, 12 April 1961	53	.....
first person on the Moon, 21 July 1969	45	.....
first spacecraft to land on a comet, 12 November 2014 (*Calculated from 1st of September 2015)	.....	.....







Task 4: Calculate where your event should go on the timeline. Where will you put your event on the timeline?

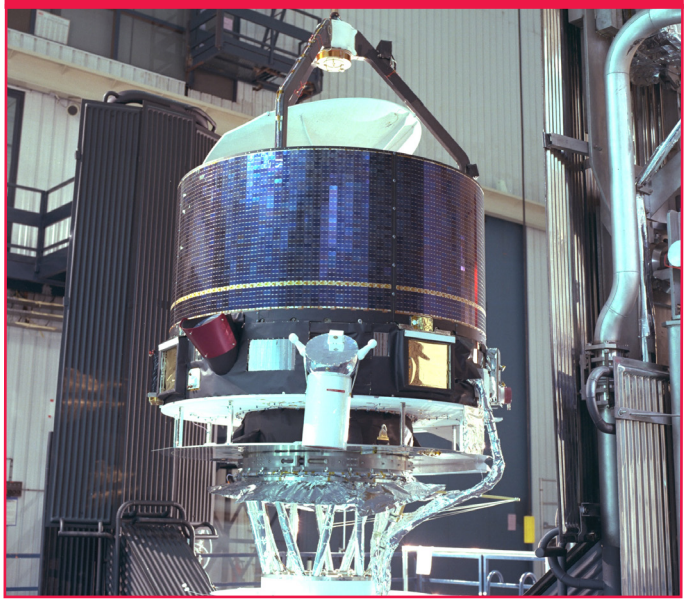
event	how many years after the beginning of the Universe?	time on timeline of the Universe
beginning of the Universe	0	1 January
birth of galaxies	0.8 billion	22 January
birth of Sun, planets and comets	.....	.....
creation of the Moon	.....	.....
heavy bombardment	.....	.....
first life forms emerge	.....	.....
mammals appear on Earth	13.6 billion	26 December 17:02:36.5
extinction of dinosaurs; more mammals emerge	.....	.....
first ancestors of man appear	.....	.....
Homo sapiens appear	.....	.....
Stonehenge is built	.....	.....
telescope is invented in 1608	.....	.....
first person in space, 12 April 1961	.....	.....
first person on the Moon, 21 July 1969	.....	.....
first spacecraft to land on a comet, 12 November 2014 (*Calculated from 1st of September 2015)	.....	.....

→ SPACE CONTEXT @ ESA

Giotto

The last time that comet 1P/Halley visited the inner Solar System was in 1986, the first time since the beginning of the Space Age. The European Space Agency's (ESA) Giotto spacecraft (Figure 5) flew past comet 1P/Halley obtaining the first ever close-up pictures of a comet nucleus (Figure 6).

Figure 5



↑ Giotto ready for the solar simulation test.

Figure 6

↑ Image of the nucleus of Comet 1P/Halley as viewed by Giotto.

Rosetta

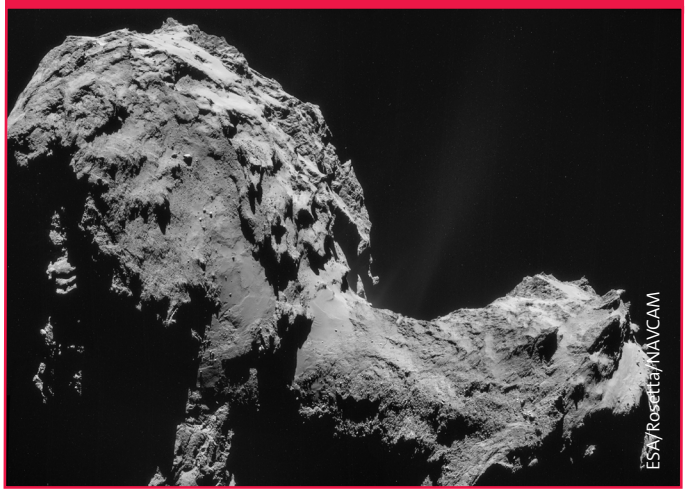
In 2004, the ESA Rosetta mission was launched on a ten year journey to meet with, and land on, comet 67P/Churyumov-Gerasimenko. This comet is a regular visitor to the inner Solar System and orbits the Sun every 6.5 years.

Rosetta's aim is to study a comet from close-up, getting much closer to comet 67P/Churyumov-Gerasimenko than Giotto got to comet 1P/Halley in 1986. As well as observing the comet from orbit, Rosetta is also carrying a small lander called Philae, which will travel to the surface of the comet.

Comets are believed to have remained mostly unchanged since our Solar System was formed 4.6 billion years ago. This means that they contain key information about the conditions in the early Solar System. Since comets contain frozen water (ice) it is thought that comets might have brought water to Earth during impacts early in the history of the Solar System. In addition, comets contain organic materials - materials containing carbon, which is essential for life. Comets may also have played an important role in the evolution of life on Earth.

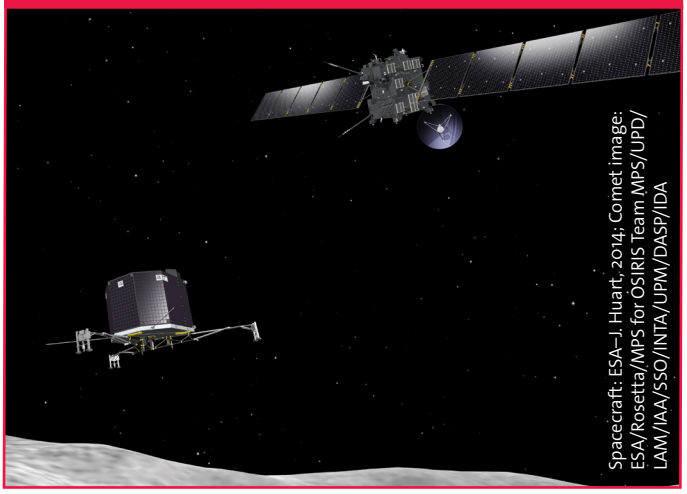
With such a long journey to make, Rosetta was put into hibernation mode in June 2011 to limit its use of power and fuel. In January 2014, Rosetta's internal 'alarm clock' carefully woke up the spacecraft in preparation for arriving at comet 67P/Churyumov-Gerasimeko on 6 August 2014. Rosetta is now studying the comet in detail. Figure 7 shows a photograph taken by Rosetta on 19 September 2014 when the spacecraft was less than 30 kilometres from the comet.

Figure 7



↑ Image of comet 67P/Churyumov-Gerasimenko using Rosetta's NAVCAM taken on 19 September 2014 when Rosetta was less than 30 kilometres from the comet.

Figure 8



↑ Artist's impression of the Rosetta spacecraft with the Philae lander on its way to the surface of comet 67P/Churyumov-Gerasimenko.

On 12 November 2014, Rosetta's Philae lander successfully touched down on the surface of the comet. This was the first time in history that such an extraordinary feat had been achieved.

As comets have very low gravity, it was planned for Philae to use dedicated ice screws, fire harpoons to attach itself to the surface and use a small thruster to push the lander into the surface of the comet, all to stop it 'bouncing off'. However, the events of the actual landing were more dramatic. For reasons not yet understood, Philae's thruster did not work and its harpoons did not fire and so the lander gently bounced along the surface several times before eventually settling in a shadowed location.

Despite this Philae managed to complete its first set of science experiments before its main battery ran out. Due to the shadowed location Philae's solar panels have not (yet) received enough sunlight to charge up its back-up battery. This means that Philae is now in hibernation and will 'sleep' until it receives more sunlight – perhaps in the first half of 2015.

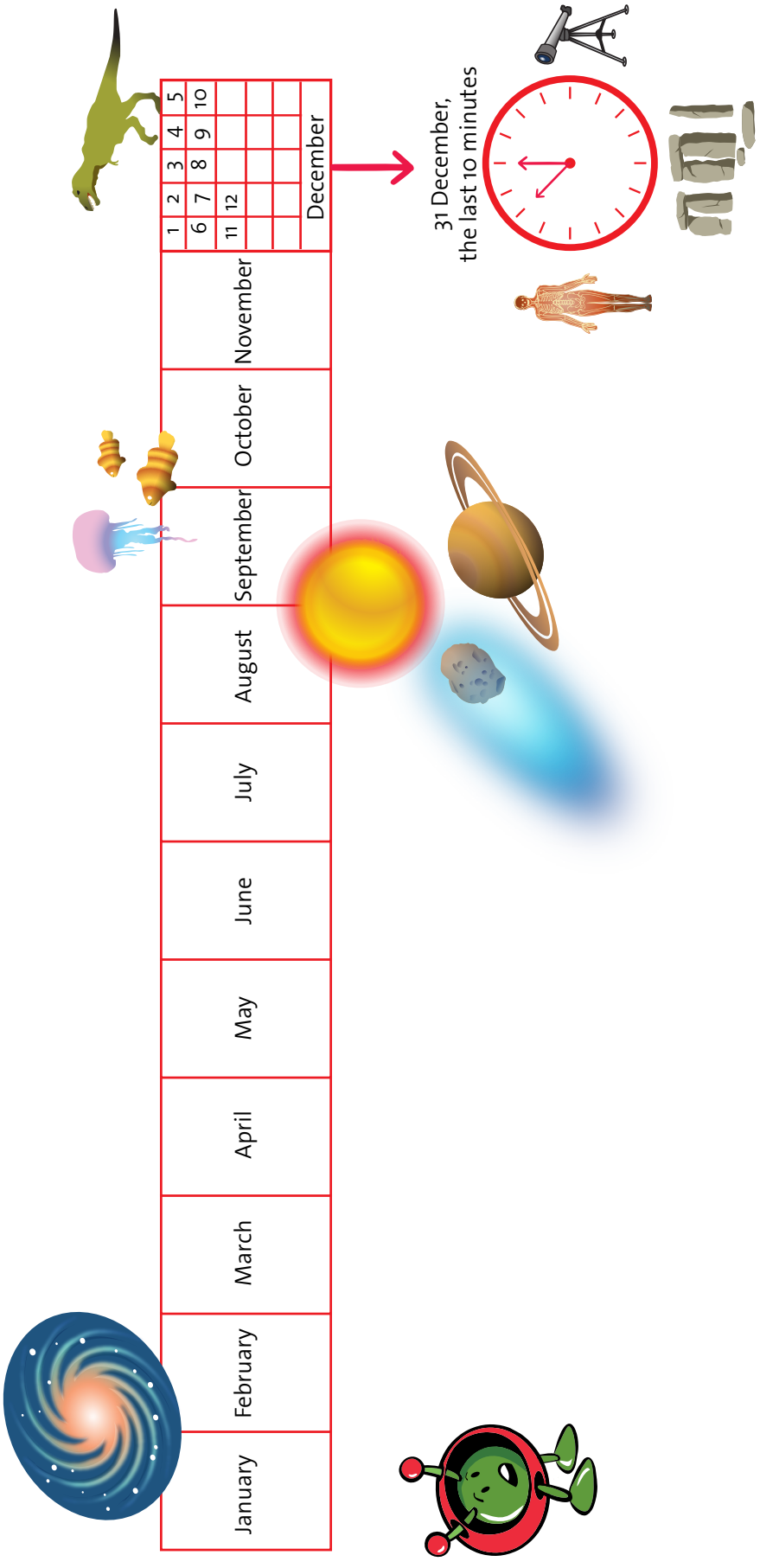
Meanwhile the Rosetta spacecraft will carry on studying the comet from orbit. Rosetta will travel towards the inner Solar System with the comet and will continue to watch from close quarters while the icy comet heats up and becomes much more active as it approaches the Sun.

Figure 9

↑ Rosetta's lander Philae is safely on the surface of Comet 67P/ Churyumov-Gerasimenko. One of the lander's three feet can be seen in the lower left corner.

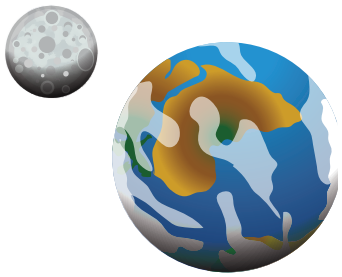
→ APPENDIX

Timeline of the Universe for class display



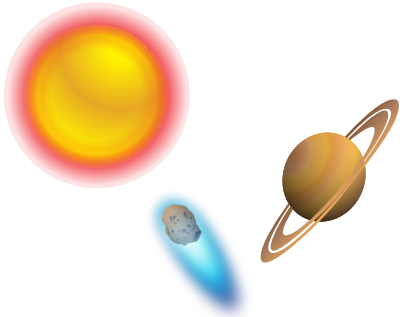
Cards for the events of the Universe

creation of the Moon

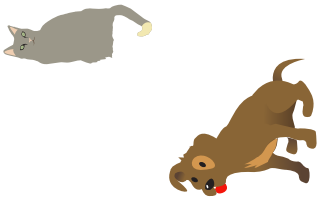


extinction of the dinosaurs

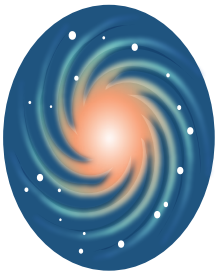
birth of Sun, planets and comets



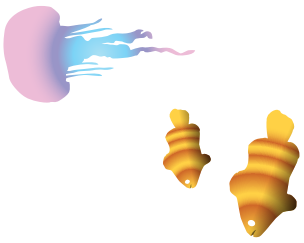
mammals appear on Earth



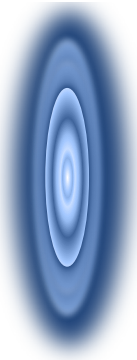
birth of galaxies



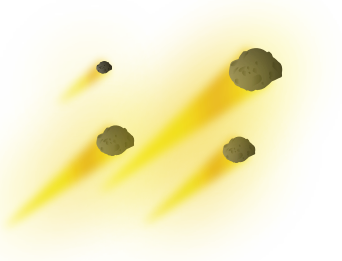
first life forms appear



beginning of the Universe

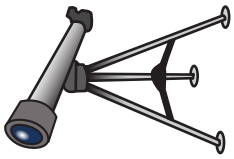


heavy bombardment

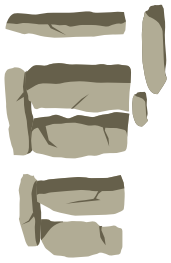


Cards for the events of the Universe

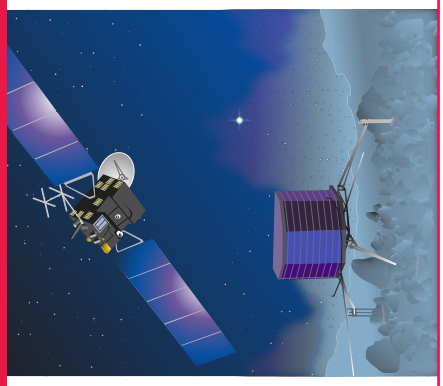
telescope is invented



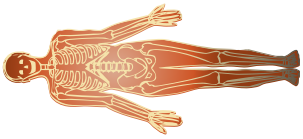
Stonehenge is built



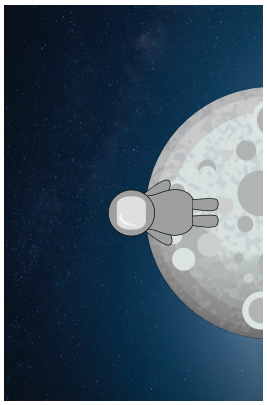
first spacecraft to land on a comet



Homo sapiens appear

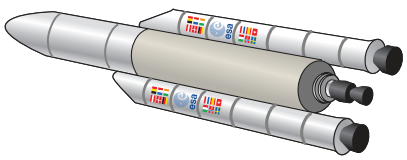


first person on the Moon



first ancestors of man appear

first person in space



Links

ESA Kids (child-friendly fun & information in several European languages)

ESA Kids homepage: www.esa.int/esaKIDSen/
Planets and moons homepage: www.esa.int/esaKIDSen/Planetsandmoons.html
The Solar System and its planets (links to articles for all of the planets):
www.esa.int/esaKIDSen/SEMF8WVLWFE_OurUniverse_0.html
Comets and meteors: www.esa.int/esaKIDSen/Cometsandmeteors.html
Rosetta: www.esa.int/esaKIDSen/SEM269WJD1E_OurUniverse_0.html
Comets: www.esa.int/esaKIDSen/SEMYC9WJD1E_OurUniverse_0.html
Asteroids: www.esa.int/esaKIDSen/SEMCM9WJD1E_OurUniverse_0.html
The Big bang: www.esa.int/esaKIDSen/SEMSZ5WJD1E_OurUniverse_0.html
Life in space: www.esa.int/esaKIDSen/LifeinSpace.html
Paxi fun book: esamultimedia.esa.int/multimedia/publications/PaxiFunBook/

Teach with space

ESA teach with Rosetta website: ww.esa.int/Teach_with_Rosetta/
ESA teach with Rosetta resources for primary school level (including teacher guides and pupil activities and colour, cut and build activities): www.esa.int/Education/Teach_with_Rosetta/Rosetta_resources_for_primary_school_level
ESA teach with space - our solar system | PR01: esamultimedia.esa.int/docs/edu/PR01_Our_Solar_System_teacher_guide_and_pupil_activities.pdf

Rosetta

ESA Rosetta mission: www.esa.int/rosetta
ESA Rosetta blog: blogs.esa.int/rosetta/
ESA Rosetta website: www.esa.int/Our_Activities/Space_Science/Rosetta
ESA Rosetta website (technical): sci.esa.int/rosetta/
Rosetta videos and animations (including Rosetta's launch, Rosetta's twelve-year journey in space, Chasing comets, Rosetta's orbit of the comet and Philae's mission at comet 67P):
www.esa.int/Education/Teach_with_Rosetta/Rosetta_videos2
Rosetta images (a selection of images taken by the Rosetta spacecraft of the comet and other Solar System objects during its journey and images of the Rosetta spacecraft and Philae lander):
www.esa.int/Education/Teach_with_Rosetta/Rosetta_images2
Rosetta mission timeline: www.esa.int/Education/Teach_with_Rosetta/Rosetta_timeline
Rosetta's Frequently Asked Questions: www.esa.int/Education/Teach_with_Rosetta/Rosetta_s_frequently_asked_questions
Where are Rosetta and the comet now?: sci.esa.int/where_is_rosetta/
Ambition the film: www.esa.int/spaceinvideos/Videos/2014/10/Ambition_the_film
Demonstrating Rosetta's Philae lander on the Space Station: www.esa.int/spaceinvideos/Videos/2014/11/Demonstrating_Rosetta_s_Philae_lander_on_the_Space_Station

Comets

ESA Kids article on comets: www.esa.int/esaKIDSen/SEMWK7THKHF_OurUniverse_0.html
ESA Giotto website: sci.esa.int/giotto/

International Space Station (ISS)

International Space Station: www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station
Where is the International Space Station?: www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/Where_is_the_International_Space_Station
Astronauts: www.esa.int/Our_Activities/Human_Spaceflight/Astronauts

Paxi animations

Who is Paxi: www.esa.int/spaceinvideos/Videos/2014/11/Who_is_Paxi
Paxi - Rosetta and comets: www.esa.int/spaceinvideos/Videos/2014/11/Paxi_-_Rosetta_and_comets
Paxi - The Solar System: www.esa.int/spaceinvideos/Videos/2015/01/Paxi_-_The_Solar_System

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