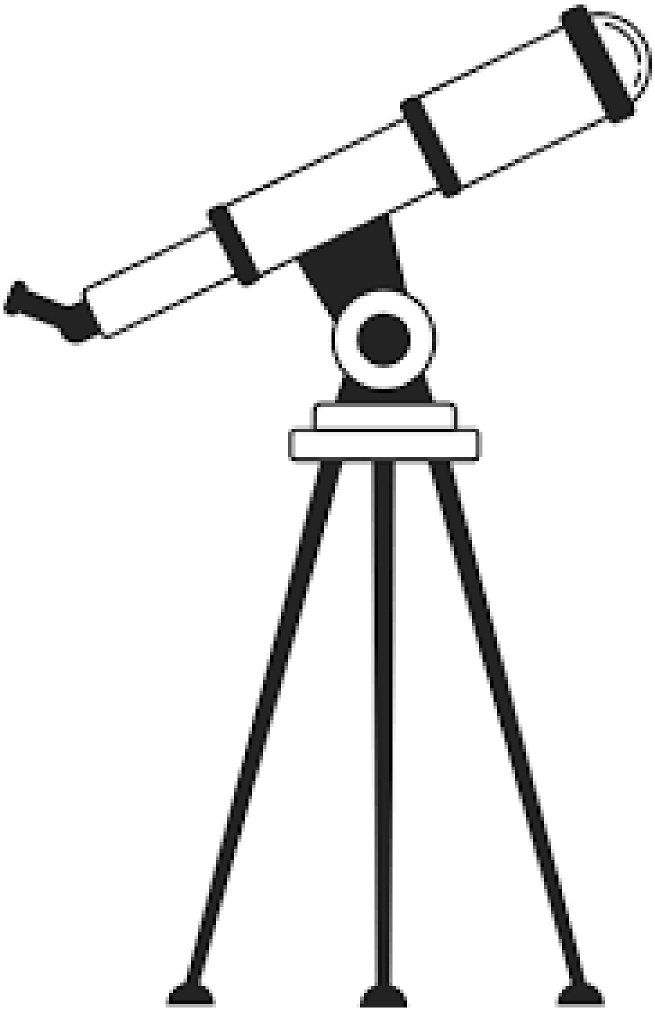
Space and beyond



L1 Telescopes

Distant stars and galaxies are too far away for us to reach. We cannot go to them to study them. So everything we know about distant stars and galaxies comes from analysing the radiation they produce.

Telescopes are devices used to observe the universe. There are many different types and some are even sited in space.

Optical telescopes observe visible light from space. Small ones allow amateurs to view the night sky relatively cheaply but there are very large optical telescopes sited around the world for professional astronomers to use. Optical telescopes on the ground have some disadvantages: They can only be used at night. They cannot be used if the weather is poor or cloudy.

Objects in the universe emit other electromagnetic radiation such as Infrared, X-rays and gamma rays. These are all blocked by the Earth's atmosphere but can be detected by telescopes placed in orbit round the Earth.

Telescopes in space can observe the whole sky and they can operate both night and day. However, they are difficult and expensive to launch and maintain. If anything goes wrong, sometimes only astronauts can repair them.

<u>Location of telescopes</u>

Major observatories on Earth are strategically placed in locations such as Chile, Hawaii, Australia, and the Canary Islands. These sites are carefully selected based on several key factors that significantly impact astronomical research.

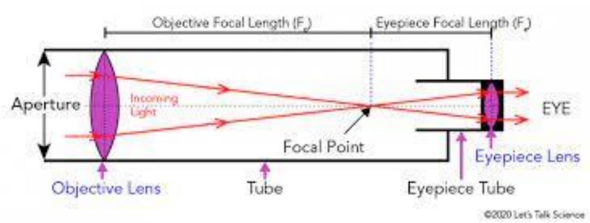
One crucial factor influencing the choice of site is high elevation. Observatories situated at high altitudes provide clearer views of the night sky due to reduced atmospheric interference. Additionally, locations with frequent cloudless nights are preferred as they ensure maximum observation time without disruptions.

Moreover, astronomers opt for sites with low atmospheric pollution and dry air to minimize distortions in their observations. Being at a sufficient distance from built-up areas helps prevent light pollution, which can obscure the visibility of celestial bodies.

<u>How do telescopes work?</u>

A telescope has two optical elements:

1. An objective lens or mirror to collect light from the object being observed and form an image of it
2. An eyepiece which produces a magnified image of the image from the objective that we can view



$$\text{magnification} = \frac{\text{focal length of objective lens}}{\text{focal length of eyepiece lens}}$$

<u>Example calculation</u>

If the focal length of the objective lens in a telescope is 800 mm and the focal length of the eyepiece lens is 20 mm, what is the magnification?

Magnification = 800 mm / 20 mm = 40x

Independent practice – Answer questions in book

1. What is a telescope?
2. What do optical telescopes observe?
3. A person goes outside with their telescope, suggest why they can't see anything.
4. What type of radiation can orbiting telescopes detect?
5. Explain the type of locations that astronomers will choose for observatories. Keywords: remote, pollution, elevation, clear.
6. What is the difference between the eyepiece lens and the objective lens?
7. If the focal length of the objective lens is 1500 mm and the focal length of the eyepiece lens is 30 mm, what is the magnification?
8. If the focal length of the objective lens is 600 mm and the focal length of the eyepiece lens is 15 mm, what is the magnification?
9. If the focal length of the objective lens is 2000 mm and the focal length of the eyepiece lens is 40 mm, what is the magnification?
10. If the focal length of the objective lens is 900 mm and the focal length of the eyepiece lens is 18 mm, what is the magnification?
11. If the focal length of the objective lens is 2500 mm and the focal length of the eyepiece lens is 50 mm, what is the magnification?
12. If the focal length of the objective lens is 700 mm and the focal length of the eyepiece lens is 14 mm, what is the magnification?
13. If the focal length of the objective lens is 1800 mm and the focal length of the eyepiece lens is 36 mm, what is the magnification?

L2 Exoplanets

Exoplanets are planets that orbit around other stars. They are very hard to see directly with telescopes as they are relatively small and very far away. They can also be hidden by the bright glare of the stars they orbit. This means we have to use other ways to detect and study these distant planets.

<u>How do we explore space?</u>

The conditions in space are hostile to life and travelling in spacecraft is difficult and expensive. Scientists are using different methods to see if there is life on planets other than the Earth. Space probes can explore other planets without needing astronauts.

<u>How can we see if there is life on other planets</u>

The Earth's atmosphere contains about 21% oxygen as a result of photosynthesis by plants and single-celled organisms. This means if we found evidence of oxygen in the atmosphere of another planet, it could mean the presence of life. It is possible to detect oxygen and other gases on other planets by studying the light reflected from planets.

It is thought possible that alien civilisations, capable of transmitting radio signals, may exist. The Search for Extra-Terrestrial Intelligence (SETI) is a programme that uses radio telescopes to look for non-natural signals coming

<u>Is it likely there is other life in the universe?</u>

- It is estimated there are up to 400 billion stars in our galaxy, the Milky Way.
- There could be 50 billion exoplanets orbiting these stars.
- If even 1% of these were earth-like there are 500 million stars in our galaxy alone capable of supporting life.
- It is estimated that there are at least as many galaxies as there are stars in our galaxy.

<u>Wobbly stars (radial velocity)</u>

- One way to search for exoplanets is to look for “wobbly” stars. A large planet orbiting a star causes the star to orbit off-centre. It is pulled to the side by gravity between the star and the planet. From a long way away, this makes the star look like it is wobbling. Only large planets can be detected this way but already hundreds of exoplanets have been discovered using this method.

<u>Transit Curve method</u>

- This can be used to detect smaller Earth like planets. Astronomers look for the drop in the brightness of a star as an exoplanet, orbiting the star, passes between it and the Earth. The dip in brightness is evidence for the exoplanet.

<u>Limiting space travel</u>

There are many factors that limit humans ability to travel in space. For example limited technology, the large distances travelled. IT is also very expensive and would have negative impacts on human health.

Independent practice

1. Why is Mars not an exoplanet?
2. Do you think it possible for humans to know the true number of exoplanets? Why or why not?
3. What is the goldilocks zone?
4. Where does the Earth's oxygen come from?
5. Why do humans look for oxygen?
6. What does the term non-natural radio signals refer to?
7. Why can only large exoplanets be observed from wobbly stars?
8. What does a drop in brightness for a star suggest?
9. Complete the sentences
    A. Space travel is expensive because….
    B. Space travel is expensive but….
    C. Space travel is expensive so…..
10. Explain what limits humans ability to travel in space.
11. What are some reasons for and against looking for exoplanets and space travel?

L3 The Big Bang and age of the universe

A light year is the distance that light is able to travel in a year. We need a scale this big because of the huge distances involved in space, and it allows for easier comparison between stars.

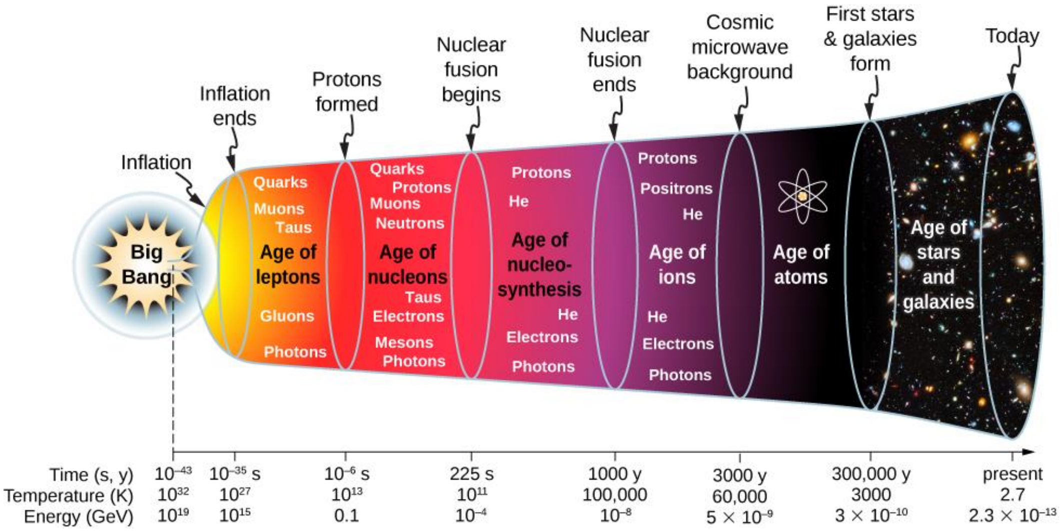
The observable universe is estimated to be about 93 billion light years in diameter. This means that the farthest objects we can see with our most advanced telescopes are about 46.5 billion light years away in each direction. It's important to note that the universe may actually be much larger than what we can observe.

The universe is constantly expanding, which means that the distance between galaxies is increasing over time. Galaxies are vast collections of stars, planets, gas, dust, and other celestial objects held together by gravity. Our own galaxy, the Milky Way, is just one of billions of galaxies in the universe. Each galaxy can contain anywhere from millions to trillions of stars.

The **Big Bang theory** is a theory of how the universe began.

It says that the ENTIRE universe and everything in it was at one point compressed into one tiny, infinitely small point. Scientists have calculated that the universe is (approximately) 13.7bn years old. That means, the big bang happened about 13.7bn years ago!

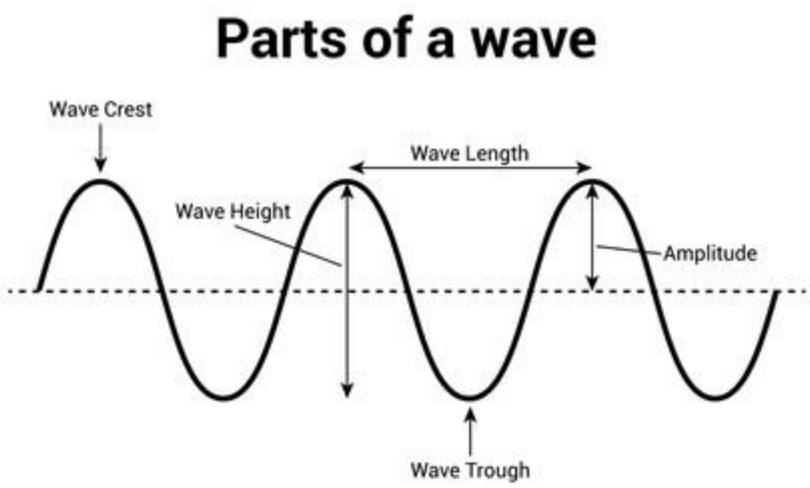
- Time zero - Before the big bang, there is no concept of time. The universe is infinitely small and infinitely hot. The forces that we know (gravity, electromagnetism etc.) do not exist.
- 1 second after big bang - 1 second after the big bang, the first particles form. It is still incredibly hot, so the only particles that can exist are **protons** and **neutrons**.
- 3 seconds after Big Bang - Protons and neutrons come together to form the nuclei of simple elements (hydrogen, helium, lithium)
- 3-10,000 years after big bang - This is known as the radiation era of the universe. There is very little matter (stuff!) and the universe is mostly full of high frequency electromagnetic radiation
- 300,000 years after big bang - This is the beginning of the era of matter domination. The temperature is now low enough for electrons to bind with nuclei and form neutral atoms.
- 300m years after big bang - The first stars are born. Groups of these stars will go on to become the earliest galaxies
- 10 billion years after big bang - Our sun and the solar system that the Earth is in is born!
- Today - The temperature from the big bang was extremely hot. As the universe gets larger, the temperature falls which is still happening today.



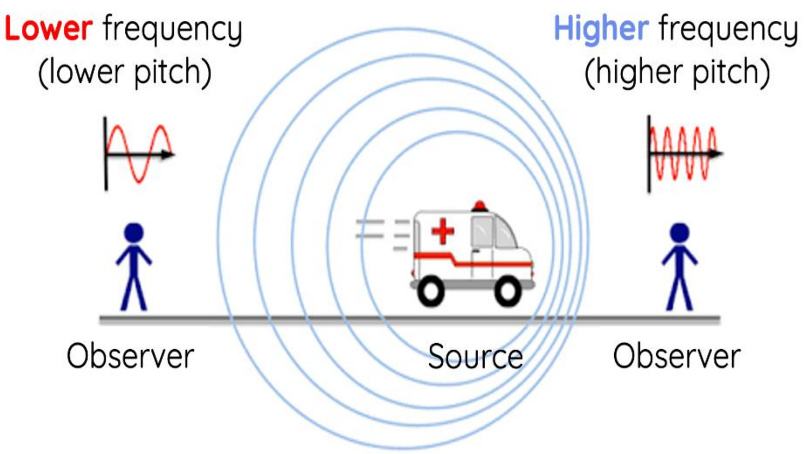
Independent practice

1. What are light years a measure of?
2. Why do we use light years to measure the size of the universe?
3. How do scientists think the universe began?
4. What were the first particles to form?
5. Which element nuclei were the first to form?
6. During the radiation era what was the universe mostly full of?
7. What was required for electrons to bind with nuclei to form neutral atoms?
8. Which formed first, stars or atoms?
9. As the universe gets larger what happens to the temperature?
10. Explain why it is called the Big Bang theory and not the simply the Big Bang.
11. Explain why the theory of the origins of the universe may change in the future.

L4 Evidence for the bigbang



The doppler effect

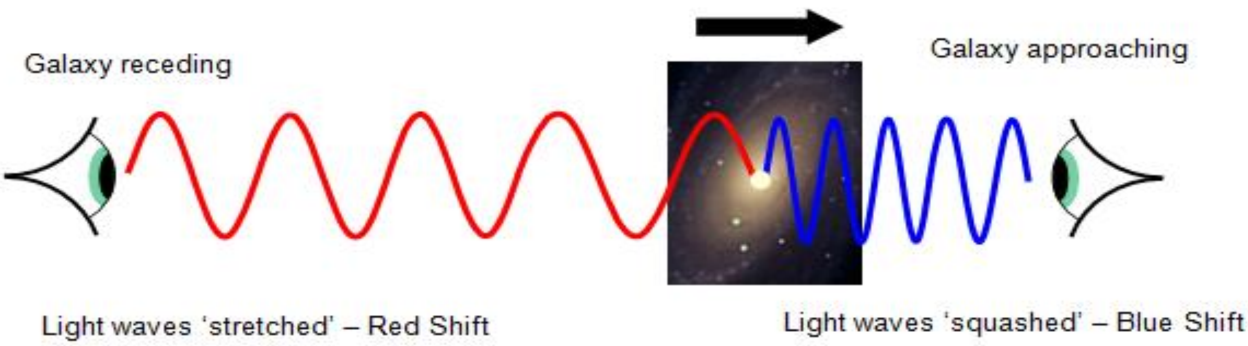


A fire engine sounds different once it has driven past you due to the doppler effect. When a fire engine is moving towards you the waves are closer together and has a shorter wavelength, making it sound more high-pitched. Once it has driven past you the waves get further apart, increasing the wavelength. This causes it to sound more low-pitched.

Since the big bang the universe has been expanding. From any point in the universe, it is moving away from us. The galaxies are moving away from us, these galaxies give out light from the stars.

Red has the longest wavelength, and violet has the shortest.

As wavelength of light increases, we call this …..REDSHIFT.. As the wavelength of light decreases, we call this …BLUESHIFT...



Independent practice

1. Complete the sentences below
    A. Distance from one point on a wave to the next is called the ___________
    B. Objects moving towards you will have a _________ wavelength
    C. Objects moving towards you will have a _________ frequency
    D. Objects moving away from you will have a _________ wavelength
    E. Objects moving away from you will have a _________ frequency
2. Explain the doppler effect using an ambulance as an example.
3. What wavelength of light is the longest?
4. What is the name for the effect where the wavelength of light increases.
5. Explain the link between wavelength and frequency.
6. What caused the universe to start expanding?
7. Why are galaxies moving away from us?
8. Explain how the red shift effect provides evidence for the big bang.
9. Suggest what evidence there Would be if the universe was getting smaller

L5 Life cycle of a star

Insert explanation.

The life cycle of a star.

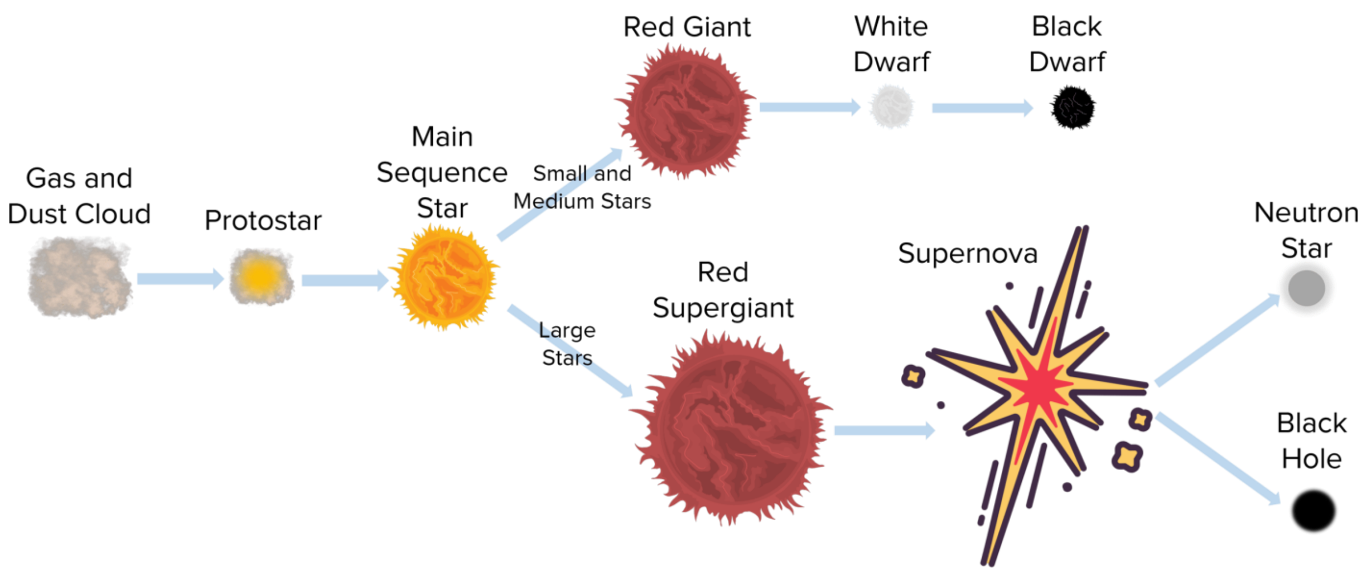
1. Clouds of gas and dust (nebula) gather due to gravity- **protostars** (baby stars) form.
2. They grow into stars like our Sun (**main sequence star**)
3. When the star runs out of hydrogen fuel it cools down and swells out, becoming a **red giant or a red super giant** depending on size of star.

Low mass Star

4. The red giant will form a **white dwarf**
5. The star will live out its days as **a black dwarf.** (Because the universe's oldest stars are only 10 billion to 20 billion years old there are no known black dwarfs—yet.)

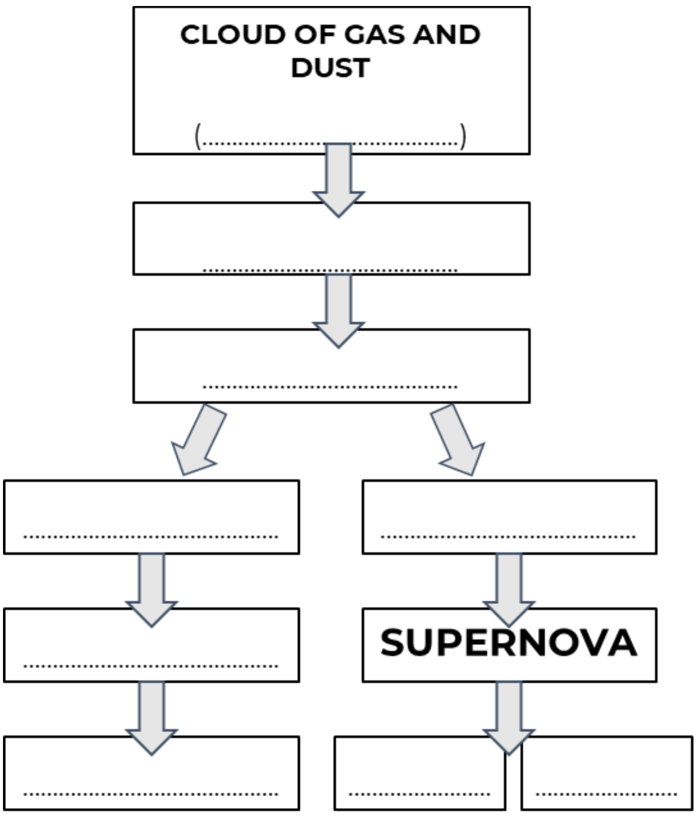
High Mass Star

4. The red super giant will explode in **a supernova**. A supernova is the largest explosions in the universe Forms all the elements heavier than iron
5. The explosion crushes the core into a **neutron star**
6. If there is enough mass a **black hole** can form



Independent practice

1. What forms a protostar?
2. Give the sequence of stages that all stars will follow.
3. Why are there no know black dwarf stars?
4. Put these stages in order for a Small Sun-sized star. BLACK DWARF/PROTOSTAR/RED GIANT/ MAIN SEQUENCE / WHITE DWARF
5. Explain why the sun will not go on to form a black hole.
6. A supernova can throw out dust and gas in the explosion. Suggest what will happen next.
7. During main sequence stage of life stars will use up the fuel inside them, once it runs out it will end that stage. Suggest if low mass or high mass stars use the fuel more quickly, and then which will stay main stage for longer.
8. Copy and complete the summary diagram for the life cycles of stars. Indicate clearly the route taken for (a) stars of similar mass to our Sun (b) stars with a much higher mass than our Sun.



9. Extended writing. Summarise the life cycle of stars of both a large mass and the life cycle of small mass stars.