Is there life beyond earth?

with Dame Dr Maggie Aderin-Pocock

Royal Institution Christmas Lectures Activities

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In this year's CHRISTMAS LECTURES from the Royal Institution (Ri) supported by CGI, Dr Dame Maggie Aderin-Pocock will take us on an epic voyage through time and space.

Scientists in 2025 detected the 'strongest hint yet' of biological activity outside our solar system on exoplanet K2-18b, sparking growing excitement about the real possibility of extraterrestrial life. In this series of lectures, Maggie sets out on a journey to find it.

Exploring Exoplanets: Design, Detect, Discover!

This is a key stage 3 worksheet learning about exoplanets and creating your own exoplanet detection experiment box.

Learning objectives

- Understand what an exoplanet is
- Discover how scientists can detect exoplanets around distant stars
- Make your own exoplanets and exoplanet detector

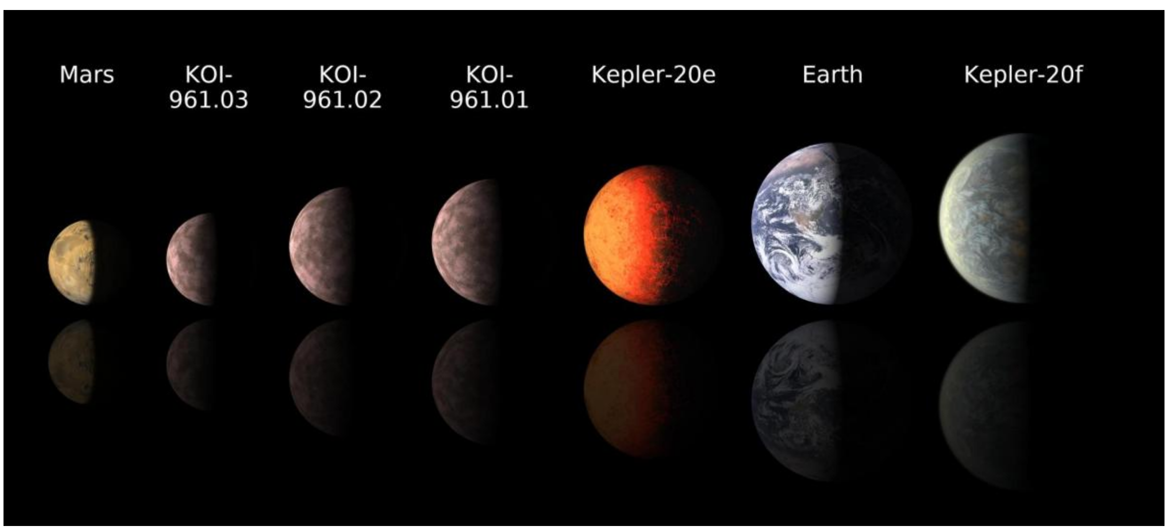
Background

An **exoplanet** is a planet that orbits around a star outside of our Solar System. Just like Earth orbits around the Sun, other planets orbit around some of the stars that you can see in the night sky. Although we can't see them with our eyes, astronomers have developed different methods to find them.

Our Sun has 8 planets – but other stars can have their own systems of planets too. So far, scientists have discovered over 5,000 exoplanets... and that's just the beginning!

These planets are very far away. The closest exoplanet, Proxima Centauri b is 4 light-years away – that's about 40 trillion kilometres! Using today's technology, it would take over 75,000 years to get there.

The Milky Way has about 100 billion stars, and most of them may have planets orbiting them. That means there could be hundreds of billions of exoplanets in our galaxy alone.



Some examples of exoplanets compared with Mars and Earth. Credit NASA

Activity 1- Telescope techniques: detecting an exoplanet

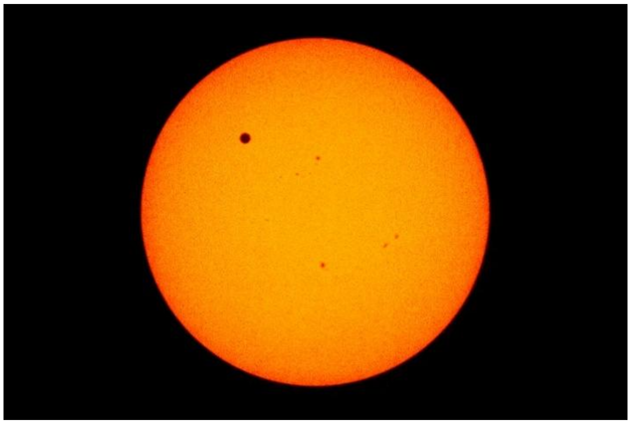
Exoplanets are far away and don't shine like stars, so astronomers detect them indirectly – by looking at what the planet does to its star.

Let's see if you can match the description of the method with the name. Draw lines matching the method to the description.

Method	Description
a. Transit method	1. Planets orbiting pulsars affect the timing of the star's regular radio pulses, which can be measured.
b. Radical Velocity method	2. A planet's gravity bends and focuses light from a distant background star, making the star appear brighter and revealing the planet.
c. Direct Imaging	3. Measures the tiny 'wobble' of a star caused by a planet's gravitational pull
d. Pulsar Timing	4. Very rarely, telescopes can photograph a planet directly by blocking out the bright light of the star
e. Gravitational microlensing	5. A planet passes transits across its star, temporarily blocking some of the light. Telescopes detect this dip.

Transit method

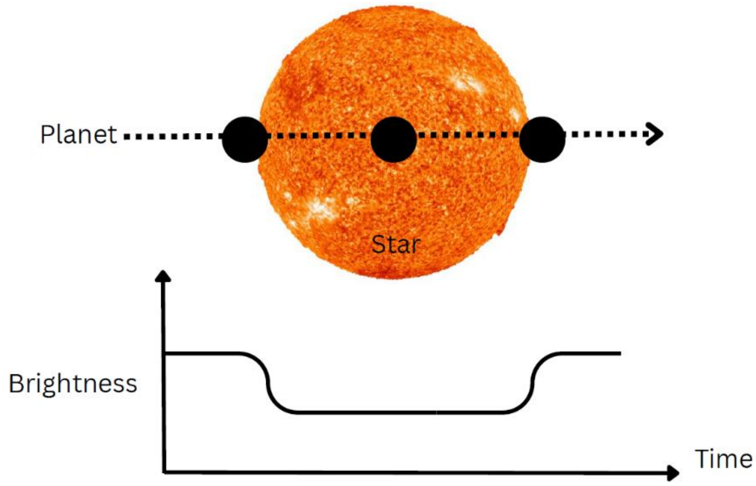
The method we are going to focus on today is the transit method. A transit is where a planet passed in front of its star, causing the star's light to dim slightly when it is observed.



Transit of Venus across our Sun. Credit NASA

Observing planetary transits dates back to 1631 when Pierre Gassendi first observed Mercury transiting the Sun. However, it wasn't until nearly 370 years later, in 1999 that astronomers detected the first exoplanet transit using the transit method. HD 209458 b is over 160 light-years away, and its detection was the first time that scientists were able to study the atmosphere of a planet outside of our solar system.

Here's a graph showing how we can use the transit method to detect an exoplanet



Since the first detection, the transit method has been used to discover many exoplanets. As of 2025, over 5,000 exoplanets have been confirmed, with the majority of these detected using the transit method. This method has identified planets, but also provided insights into their sizes, compositions, and potential habitability.

Activity 2: Working out information from exoplanet data

We are going to look at **transit depth** to learn more about exoplanets.

- **Transit depth** is the amount of light blocked by the exoplanet, expressed as a fraction or a percentage
- We can calculate the transit depth by dividing the area of the exoplanet by the area of the star – both of these can be estimated as circles

Step 1 – Finding the exoplanet radius

The transit depth can be expressed through this equation:

$$t = \frac{r^2}{R_{star}^2}$$

where t is the transit depth, r is the radius of the exoplanet, and R_{star} is the radius of the star.

We can rearrange this to find the radius of the exoplanet:

$$r = R_{star}\sqrt{t}$$

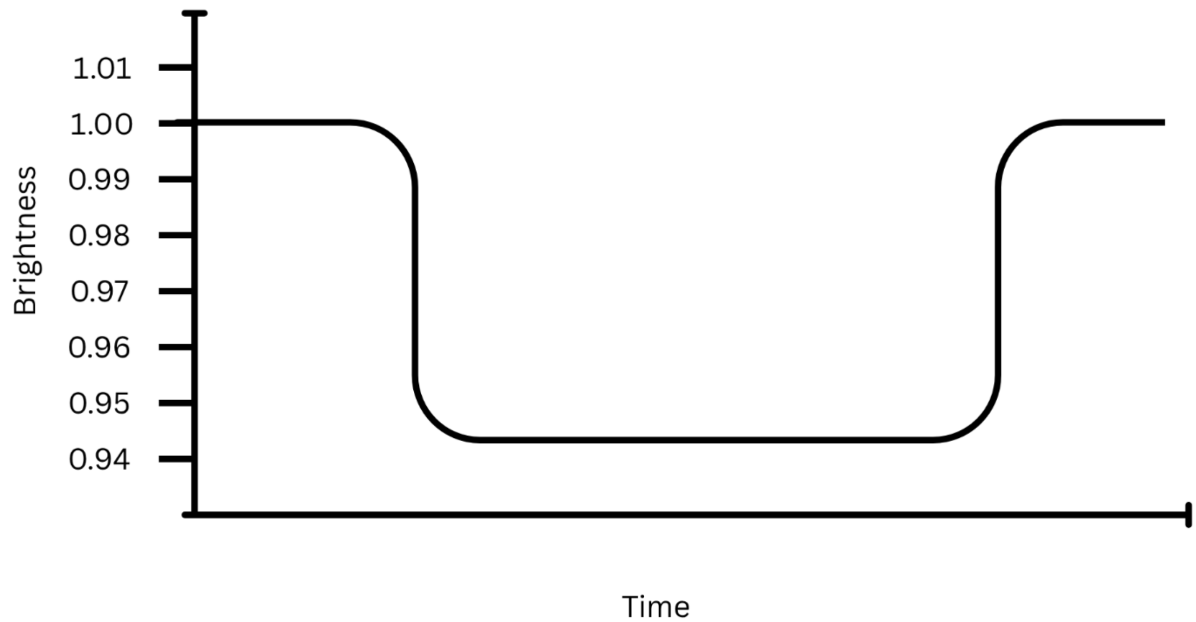
By measuring the transit depth, and knowing the star's radius astronomers can determine the size of the exoplanet.

Step 2 – Calculating the volume of the exoplanet

Once we know the radius, we can estimate the volume of the exoplanet using the formula for the volume of a sphere:

$$Volume = \frac{4}{3}\pi r^2$$

Graph 1 – the radius of this star is 700,000,000 m



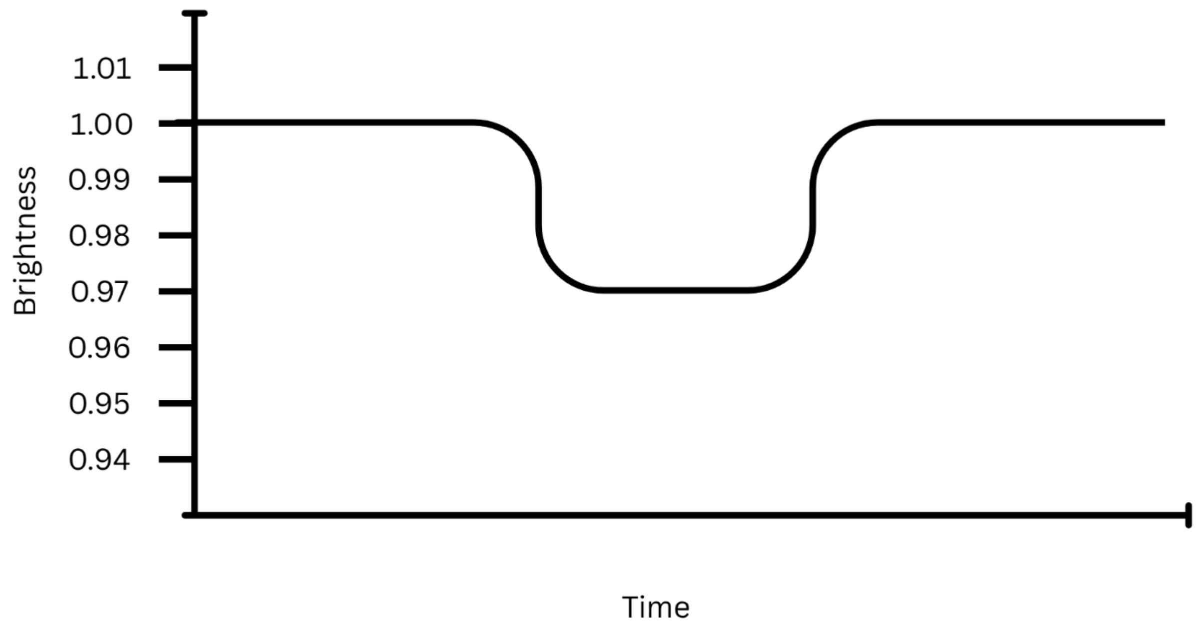
Calculate the radius of this exoplanet. Round it to the nearest 3 sf

$$r = R_{star}\sqrt{t}$$

Calculate the volume of this exoplanet. Round it to the nearest 3 sf

$$Volume = \frac{4}{3}\pi r^2$$

Graph 2 – the radius of this star is 700,000,000



Calculate the radius of this exoplanet. Round it to the nearest 3 sf

$$r = R_{star}\sqrt{t}$$

Calculate the volume of this exoplanet. Round it to the nearest 3 sf

$$Volume = \frac{4}{3}\pi\, r^2$$

There are lots of different types of exoplanets, just like our solar system has planets with different sizes!

Jupiter is our largest planet – nearly 11 times wider than the Earth. Mercury is the smallest planet in the solar system and is one third the size of the Earth. These two planets would produce different graphs if they were detected using the transit method.

Which of these exoplanets do you think is more like Jupiter?

Which one is more like Mercury?

Activity 2 – Detect your own exoplanet

Now we are going to make your own version of an exoplanet detector which will use the transit method.

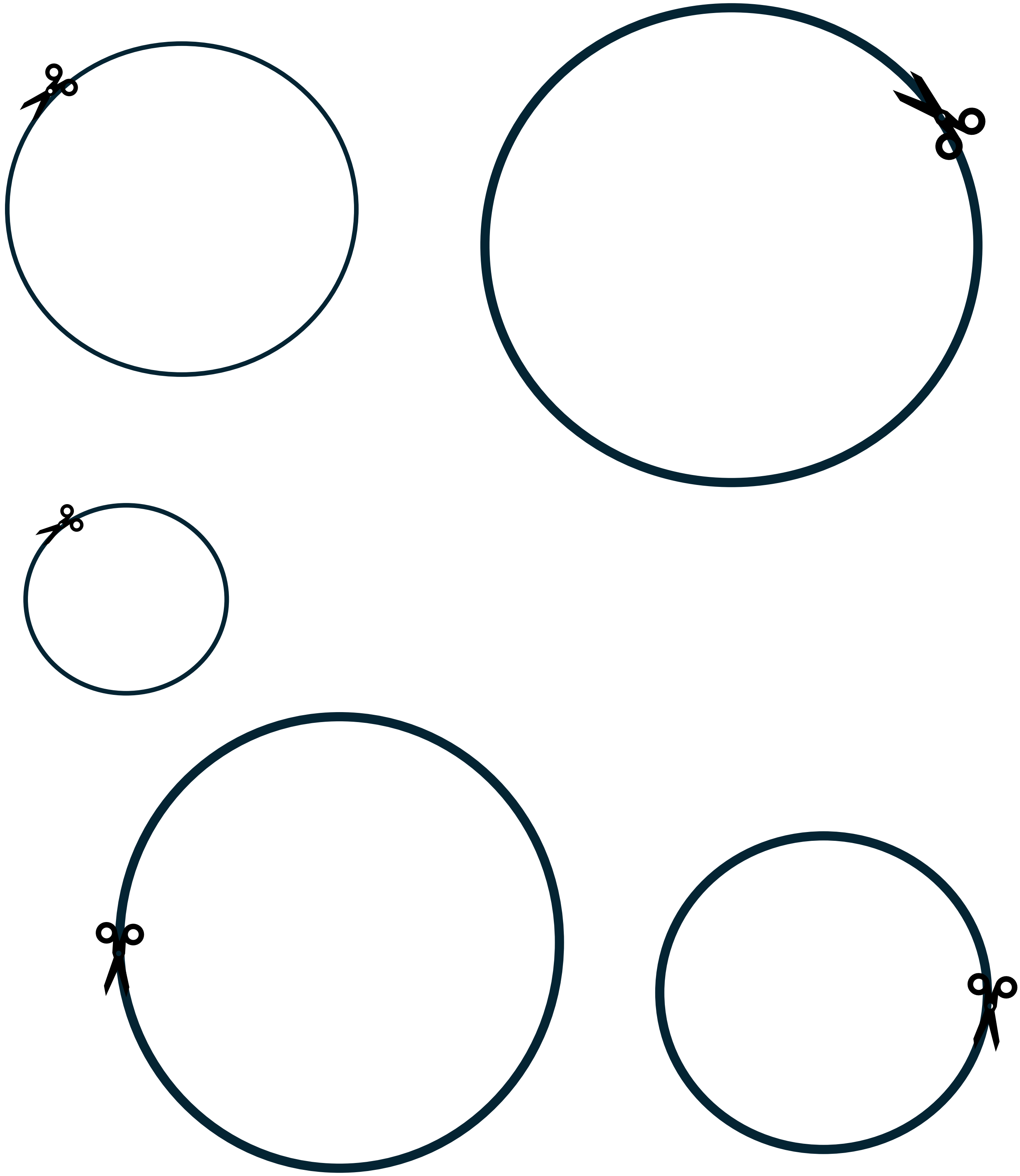
Equipment needed:

- Shoebox
- Scissors
- Pencil
- Light meter / light detector app

Method:

1. Cut out and design your exoplanets using the template on the next page
2. Download a light detector app or set up a light meter
3. Ask an adult to cut a hole in the middle of your shoebox lid. The hole should be in the middle and approximately 7 cm wide
4. Attach an exoplanet to a pencil using sticky tape
5. Move the exoplanet across the gap and see the light change. Measure the amount of light recorded when the exoplanet:
    a. Isn't blocking any light
    b. Has moved ¼ way across the star
    c. Has moved ½ way across the star
    d. Has moved ¾ across the star
6. Congratulations! You have collected data about your exoplanets – time to decide if you think life could be there

Design your own Exoplanets: Colour in and create your own Exoplanets using this template



Answer sheet

Activity 1:

A -> 5

B -> 3

C -> 4

D -> 1

E -> 2

Activity 2:

Graph 1

Radius : 171,000,000 m

Volume: 1.22×10^{17} m^3

Graph 2

Radius: 121,000,000 m

Volume: 6.16×10^{16} m^3