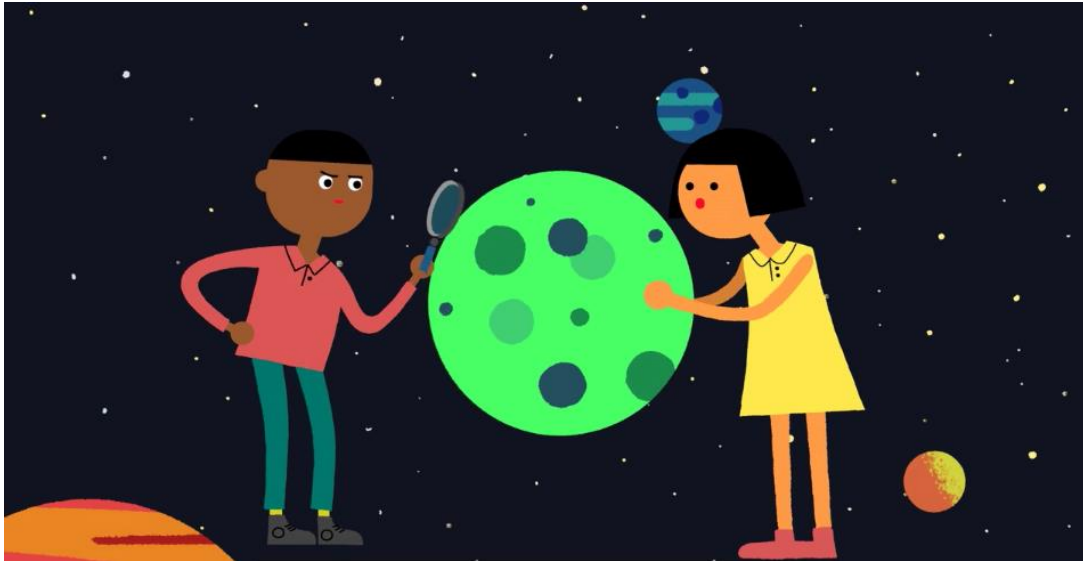# Looking for a habitable exoplanet
## Key Stage 4

Topics covered: Extrasolar planets, light curves, planetary transit, Kepler's third law

Watch the video "Are there aliens?" https://vimeo.com/122515138

The extrasolar planet Kepler-22b was discovered in 2011 by NASA's Kepler space telescope. It orbits a G-type star called Kepler-22, a star similar to the Sun but 300°C cooler. It lies 600 light-years from Earth in the constellation of Cygnus. The planet was discovered using a technique called the transit method - as the planet crosses the face of the star the intensity of starlight reaching the telescope drops – this can be seen in figure 1.
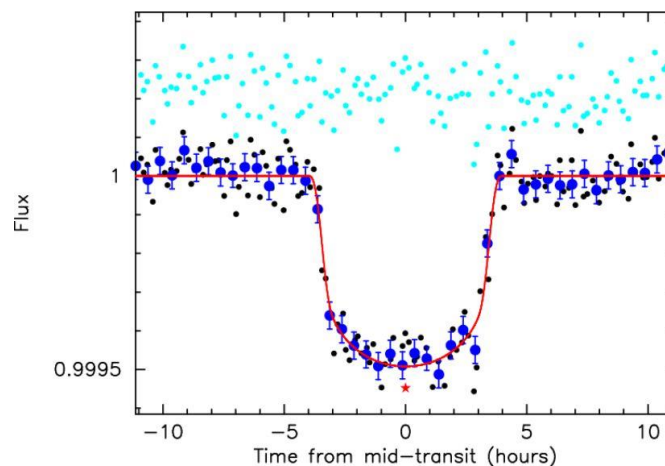
Figure 1
Credit: Borucki, W.J., et al (2011) Kepler-22b: A 2.4 Earth radius planet in the habitable zone of a sunlike star. Astrophysical Journal.

Figure 1 shows one transit over time. As the planet orbits the star more and more transits are recorded – this results in a light curve with regular dips.

1. What kind of information can you get about the planet's orbit from its light curve?

Johannes Kepler was a Danish astronomer who looked at the motions of planets around the Sun. His third law relates the orbital period of a planet to its orbital distance from the Sun:

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

Where T is orbital period in seconds; r is orbital distance in metres; M is the mass of the star in kilograms; G is the gravitational constant = 6.67 x 10^{-11} Nm^2/kg^2

2. Use Kepler's third law to calculate the orbital distance of Kepler-22b from its host star. You will need to rearrange the equation and make r (distance) the subject. T = 290 days (convert this into seconds); M = 1.93 x 10^{30} kg. Your answer for r will be in metres – convert this into kilometres.

3. Is Kepler-22b closer to its star or further away compared to the Earth from the Sun? (Earth-Sun distance = 1.5 x 10^8 km).

Taking into account its orbital distance, scientists can estimate the temperature on Kepler-22b:
- If the atmosphere is very thin (presuming the planet is made of rock), the average temperature will be −11°C.
- If it has a thick atmosphere like Venus it may have an average temperature of 460°C.
- If the atmosphere is Earth-like then the temperature could be 22 °C, perfect for liquid water and potentially life.

4. List all the properties of a planet that would be make it habitable.

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1. The time between dips gives the orbital period.
2. Orbital distance, r = 1.28 x 10^8 km (128 million km)
3. Kepler-22b is closer to its star than the Earth is to the Sun.
4. Made of rock; has an atmosphere that keeps the temperature within 0 - 100°C; not too close or too far from its star; has a magnetic field to protect it from high energy particles from its star; has a stable orbit; the star has a long lifetime (so that life can evolve); it has the right chemical compounds for life