IS ANYONE HOME?

Your guide to exoplanet habitability
(for life as we know it)

STARS

ACTIVITY

Stars release UV light, X-rays, and energetic particles, all of which can be harmful to life and strip away a planet's atmosphere.

Some stars are more active than others.

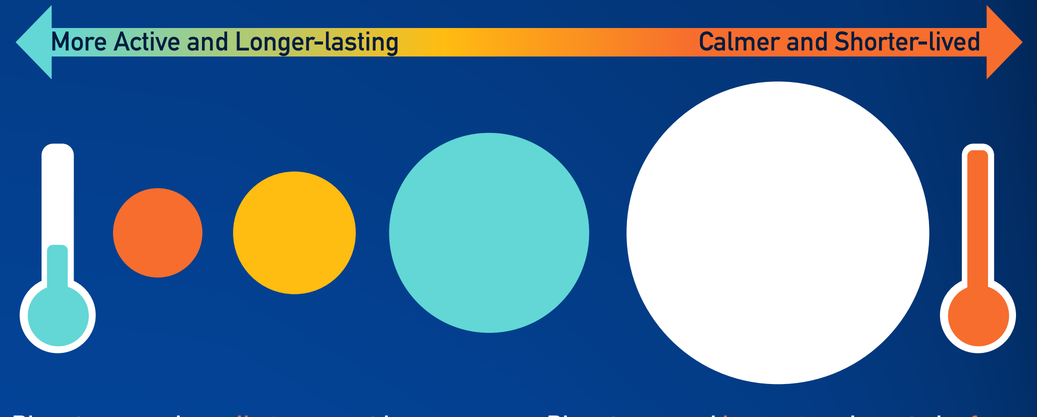
AGE

Young stars are often very active.

Old stars expand quickly, engulfing nearby planets.

SIZE AND TYPE

Some stars may be good for life, others may just be too extreme. These stellar factors determine where a habitable planet might be found and if life could survive there at all.



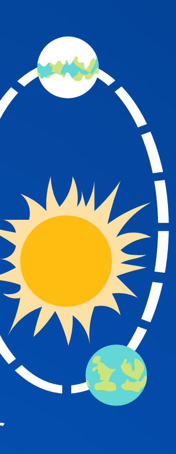
Planets around small stars must be very close to their volatile hosts. Any life could be fried by stellar activity.

Planets around large stars have to be far from their star and may not have enough time to develop life before the star dies.

PLANETS

ORBITS

How and where a planet orbits its star is very important for its habitability.



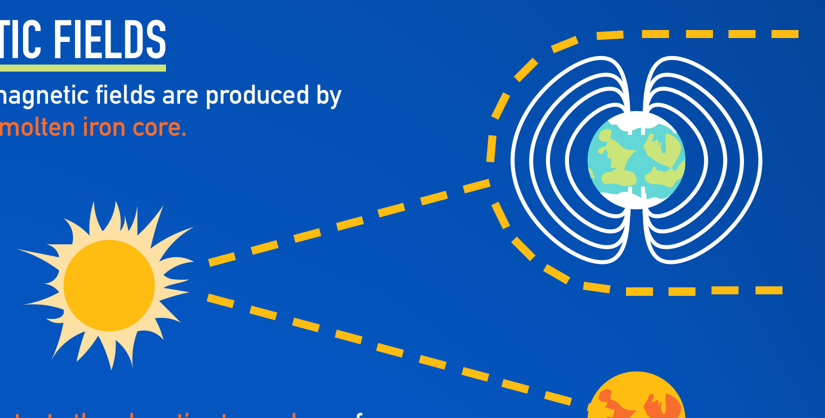
Habitable planets are likely found in the Goldilocks zone, meaning they're just the right distance from their star for liquid water to exist on the surface.

Planets in eccentric orbits — or those experiencing dramatic changes in tilt — could have extreme seasons.

Planets which orbit too closely to each other can affect the stability of each other's orbits and climates.

MAGNETIC FIELDS

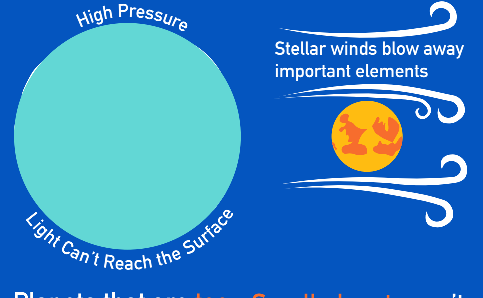
On Earth, magnetic fields are produced by a spinning molten iron core.



The field protects the planet's atmosphere from harmful activity from its star, which could impact the habitability for some forms of life.

PLANET SIZE

The size of a planet plays a large role in how much atmosphere it can hold.



Planets that are too large hide their surfaces under atmospheres much thicker than Earth's.

Small planets can't keep their stars' stellar winds from blowing away their atmospheres.

COMPOSITION

A planet must include the elements needed for life.

Water, especially liquid water, is considered the key component for life.

But too much of them could disrupt the planet's chemistry, climate or plate tectonics.

Radioactive elements help drive life-supporting processes like plate tectonics and magnetic field formation.

ATMOSPHERE

TEMPERATE CLIMATE

To keep oceans of liquid water, a planet requires a temperate climate.

This means an atmosphere that supplies the right amount of global warming.

Water, carbon dioxide, methane, clouds and particles all can impact surface temperature.

Detecting gases that are made by life is one way we could confirm a planet's habitability

WATER

ICE CAPS

As on Earth, ice caps help regulate the climate of a planet by reflecting energy from its star.

The larger the ice caps, the colder the atmosphere, meaning more ice can form.

If the caps become too large, they can lead to an extreme ice age! In response the planet will accumulate greenhouse gases, heat up and melt the ice.

ICY OCEAN WORLDS

Like Jupiter's moon Europa, exoplanets may have vast oceans hidden beneath thick layers of ice.

It's possible that life thrives in these oceans if tidal heating and radioactivity keep them warm. The ice would protect life from dangerous activity from the star.

OCEANS

Water is essential for life as we know it, because it acts as a solvent for organic chemistry, the foundation of life on Earth.

Deep oceans can protect early life from an active star. They also help stabilize the climate and transport energy across its surface.

HYDROTHERMAL VENTS

These vents are like deep sea mini-volcanoes that create nutrient-rich hot water.

They are possible places for early life to form.

TIDES

Tides on Earth are powered by the Moon and the Sun. They help stabilize the orbit and tilt of the planet, as well as slow the spin rate.

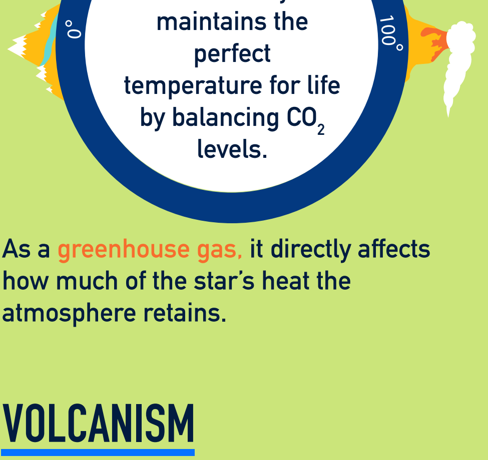
If the tidal force is too strong the planet could experience tidal locking, which would dramatically alter the planet's climate.

Tides help warm oceans, circulate nutrients all over the planet, move currents, and influence plate tectonics.

SURFACE

CARBON CYCLE FEEDBACK

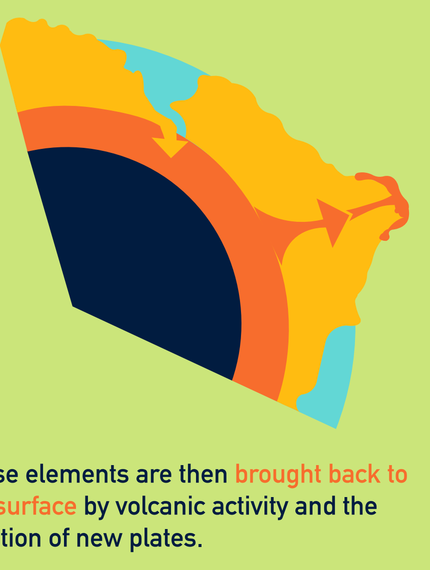
This process, which involves volcanoes, oceans, atmosphere, geology and other factors, controls how much carbon dioxide (CO_2) is in the atmosphere.



As a greenhouse gas, it directly affects how much of the star's heat the atmosphere retains.

PLATE TECTONICS

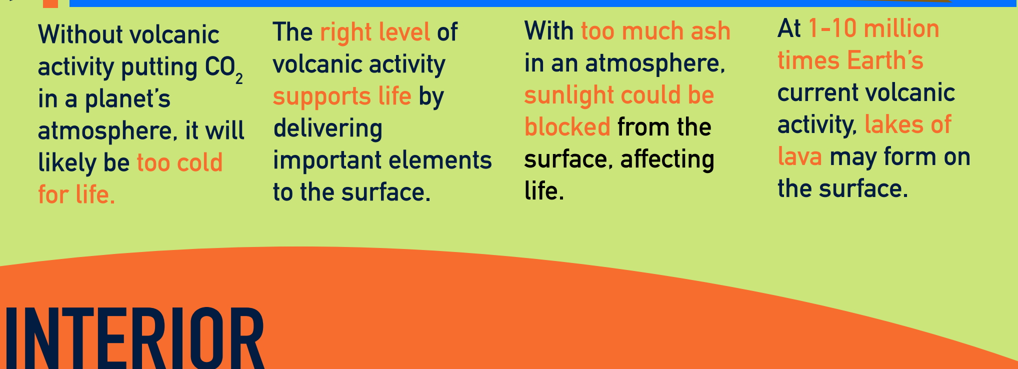
As the plates move into the planet's interior, they carry important elements that have settled on the seafloor.



These elements are then brought back to the surface by volcanic activity and the creation of new plates.

VOLCANISM

Volcanoes bring important elements like CO_2, nitrogen and water from deep within a planet to the surface in a process called mantle outgassing. Not only are these elements important for life, but as a greenhouse gas CO_2 also helps the atmosphere retain heat.



Without volcanic activity putting CO_2 in a planet's atmosphere, it will likely be too cold for life.

The right level of volcanic activity supports life by delivering important elements to the surface.

With too much ash in an atmosphere, sunlight could be blocked from the surface, affecting life.

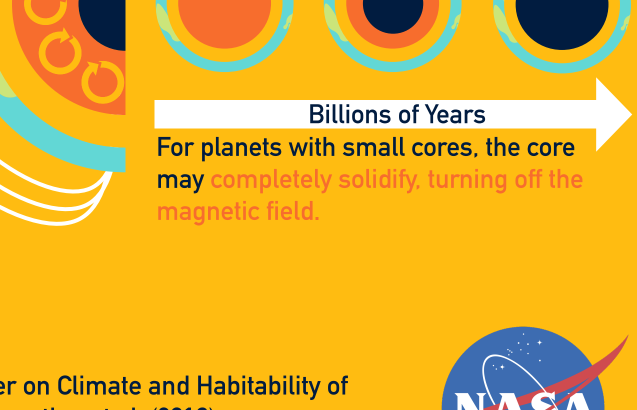
At 1-10 million times Earth's current volcanic activity, lakes of lava may form on the surface.

INTERIOR

CORE

A liquid iron core is important for protecting life on a planet's surface. The movement of molten iron generates a magnetic field, which shields the atmosphere from stellar activity.

Some planets with iron cores, like Earth, start with a completely liquid core which crystallizes over time.



For planets with small cores, the core may completely solidify, turning off the magnetic field.

SOURCES

Based on "Impact of Space Weather on Climate and Habitability of Terrestrial Type of Exoplanets," Airapetian et al. (2019).

Specific contributions from Ravi Kumar Kopparapu, Wade Henning and Joshua Schlieder.

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