EXOPLANETS
THE NEXT 20 YEARS

Researchers have found nearly 2,000 worlds beyond our Solar System. Now they hope to understand them.

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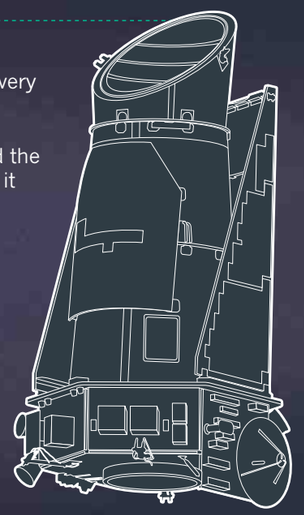
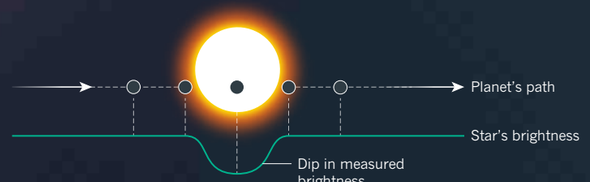
Twenty years ago this month, astronomers announced the discovery of 51 Pegasi b, the first confirmed planet orbiting a Sun-like star. The hellish gas giant orbits just beyond the searing heat of its parent star, and it opened astronomers' eyes to the astonishing range of alien worlds that exist throughout the Galaxy.

The tally of known extrasolar planets now stands at 1,978, with nearly 4,700 more candidates waiting to be confirmed. On 29 November, exoplanet researchers will gather in Hawaii to review these extreme solar systems — and map out a path for the next two decades.

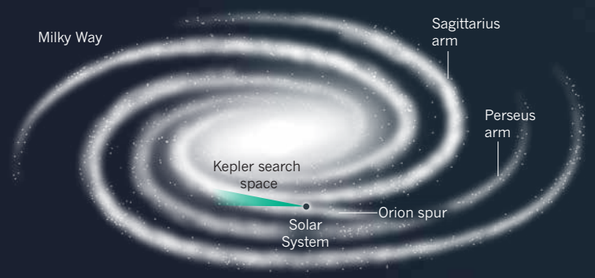


The search so far

By far the greatest haul of exoplanets has come from NASA's Kepler spacecraft (pictured above), which for four years stared at a small patch of the night sky in search of stars that dim temporarily as planets cross their faces. The main Kepler mission ended in 2013, but planet hunting continues in a revamped 'K2' mission.

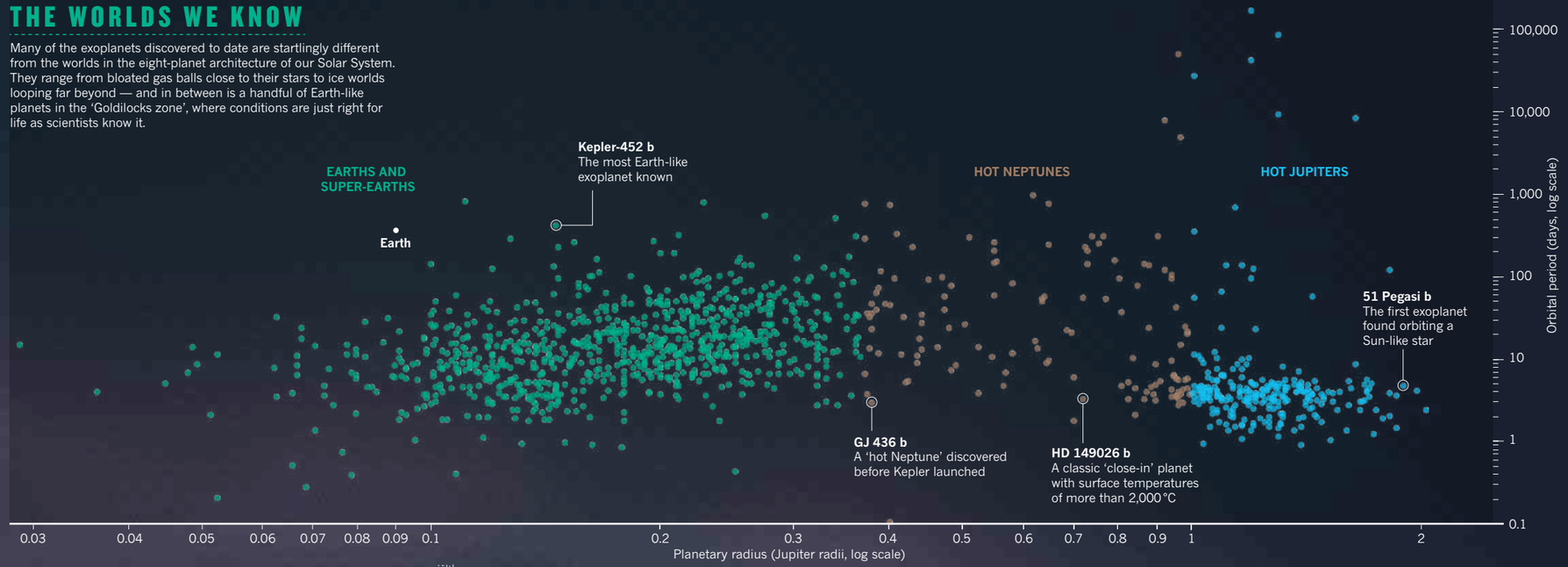


Kepler's field of view covers only about 1/400 of the night sky.



THE WORLDS WE KNOW

Many of the exoplanets discovered to date are startlingly different from the worlds in the eight-planet architecture of our Solar System. They range from bloated gas balls close to their stars to ice worlds looping far beyond — and in between is a handful of Earth-like planets in the 'Goldilocks zone', where conditions are just right for life as scientists know it.



DATA FOR PLANETS SCATTERPLOT: EXOPLANET.EU; KEPLER PICTURE: REDRAWN FROM NASA IMAGE

THE NEXT FRONTIER

Astronomers now have to figure out what to do with this bonanza of planet discoveries. The research goals for the next two decades include gathering data on what the planets actually look like, from the clouds in their atmospheres to the conditions on their surfaces.

What's next?

GEMINI PLANET IMAGER
This mission is teasing out the heat of planets from that of their host stars, allowing direct measurements of characteristics such as mass, temperature and atmospheric composition.

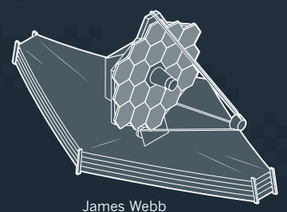
NEXT-GENERATION TRANSIT SURVEY
An ongoing project to search for exoplanets in Southern Hemisphere skies.

TRANSITING EXOPLANET SURVEY SATELLITE
The spacecraft, set to launch in 2017, will search for rocky worlds around nearby bright stars. Astronomers can then follow up the finds using ground-based telescopes.

JAMES WEBB SPACE TELESCOPE
Targeted for a 2018 launch, the telescope will measure planetary atmospheres in infrared wavelengths to probe their chemical compositions.

PLATO
The space observatory, set to begin operating in 2024, will search for Earth-like worlds in the habitable zones of up to 1 million stars.

Transiting Exoplanet Survey Satellite



James Webb Space Telescope

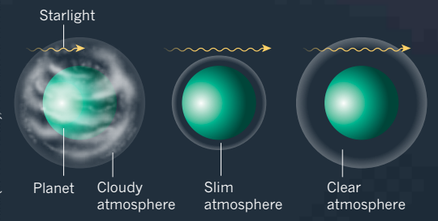
SPECTRA: D. DEMING *ET AL. ASTROPHYS. J.* **774**, 95–112 (2013). CC-BY-3.0.
HABITABILITY PLOT: R. BARNES, V.S. MEADOWS & N. EVANS *ASTROPHYS. J.* (IN THE PRESS); PREPRINT AT HTTP://ARXIV.ORG/ABS/1509.08922

How many are there?

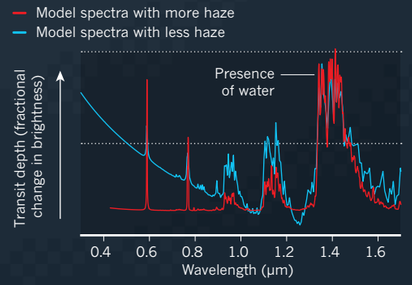
Untold numbers of exoplanets remain undiscovered, but astronomers are starting to get a better handle on the fraction of Earth-sized planets that might contain liquid water. The most common stars in the Galaxy are M dwarfs, which are smaller and cooler than the Sun; scientists estimate that there is up to one Earth-sized planet for every two M dwarfs. A fraction of those planets might be habitable.

What do they look like?

The newest frontier is probing exoplanet atmospheres, looking at what changes as a planet slips on and off the face of its star (as seen from Earth).

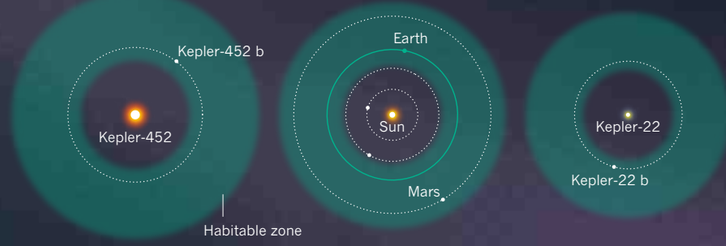


Chemical analyses of how the starlight is absorbed reveals compounds such as water in the cloudy skies of distant exoplanets.



Are they habitable?

The most intriguing planets lie in the habitable zones of their stars, where temperatures allow liquid water to exist on the planet's surface. The placement and width of the habitable zone varies depending on how bright the host star is; the dimmer the star, the closer the planet must be to lie in the habitable zone.



So, is there life?

Maybe. Now the question is how to decide which of the potentially thousands of exoplanets to pursue further. Researchers recently devised a 'habitability index' that shows which planets are most likely to have liquid water on their surface. The index can be compared against other measures — such as the amount of starlight received by the planet — to explore which planets might be worth targeting first for searches for extraterrestrial life.