In 1543, Polish astronomer Nicolaus Copernicus published *On the Revolutions of the Heavenly Spheres*, showing that the Earth, far from being the privileged center of the universe, is just another planet orbiting the Sun. Since then, the discovery that our Sun is a typical star among the billions in the Milky Way, which in turn is but one of the billions of galaxies we observe in all directions, has strengthened the notion that our place in the universe is merely ordinary. This assumption of our cosmic mediocrity is called the Copernican principle.

But perhaps the Copernican principle is wrong. Compared to other terrestrial planets in our solar system, the Earth seems special. It alone has oceans of water, plate tectonics, and a large moon. As far as we know, it alone hosts life. Since the first detections of planets orbiting other stars in the mid-1990s, we’ve discovered hundreds of exoplanets, but none resembles the Earth. Could we and our world be unique? In the near future, this question will be answered by one of three detection methods: stellar radial velocity, planetary transits, and gravitational microlensing.

### RADIAL VELOCITY

A planet orbiting a star causes the star to “wobble” back and forth. The radial velocity method detects this wobble by examining the color of starlight. As the star moves toward an observer, its light becomes bluer; as it moves away, its light becomes redder. By analyzing these color shifts over time, the presence of planets, along with their masses and orbits, can be inferred. So far most exoplanets have been found using radial velocity measurements.

### PLANETARY TRANSITS

The transit method finds planets by looking at the total amount of light from a star over time. If a planet passes in front of its star as viewed from Earth, the star’s light slightly dims during the planet’s transit. Measuring how much the starlight diminishes reveals the planet’s diameter. Many exoplanets can be studied with both radial velocity and transits. The combined data can allow astronomers to estimate not only a planet’s size, mass, and orbit, but also its density, temperature, and atmospheric composition.

Both radial velocity and transit methods overwhelmingly favor detecting Jupiter-mass planets that orbit their stars at a fraction of the distance between Mercury and our Sun.

### REFINING THE SEARCH

The vast majority of detected exoplanets have been gas giants like Jupiter and Saturn that closely orbit their stars. But as observational data accumulate and new search projects come online, scientists have begun discerning the telltale signatures of smaller, terrestrial exoplanets several times the Earth’s mass. This graph plots the diminishing size of the smallest known exoplanets. In little more than a decade, the record has dropped over an order of magnitude. Extrapolating from this trend, astronomers should begin detecting Earth-mass exoplanets around 2011 or 2012, though this may happen much sooner.

### HABITABLE ZONES

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Life as we know it requires liquid water. If a planet orbits its star too closely, any water evaporates into steam; too far away, and water freezes into ice. The sweet spot between these extremes is the “habitable zone” (HZ). A star’s mass determines its HZ; the more massive a star is, the brighter it shines, pushing the HZ further out. Astronomers now believe the first Earth-mass exoplanet within an HZ will be found around a red dwarf, the smallest, dimmest, most numerous type of star in our galaxy. Planets in a red dwarf’s HZ orbit so closely that they should be detectable with radial velocity or transit searches.

### THE KEY QUESTIONS OF EXOPLANETS:

Do planets form around other stars? How can we detect and study them? Are there other planets like Earth?

### MICROLENSING

Gravitational microlensing is a newer technique to find exoplanets that uses effects predicted by Einstein’s theory of general relativity. Just as a magnifying glass can enlarge an image, a star’s gravitational field can bend space and magnify light in a process called microlensing. When a distant bright star aligns with a dimmer lensing star that is closer to Earth, the distant star’s light brightens. If planets orbiting the lensing star are perfectly aligned, they too will magnify the distant star’s light, allowing astronomers to estimate their mass and orbital distance. Microlensing works best for planets orbiting their stars at Earth-Sun distances or greater. Since each chance alignment only occurs once, microlensing can’t be used to closely study individual planetary systems, but rather provides a statistical sample of exoplanet populations.

### THE ISSUE: DISCOVERING HABITABLE WORLDS

Astronomers using radial velocity, transit, or microlensing searches are racing to discover the first Earth-like exoplanet. New telescopes, improved data analysis, and the realization that red dwarf stars are excellent planet-hunting targets imply that the first Earth-mass exoplanet in a “habitable zone” will be found in the next few years. If that planet transits its star, we may be able to analyze its atmosphere. If its atmosphere contains water, oxygen, carbon dioxide, and methane, we’ll have found more than a habitable world—we’ll have discovered the first credible signature of alien life.

### SOUND BITE

We have found nearly 300 exoplanets using radial velocity, transits, and microlensing, and are likely to find an Earth-mass exoplanet in the near future.