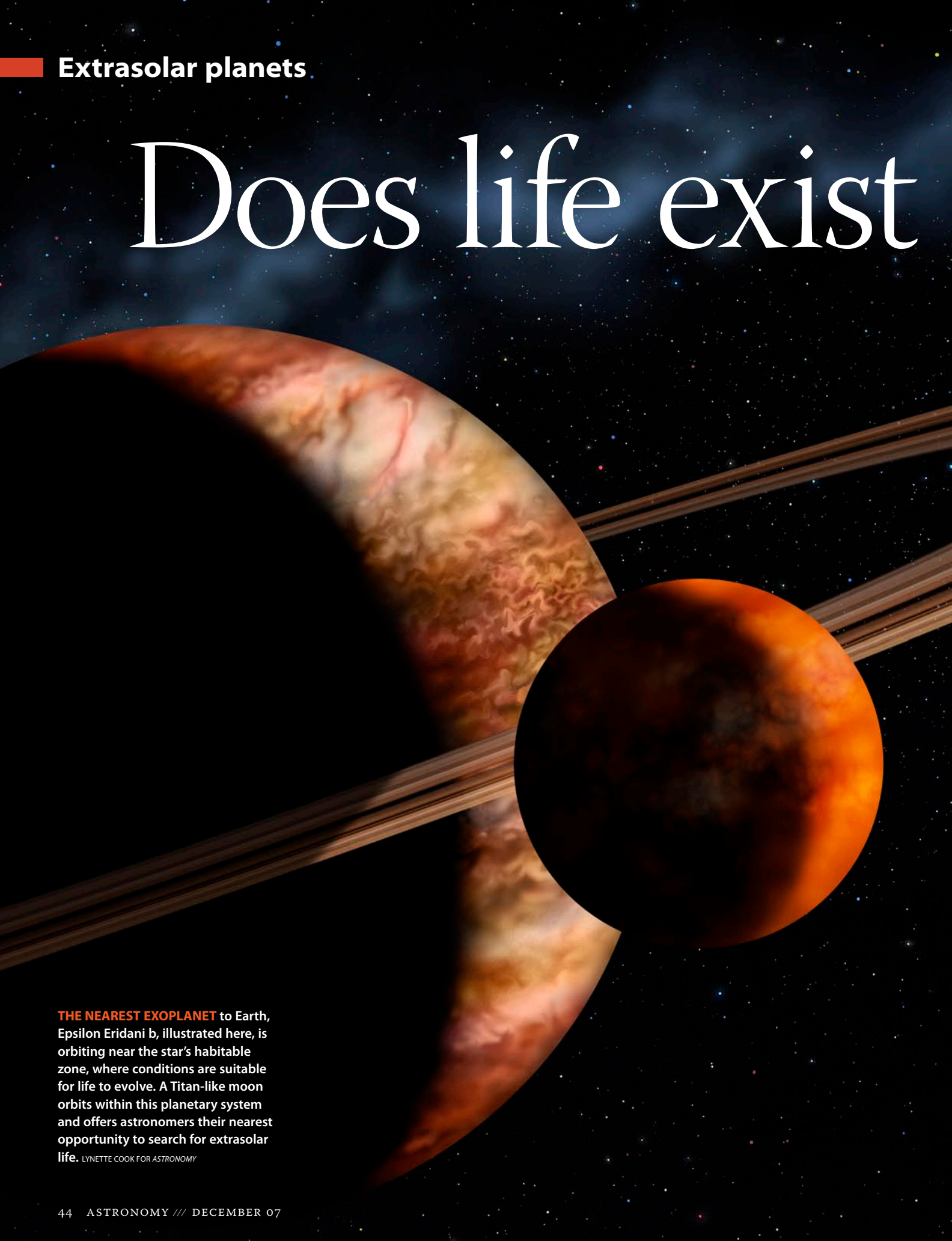


Does life exist



THE NEAREST EXOPLANET to Earth, Epsilon Eridani b, illustrated here, is orbiting near the star's habitable zone, where conditions are suitable for life to evolve. A Titan-like moon orbits within this planetary system and offers astronomers their nearest opportunity to search for extrasolar life. LYNETTE COOK FOR ASTRONOMY

on this exoplanet?

Just 10 light-years away, the Sun-like star Epsilon Eridani anchors a planetary system that may hold the seeds of life. /// BY RAY VILLARD

Could the embryonic stages of life be taking place a scant 10 light-years from Earth? Astronomers searching for new worlds where life can take hold find the planetary system surrounding the Sun-like star Epsilon Eridani intriguing. Possible moons around an exoplanet that swoops near the star's habitable zone makes Epsilon Eridani worth a closer look.

In 1960, American astronomer Frank Drake targeted Epsilon Eridani in a search for extraterrestrial intelligence. Drake aimed the 40-foot (12 meters) Green Bank radio telescope at the star and listened for transmissions from intelligent life dwelling on any orbiting planets.

Then, astronomers didn't know the star was only 800 million years old — too young for intelligent life to have evolved, assuming Earth's rate of biological evolution is typical. (The first primitive microorganisms likely began populating a youthful Earth when our Sun was only 800 million years old.)

It wasn't until 1998 that astronomers discovered a gas-giant planet (called Epsilon Eridani b) orbiting Epsilon Eridani. What's tantalizing is that life could be emerging right now on a young, comparatively massive, Titan-like moon orbiting Epsilon Eridani b — a possibility that intrigues modern day astrobiologists.

A slight wobble

Radial-velocity observations detected the star's slight wobble, which the scientists interpreted as the gravitational tug of a planet. Artie Hatzes, of Thuringia State Observatory in Germany, and co-investigators at McDonald Observatory in Texas reported finding the distant planet in 2000.

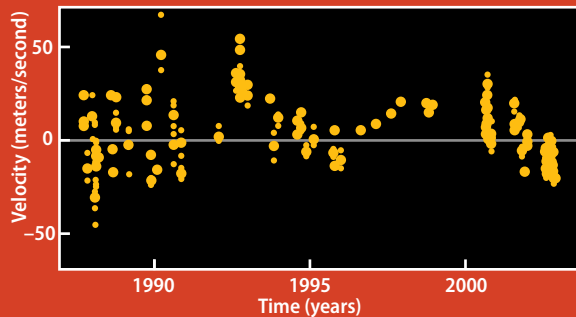
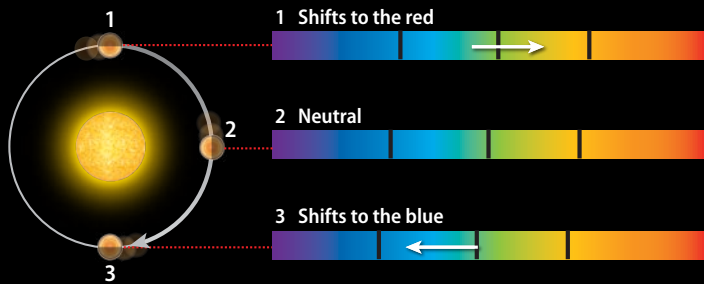
But radial-velocity measurements allow astronomers to set only a lower limit on the planet's mass. What's more, some astronomers doubted the planet existed at all. Because Epsilon Eridani is a young and active star, the suspected gravitational pull of an orbiting planet could instead be caused by gas motions on the star's surface.

More recent Hubble Space Telescope observations, made by G. Fritz Benedict and Barbara E. McArthur of McDonald Observatory, yielded a precise mass for the exoplanet. Hubble measured how the planet causes a slight displacement in the star's motion. Combined with ground-based measurements of the star's wobble, this shows the planet's orbit tilts 30° relative to Earth's. The combined Hubble and ground-based telescopic data yield a precise measurement of the planet's mass — 1.5 Jupiter-masses — and confirm the initial estimate made in 2000. Epsilon Eridani b is real,



SUN-LIKE STAR Epsilon Eridani lies about 10.5 light-years away in the constellation Eridanus. The third-closest star to Earth viewable without a telescope, Epsilon Eridani shines at 3rd magnitude. ASTRONOMY: ROEN KELLY

Radial-velocity method



DOPPLER MEASUREMENTS show Epsilon Eridani wobbles slightly. Velocity-versus-time measurements were astronomers' first indication of a planet orbiting the nearby star. *ASTRONOMY*: ROEN KELLY

ROEN KELLY, AFTER CALIFORNIA AND CARNEGIE PLANET SEARCH TEAM

and it's too small and lightweight to be a brown dwarf. These contain at least 12 Jupiter-masses.

The Hubble observations reveal that planet's orbit lies in the same plane as a vast ring of dust orbiting Epsilon Eridani. This tends to confirm the idea that planets form from a disk of dust encircling a newborn star.

Abode of life?

Astronomers concluded from radial-velocity measurements that Epsilon Eridani b is a gas giant — a fact that rules it out as a place for finding life as we know it. The behemoth's atmosphere is probably a lot like Jupiter's — mostly hydrogen and helium, with trace amounts of methane, ammonia, and other gases. The planet likely has no solid surface. Astronomers suspect its deep, turbulent atmosphere has huge convection cells that alternately cook and freeze any organic material caught up in their vertical motions.

However, potentially habitable moons could very likely circle Epsilon Eridani b. In 2006, Robin Canup and William Ward of the Southwest Research Institute in Boulder, Colorado, published research that suggests satellites are common around jovian planets. Their simulation models the growth of moons that formed within disks of dust and gas pro-

Ray Villard is the news director at the Space Telescope Science Institute in Baltimore. His most recent article for *Astronomy* was "Hubble discovers 16 exotic planets" in the January 2007 issue.

A planet's gravity tugs on its parent star, inducing a wobble in the star's motion. As the star moves closer to Earth, the star's spectral lines shift toward the blue; as the star moves away, the lines shift to the red. These changes allow astronomers to deduce a planet's minimum mass. A variation on this technique — in which a planet alters the timing of a pulsar's signal — has led to the discovery of four planets. *ASTRONOMY*: ROEN KELLY

Pros

This is now the leading method — about 90 percent of known exoplanets were found with this technique. It's great at finding heavy planets, which cause bigger changes in radial velocity.

Cons

This method yields only a minimum mass — the planet could actually be much more massive. Observations must stretch over a long period to find planets in large orbits.

duced during the final stages of a gas-giant planet's growth. The model reproduced the basic properties of Jupiter and Saturn's satellite systems.

Canup and Ward propose moons grow through a balance of two processes. First, a flow of material supplies gas and small particles to a disk orbiting the gas planet. Satellites grow inside these disks.

Next, the satellites spiral into the planet thanks to drag and gravitational interactions with the disk. In terms of the total amount of material available for making satellites, these two processes balance out. If most of the mass goes into one body, their model suggests a Mars-sized moon could form around a Jupiter-mass planet.

What's intriguing is that the two largest gas giants in the solar system host a family of chemically and geologically diverse satellites. There's Jupiter's volcanic moon Io, Europa with a likely subsurface ocean of water, and Saturn's largest moon Titan with its dense and organic-rich atmosphere.

Jupiter's four Galilean satellites and Saturn's planet-sized moon Titan show great variety. But the total mass in each satellite system is similar — one-hundredth of 1 percent of its parent planet's mass.

Earthlike Titan

Titan's makeup compares to Earth's composition before life appeared nearly 4 billion years ago. Organic compounds coat Titan's surface. The moon's dense atmosphere of nitrogen and methane cloud layers resembles early Earth's primeval chemistry. Titan's hydrological cycle of liquid methane and ethane rainfall forms lakes and rivers.

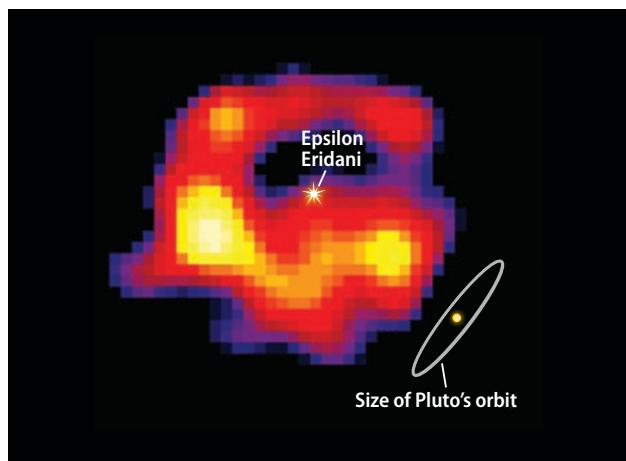
Titan is a dynamic world with complex geologic processes. Its few craters indicate its surface may be relatively young due to earthlike processes of tectonics, erosion, wind, and volcanism. NASA's Cassini spacecraft photographed a 19-mile-wide (30 km) volcano. Saturn's tidal pull may power the volcano, which continuously replenishes Titan's atmosphere with methane. "Titan is 'Earth II.' Anywhere you find complexity and energy, you want to go looking for life," says planetary astronomer Keith Noll of the Space Telescope Science Institute in Baltimore.

Occasional comet impacts on Titan may warm localized regions, causing brief chemical reactions that may be the precursors of life. But there's a problem. At 1 billion miles (1.6 billion km) from the Sun, Titan is a frigid place at nearly -300° Fahrenheit (-180° Celsius). So, many astronomers consider Titan a case of "arrested development," at least for life as we know it. Move Titan closer to the Sun, however, and astrobiology could explode across the great earthlike moon.

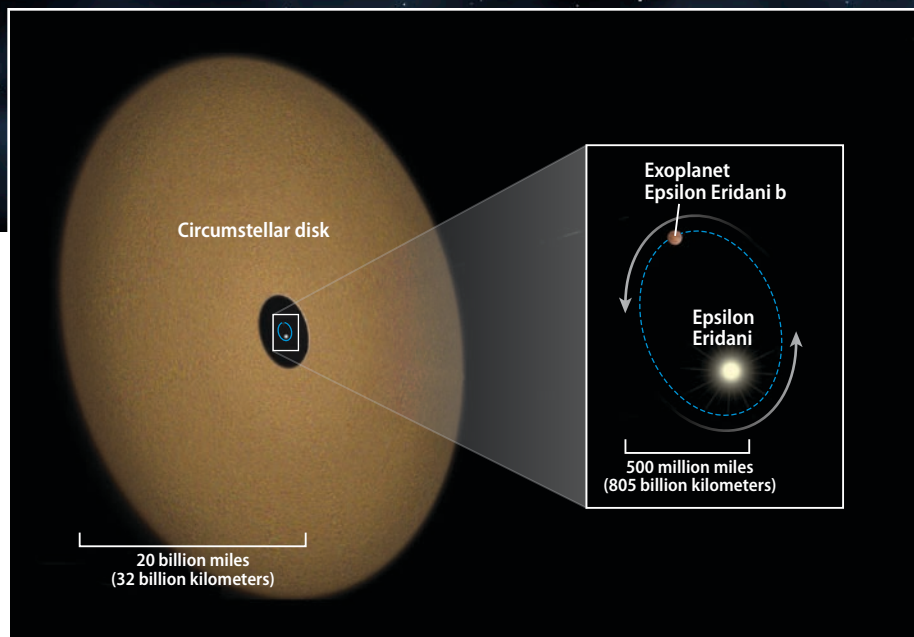
Similar processes could happen on any Titan-like world orbiting Epsilon Eridani b. Such a world would be much warmer, at least for a portion of its 7-year orbit about the star. The planet's elongated, or eccentric, orbit carries it as close to Epsilon Eridani b as Earth is from our Sun, and as far away as Jupiter.

Cold and hot

What's tantalizing is that the planet's orbit carries it close to — but not inside — Epsilon Eridani's habitable zone, the region where temperatures are warm enough for liquid water



PLUTO'S ORBIT is small compared to the disk of dust and gas surrounding Epsilon Eridani. Astronomers used the James Clerk Maxwell Telescope to capture this false-color image of the star's disk. Bright colors show where dust is most abundant. The black area near this image's center indicates no dust or gas exist there. One possible explanation is one or more exoplanets swept up the material during their formation. JCMT/UKRIT



JUPITER-LIKE EXOPLANET Epsilon Eridani b orbits its Sun-like star, Epsilon Eridani, every 6.9 Earth years. The Hubble Space Telescope shows the exoplanet orbits in the same plane as the star's circumstellar disk. This confirms planets form from disks around stars.

to remain on the surface of a planet with an atmosphere. Epsilon Eridani is a K-class star, slightly cooler than our Sun and one-quarter its brightness. This means the habitable zone would be smaller and narrower than our Sun's.

Because of the planet's eccentric orbit, any satellites would experience long, cold winters and brief, hot summers. As German astronomer Johannes Kepler (1571–1630) deduced 400 years ago, a planet moves fastest along its orbit when closest to the Sun and slowest when farthest away.

Still, a large moon might remain cozy for life over the long winter at Epsilon Eridani b. A thick atmosphere could retain heat, especially if it contains greenhouse gases like carbon dioxide and methane. Geothermal activity or tidal forces from the planet's gravity could also induce heat on this extrasolar moon. Such is the case with Jupiter's moon Io and Saturn's moon Enceladus. And temperature swings likely wouldn't affect subterranean life on this world, should it exist there.

Searching for life

Drake's 1960s search for extraterrestrial intelligence, called Project Ozma, was a bold and visionary experiment — and the first scientific search of its kind. Today's astronomers continue to search for signs of life, albeit on a smaller scale.

Epsilon Eridani b is a compelling incentive for astronomers to build ever larger telescopes to investigate the planet and perhaps one day even identify moons circling it. Over the very long term, Epsilon Eridani b will be an exciting target for the first interstellar space probes to reconnoiter. Perhaps, one day, a robotic probe having an artificial intelligence equivalent to that of a toddler could even land at Epsilon Eridani b to curiously search for the genesis of life. ■

WEB EXTRA

To learn more about astronomers' plans to visit Epsilon Eridani, visit www.Astronomy.com/toc.