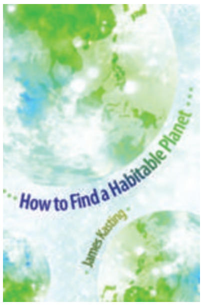
Innumerable globes like this one?



How to Find a Habitable Planet

by James Kasting

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"There is a single general space, a single vast immensity which we may freely call Void; in it are innumerable globes like this one on which we live and grow."

So wrote the Dominican friar and philosopher Giordano Bruno in *De L'infinito Universo et Mondi*, in 1584. A quarter of a century later — ten years after Bruno was burned at the stake for this and other heresies — Galileo made the first telescopic observations of other planets in our solar system. Today, more than 450 planets have been detected around other stars. Although these globes are decidedly unlike the one on which we live and grow, exoplanet astronomers are setting their sights on the detection of habitable, and possibly inhabited, worlds.

In *How to Find a Habitable Planet*, geoscientist and astrobiologist James Kasting explores the science behind this emerging phase of exoplanet discovery. A blend of biogeochemistry, planetary science and astronomy, the book examines the factors and processes that yield habitable conditions, and the methods that astronomers will use to search for habitable and inhabited worlds beyond our solar system. Kasting's wealth of first-hand experience — as a researcher focused on the evolution of planetary atmospheres and as the chair of NASA's Exoplanet Exploration Program Analysis Group — makes for authoritative writing across the full range of topics covered.

Following a brief foray into the history of thought concerning life on other planets, Kasting explores the science of habitability and the methodology of exoplanet astronomy in three well-integrated sections. The interacting factors and processes that have endowed the Earth with liquid water at the surface — the book's key metric of habitability — are discussed in the first section: 'Our Habitable Planet Earth'. The formation of the solar system and the distribution and redistribution of volatile materials provided the Earth with its current inventory of water. Tectonic activity cycles water between the lithosphere and the surface environment, and maintains the carbonate–silicate cycle — a key feedback on greenhouse warming. Solar radiation provides energy to warm the planet's surface. And the atmosphere — with a composition continually influenced by geology, biology and photochemistry — provides sufficient surface pressure and greenhouse warming to keep water in its liquid form. Kasting explains these processes in detail, individually and in their complex interactions, as he tracks them across the evolution of the Sun–Earth system.

If Earth is 'just right', Venus (too hot) and Mars (too cold) are cautionary tales for worlds aspiring to habitability. In the second section, 'Limits to Planetary Habitability', the climate histories of these worlds are used to exemplify the processes that define the inner and outer reaches of the 'continuously habitable zone'. Venus's proximity to the sun induced a runaway greenhouse effect that led to the loss of the planet's water, and the development of the hellish conditions that prevail at its surface today. Mars may have begun its history with liquid water at the surface, but the loss of its atmosphere over time eliminated the potential for a strong greenhouse effect; essential for keeping the planet warm owing to the lower levels of solar radiation it receives.

In a prelude to the book's final section we learn that early searches for inhabited exoplanets will probably focus on stars of similar mass to the Sun. Planets around low mass (dim) stars would have to maintain close orbits to intercept sufficient radiation to keep warm. As a result, they would become tidally locked — like our moon — potentially causing any volatiles to freeze out on the permanently dark side of the planet. At the opposite end of the spectrum, massive stars emit high-energy radiation that may be difficult for life to handle. They also burn out quickly, leaving little time for life to develop.

The final section, 'How to Find Another Earth', combines lessons learned in habitability with the basics of astronomy to explore the methodology of exoplanet observation. Early chapters describe current methods of observation, which have predominantly identified large worlds orbiting close to their stars. Subsequent chapters discuss the future of exoplanet research: direct imaging and spectroscopy could yield evidence of habitable conditions and even life. These final chapters bring the book full circle, linking the information accessible through astronomy to the basic stellar, orbital, planetary and atmospheric factors that determine habitability.

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The book should appeal to professional and armchair scientists alike. Material is presented as if to a class of non-specialist undergraduate scientists. A modest familiarity with maths, physics and chemistry will suffice to unlock most of the book's content, and consistent attention is paid to explaining more challenging concepts in simple terms. But the book also frequently touches on the primary literature — including Kasting's own seminal contributions to modelling planetary atmospheres — and thereby provides detail for those interested in a deeper account of the subject matter. Given the broad-ranging subject matter and up-to-date account of the state of exoplanet science, all but those closest to the field — and perhaps even many in it — will find it difficult not to learn something new.

Written in a clear and often conversational style — and infused throughout with Kasting's personal optimism regarding the existence of, and our ability to detect, habitable and inhabited worlds beyond our own — this is an informative and worthwhile read for anyone who looks to the stars and wonders if there is anybody out there. ❐

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