Planetary Dyspepsia: Finding Planets that work by understanding the planets that don’t

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In our search for life outside of our solar system, the all-important question is “Where to look?” With more than 4000 exoplanets discovered, nature has revealed a diversity of rocky worlds. From exo-Mercuries to super-Earths, the vast majority of rocky planet discovered to date are unlike anything found in our Solar System. Our current data set reveals planets with masses smaller than Mercury to ten times that of Earth. For these rocky planets, the diversity increases even more so with the relative abundances of rock-building elements in stars showing factors of two difference relative to the Sun and Earth. In the building a predictive model of the trajectory a planet can take, the Earth offers our best data set to benchmark these models. The Earth, however, is unique, even in our Solar System as it undergoes plate tectonics, underwent remelting to produce continental crust and, of course, is abundant with life. We are presented with a problem: how to reconcile the need to know where to best point our telescopes to find life, the large and decidedly non-Earth parameter space of rocky exoplanet and our best source of benchmark data for any predictive models of exoplanet evolution being exceedingly complex and unique in the Earth. Given the problem’s scale coupled with the inherent need for a cross disciplinary approach to solve it, where do we start? Underlying each of these questions is a want to search for “Earth-like,” habitable planets with temperate climates over geologic timescales. As such, knowing which planets based on their observable properties are less likely to produce these conditions tell us where not to look for life. Here I present a series of examples of rocky planet compositions, ages and formation environments that outline the parameter space of planetary conditions over which emergence should be explored. By taking an “outside-in” approach to mapping the parameters for which planets stop behaving in an Earth-like manner, many of the complexities present in our models for the Earth evolution are much less relevant. By concentrating on only the most basic aspects of a planet’s evolution, we can quickly trace the planets with trajectories that are not fruitful for expensive observational follow up time in our search for life. Indeed, by mapping those planets which are more likely to be non-Earth-like can provide us with a much more robust data set to understand the population of planets to which Earths and non-Earths belong.

