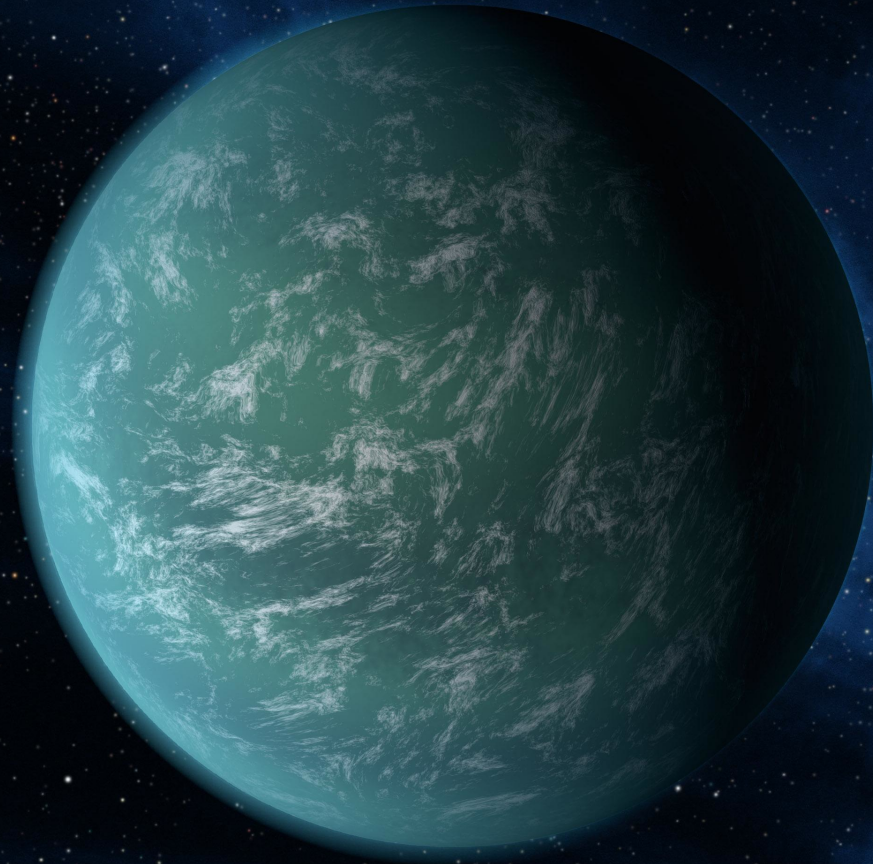# Searching for Water in Distant Worlds
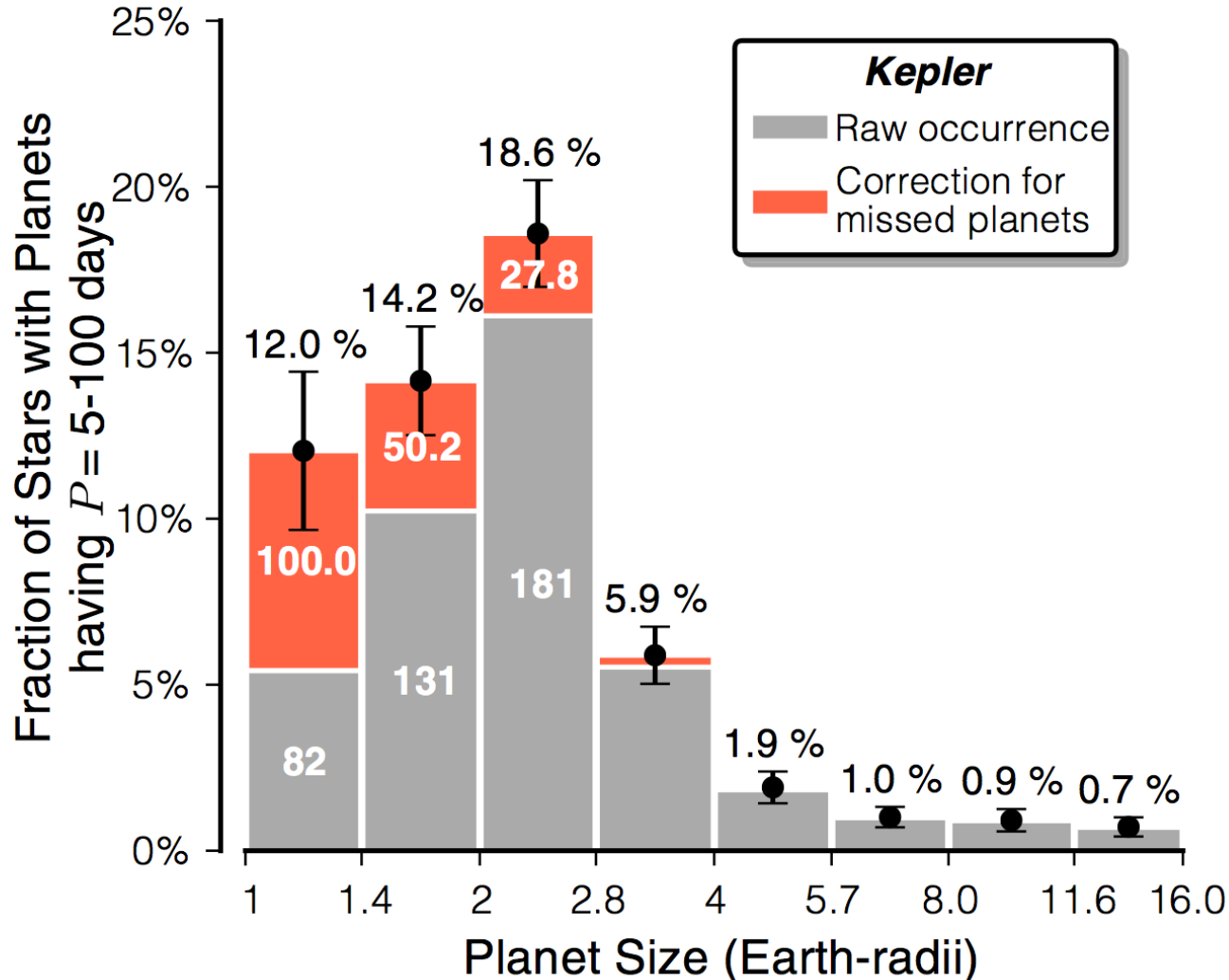
Leslie Rogers

2015 Sagan Fellow
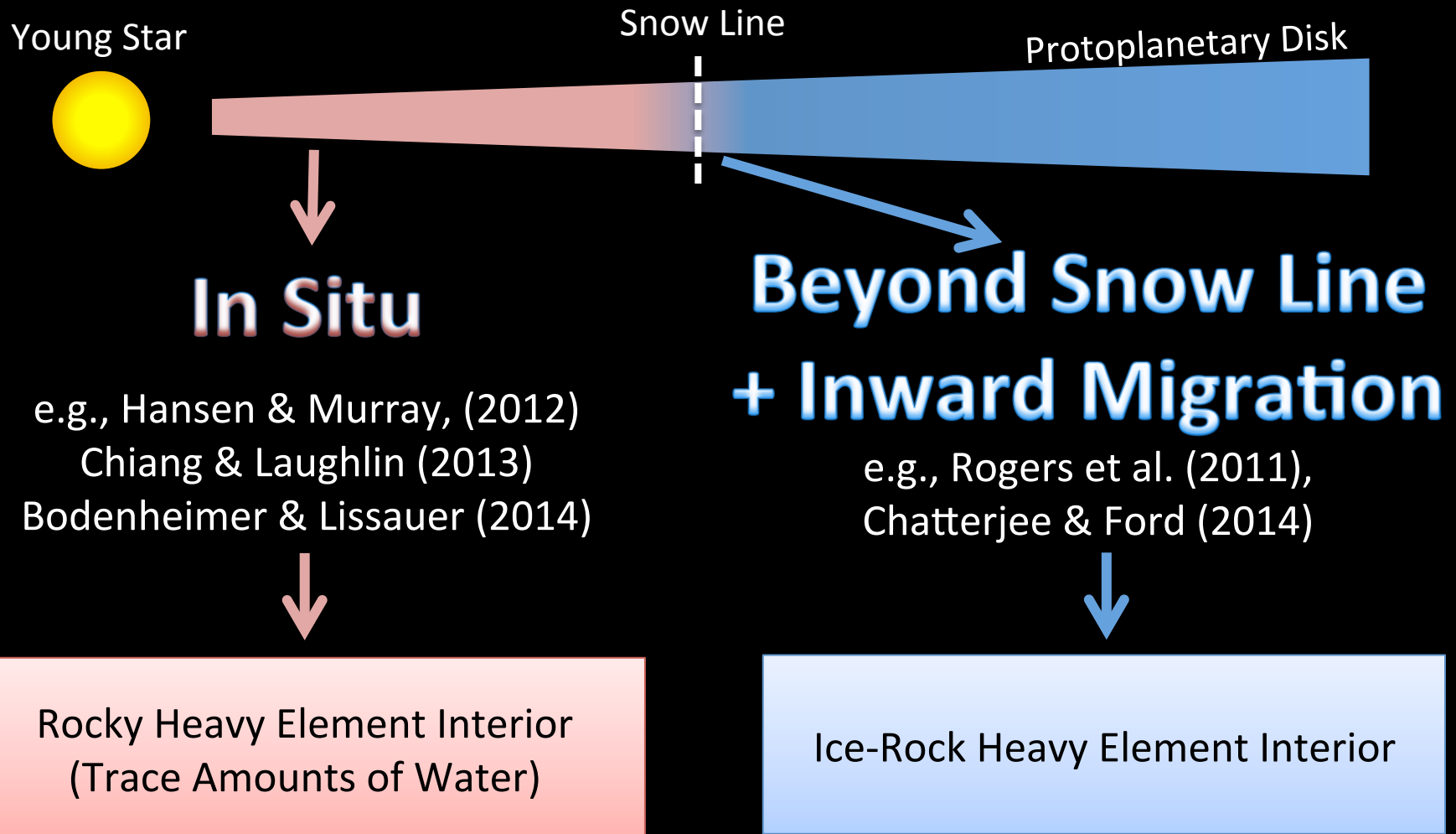
University of California at Berkeley

Close-in sub-Neptune-size planets are common!

Petigura et al. (2013) found that roughly 50% of sun-like stars host a 1 $R_\oplus$ to 4 $R_\oplus$ planet with an orbital period between 5 and 100 days.

There are competing theories for how these close-in sub-Neptune-size planets formed

Young Star

Snow Line

Protoplanetary Disk

In Situ

e.g., Hansen & Murray, (2012)
Chiang & Laughlin (2013)
Bodenheimer & Lissauer (2014)

Beyond Snow Line + Inward Migration

e.g., Rogers et al. (2011),
Chatterjee & Ford (2014)

Rocky Heavy Element Interior
(Trace Amounts of Water)

Ice-Rock Heavy Element Interior

The bulk water content of a planet is a tracer of formation location

The total water content in a planet is difficult to constrain with current observations

Challenges:

- Exoplanet transmission spectra (e.g., Madhusudhan et al., 2014; Fraine et al., 2014) only probe the very upper layers of the planets' atmospheres.

- Since water is intermediate in density between H/He and rock, the fraction of a planet's mass in water is poorly constrained by measurements of the planet's mass and radius (Adams et al., 2008; Rogers & Seager, 2010a,b).
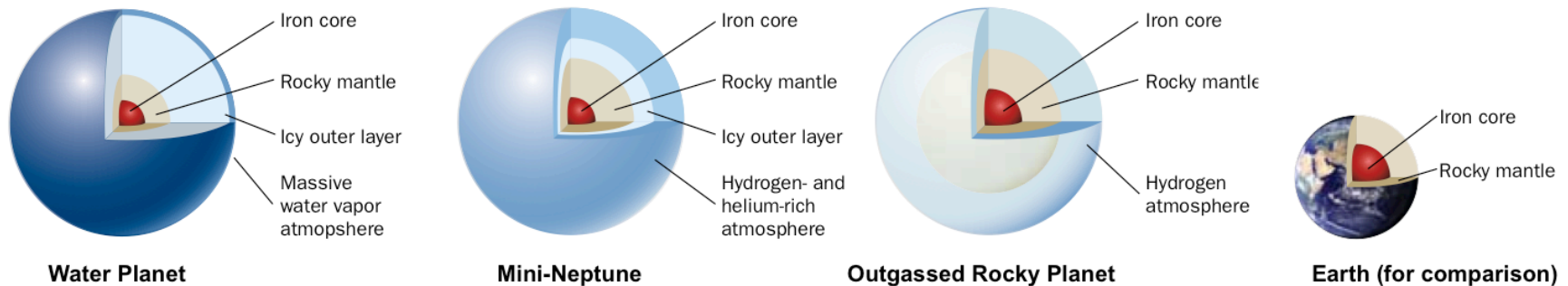

Composition scenarios for the sub-Neptune-size planet GJ1214b (6.5 $M_\oplus$, 2.7 $R_\oplus$) that are all consistent with the measured planet mass and radius. Image adapted from the January 16, 2010 edition of Science News; based on models from Rogers & Seager (2010).

Searching for Water in Distant Worlds

As a Sagan Fellow, I will explore three complementary approaches to constrain the bulk water content of distant exoplanets.

Atmospheric Spectra
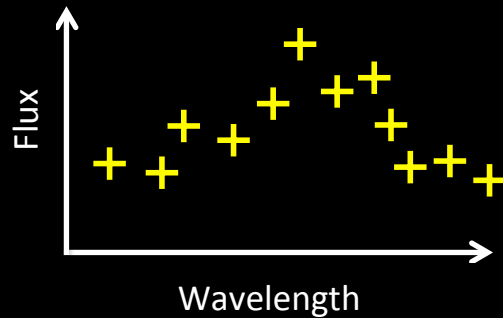
Study the planet interior-atmosphere connection to identify atmospheric abundance patterns that could be used as robust indicators of water in the deep interior.

Radio Aurora
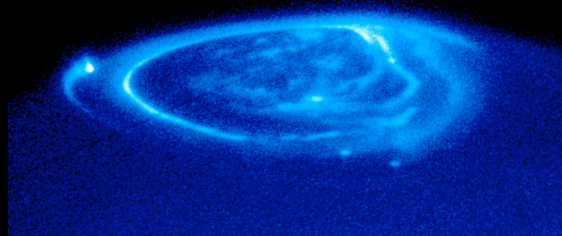
Future detection of exoplanet radio aurora may allow the measurement of exoplanet magnetic fields. The presence of a dynamo magnetic field provides additional constraints on planet interior structure and thermal evolution.

Population Statistics
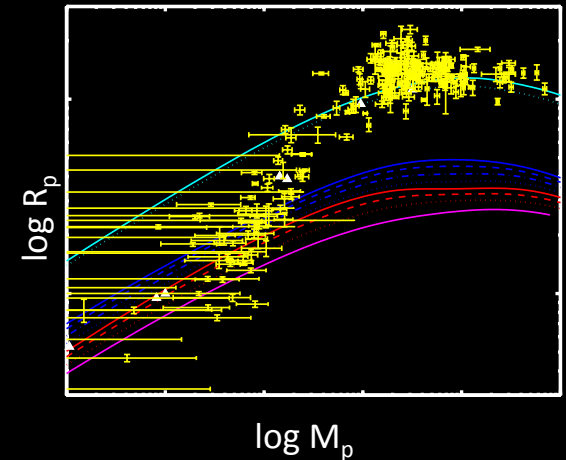
Consider large numbers of observed exoplanets to identify sub-populations and trends in the planet M_p-R_p distribution, breaking some of the degeneracies in exoplanet compositions.