How frequent is biotic life in space?

The Impact of Kepler on the likelihood of Extra-terrestrial Life

ILASOL 1/12/2013
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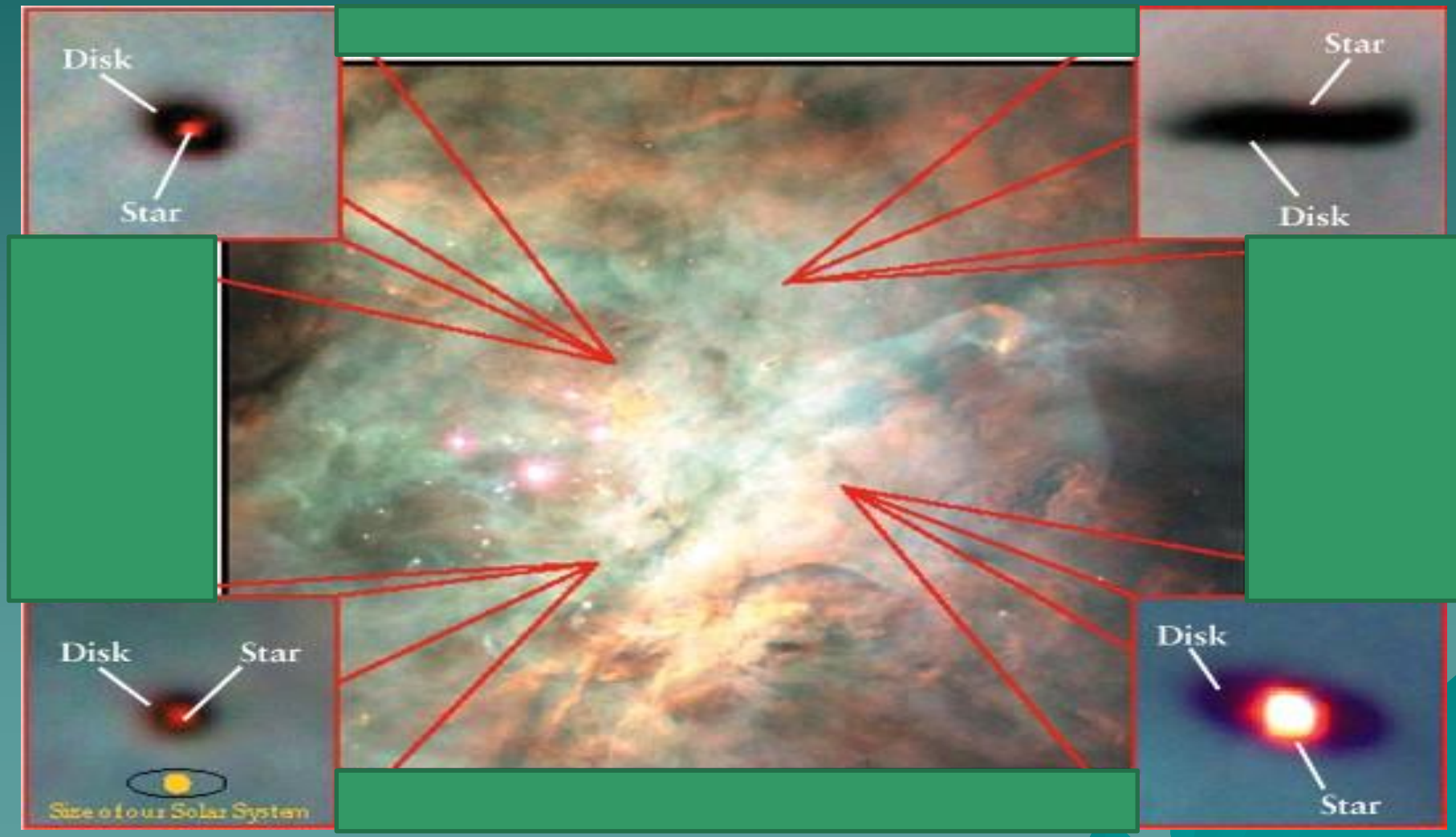
How frequent are terrestrial exo-planets?

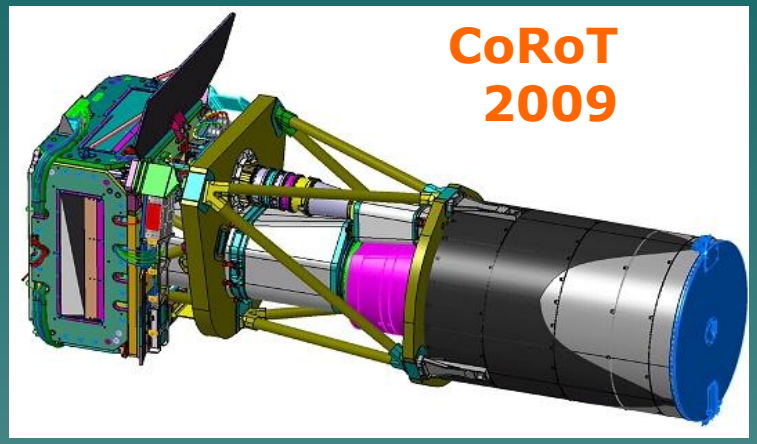
- 1990: do stars have planets?
- 2000`s: The exo-planet boom
- 2009: how about Earthlike planets?
- 2011: in the Habitable zone?
- What has changed with Kepler?

Planetary disks being born in Orion



Doppler method is biased: massive,near-sun planets

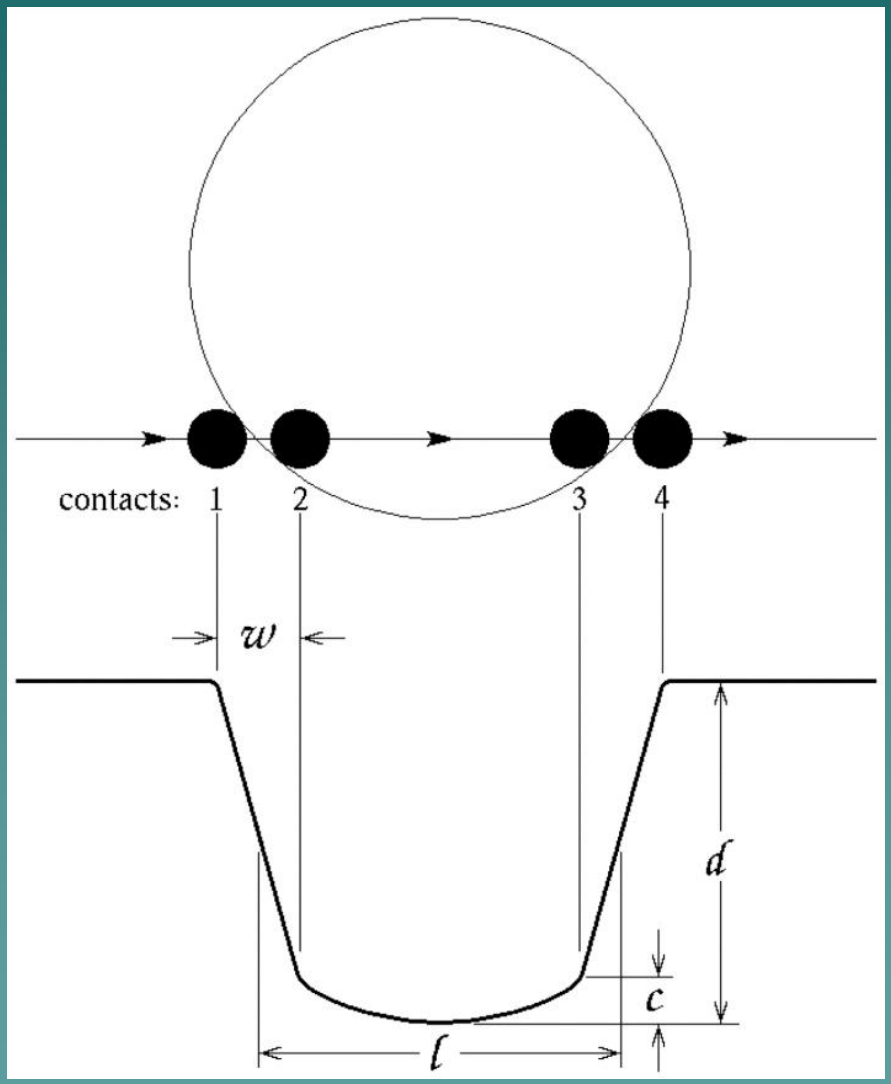
Space-telescoes for the search of Earthlike planets

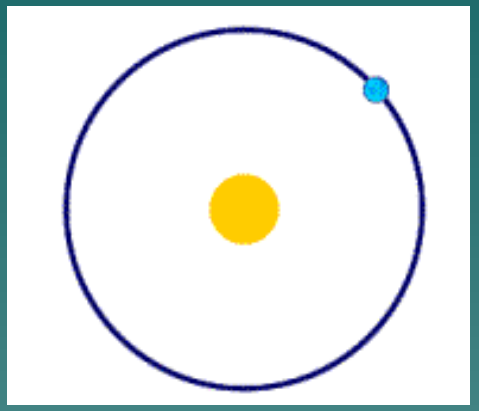


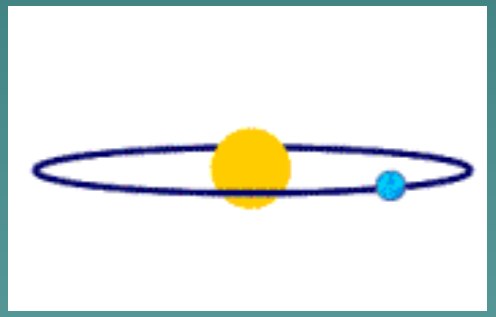
SIM

Kepler
2010

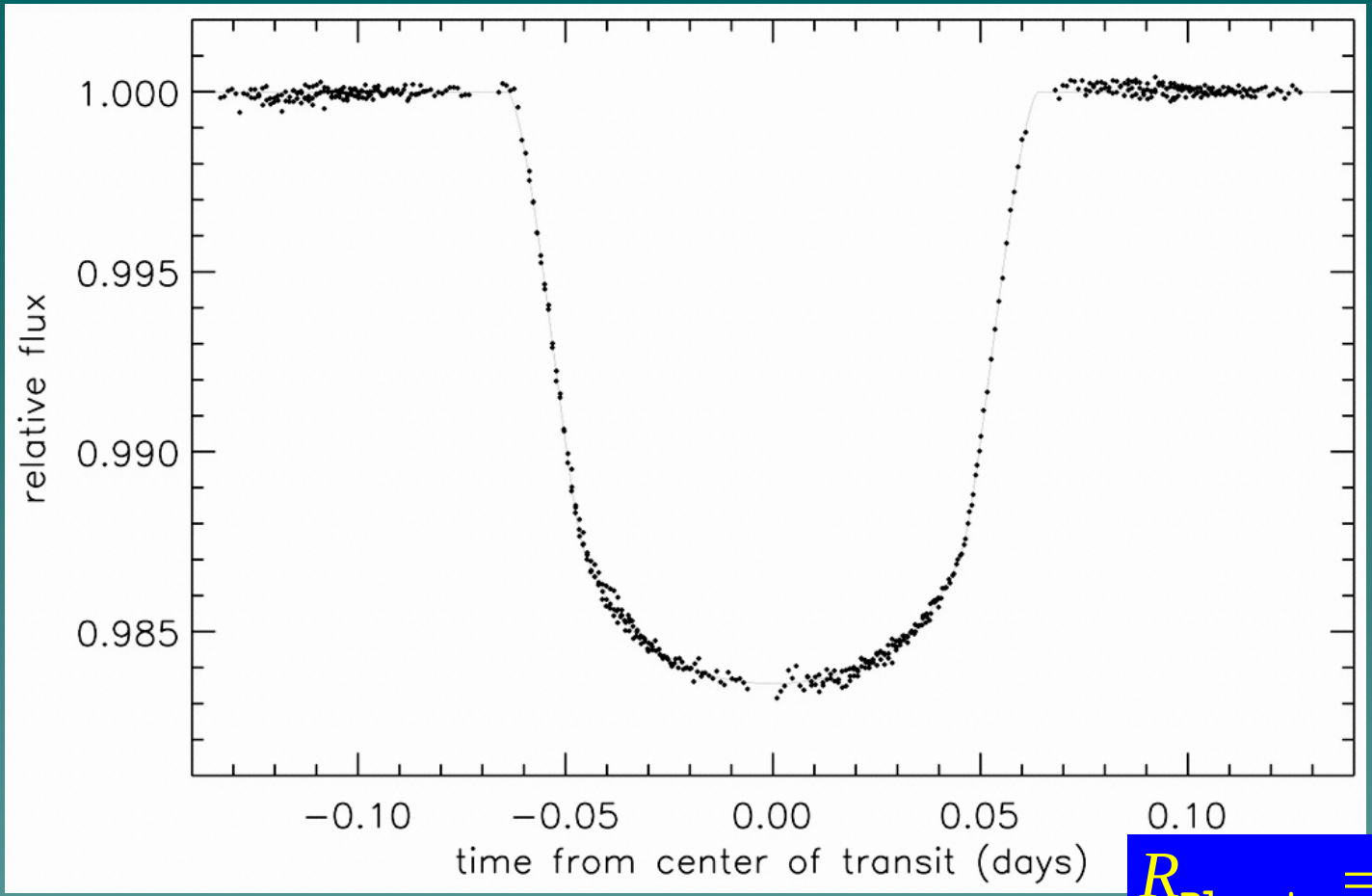
The transit method







The inclination must be very close to 90°



HD209458

- Planet mass
- Planet radius
- Planet density

$$R_{\text{Planet}} = 1.35 \pm 0.06\ R_{\text{Jup}}$$

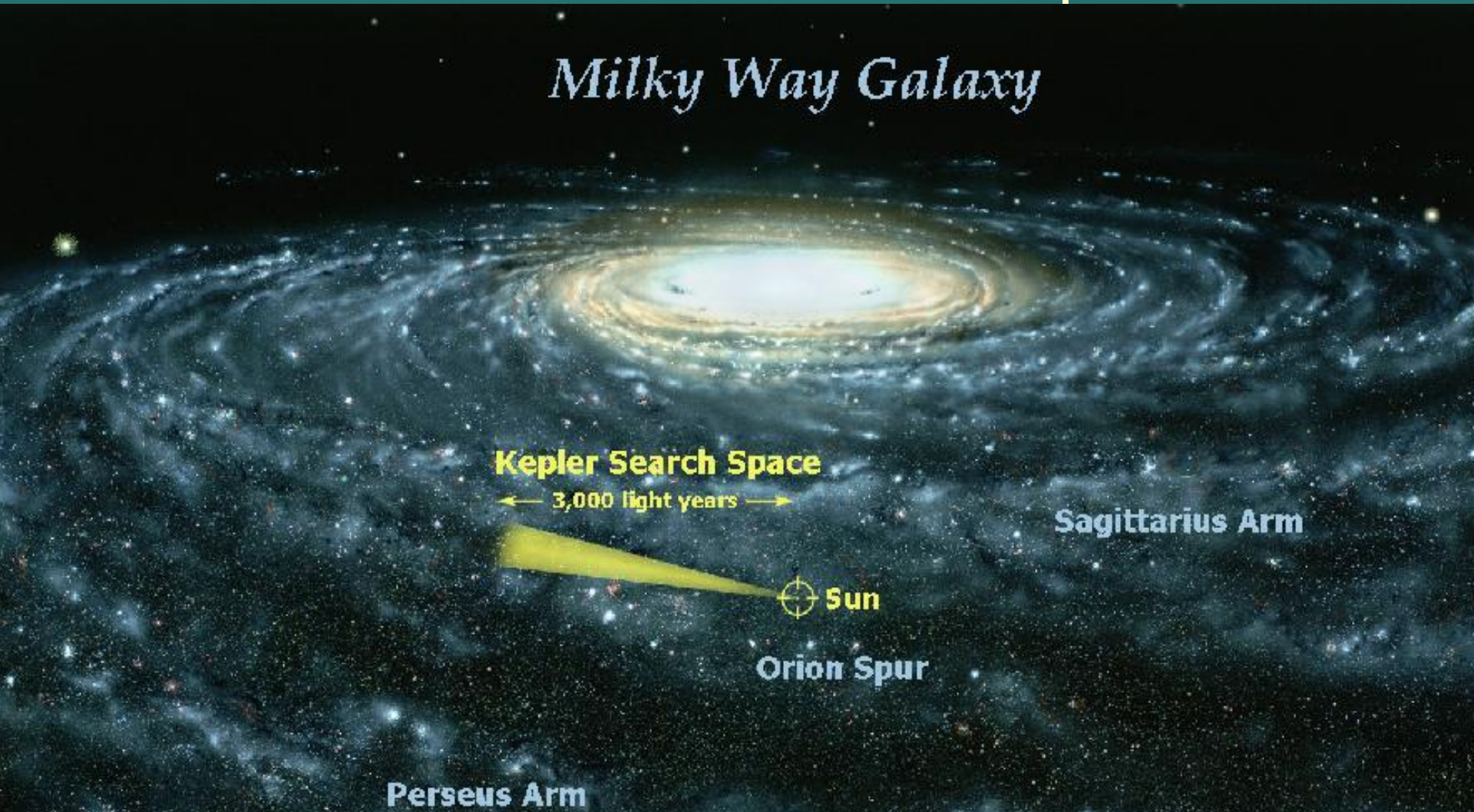
$$i = 86^{\circ}.7 \pm 0^{\circ}.1$$

$$M_{\text{Planet}} = 0.65 M_{\text{Jup}}$$

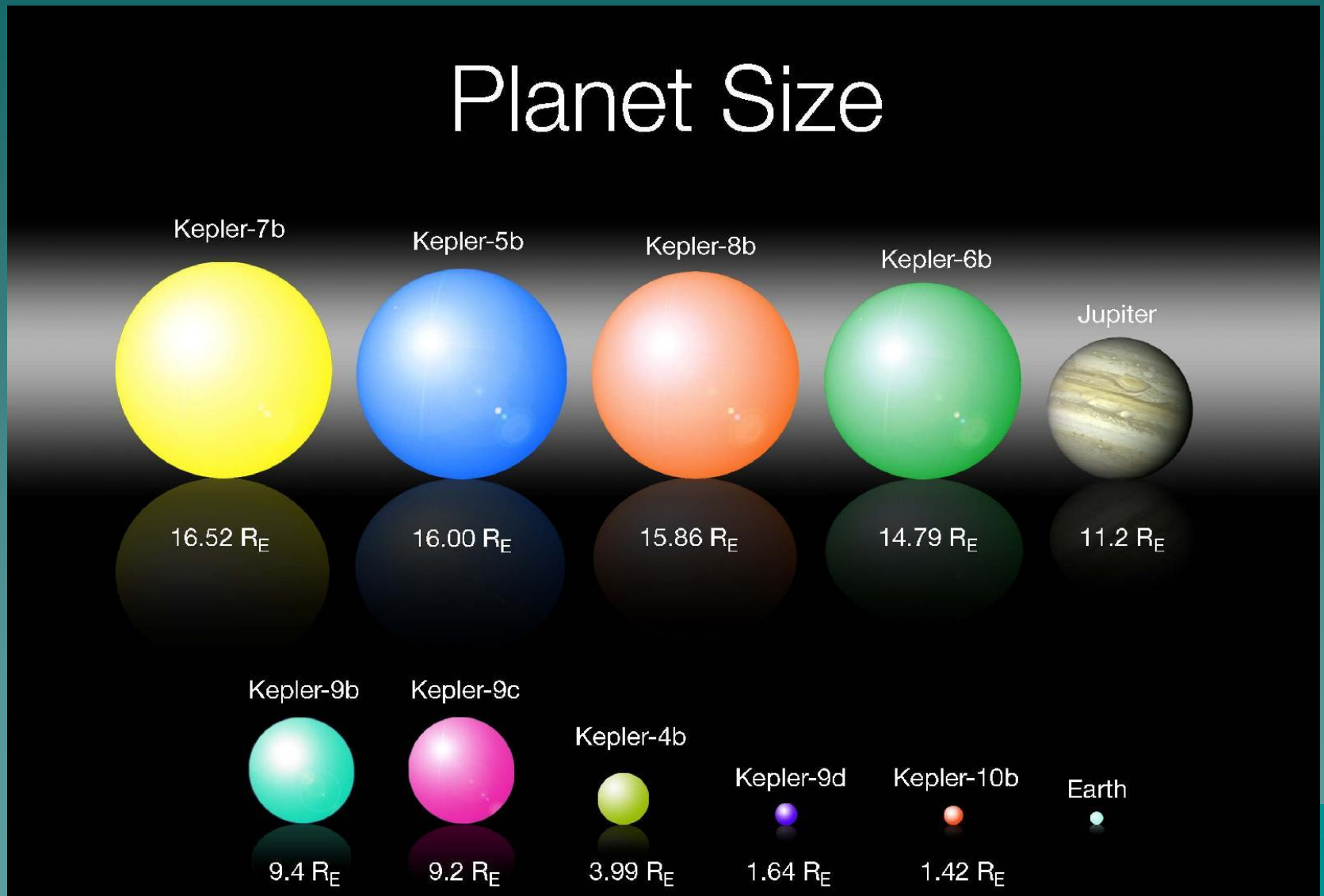
$$\overline{\rho}_{\text{.Planet}} = 0.35\ \text{g cm}^{-3}$$

The Kepler mission

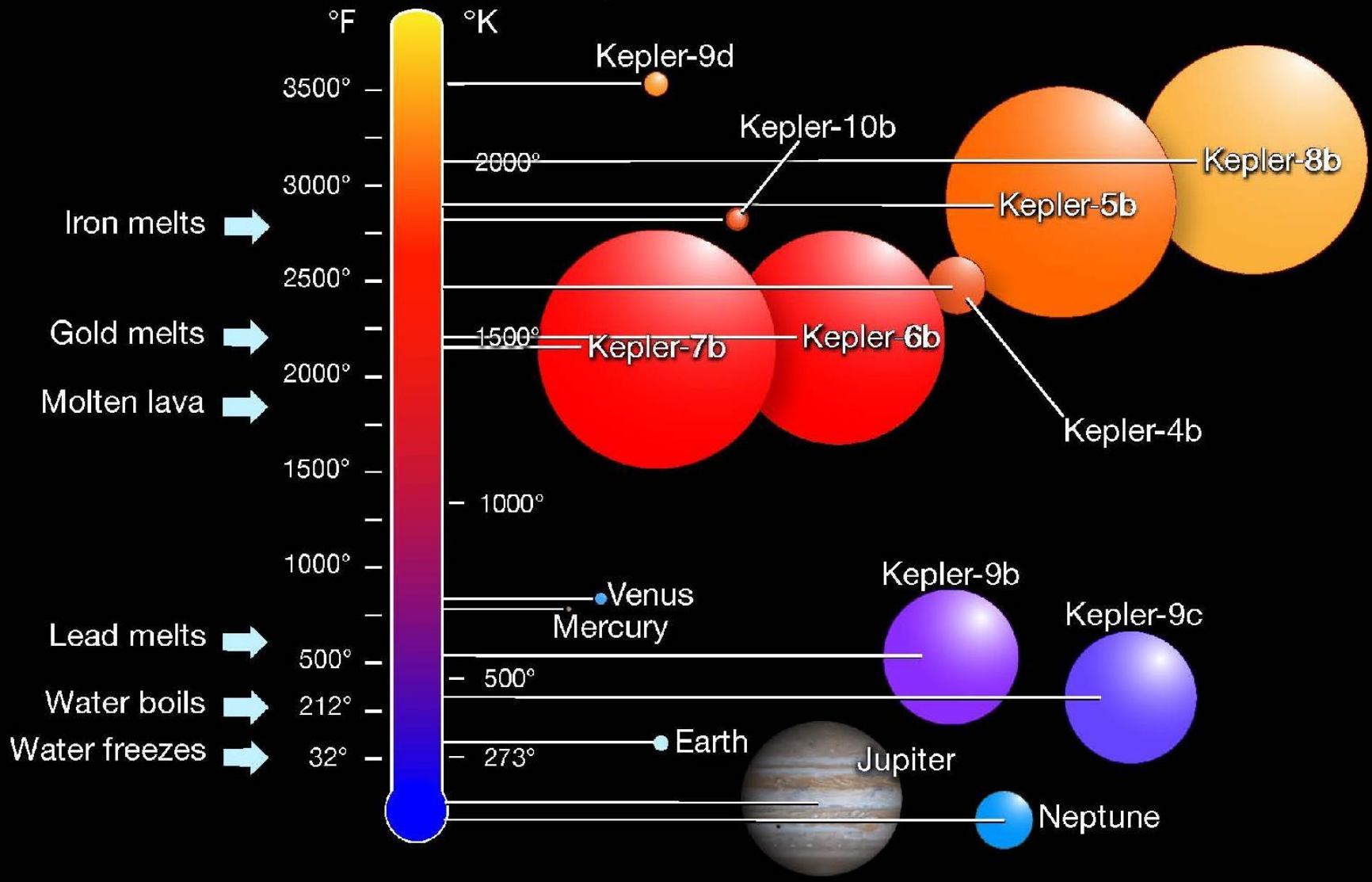
Search of Earthlike exo-planets



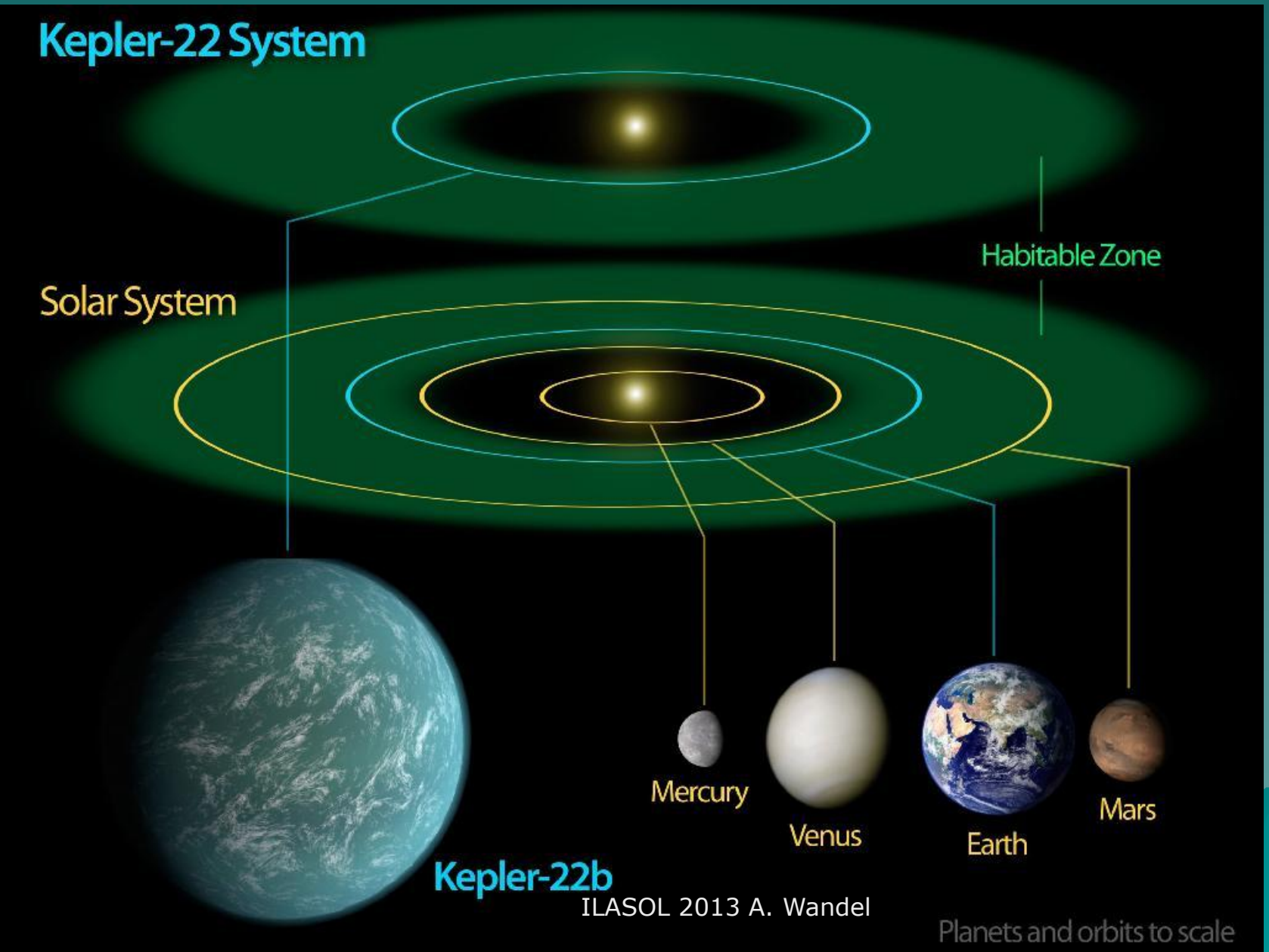
Kepler's first planets



Planet Temperature & Size



The Habitable Zone

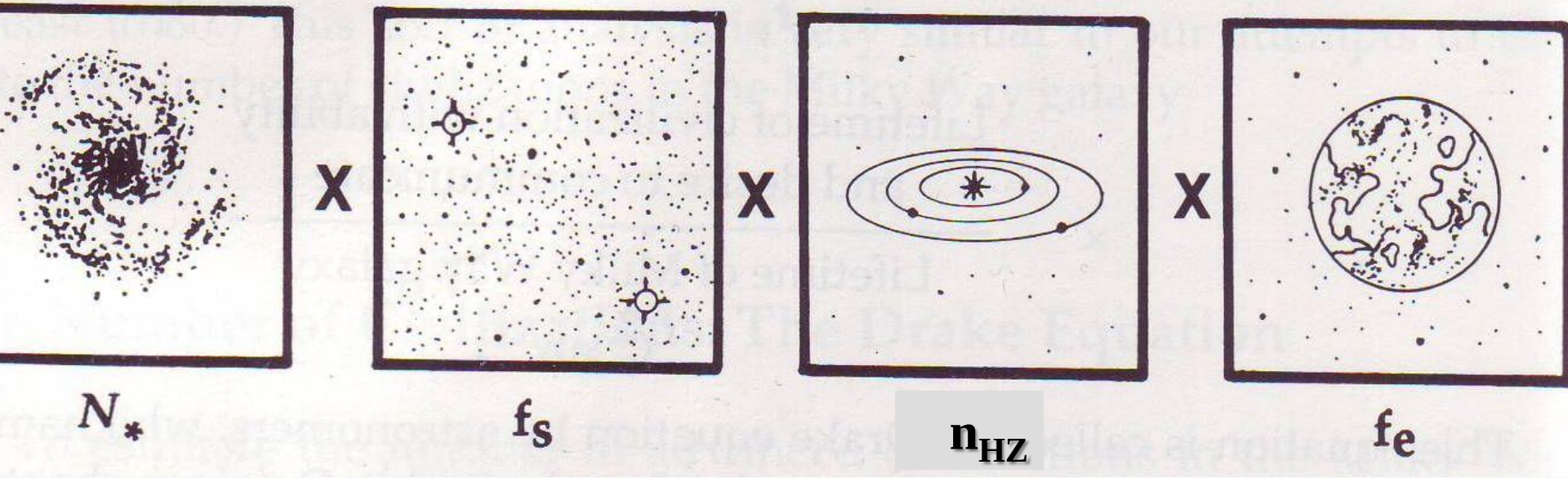


How many **biotic** wolds in our Galaxy ?

Kepler 22b 5.12.2011

Kepler 20e,f 19.12.2011

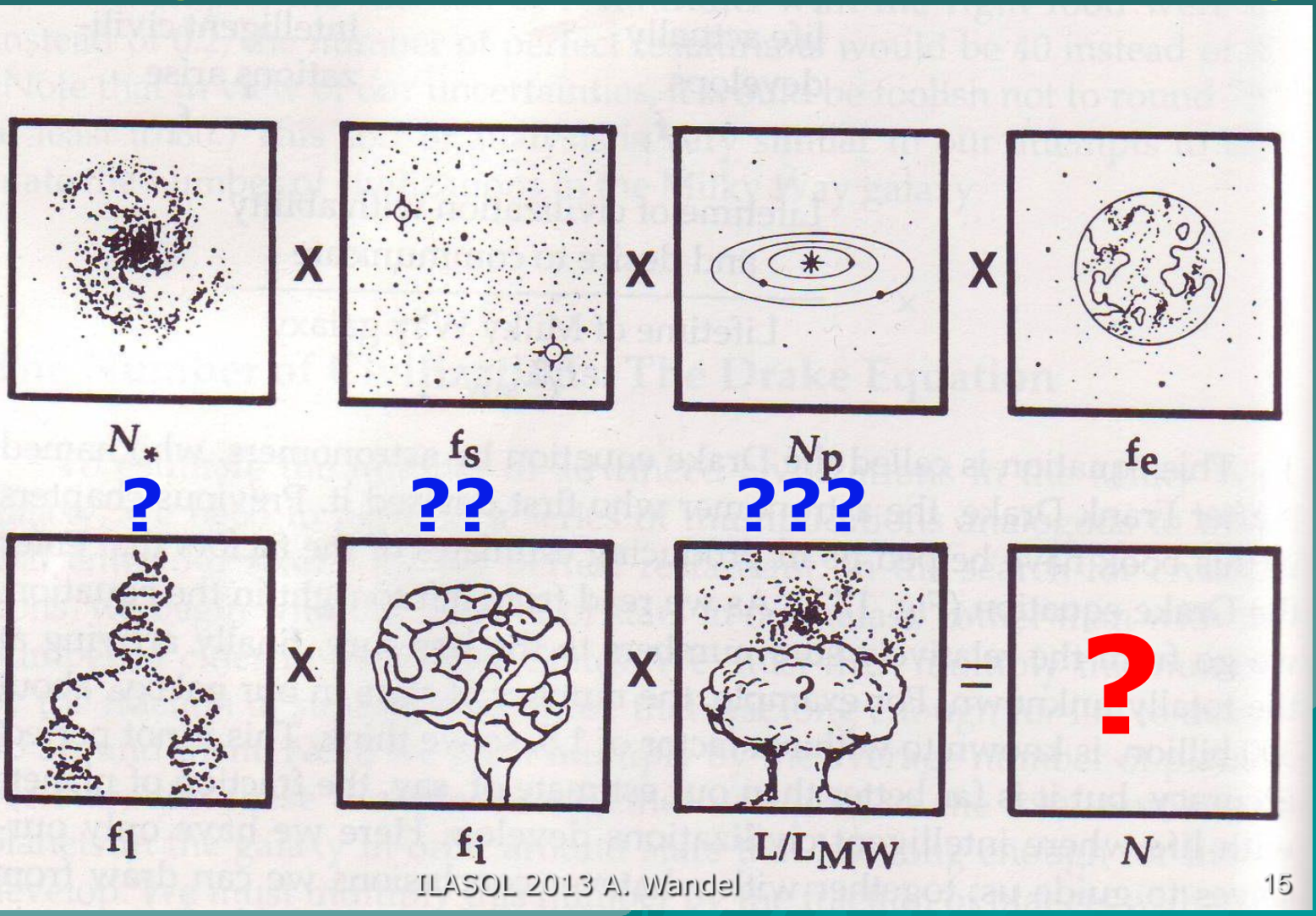
10^{11} stars **10% Sunlike** **Planets in HZ** **Earthlike**



N_* X f_s X n_{HZ} X f_e

The Drake equation

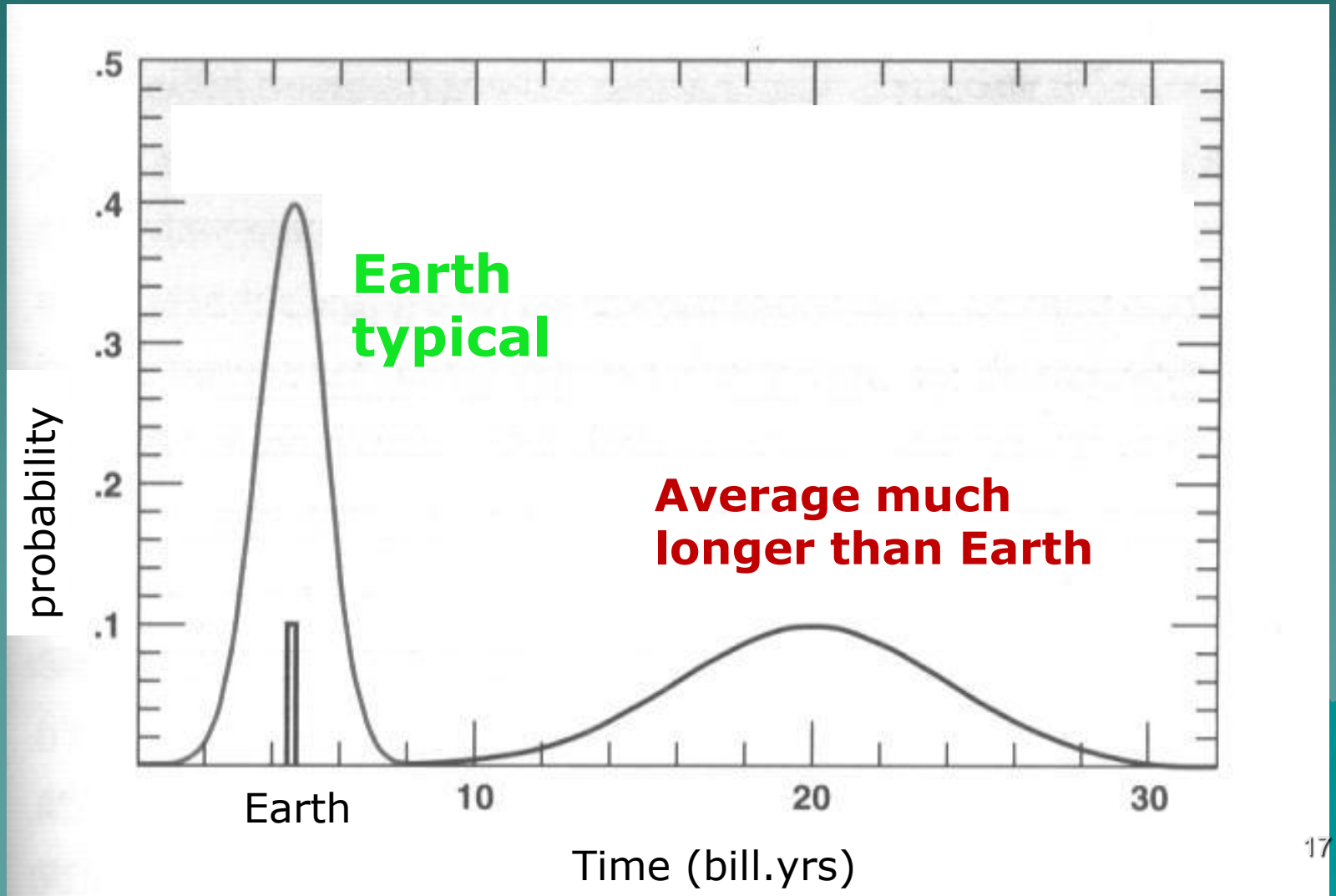
How many **civilizations** in our Galaxy?



How many biotic planets are in our cosmic neighborhood?

- According to Kepler misson's findings, earth-sized planets are frequent
- Obviously some earth-sized planets are within the Habitable Zone of their sun
- Thus probably F(E planet in HZ)~1 and the number of biotic planets depends merely on the probability for evolution of life within the Main Sequence lifetime of their sun
- On Earth life has appeared ~1Gy after the formation of the Solar System, that is 10% of the MS-lifetime of the Sun, but complex life took longer.

Two probability distributions for evolution of life on terrestrial planets vs. time



The probability for the evolution of biotic life on an Earthlike planet :

Two extreme situations:

Optimistic: Earth is a typical case, $F_b \sim 1$

Pessimistic: Usually evolution of biotic life takes much longer than it took on Earth $F_b << 1$

The distance to our nearest living neighbor

Probable distance to nearest biotic exo-planet:

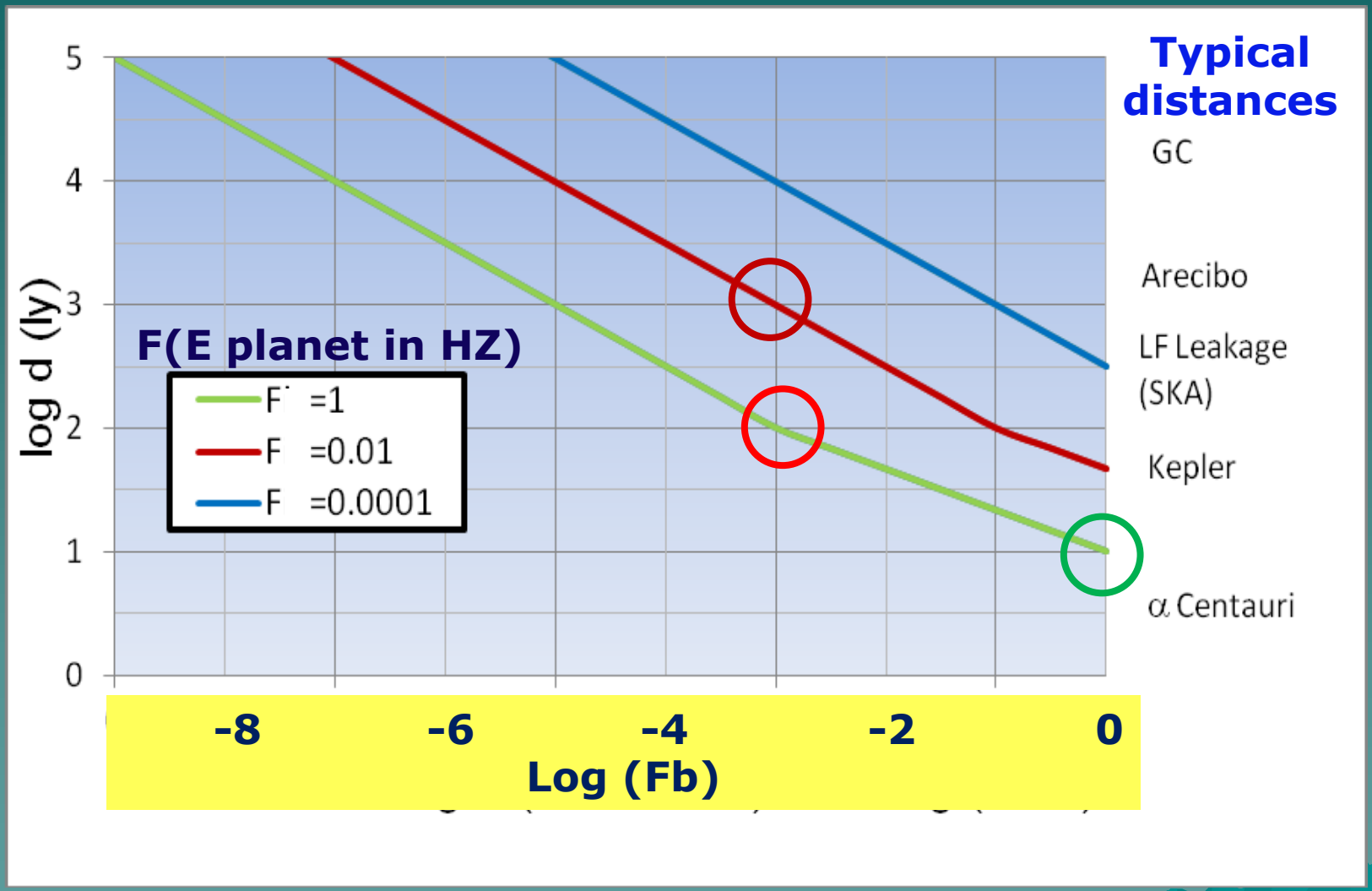
$$D_b \sim 10 \text{ ly } F_b^{-1/3}$$

In the two extreme scenarios:

Optimistic: $F_b = 1 \rightarrow D_b \sim 10$ ly

Pessimistic: $F_b = 0.001 \rightarrow D_b \sim 100$ ly

Distance to nearest biotic planet vs Fb



After the Kepler mission

For the first time in history astronomy may be able to estimate how common are biotic life bearing planets: probably some could be found within 30 ly