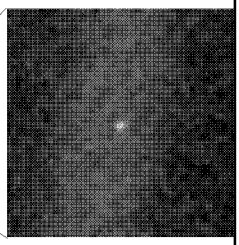
Wednesday, November 17

Seeking Other Earths



Quiz #4 will be on Friday.

Seeking Other Earths
Key Concepts

1) Direct detection of "exoEarths" (Earth-like planets around other stars) is very difficult.

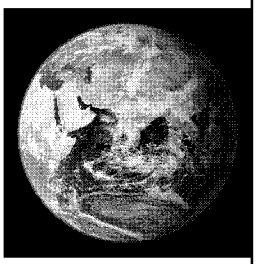
2) Planned space missions will seek exoEarths directly and indirectly – if they're funded.

3) Spectral biomarkers can indicate the presence of life on an exoEarth.

So far, we haven't found any Earth-mass planets around other stars, but the search is on…

1st goal: find Earth-like planets in the Habitable Zones of their parent stars.

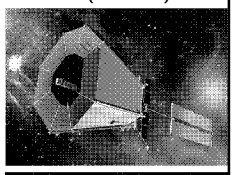
2nd goal: find whether life exists on these "exoEarths".

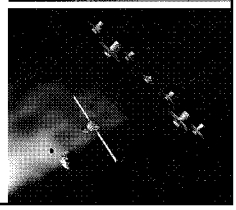


Darwin mission (European Space Agency) and *Terrestrial Planet Finder* mission (NASA)

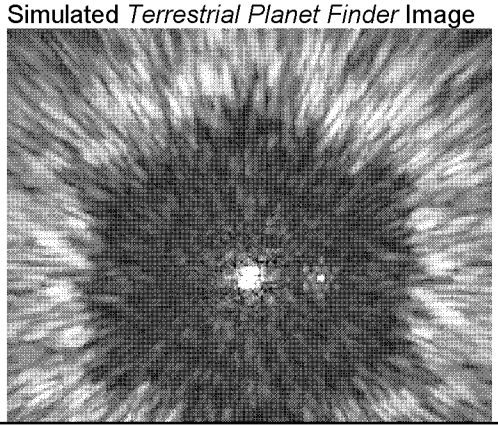
These missions were designed to search nearby stars for Earth-like planets using direct imaging.

Spectroscopic follow-up would look for molecules produced by life.

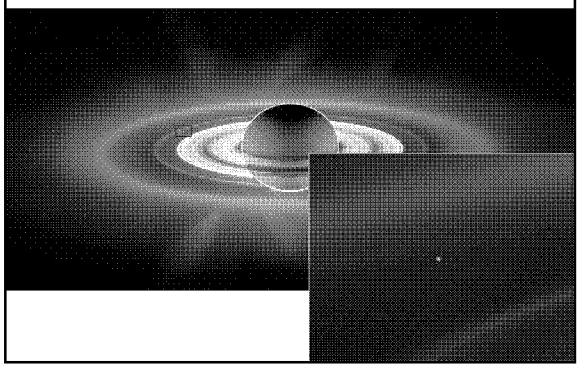


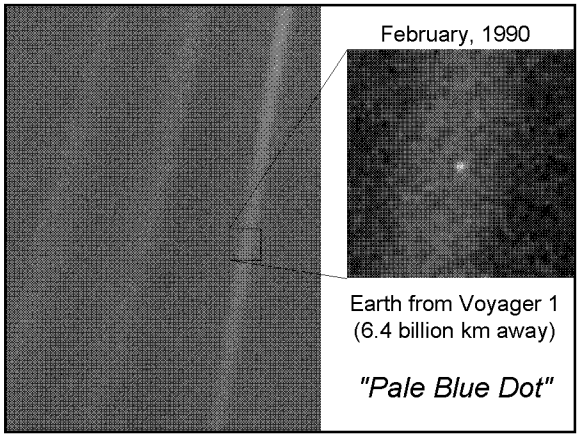


Simulated *Terrestrial Planet Finder* Image



We can't yet study other Earths, but we can prepare by studying ***our*** Earth from the outside.





Earth from Voyager 1
(6.4 billion km away)

"Pale Blue Dot"

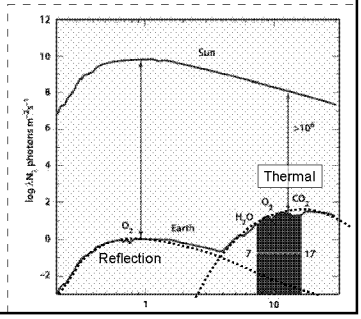
The big challenge: exoEarths are extremely faint compared to the light of their parent stars.

The spectrum of the Earth has two components:

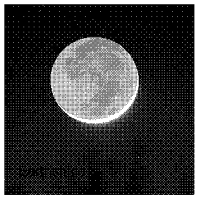
Reflected sunlight

Thermal infrared emission

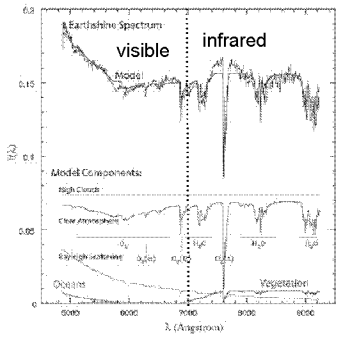
The Earth is about 2 billion times fainter than the Sun.



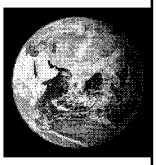
The Earth's spectrum can be measured by spacecraft, or by looking at Earthshine reflected by the Moon.



Absorption lines are due to molecules in Earth's atmosphere.



Spectral biomarkers are spectrum features indicative of life chemistry.

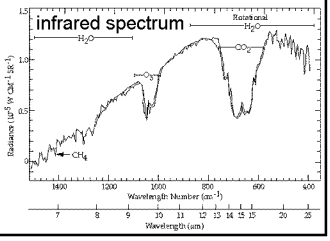


O_2 – good but easily confused with other features (false positives).

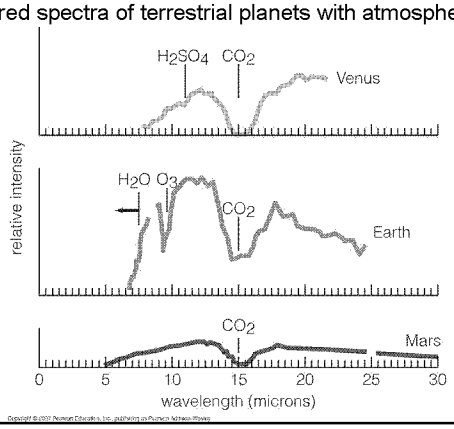
O_3 (ozone) – results from sunlight shining on O_2.

H_2O – necessary, but not sufficient for life.

CH_4 – byproduct of anaerobic life.



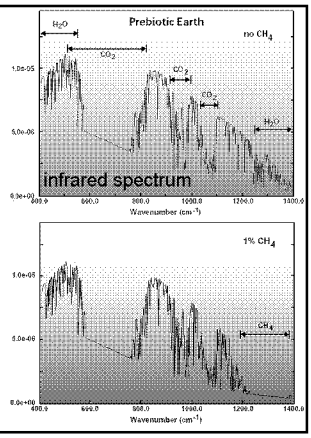
Infrared spectra of terrestrial planets with atmospheres.



Methane (CH_4) is a strong biomarker.

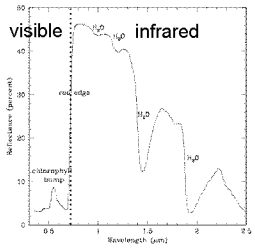
It produces infrared absorption even in small concentrations.

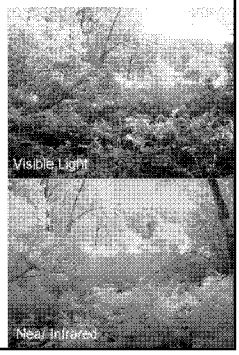
It was **stronger** in the early Earth than it is now.



Earth plants reflect infrared light, giving their spectrum a distinctive "Red Edge".

Rejecting infrared light helps plants to stay cool.

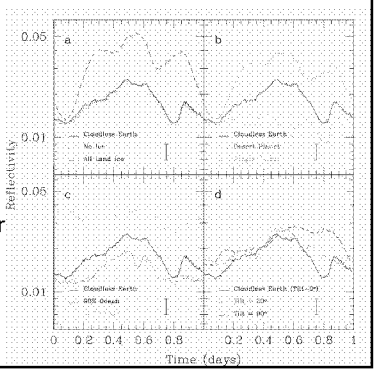




Variability in the flux of an exoEarth would reveal surface features and weather.

Oceans and continents rotate in and out of view.

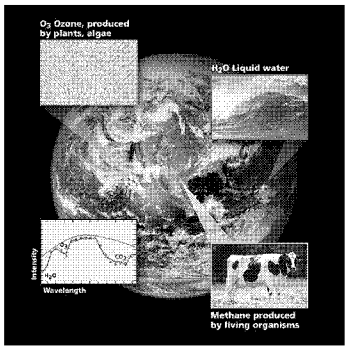
We could even infer climate: deserts, snowballs, or jungle worlds.



We can learn much about an exoEarth using spectroscopy.

Got Oxygen?

Got an Atmosphere?



Got Water?

Got Life?

The technology exists to find Earth-mass planets around other stars **today**.

Detection of an Earth-like planet in its parent star's Habitable Zone is likely in the next decade.

Many efforts are in progress from the ground and from space.

Direct imaging of exoEarths, and spectroscopy to detect spectral biomarkers, is for the future (20 – 30 years??)

Tomorrow's Lecture:

Intelligent Life in the Universe

This Week's Reading:

Chapter 12