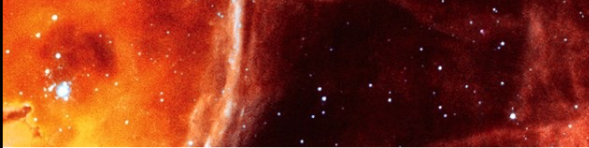


**Discovering the Essential Universe**



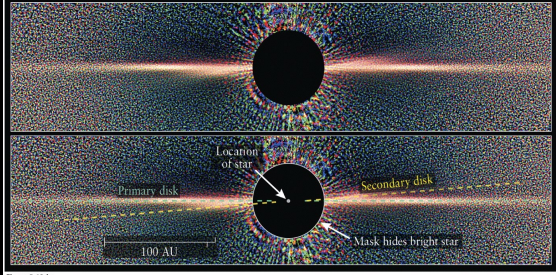
Neil F. Comins  
**CHAPTER 5**  
**Exoplanets**

© 2008 W. H. Freeman and Company

1

**Exoplanets**  
 (Extrasolar planets)

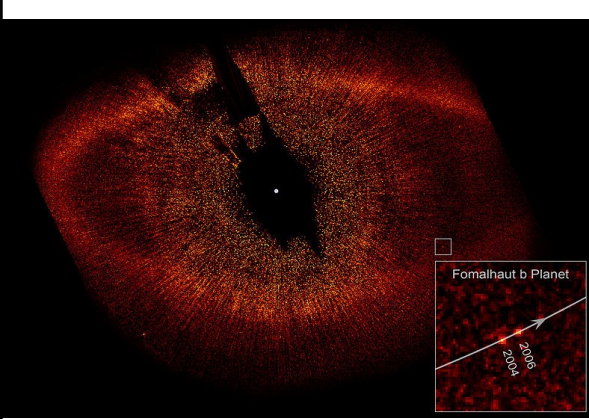
Beta Pictoris -- a circumstellar disk of matter



Location of star  
 Primary disk  
 Secondary disk  
 Mask hides bright star  
 100 AU

Figure 5-124a  
 Discovering the Universe, Eighth Edition  
 © 2008 W. H. Freeman and Company

2

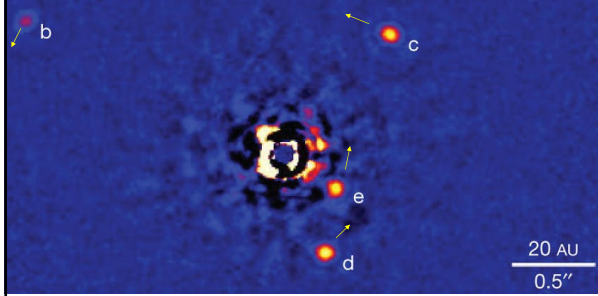


Fomalhaut b Planet  
 2004 2005 2006

NASA, ESA and P. Kalas UC Berkeley, SETI Inst.

3

HR8799

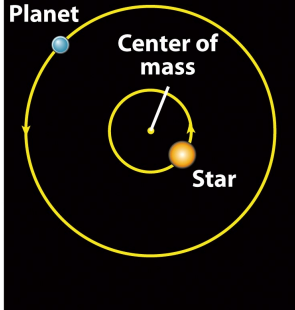


b c  
 e d  
 20 AU  
 0.5"

The first directly imaged multi-exoplanet system. This system contains a debris disk and at least four massive planets.  
 Credits: NRC-HIA, Christian Marois, Keck Observatory  
<https://www.nasa.gov/feature/jpl/20-intriguing-exoplanets-part-2>

4

**How to detect exoplanets?**



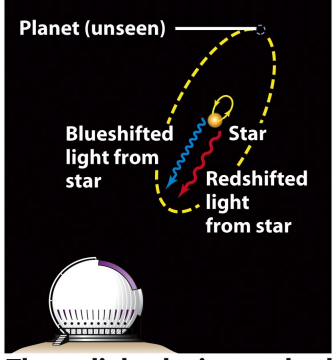
Planet  
 Center of mass  
 Star

**A star and its planet**

Figure 5-15a  
 Discovering the Universe, Eighth Edition  
 © 2008 W. H. Freeman and Company

The direct imaging method (very rare)

5

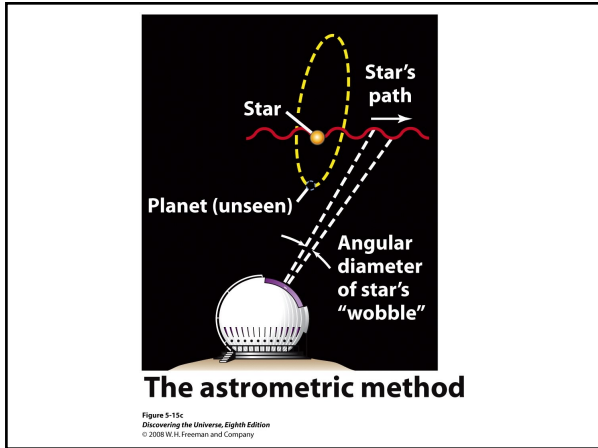


Planet (unseen)  
 Blueshifted light from star  
 Star  
 Redshifted light from star

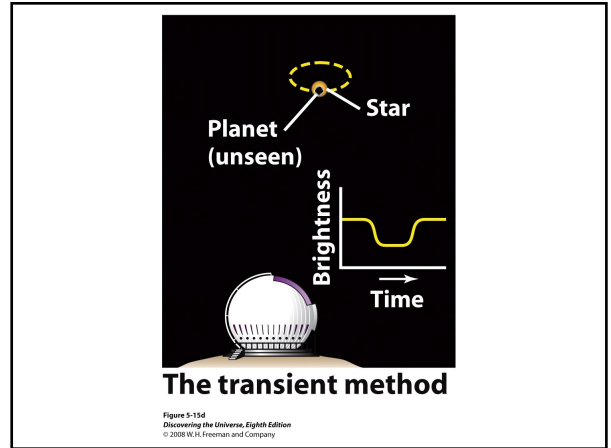
**The radial velocity method**

Figure 5-15b  
 Discovering the Universe, Eighth Edition  
 © 2008 W. H. Freeman and Company

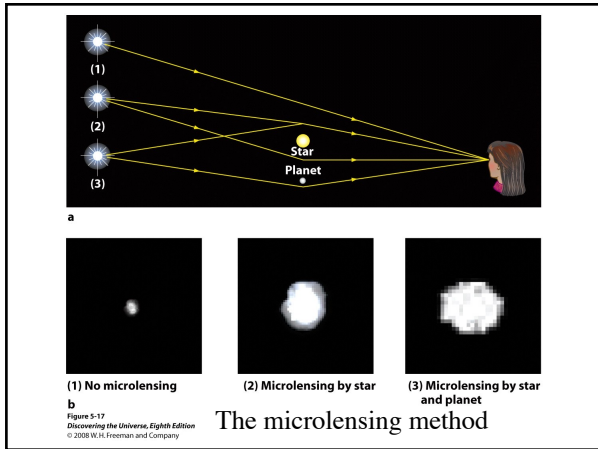
6



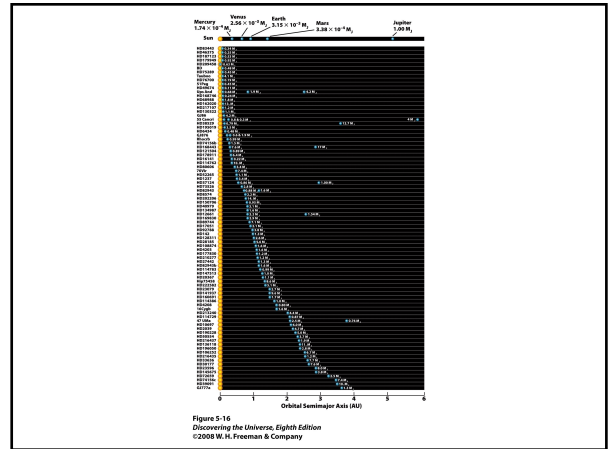
7



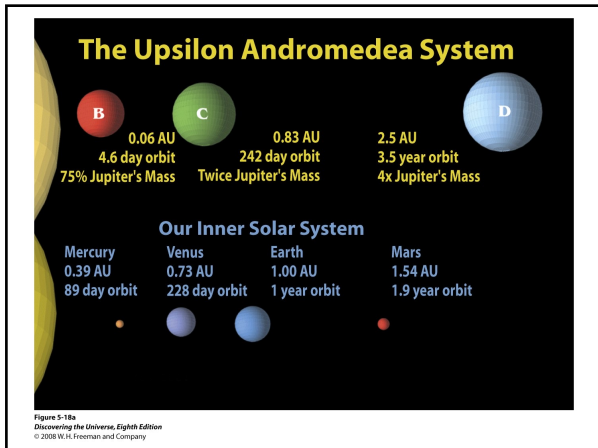
8



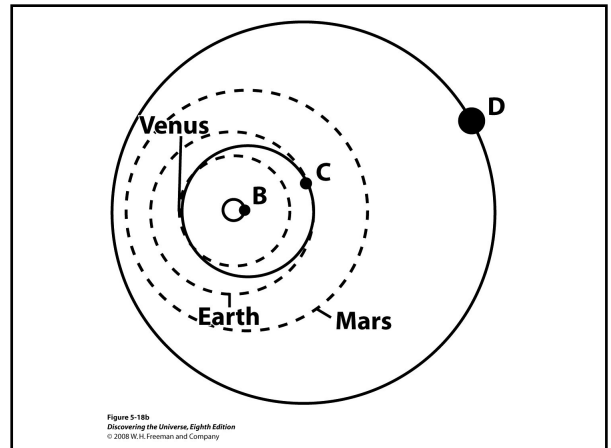
9



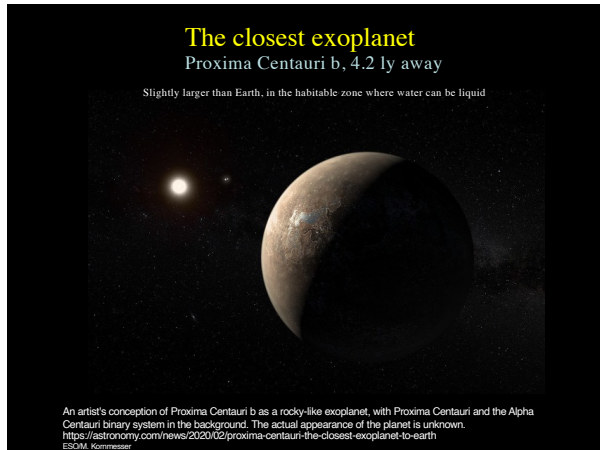
10



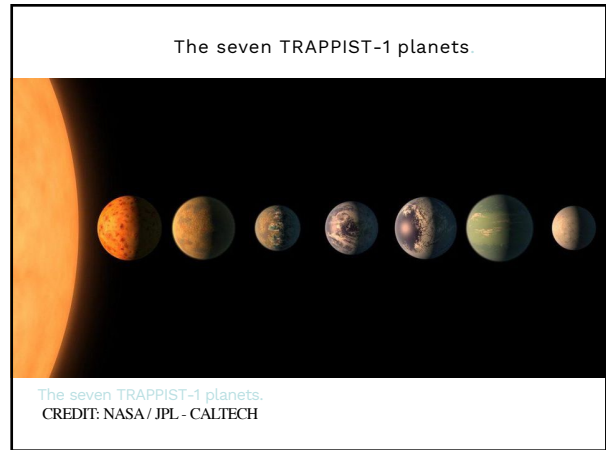
11



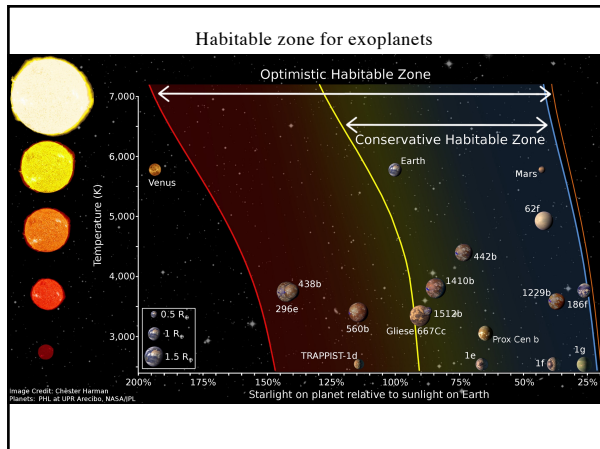
12



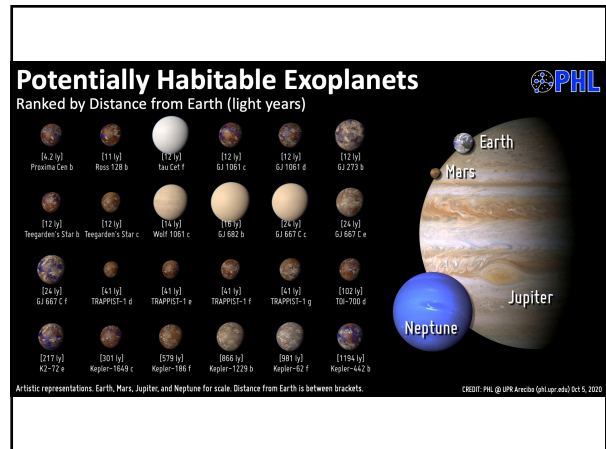
13



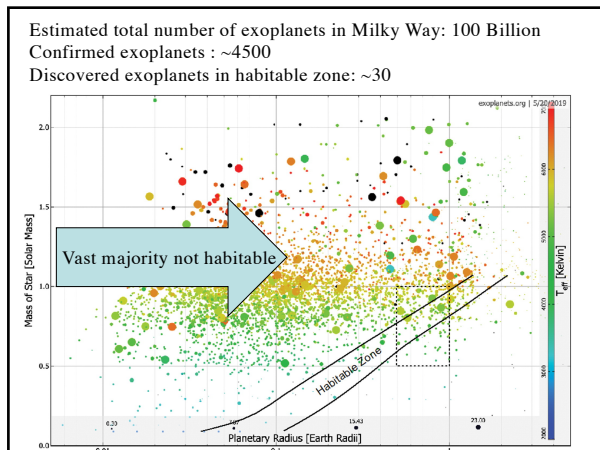
14



15



16



17

**New challenge:**

- Find exoplanets in habitable zone
- with atmosphere
- and oxygen in it

18

**Are there any exomoons discovered yet?**

There is one possible detection

**Are there any rogue planets discovered yet?**

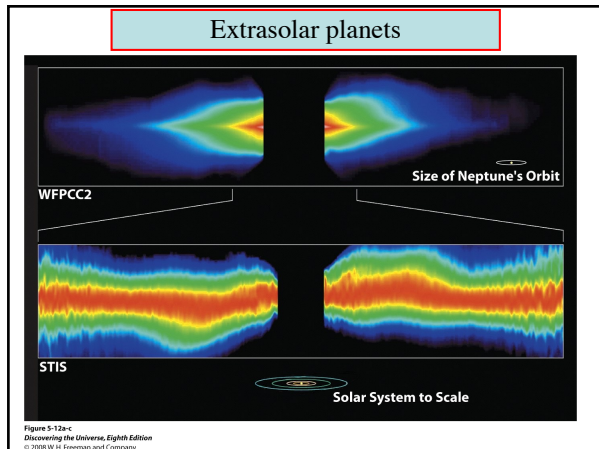
There are ~10 rogue planets discovered with microlensing  
They float on their own without a host star through the Galaxy

**50 Bill. Rouge planets are expected in the Galaxy**

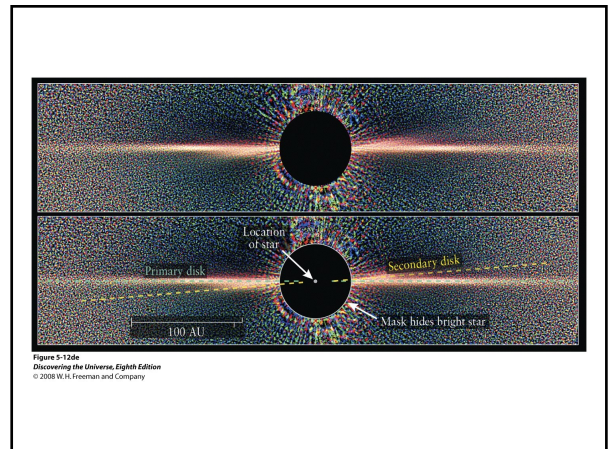
19



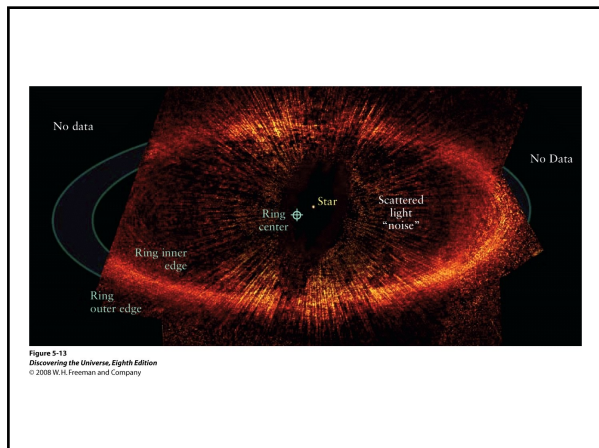
20



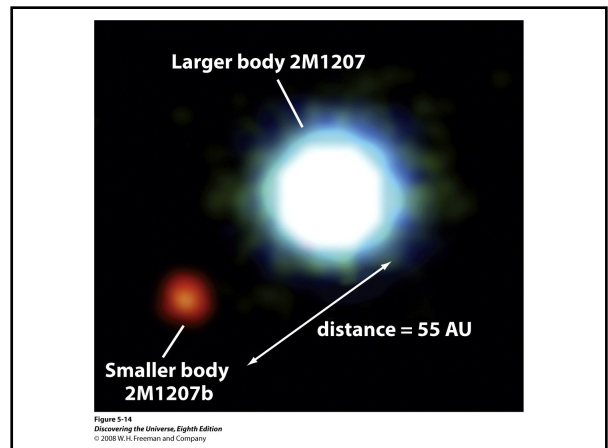
21



22

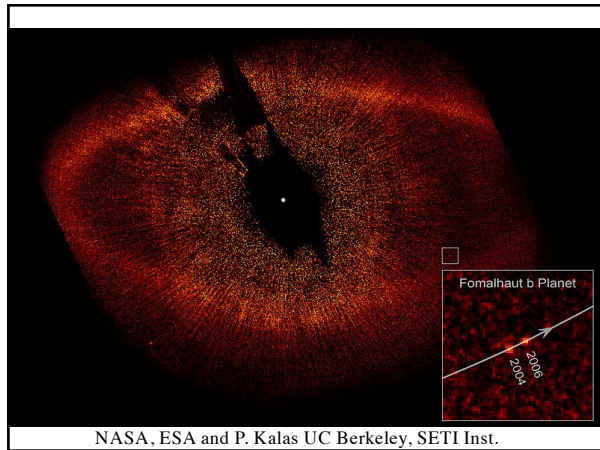


23

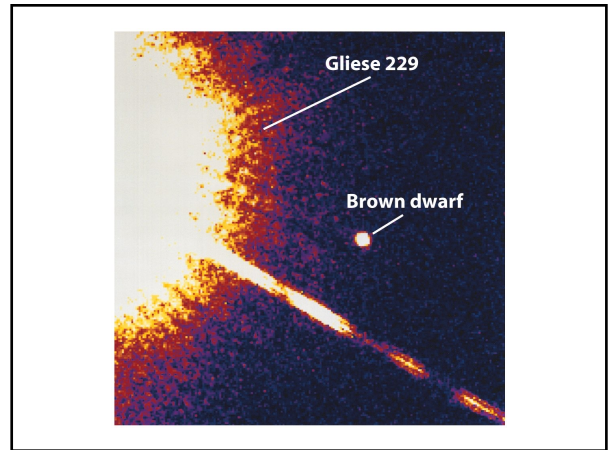


24

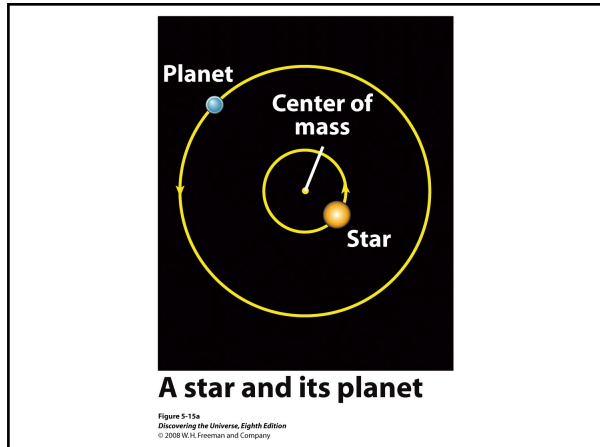




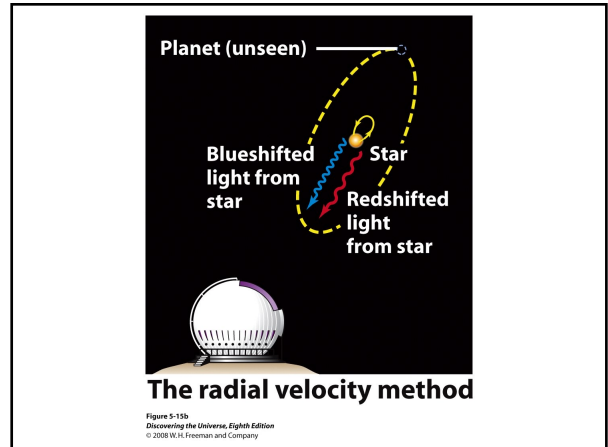
25



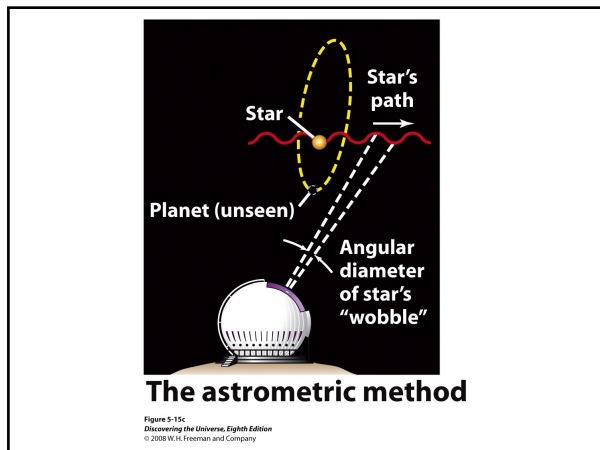
26



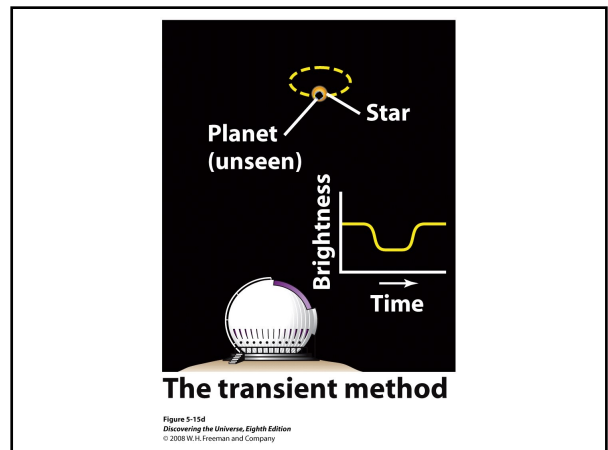
27



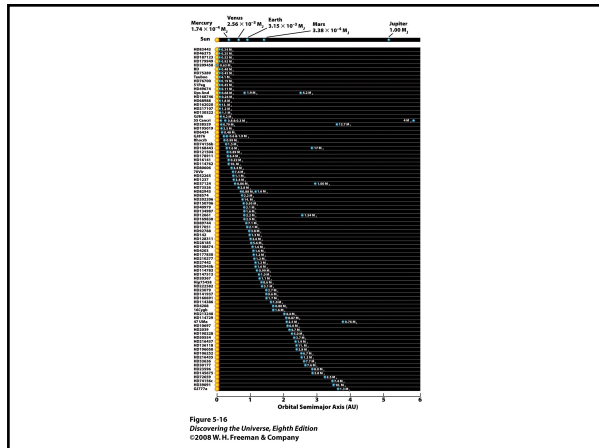
28



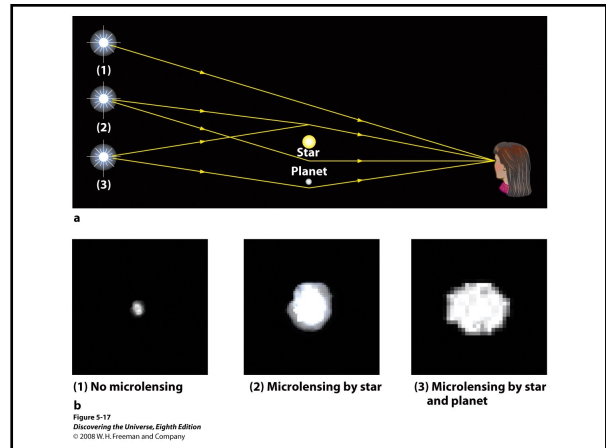
29



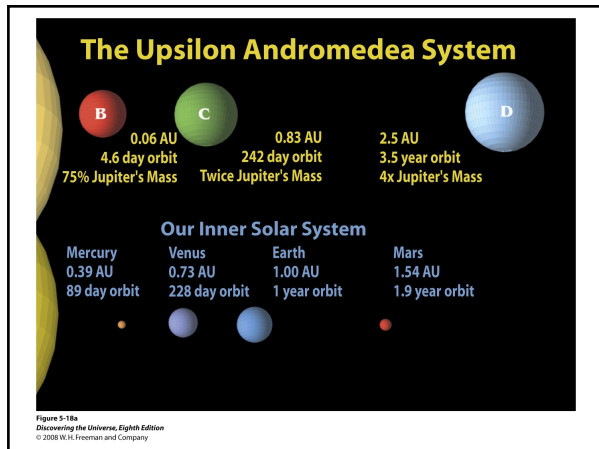
30



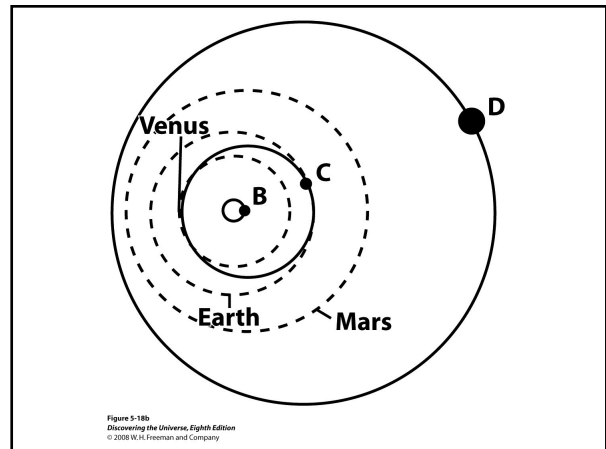
31



32



33



34