1 Origin of the Solar System

1.1 Evolution of Origins

Myths and folktales go back before recorded history

Each religion has its own version of "the beginning"

Galileo introduced modern science to the world

Rational theories used science

Decartes (1644) - vortices of particles formed Sun and planets

Buffon (1745) - passing star hypothesis, matter pulled from Sun and star formed planets. Cons - small stars in comparison to the distances.

Decartes' theory is classified as - *Evolutionary* - slow changes over long periods of time

Buffon's theory is classified as - *Catastrophic* - large changes in short periods of time

Laplace (1796) - Modern theory - Nebular Hypothesis - Newton's Gravity along with vortices, contracting and flattening.

Angular Momentum - Since Sun has most of the mass in the solar system, it should have most of the angular momentum, but it doesn't. Sun contains 0.3% of the total momentum of the solar system. Where did Sun' angular momentum go?

1.2 Solar Nebula Hypothesis

Big Bang - Creation of hydrogen and helium at a ratio of about 75% to 23% with about 2% in the form of heavier atoms; evidence from Sun's composition

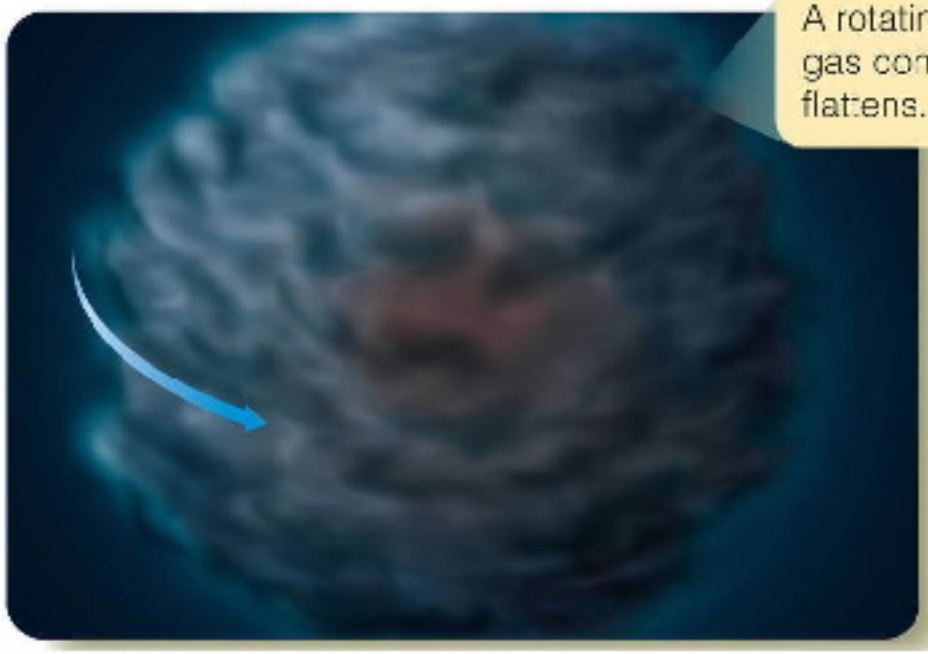
Formation of the Milky Way galaxy - stars and gas

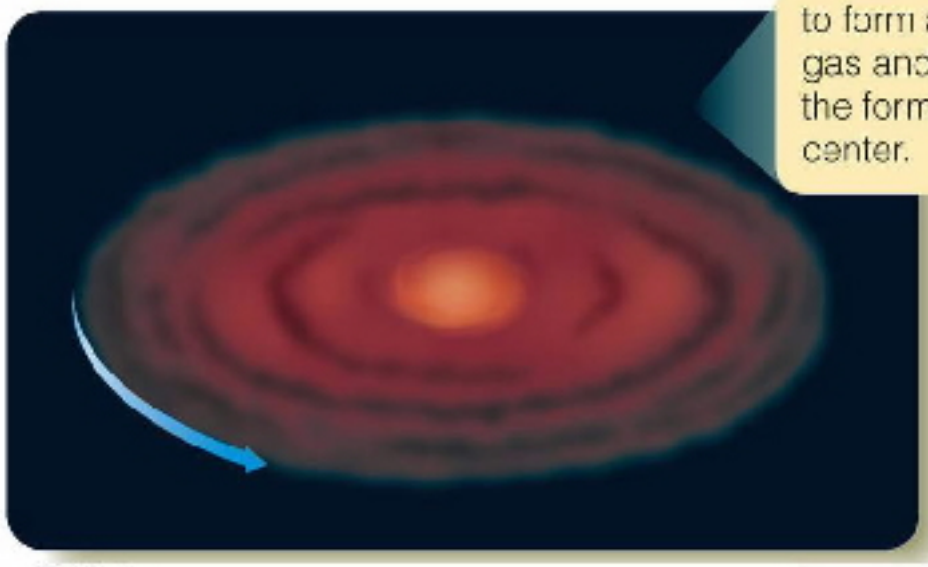
Spiral Arms - star forming regions

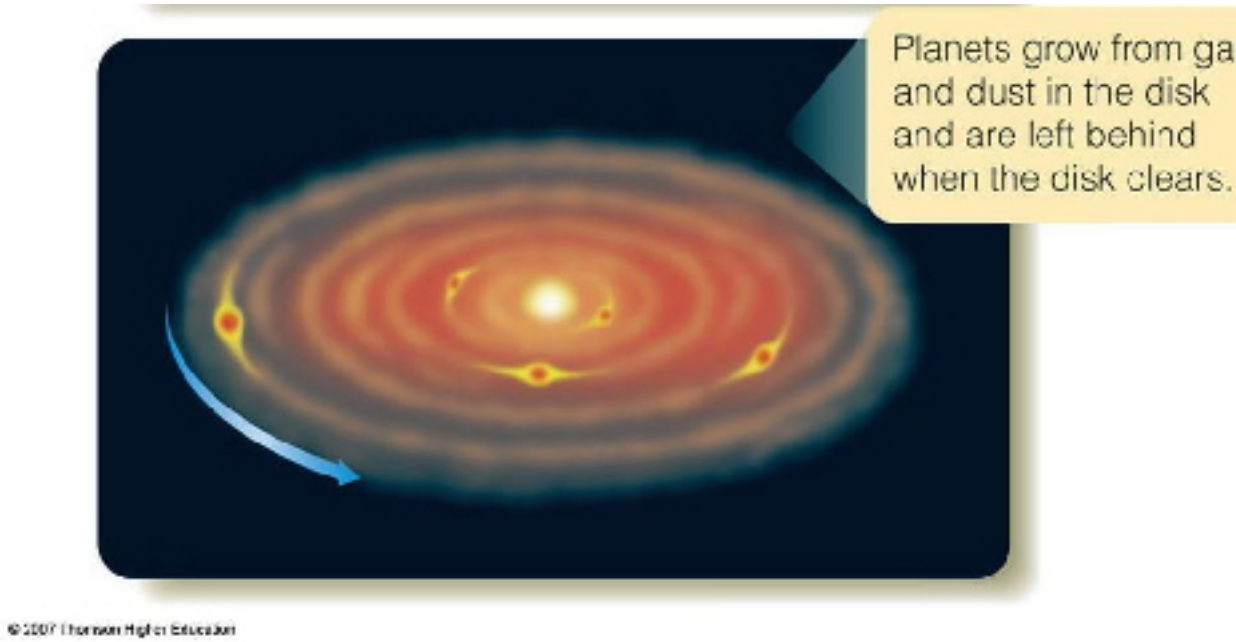
Solar Nebula - Contains mostly hydrogen and helium. Also contains debris atoms (heavy atoms) from previous generations of stars.

You and I are made of atoms from the solar nebula

The Solar Nebula Hypothesis



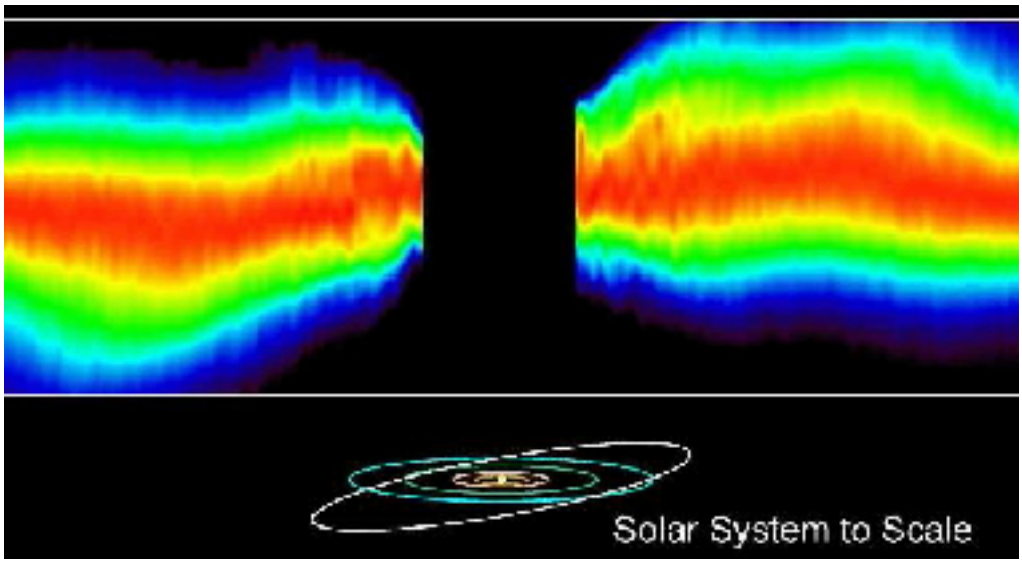




Evidence of planet formation Extra-Solar Planets - over 870 have be found. Actual planets have been detected

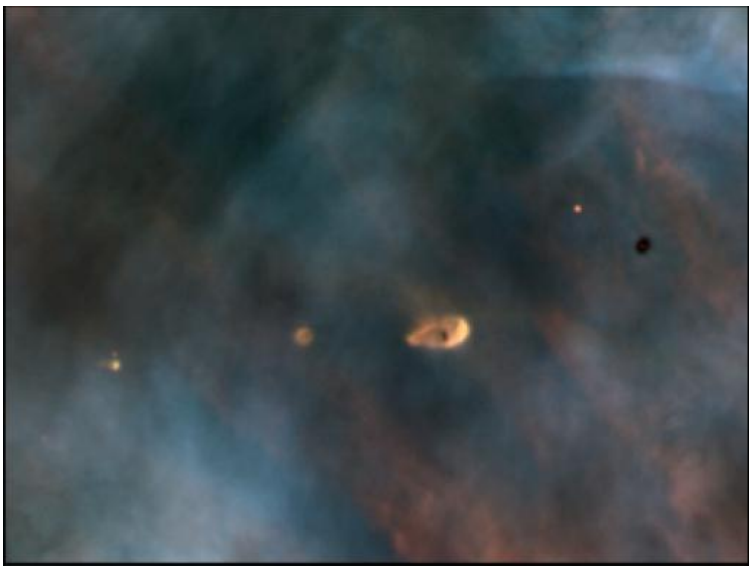
Vega - Protoplanetary disk 26 light years away

Beta Pictoris - about 10 times the diameter of our solar system

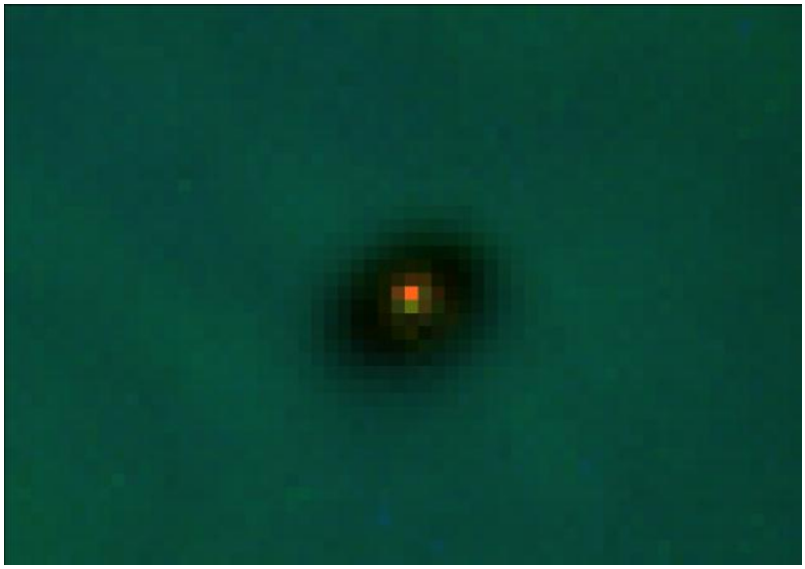


Cocoons

T - Tauri stars - variable stars as they emerge from cocoons
Herbig-Haro objects - bipolar jets interacting with nebula
EGG's - Evaporating Gaseous Globules



Infrared images by Hubble space telescope shows protostars



Learning about extra-solar systems helps us to learn about our own

1.3 Our Solar System

Revolution
Rotation

1.3.1 Two kinds of planets

Terrestrial planets - small, rocky, formed closer to Sun
Jovian planets - gas giants, no solid surface, formed far from Sun
Space debris - comets, asteroids

1.3.2 Age of the solar system

Radioactive half-life
Oldest rocks found on Moon - 4.48 billion years old.
Oldest rocks found on Earth - 4.3 billion years old
Solar System - at least 4.48 billion years old, closer to 5 billion years old
Oldest rocks found in meteorites - 4.56 billion years old
4.6 billion years is close to the accepted value
Estimates using stellar models puts Sun at about 5 billion years old

1.3.3 Solar System Building

Gravitational collapse of the solar nebula
Formation of protosun
Disk flattens out
Eddies form in disk which will eventually form planets
Planetesimals - condensation then accretion
Condensation - build up of material one atom at a time
Accretion - material sticks together
Protoplanets - large enough for gravity to draw in more material
Thermonuclear fusion in Sun- Solar wind and radiation pressure clears the solar nebula
Growth of protoplanets - differentiation & outgassing

1.4 Characteristics of the solar system

How well does the above described model for the formation of the solar system correlate to what we observe in the solar system now.

1.4.1 Orbital Characteristics

Sun rotates in the same direction as the planets orbit
All planets revolve around Sun in the same direction
All planets rotate on their axis in the same direction except two, Venus & Uranus; Catastrophic events used to explain their anomaly.
All planets orbits lie in the same plane, Pluto not considered to be a planet

1.4.2 Terrestrial & Jovian

The condensation sequence - The temperature that an element condenses from a gas to a fluid determines which elements begin to solidify and start the planet building process

Metals condense at the highest temperatures followed by silicates

Planets close to Sun will contain higher amounts of metals close to Sun and increasing amounts of silicates as you move out to Mars

These are the small dense terrestrial planets

Ices would condense out at the distances from Jupiter to Saturn

Lighter elements would remain a gas and be blown to the outer reaches of the solar system and become components of the gas giants

Table 19-3 | The Condensation Sequence

Temperature (K)	Condensate	Planet (Estimated Temperature of Formation; K)
1500	Metal oxides	Mercury (1400)
1300	Metallic iron and nickel	
1200	Silicates	
1000	Feldspars	Venus (900)
680	Troilite (FeS)	Earth (600) Mars (450)
175	H_2O ice	Jovian (175)
150	Ammonia–water ice	
120	Methane–water ice	
65	Argon–neon ice	Pluto (65)

Table 19-2 | Observed and Uncompressed Densities

Planet	Observed Density (g/cm^3)	Uncompressed Density (g/cm^3)
Mercury	5.44	5.30
Venus	5.24	3.96
Earth	5.50	4.07
Mars	3.94	3.73
(Moon)	3.36	3.40

Table 19-1 | Characteristic Properties of the Solar System

1. Disk shape of the solar system
   - Orbits in nearly the same plane
   - Common direction of rotation and revolution
2. Two planetary types
   - Terrestrial—inner planets; high density
   - Jovian—outer planets; low density
3. Planetary ring systems and large satellite systems for Jupiter, Saturn, Uranus, and Neptune
4. Space debris—asteroids, comets, and meteors
   - Composition
   - Orbits
5. Common ages of about 4.6 billion years for Earth, the moon, Mars, meteorites, and the sun

1.4.3 Clearing the nebula

Radiation pressure -blew the gases and small, low-mass specks of dust out

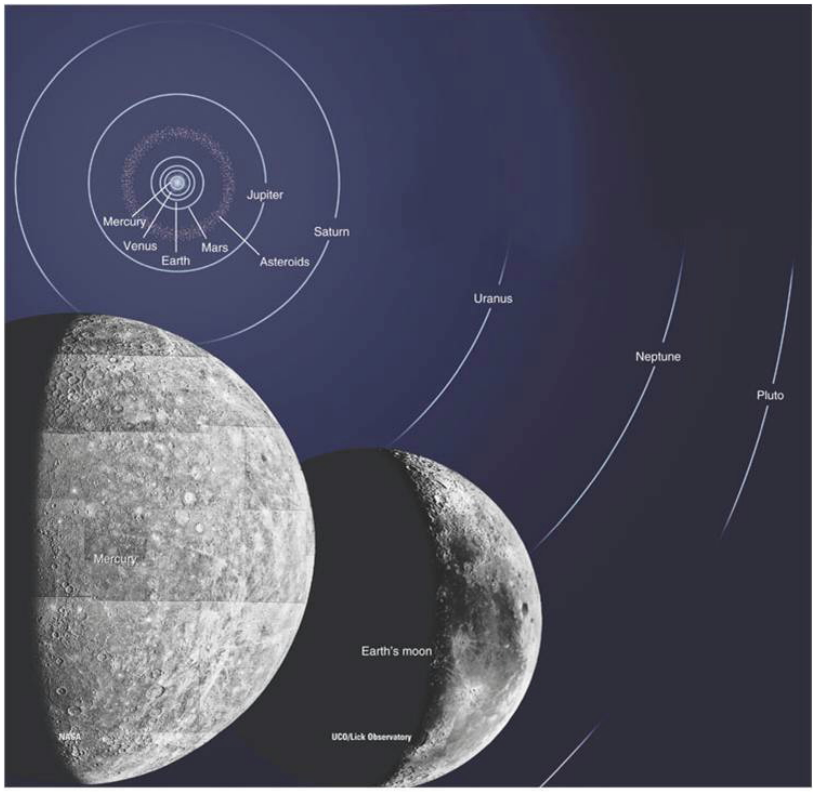
Solar wind - particles moving very fast (250 miles per second) outward from Sun

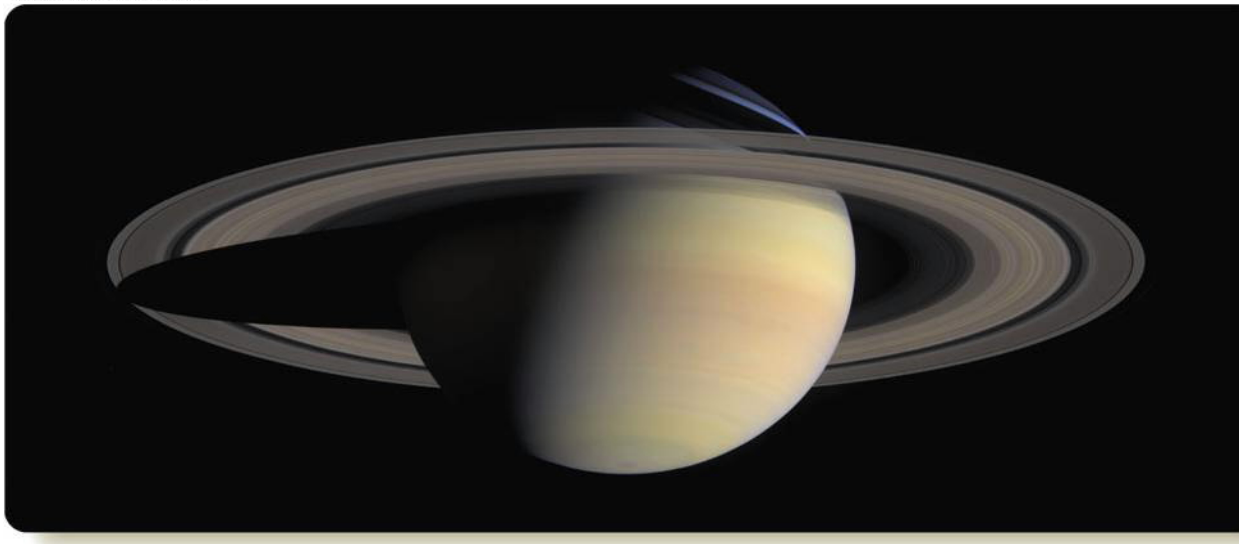
Sweeping up of space debris by the planets - cratering was frequent, planets melted

4 billion years ago was period of heavy bombardment

Ejection from the solar system by interactions with the planets

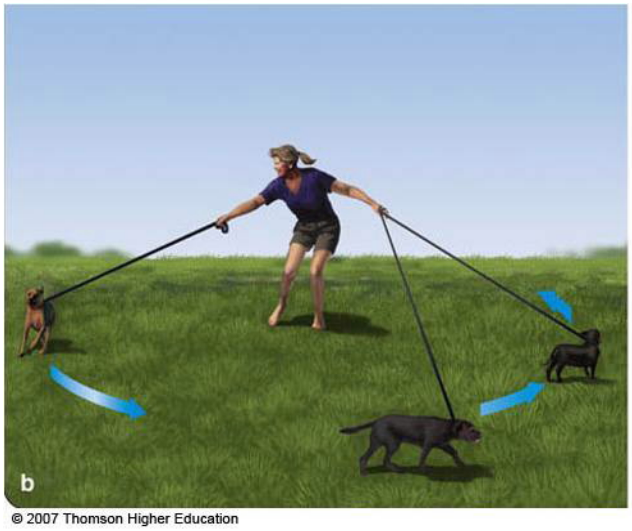
Eventually the solar system of relatively free of debris

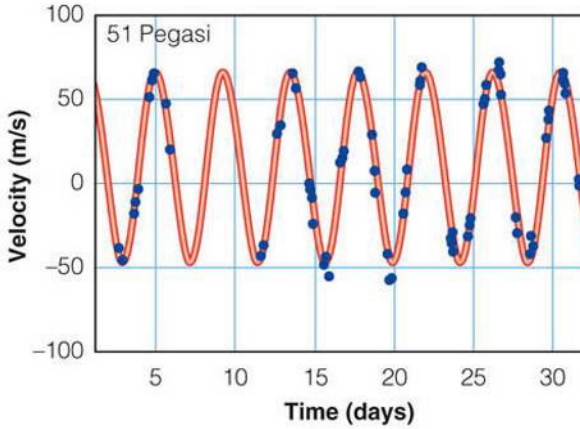


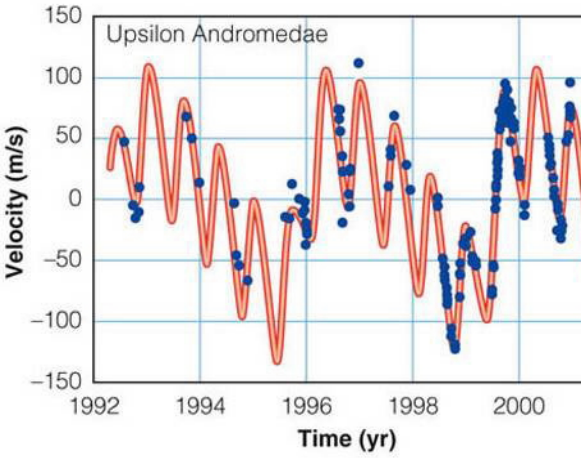


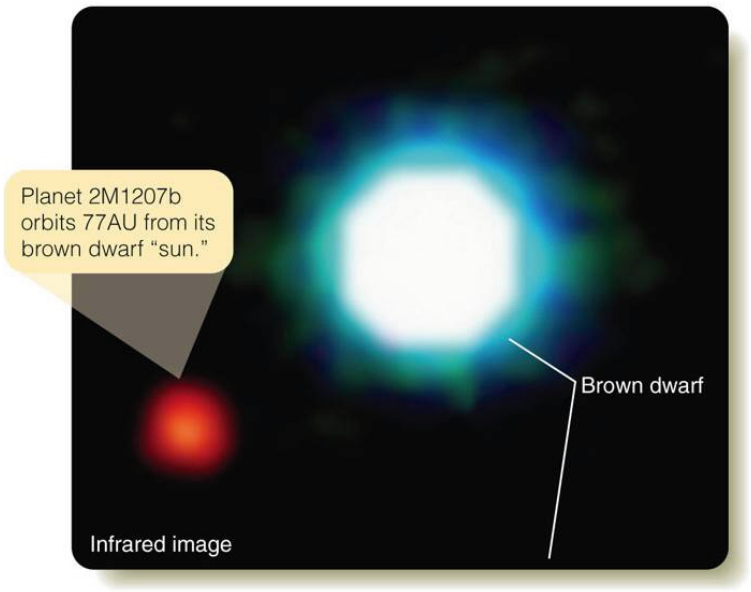
1.5 Exoplanets

Evidence of planets orbiting other stars in our galaxy.









Another example is Fomalhaut.
http://en.wikipedia.org/wiki/Fomalhaut