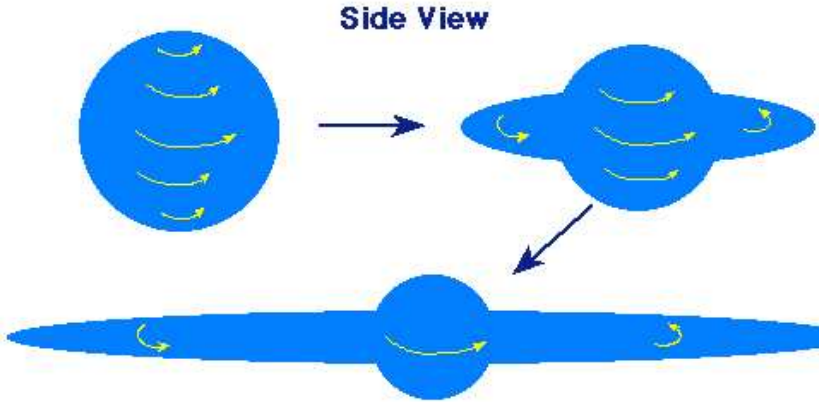
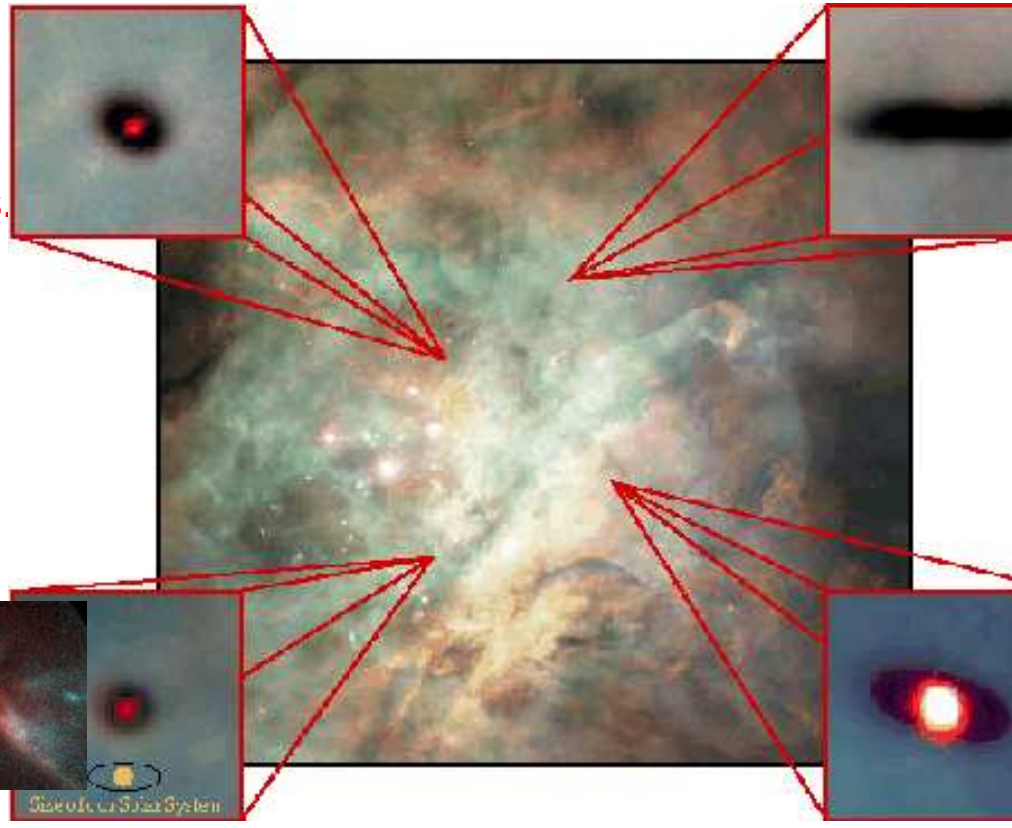
Star Formation

- Dense cores of molecular clouds collapse into hot plasma which eventually triggers nuclear reactions.
- Release of gravitational energy both heats the material and produces infrared radiation.
- Conservation of angular momentum requires spin rate to increase during collapse and disc formation.
- Emissions of protostar hidden by cooler infalling matter; eventually breaks out at poles (least resistance), producing jets.
- Dense clumps form in protostellar disc that eventually themselves collapse into planets.
- Sufficiently rapidly rotating collapses form double or multiple stars.
- Young star's emissions sweep out gas and dust from planetary system.



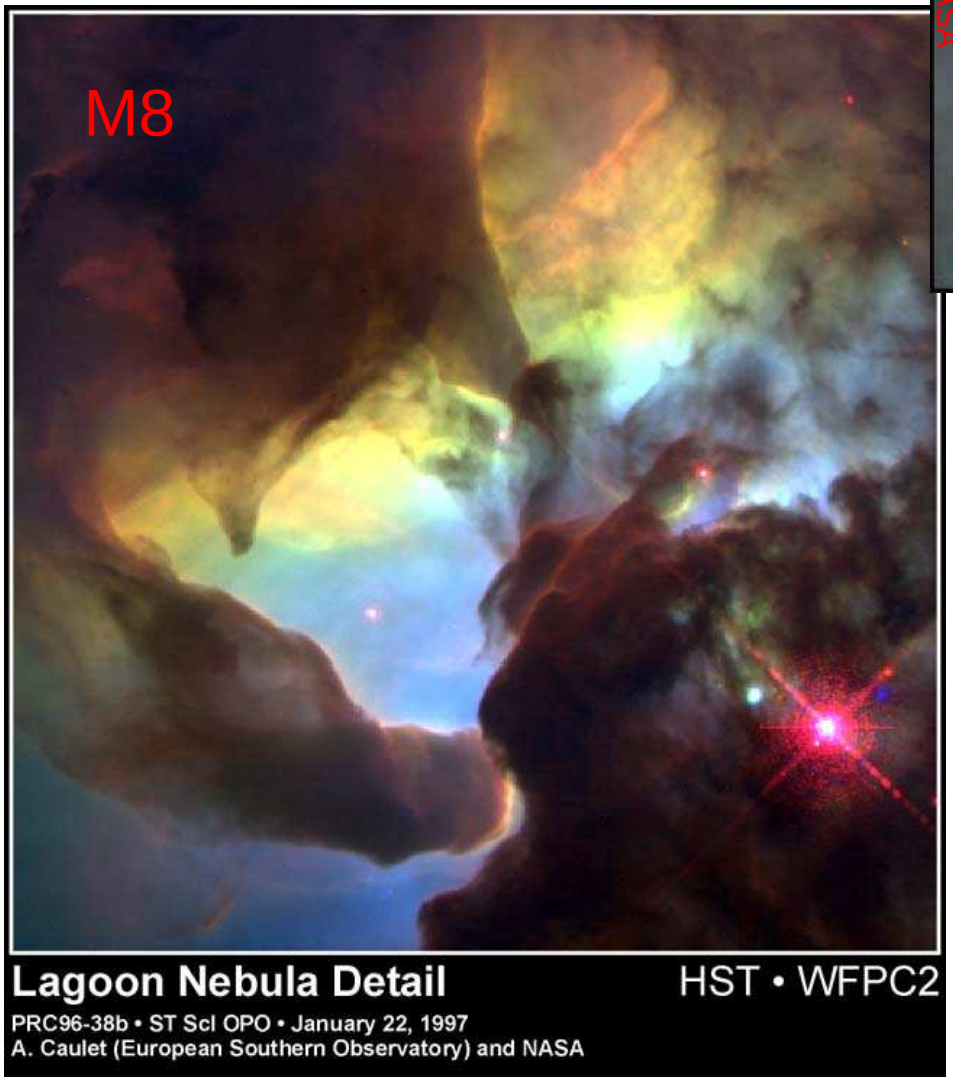
csep10.phys.utk.edu/astr161/lect/solarsys/nebular.html

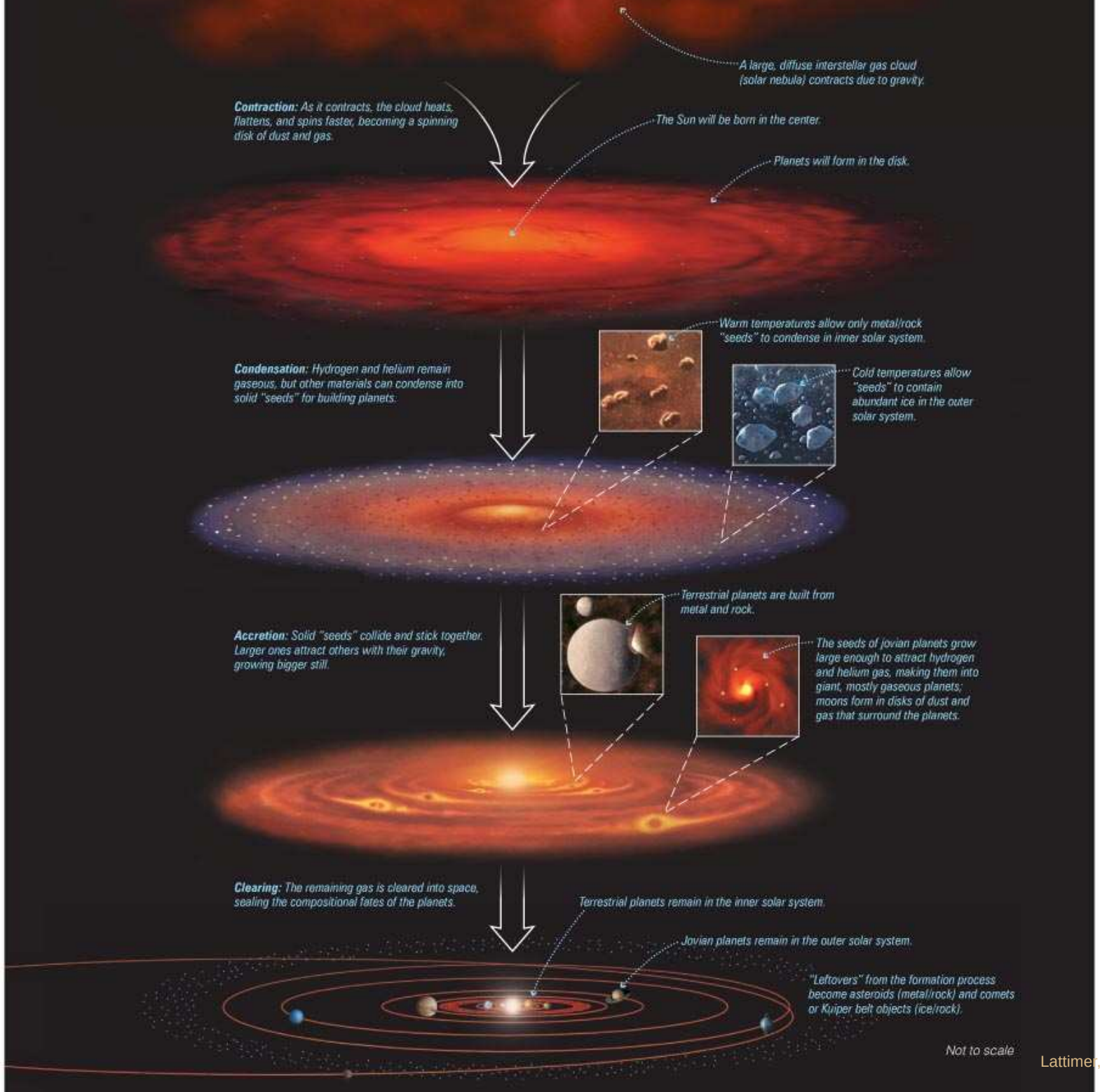


C. R. O'Dell and S. K. Wong (Rice U.), WFPC2, HST, NASA

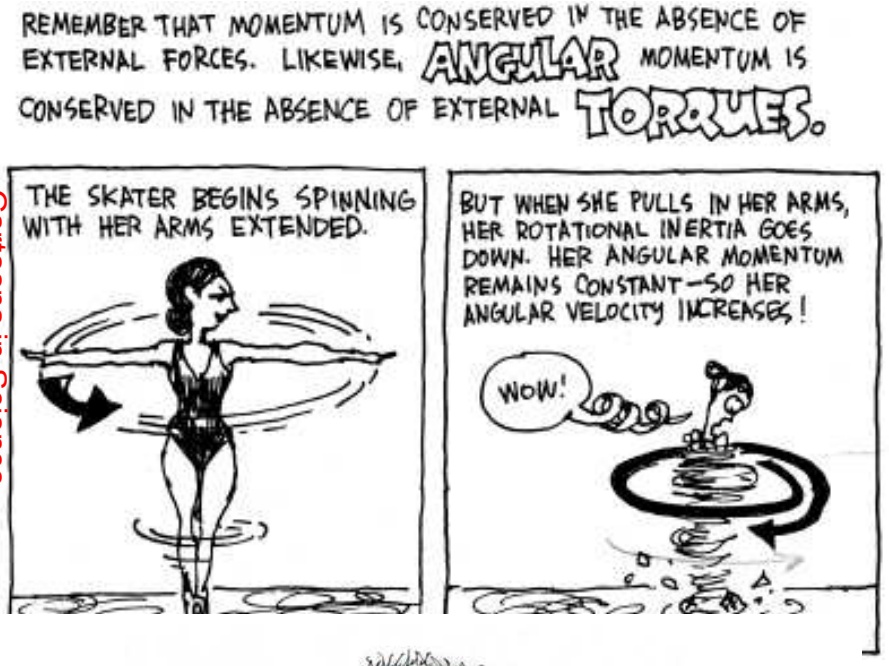
B. Reipurth (Univ. of Col.), NASA

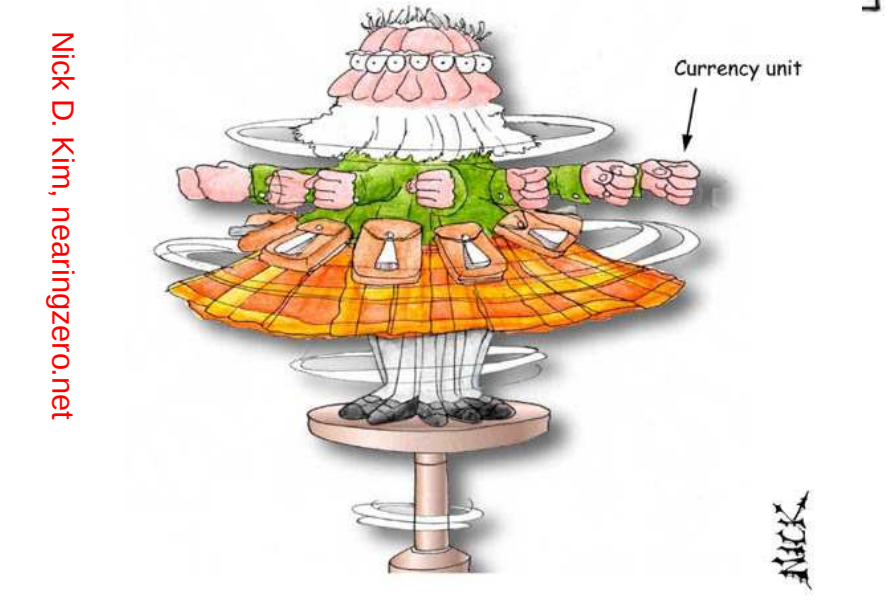
Star Forming Regions





Angular Momentum and Condensation





Centrifrugal Force, *n.*

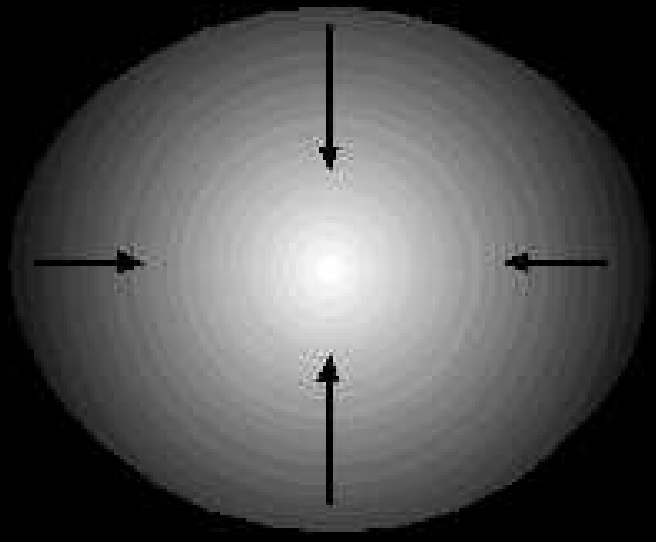
The strong inward force experienced by a unit of currency clasped in the hand of a rotating Scotsman.

Nick D. Kim, nearingzero.net

Materials in the Solar Nebula

	Metals	Rocks	Hydrogen Compounds	Light Gases
				
Examples	iron, nickel, aluminum	silicates	water (H_2O) methane (CH_4) ammonia (NH_3)	hydrogen, helium
Typical Condensation Temperature	1,000–1,600 K	500–1,300 K	< 500 K	(do not condense in nebula)
Relative Abundance (by mass)	▪	▪	■	
	(0.2%)	(0.4%)	(1.4%)	(98%)

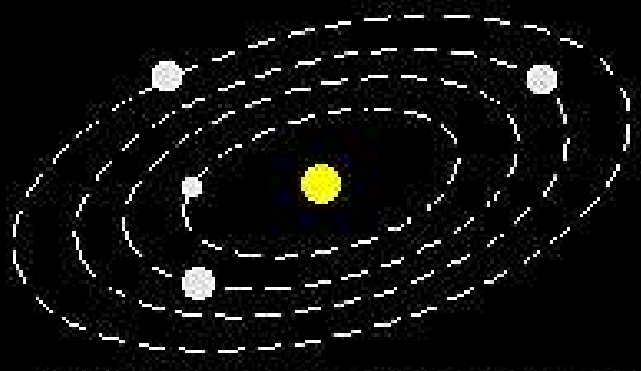
Addison-Wesley



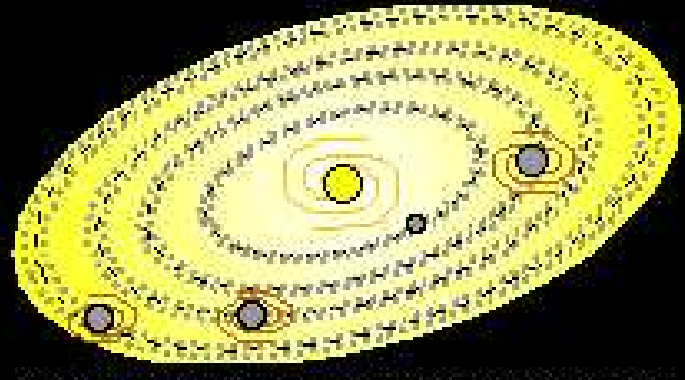
1) Large gas cloud collapses. Its spin causes it to flatten into a disk.

2) *side-view of inner part of disk:* warmer, denser, and more material closer to hot proto-Sun.

2) *above/far disk at an angle:* rock and metals condense all over the nebula; water, methane, ammonia, other ices condense only in outer part of nebula. Most of the material accumulates at the center.



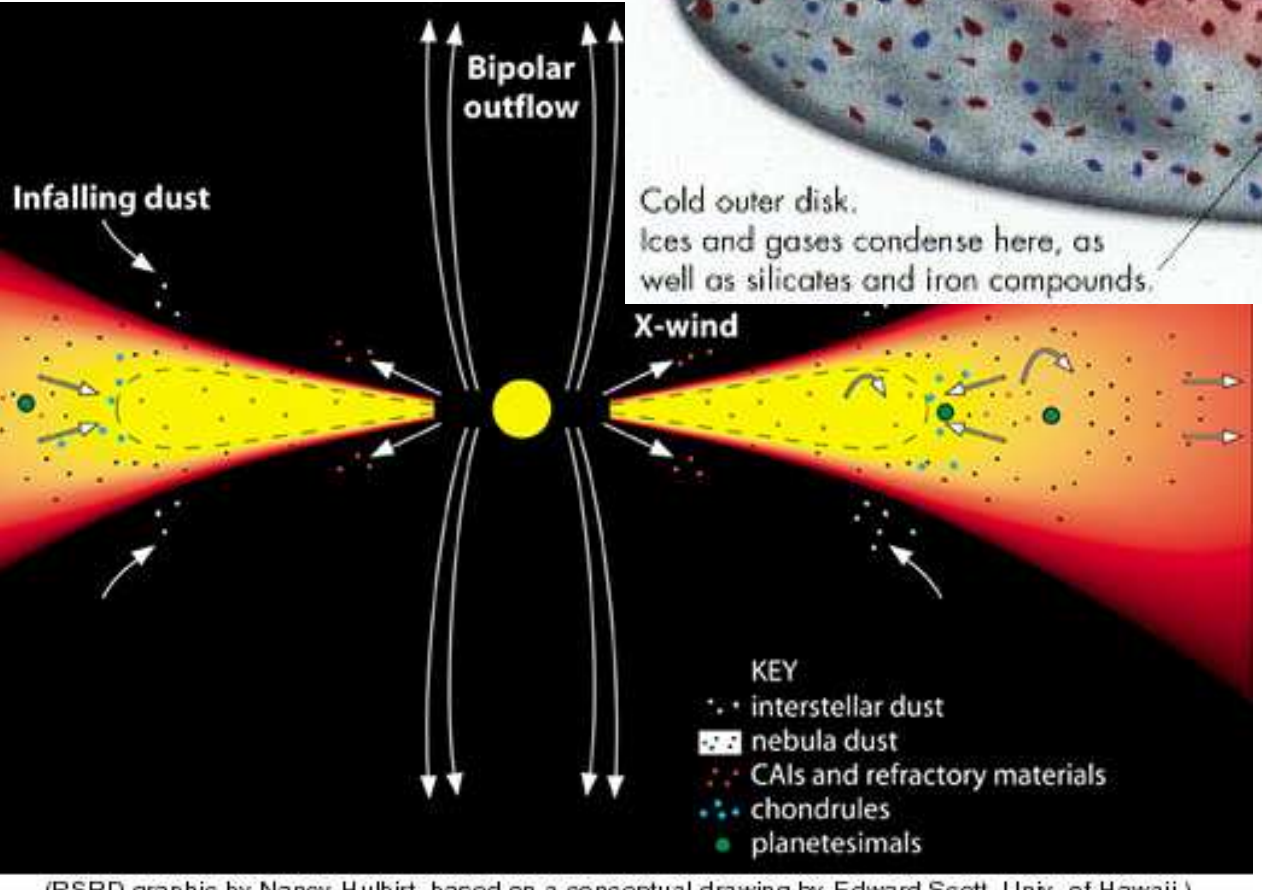
4) Sun begins fusion. Strong winds clear away nebula. Remaining planetesimals near planets get swept up or flung out.



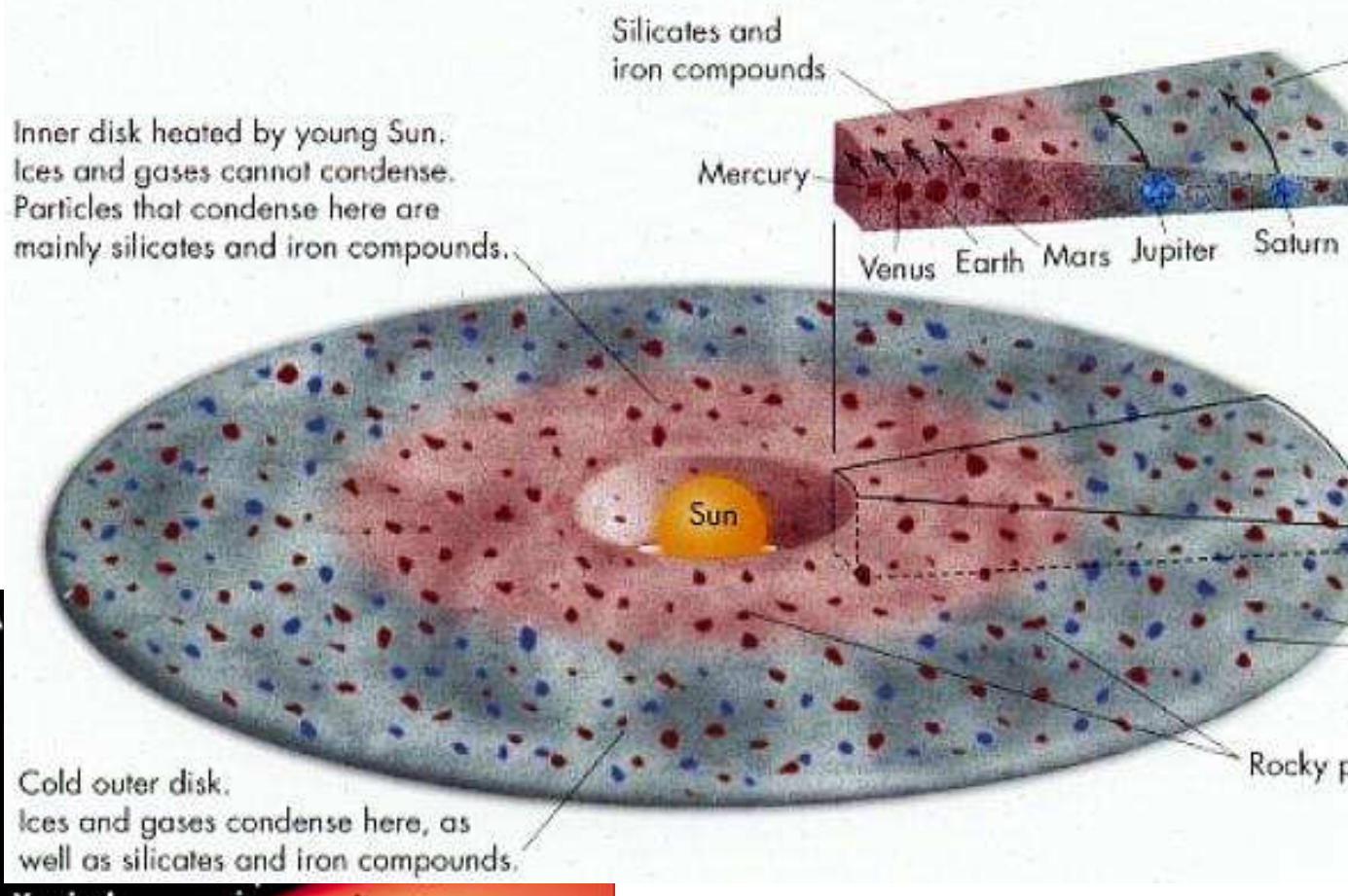
3) Solid particles collide and stick together to make planetesimals. Jovians pull in hydrogen and helium gas (proto-Sun continues to do so).

Condensation Model for making the solar system starting from upper left and proceeding clockwise (not all planets are shown).

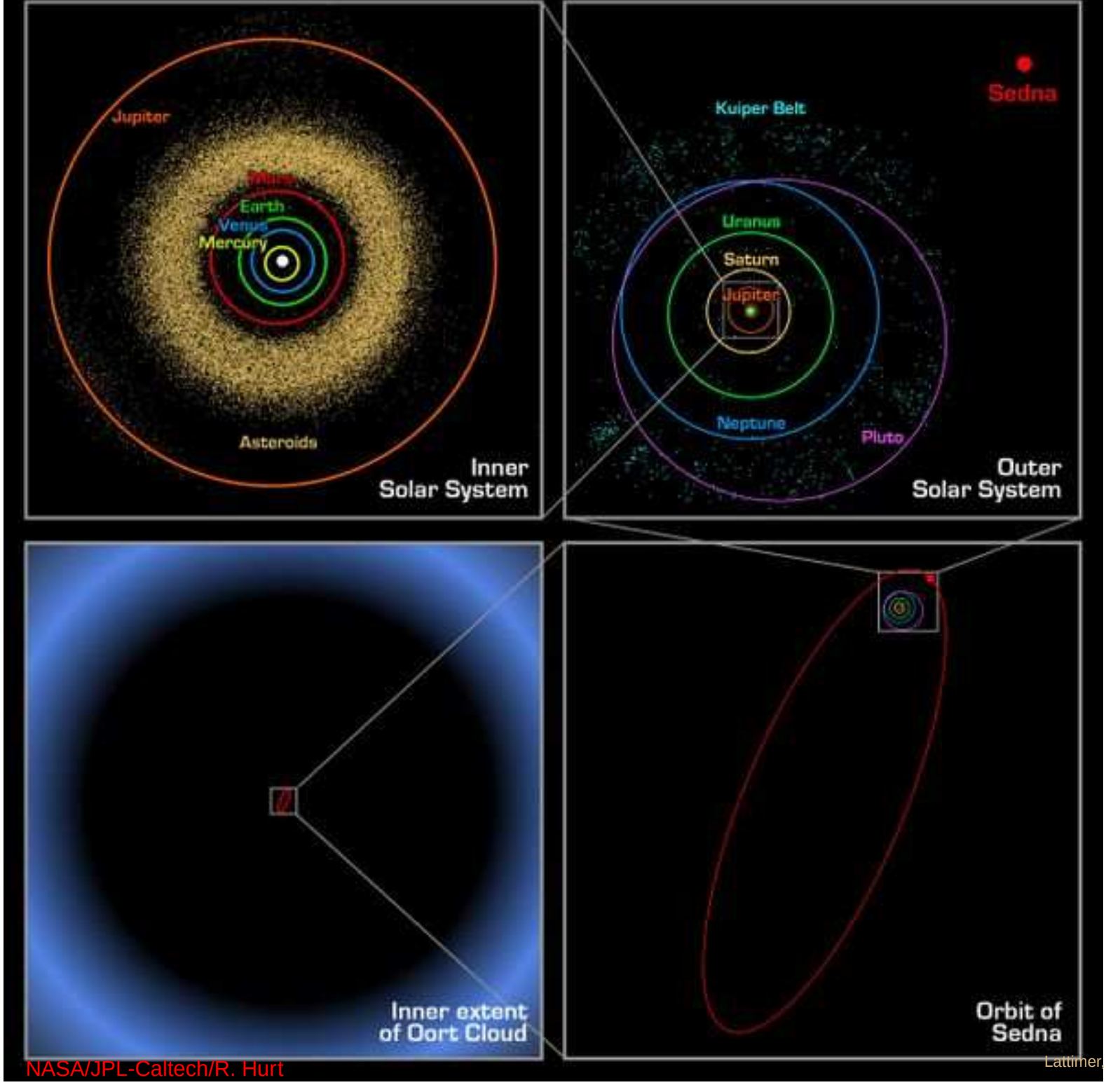
Planetismals Form



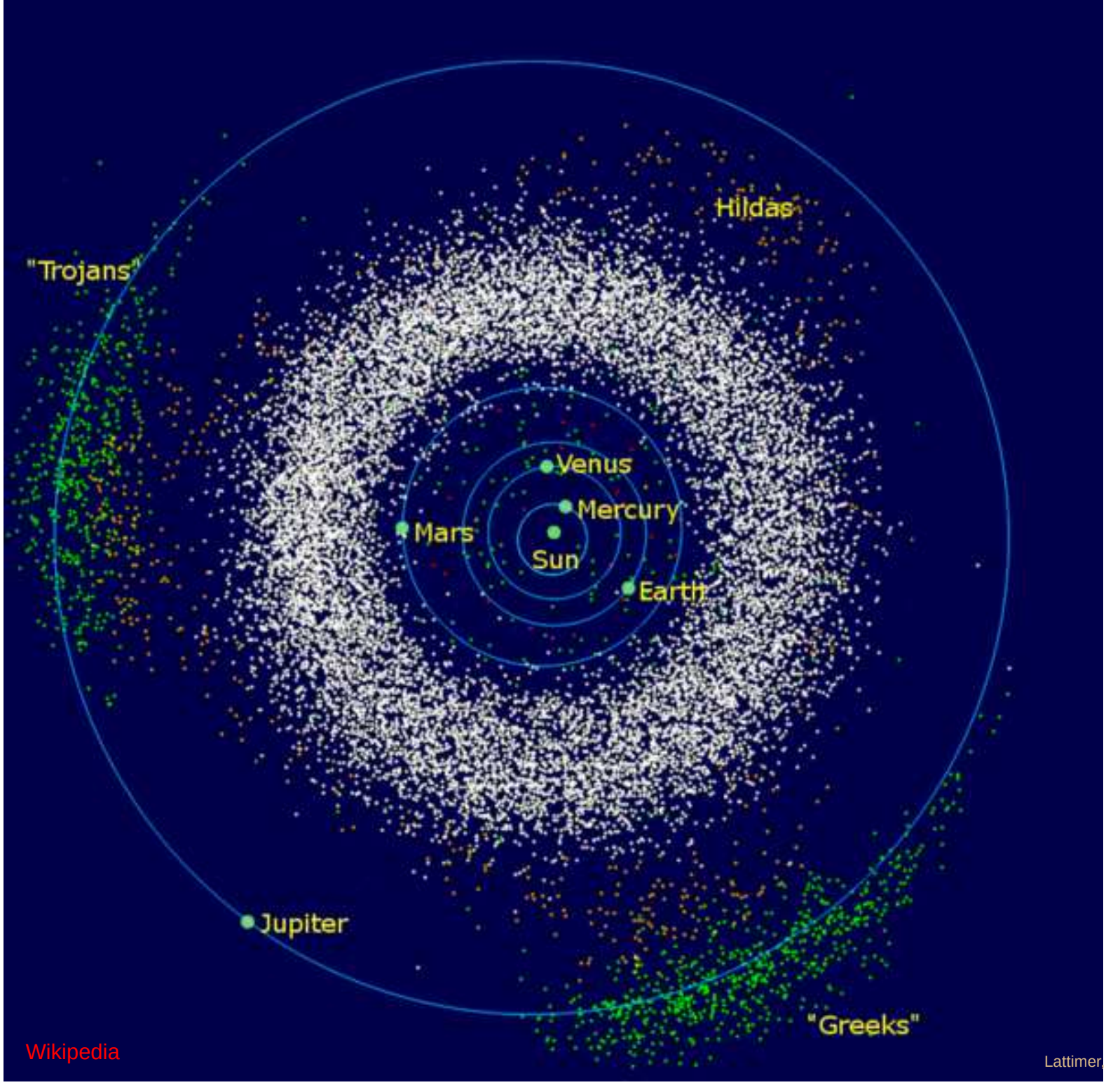
(PSRD graphic by Nancy Hulbirt, based on a conceptual drawing by Edward Scott, Univ. of Hawaii.)



www.astro.virginia.edu/class/skrutskie/astr121/notes/sscond.html



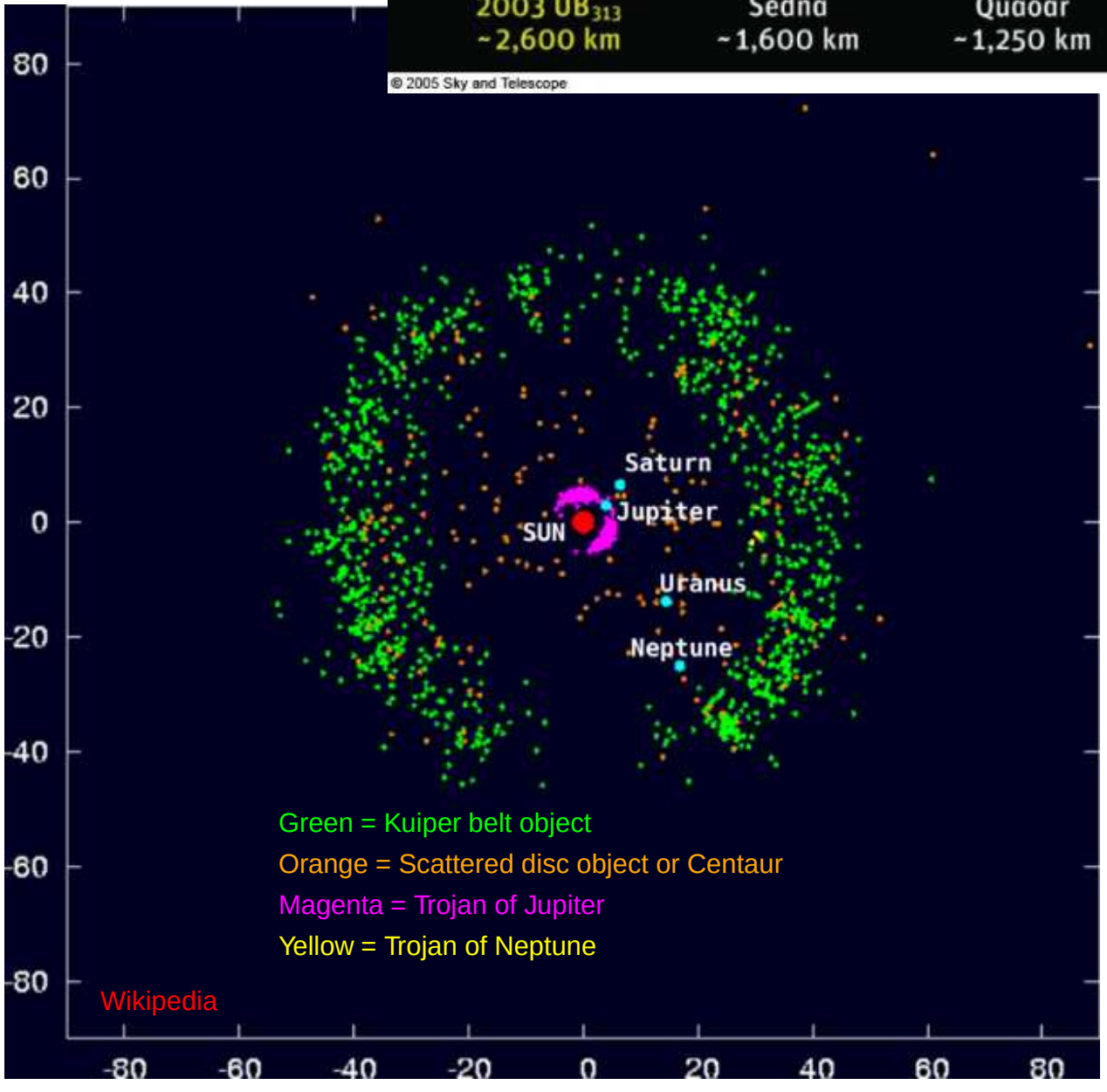
NASA/JPL-Caltech/R. Hurt


Hildas
"Trojans"
Venus
Mercury
Mars
Sun
Earth
Jupiter
"Greeks"

Wikipedia

Kuiper Belt


Eris
Charon
1,250 km
2003 UB313
~2,600 km
Sedna
~1,600 km
Quaoar
~1,250 km
Pluto
2,250 km
Moon
3,476 km
© 2005 Sky and Telescope


80
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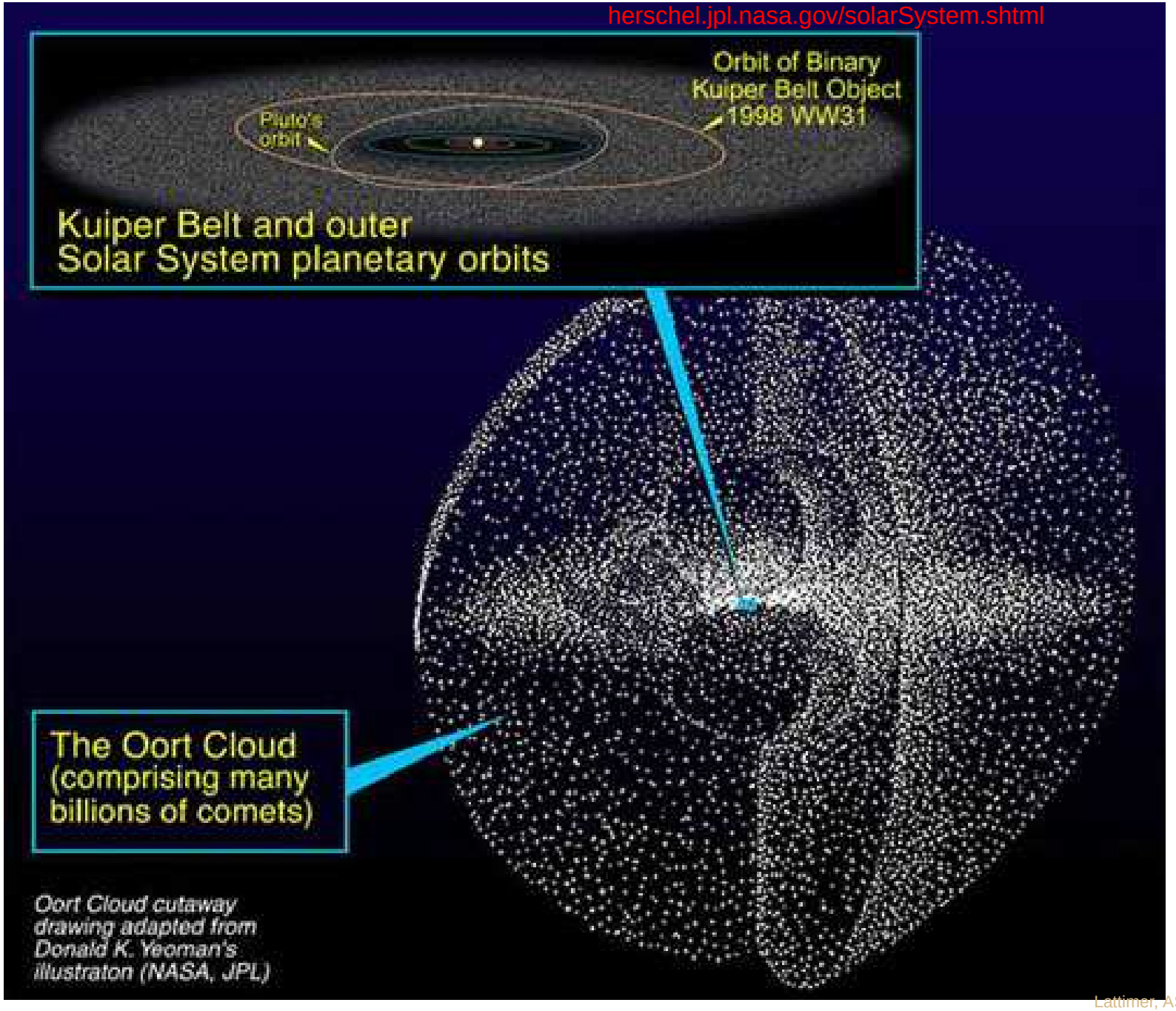
Saturn
Jupiter
SUN
Uranus
Neptune
Green = Kuiper belt object
Orange = Scattered disc object or Centaur
Magenta = Trojan of Jupiter
Yellow = Trojan of Neptune
Wikipedia

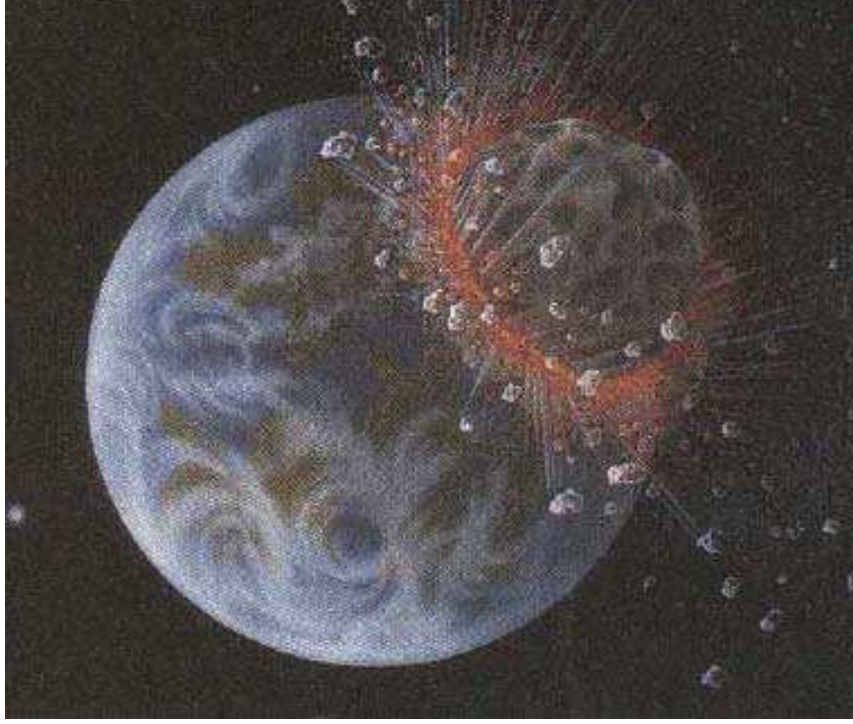
Oort Cloud


herschel.jpl.nasa.gov/solarSystem.shtml
Orbit of Binary
Kuiper Belt Object
1998 WW31
Pluto's orbit
Kuiper Belt and outer
Solar System planetary orbits
The Oort Cloud
(comprising many
billions of comets)
Oort Cloud cutaway
drawing adapted from
Donald K. Yeoman's
illustraton (NASA, JPL)

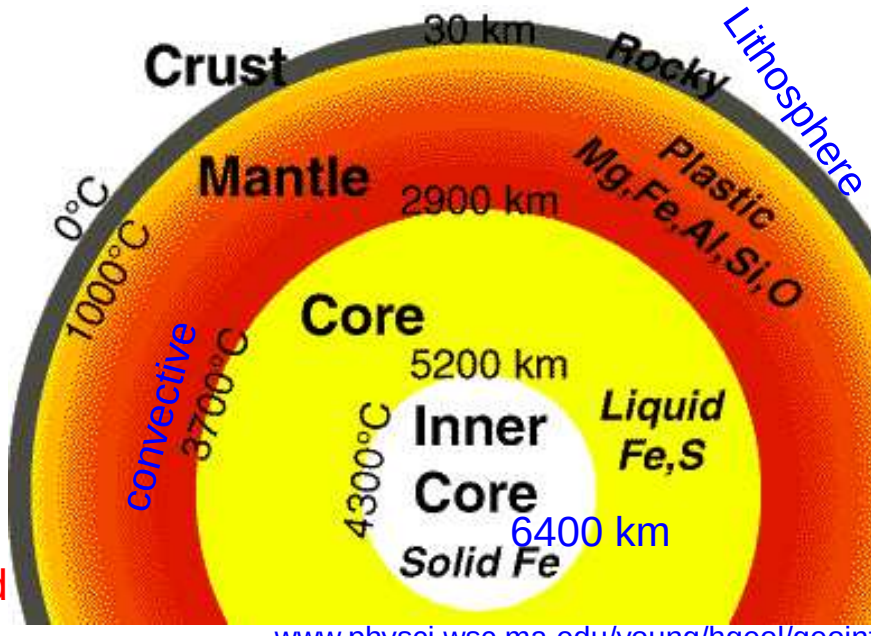
Solar System

sse.jpl.nasa.gov/planets/index.cfm

Formation of the Earth



- Earth formed 4.5 Gyrs ago.
- From a small accumulation of gas and dust, it grew by accretion and bombardment of rocky material.
- Impacts and radioactive energy release kept the early Earth very hot and molten.
- A large impact about 4.4 Gyr ago resulted in the formation of the Moon.
- The moon is the largest natural satellite of the Earth; the other moons being Cruithne , asteroid 2003 YN107, 1998 UP1 and 2000 PH5.
- The peak “Late Heavy Bombardment” was from about 4.0-3.8 Gyrs ago.
- The high temperature of the early Earth promoted differentiation, which resulted in the formation of the Earth’s core and mantle as heavier elements, like Fe, Ni, Co, Mn and S sank and lighter elements such as Si, Mg and O floated.
- The molten character of the Earth destroyed most traces, but some 4.4 Gyr-old zircons have survived
- The Earth’s crust solidified and oceans formed about 4 Gyr ago.
- Life seems to have formed on the Earth about the same time.



www.physci.wsc.ma.edu/young/hgeol/geoint timeline/formation/formation.html