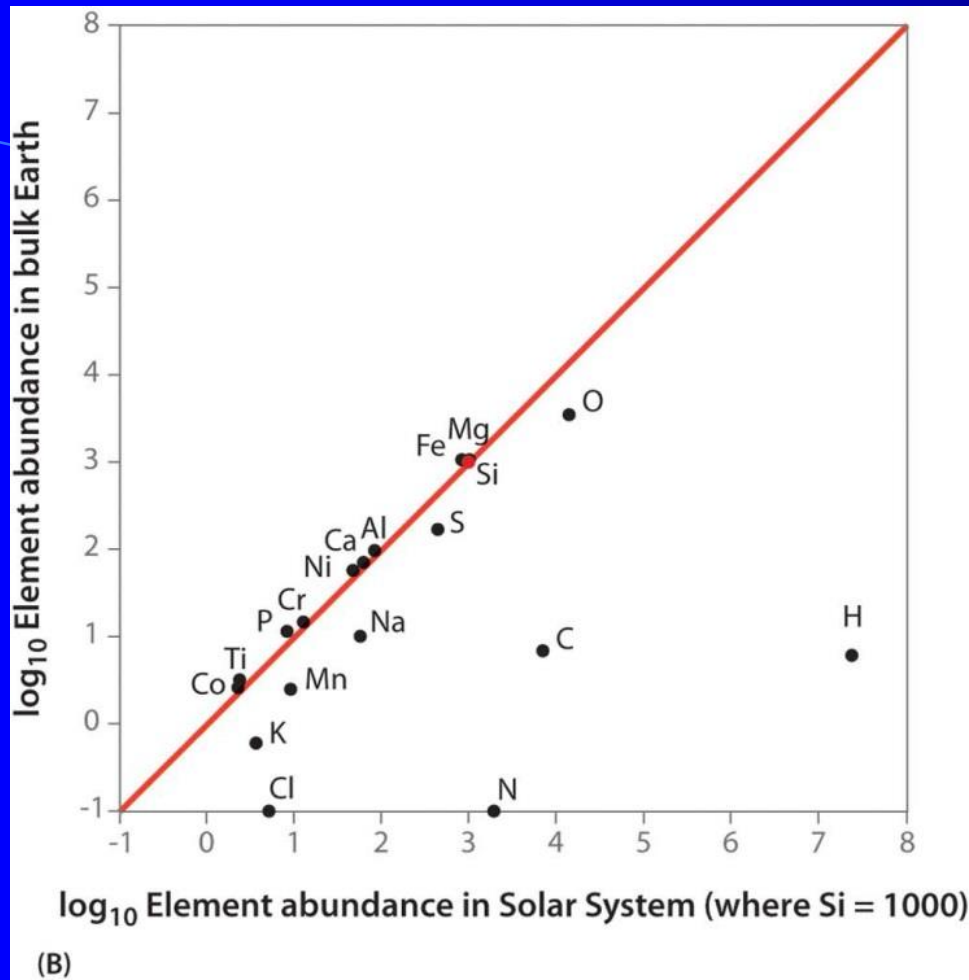


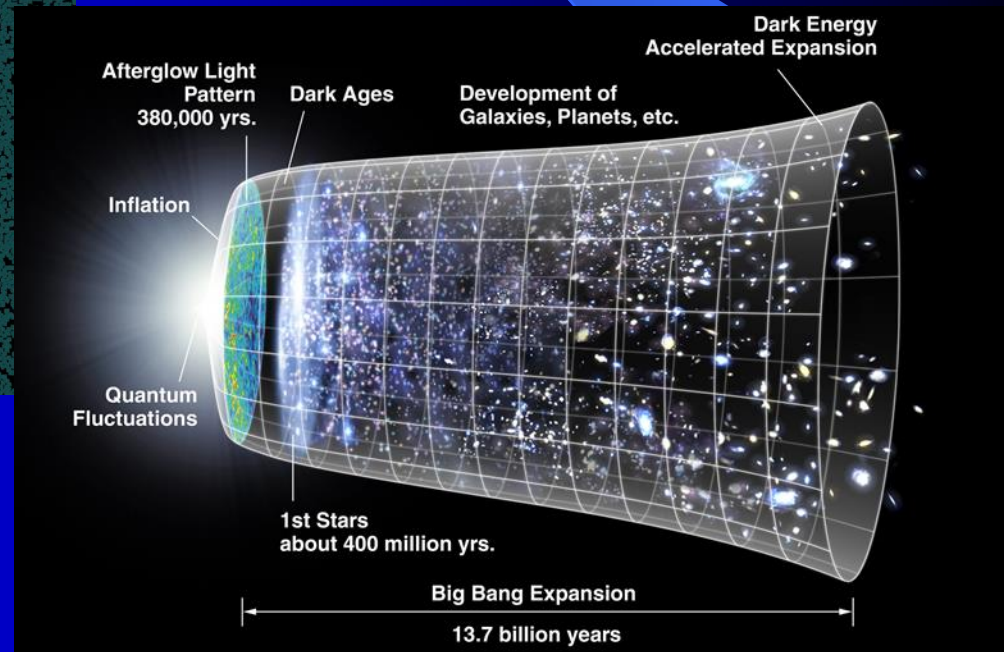
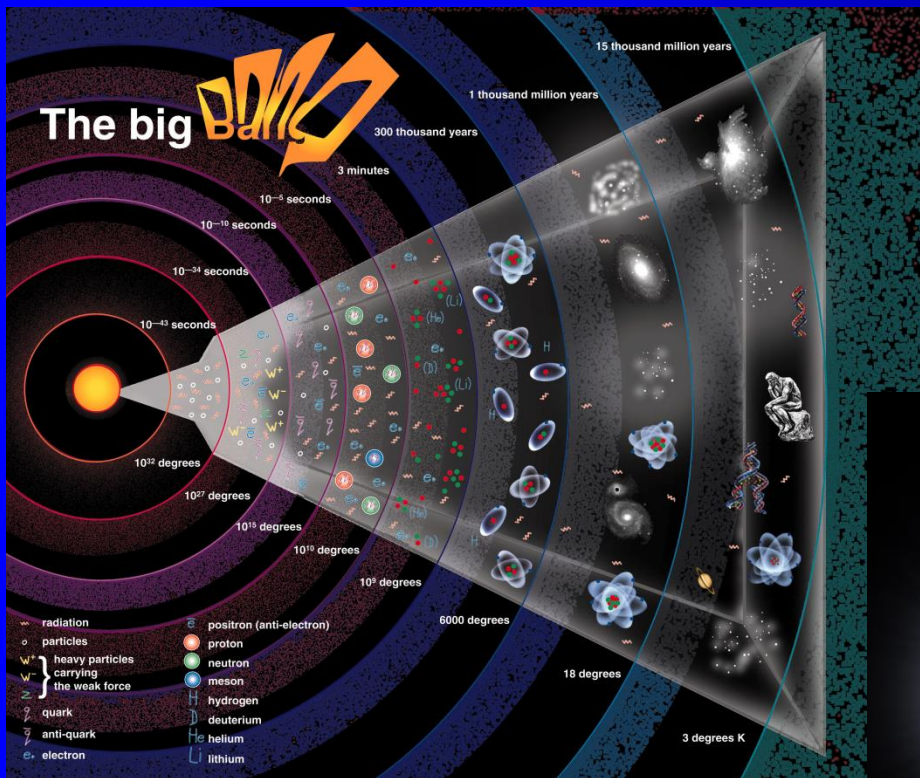
# Earth Materials I – Introduction



Element	Bulk Solar System	Bulk Earth
H	$2.431 \times 10^7$	6
He	$2.343 \times 10^6$	-
O	14130	3494
C	7079	7
Ne	2148	-
N	1950	0.1
Mg	1020	1061
Si	1000	1000
Fe	838	1066
S	445	169
Ar	103	-
Al	84	97
Ca	63	71
Na	58	10
Ni	48	58
Cr	13	15
Mn	9.2	2.5
P	8.4	11.5
Cl	5.2	0.1
K	3.7	0.6
Ti	2.4	3.2
Co	2.3	2.6

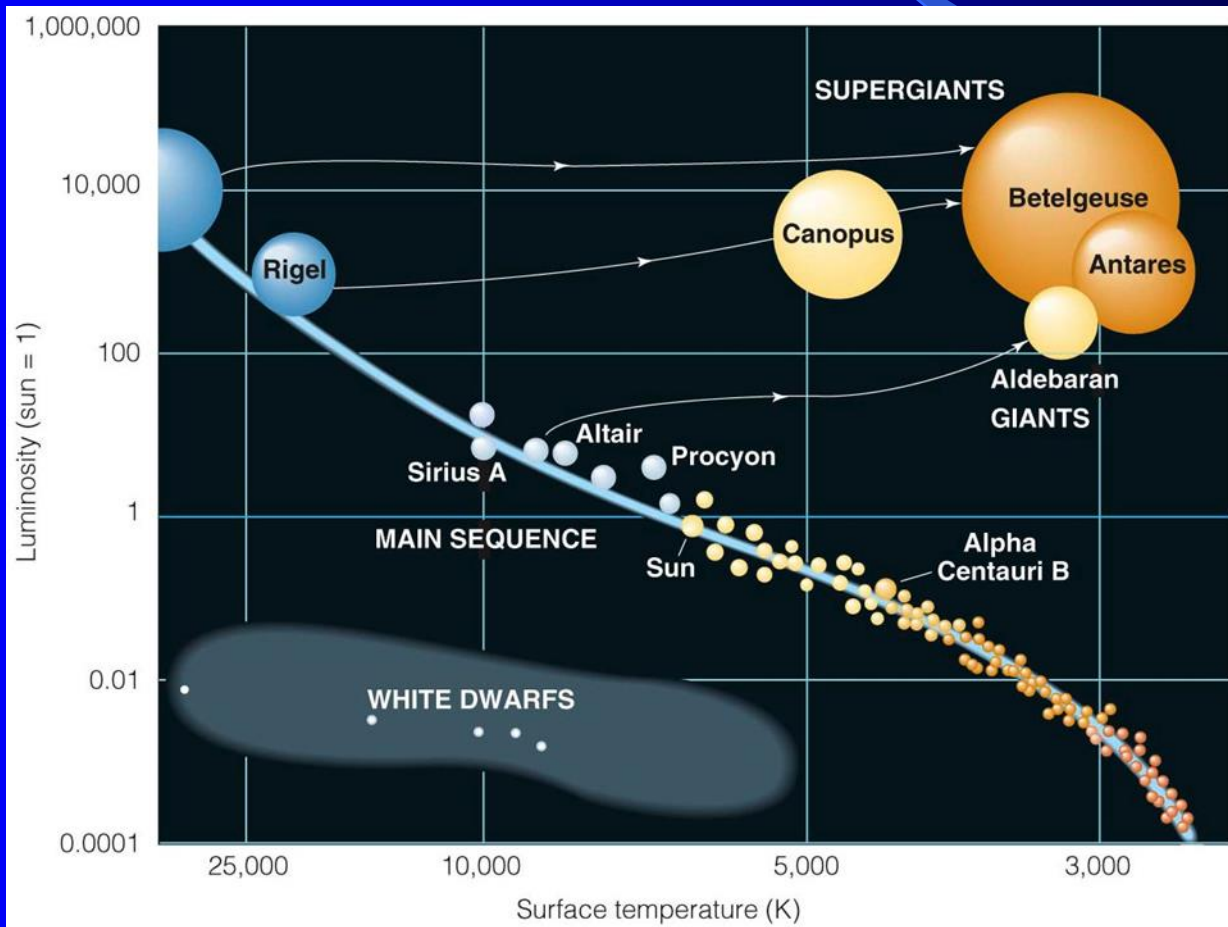
(A)

# The “Big Bang”



# Stars – Classification and Formation

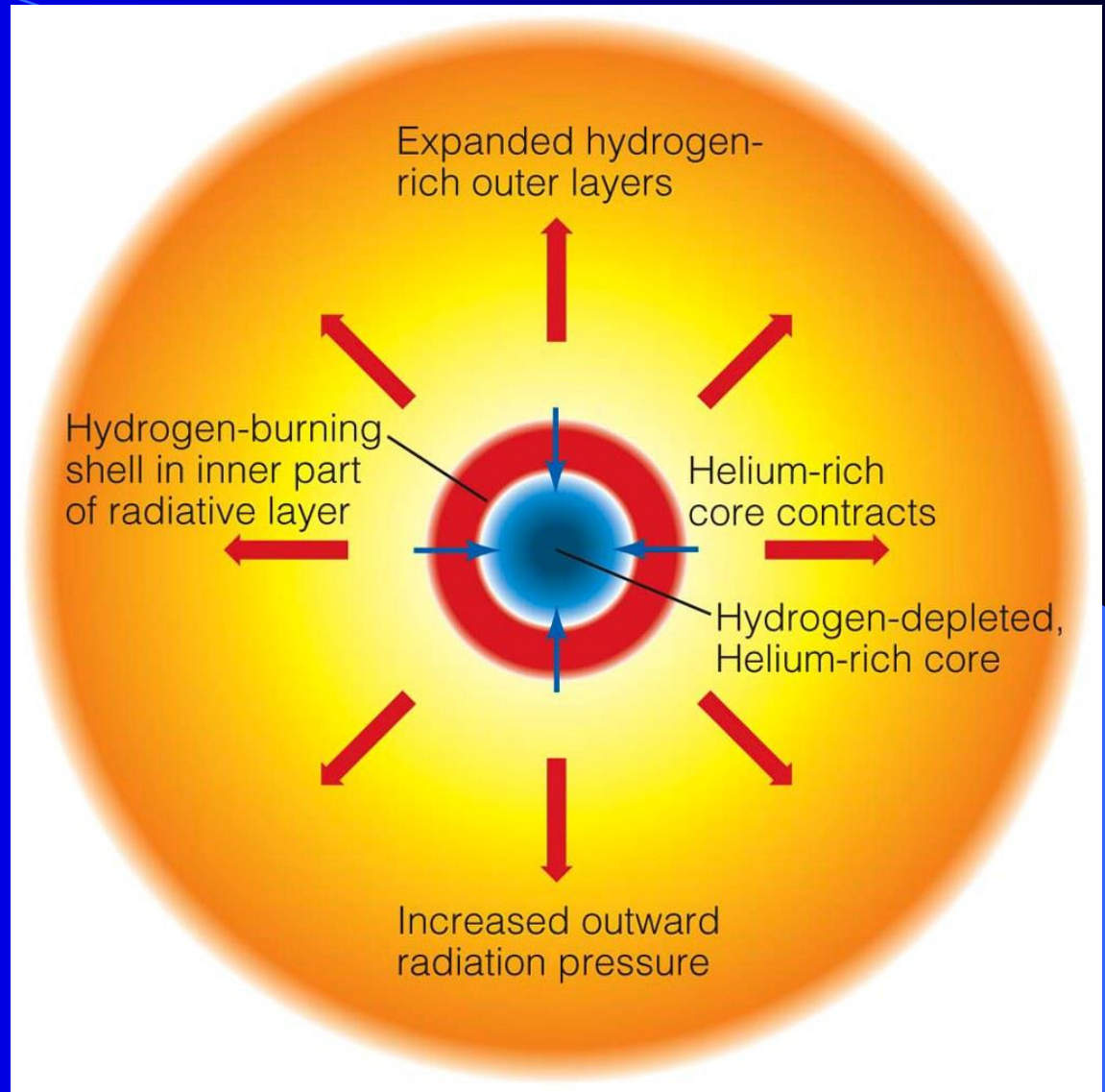
- Stars are classified by **color** and **brightness**
  - **Color** is an indication of **temperature**
  - **brightness** is a function of both the star's **luminosity** (energy emitted) and its **distance** from the Earth



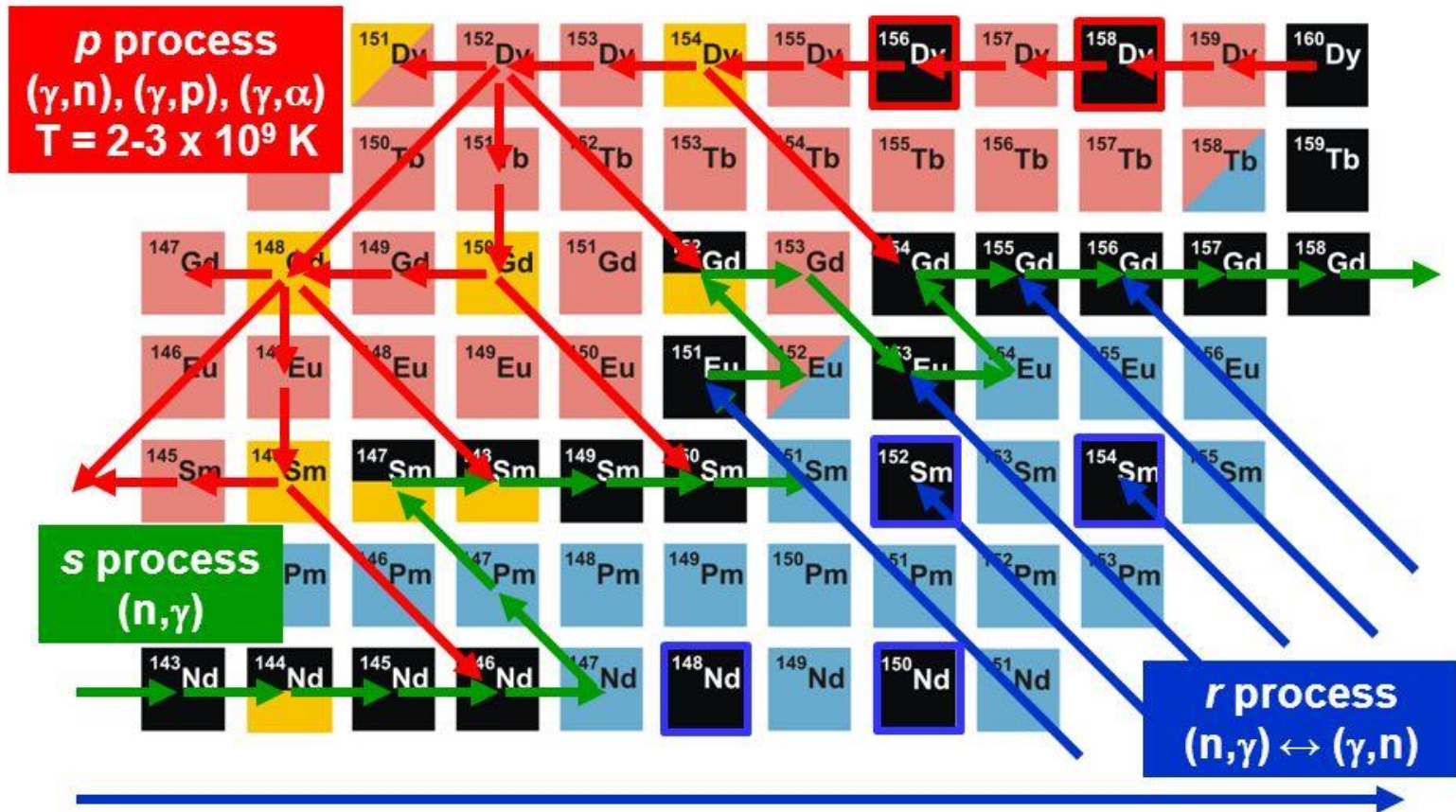
## Life history of a star

- Main sequence
- White dwarf
- Black dwarf
- In special cases – neutron star or black hole

When the star leaves the main sequence at the end of the fusion reactions a variety of processes occur, referred to as r, s, and p, which form the elements in the periodic table with atomic numbers greater than 26 (Fe).



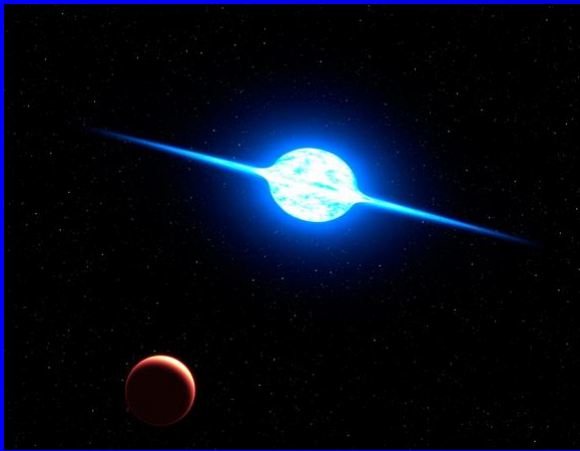
# Nucleosynthesis above iron



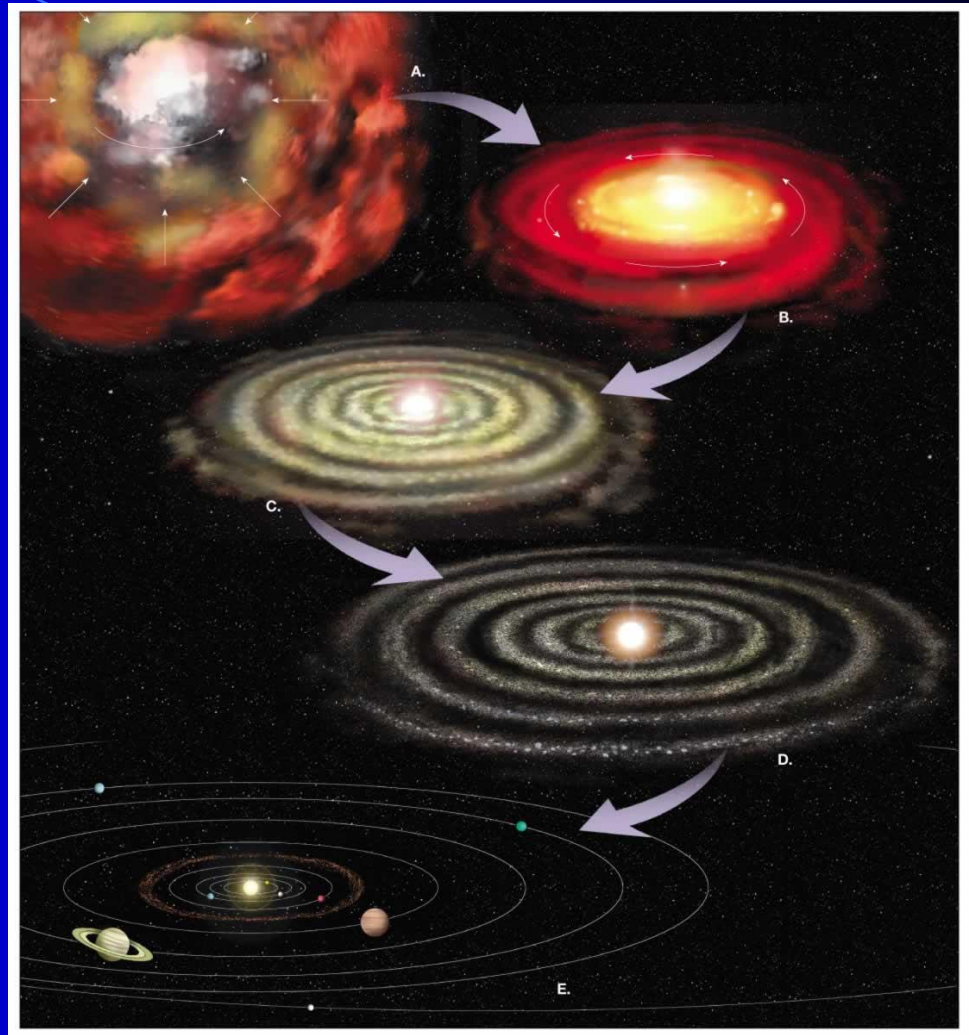
# Formation of the Solar System



Nebula



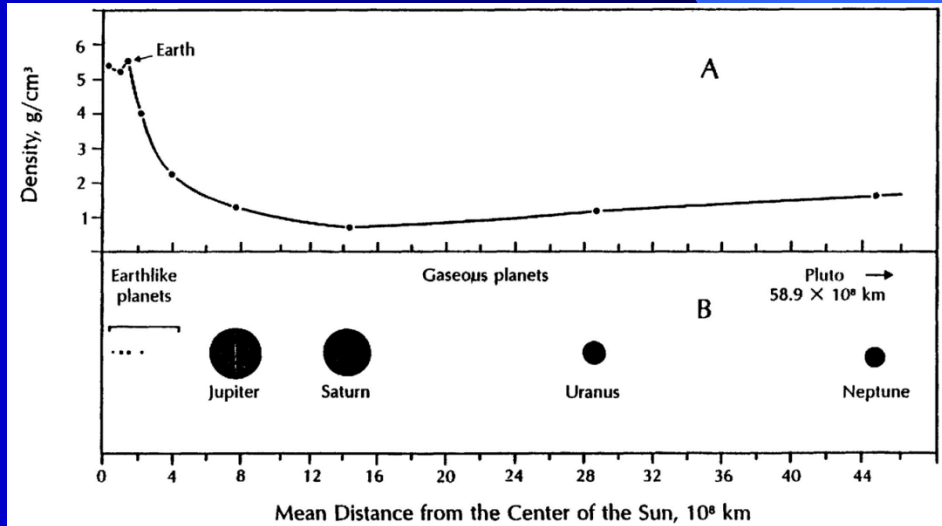
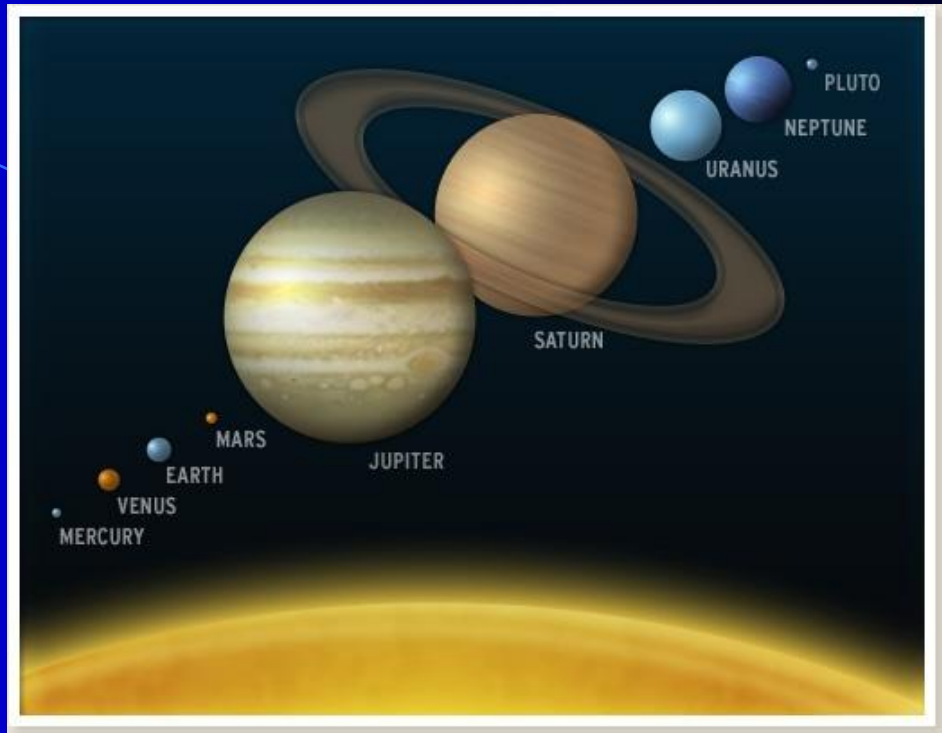
Flattened rotating nebula



Planetesimal hypothesis

# Physical Properties of the Planets

- Size
- Density
- Distance from sun



**Figure 3.1 A:** Variation of density of the planets with mean distance from the Sun. Note that the Earth has the highest density among the earthlike planets, which, as a group, are more dense than the outer gaseous planets. **B:** The planets of the solar system magnified 2000 times relative to the distance scale. The earthlike planets are very small in relation to the Sun and the gaseous planets of the solar system.

# Chemistry of the Planets - Meteorites



Iron meteorite



Stony-iron meteorite



Stony meteorite



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# Most meteorites come from the Asteroid belt

**Table 9.2** Classification and Abundances of Meteorites

Class and Subclass	Abundance	
	Fall, %	Find, %
<i>Stones</i>		
<b>Chondrites</b>		
Enstatite chondrite	1.4	
H chondrites (high-Fe)	32.2	
L chondrites (low-Fe)	36.9	
LL chondrites (low-Fe, low metal)	6.9	
Carbonaceous chondrites	4.2	
Unclassified	5.3	
All chondrites	86.9	51.7
<b>Achondrites</b>		
Ca-poor (aubrites, diogenites, ureilites, chassignites)	2.7	
Ca-rich (angrites, nakhlites, eucrites, howardites)	5.5	
Unclassified	0.3	
All achondrites	8.5	1.7
<i>Stony Irons</i>		
Pallasites	0.5	
Mesosiderites	0.8	
All stony irons	1.3	5.9
<i>Irons</i>		
I AB (coarse octahedrites)	0.8	
II AB (hexahedrites, coarsest octahedrites)	0.6	
III AB (medium octahedrites)	0.6	
IV A (fine octahedrites)	0.4	
IV B (ataxites)	0	
Others and anomalous irons	0.9	
All irons	3.3	40.7

After Henderson (1982).

**Table 9.4** Representative Chemical Compositions of Meteorites in Weight Percent<sup>a</sup>

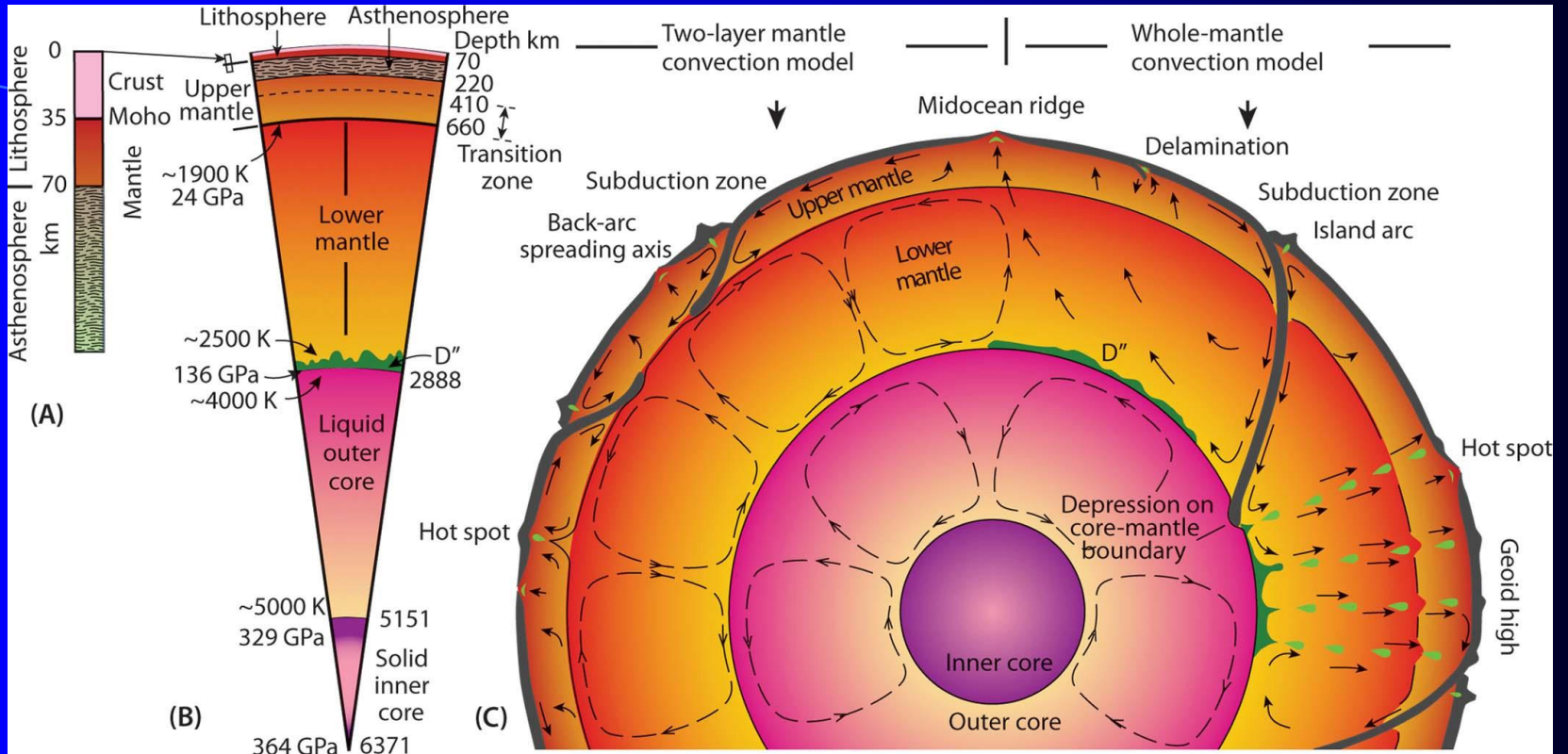
	Carbonaceous chondrite <sup>(1)</sup>	Enstatite chondrite <sup>(2)</sup>	Ca-poor achondrites <sup>(3)</sup>	Ca-rich achondrites <sup>(4)</sup>	Average iron meteorites <sup>(5)</sup>
Fe	—	20.04	2.92	0.80	90.6
Ni	—	1.96	0.17	—	7.9
Co	—	0.07	—	—	0.5
P	—	—	—	—	0.2
S	—	—	—	—	0.7
FeS	15.07	7.27	1.25	0.41	—
SiO <sub>2</sub>	22.56	41.53	54.01	48.17	—
TiO <sub>2</sub>	0.07	—	0.06	0.51	—
Al <sub>2</sub> O <sub>3</sub>	1.65	1.55	0.67	13.91	—
MnO	0.19	—	0.14	0.46	—
FeO	11.39	0.34	0.97	15.99	—
MgO	15.81	23.23	35.92	7.10	—
CaO	1.22	0.74	0.91	10.94	—
Na <sub>2</sub> O	0.74	1.26	1.32	0.67	—
K <sub>2</sub> O	0.07	0.32	0.10	0.13	—
P <sub>2</sub> O <sub>5</sub>	0.28	0.8	0.22	0.11	—
H <sub>2</sub> O	19.89	—	1.14	0.44	—
Cr <sub>2</sub> O <sub>3</sub>	0.36	0.56	0.06	0.39	—
NiO	1.23	—	0.26	—	—
CoO	0.06	—	—	—	—
C	3.10	—	—	—	0.04
LOI <sup>b</sup>	6.96	0.86(CaS)	0.51(CaS)	—	—
Sum	100.65	99.91	100.00	100.3	99.94

<sup>a</sup> A dash (—) means "not reported and probably zero," although in some cases the element in question was reported in different form.

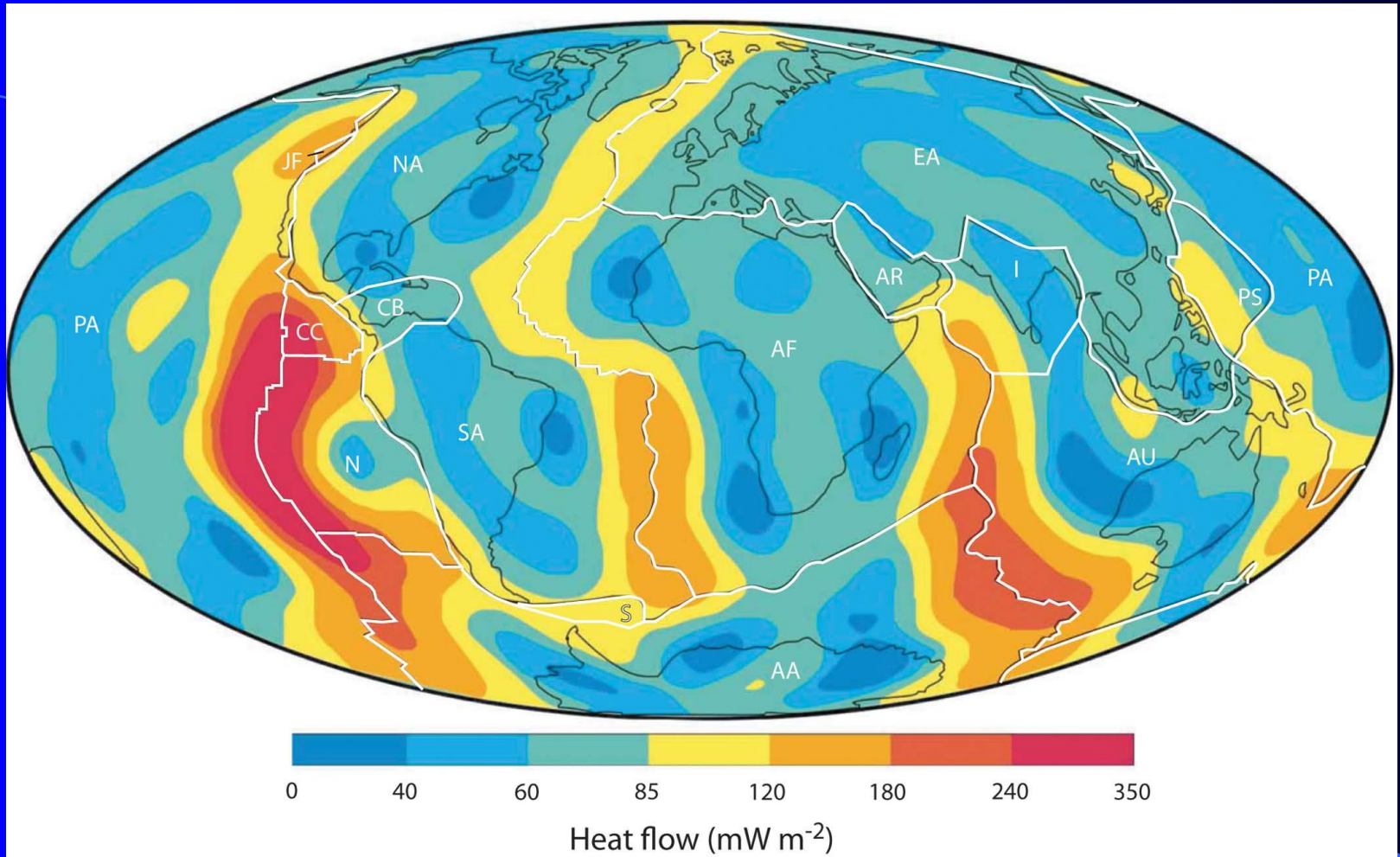
<sup>b</sup> Loss on ignition.

SOURCE: (1) Orgueil, type I, from Henderson (1982, Table 1.3); (2) Hvittis, from Henderson (1982, Table 1.3); (3) average aubrite, from Henderson (1982, Table 1.3); (4) average eucrites, from Henderson (1982, Table 1.3); (5) average iron meteorite from Glass (1982, Table 4.3).

# Structure of the Earth



# Heat Flow



# Types of Plate Interactions

