

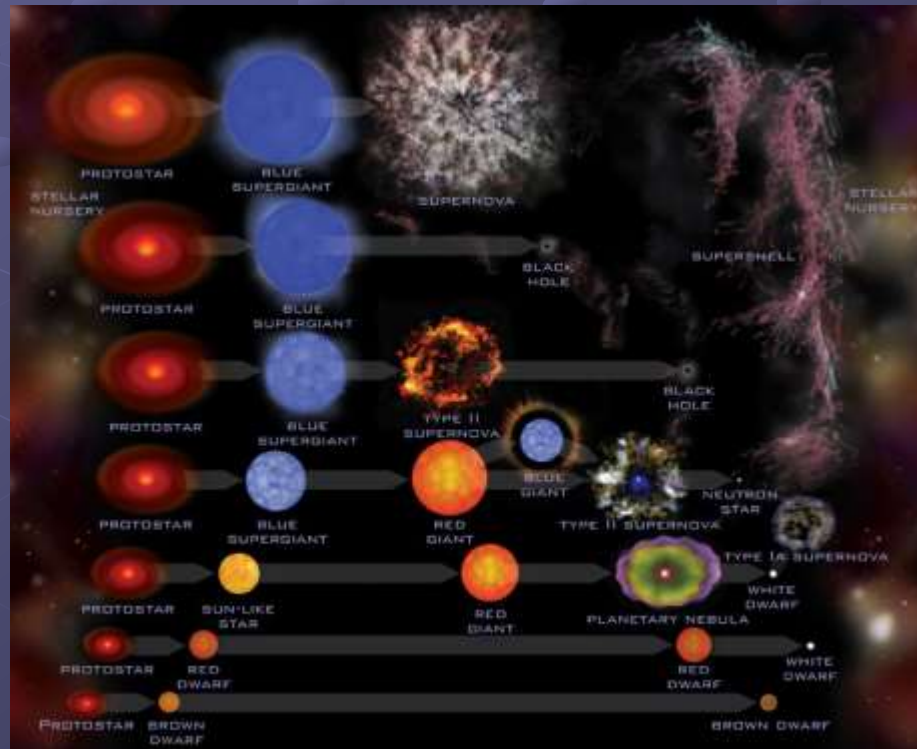
Handout 2 (yellow)

Stars and Stellar Evolution

Stellar Evolution

1

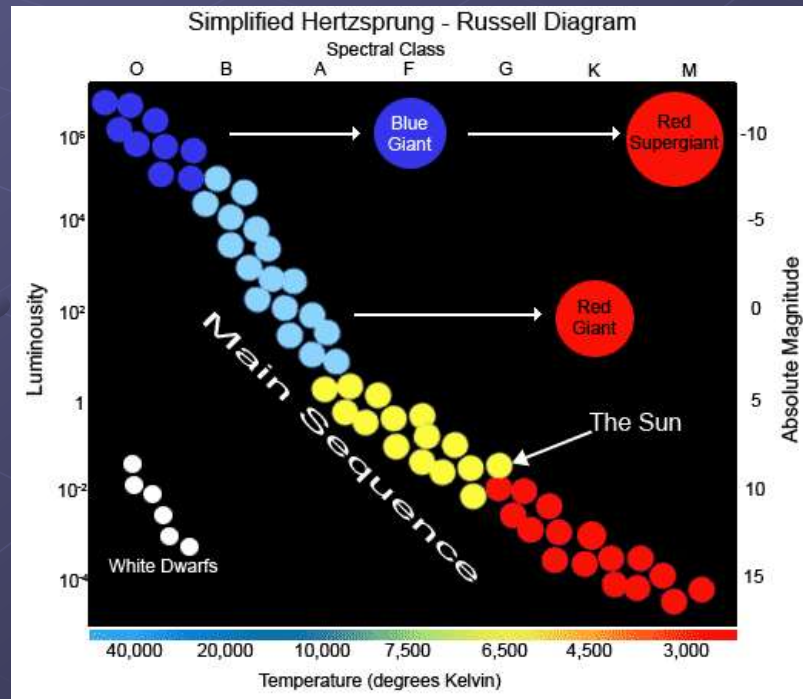
- Why are astronomers not able to observe the entire life of any star?
 - Because a star typically exists for billions of years.



2

● What is the Hertzsprung-Russell diagram?

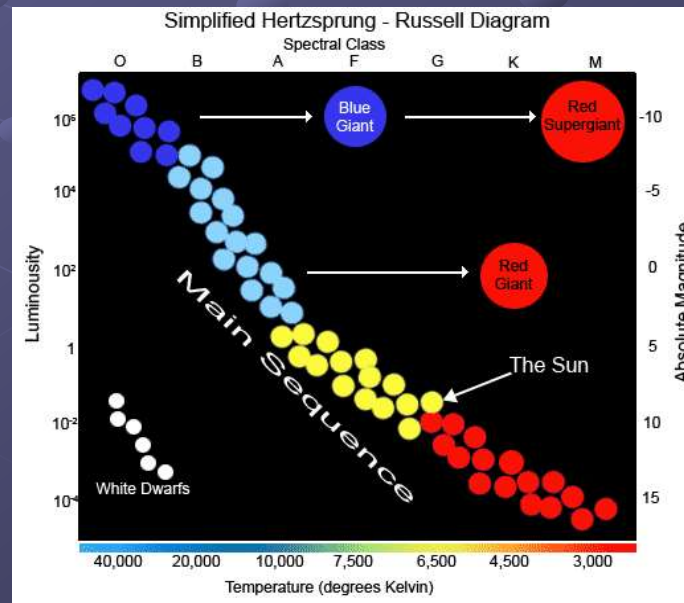
- The graph that illustrates the pattern revealed when the surface temperatures of stars are plotted against their luminosity.



3

● What is the main sequence?

- The band that runs diagonally through the Hertzsprung-Russell diagram and extends from cool, dim, red stars at the lower right to hot, bright, blue stars at the upper left.



● What is a nebula?

- A: A cloud of gas and dust where a star begins.



5

- A Nebula commonly consists of about 70 % hydrogen, 28 % helium, and 2 % heavier elements.



H B																		He B																	
Li C		Be C																		B C		C S L		N S L		O S L		F L		Ne S L					
Na L		Mg L																		Al S L		Si S L		P L		S S L		Cl L		Ar L					
K L		Ca L		Sc L		Ti S L		V S L		Cr L		Mn L		Fe S L		Co S		Ni S		Cu L		Zn L		Ga S		Ge S		As L		Se S		Br S		Kr S	
Rb S		Sr L		Y L		Zr L		Nb L		Mo S L		Tc L		Ru S L		Rh S		Pd S L		Ag S L		Cd S L		In S L		Sn S L		Sb S		Te S		I S		Xe S	
Cs S		Ba L				Hf S L		Ta S L		W S L		Re S		Os S		Ir S		Pt S		Au S		Hg S L		Tl S L		Pb S		Bi S		Po S		At S		Rn S	
Fr S		Ra S																																	
		La L		Ce L		Pr S L		Nd S L		Pm S L		Sm S L		Eu S		Gd S		Tb S		Dy S		Ho S		Er S		Tm S		Yb S L		Lu S					
		Ac S		Th S		Pa S		U S		Np S		Pu S		Am M		Cm M		Bk M		Cf M		Es M		Fm M		Md M		No M		Lr M					

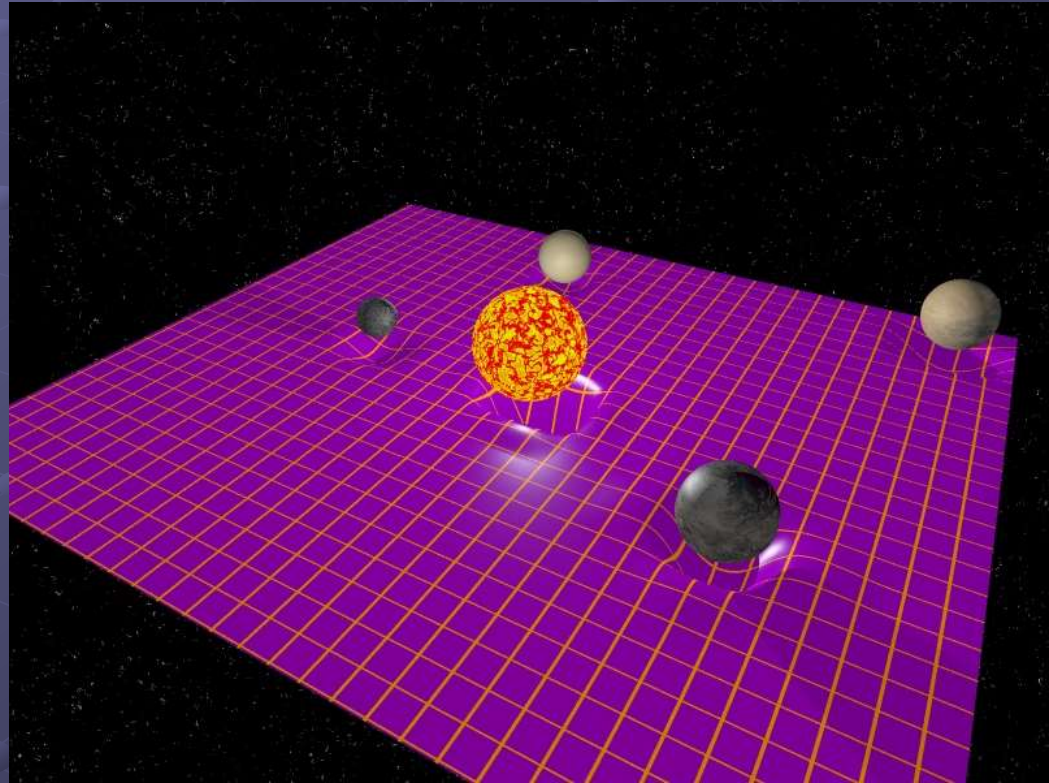
Legend:

- Big Bang (B)
- Cosmic rays (C)
- Large stars (L)
- Small stars (S)
- Supernovae (S)
- Man-made (M)

6

● What is Newton's law of universal gravitation?

- D: All objects in the universe attract each other through gravitational force.



7

- Gravitational force increases as the mass of an object:
 - C: Increases or as the distance between two objects decreases.

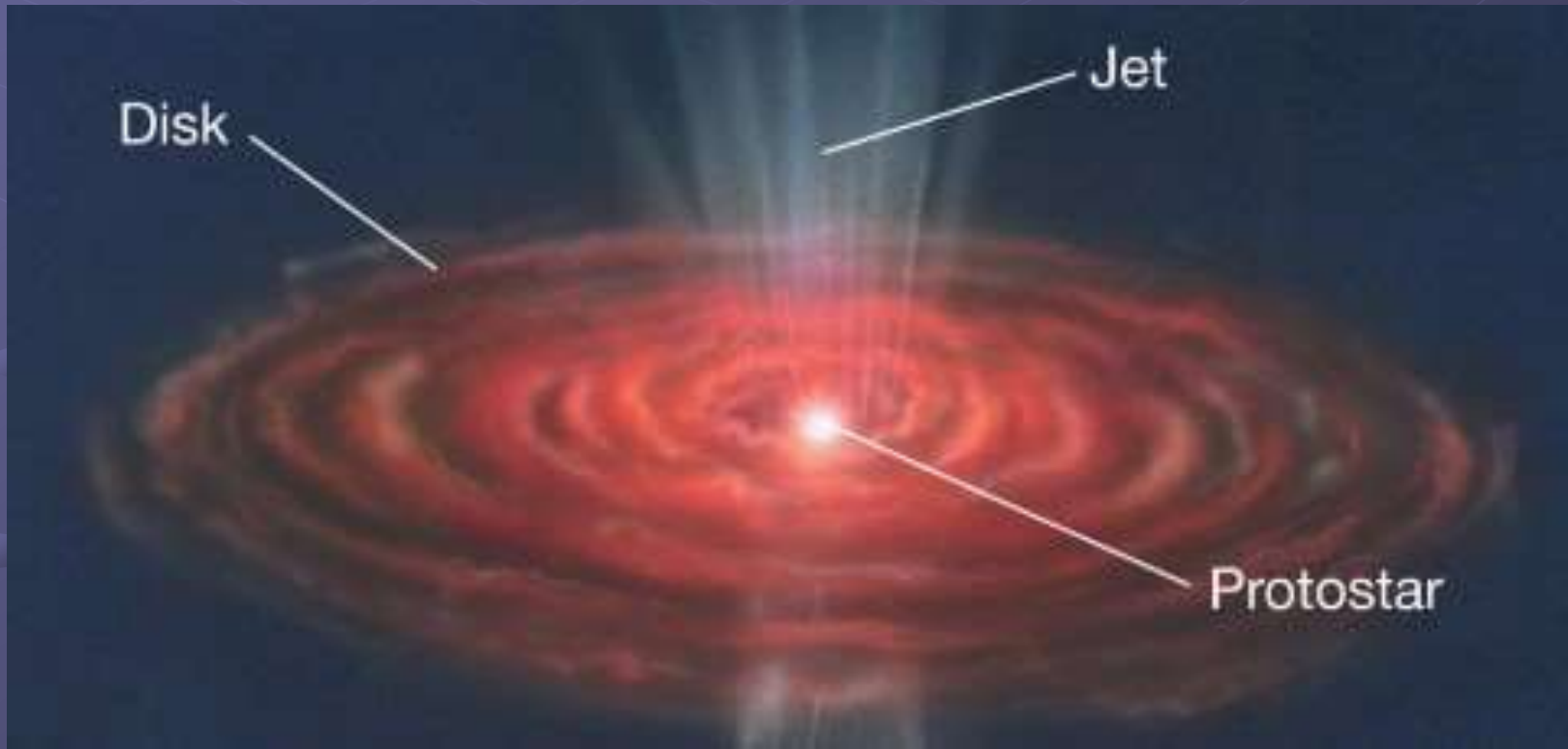


$$F_1 = F_2 = G \frac{m_1 \times m_2}{r^2}$$

8

● What is a protostar?

- The central concentration of matter in a nebula.



- What happens as more matter is pulled into a protostar?
 - Gravitational energy is converted into heat energy, and the temperature of the protostar increases.

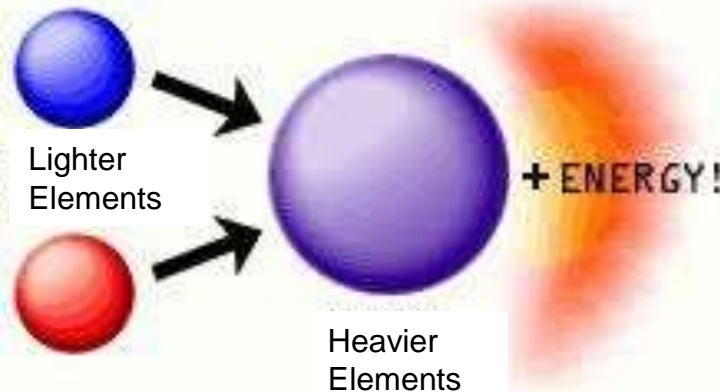


10

● What is nuclear fusion?

- A process that occurs when high temperature and pressure cause less-massive atomic nuclei to combine to form more-massive nuclei and, in the process, release energy.

Nuclear Fusion

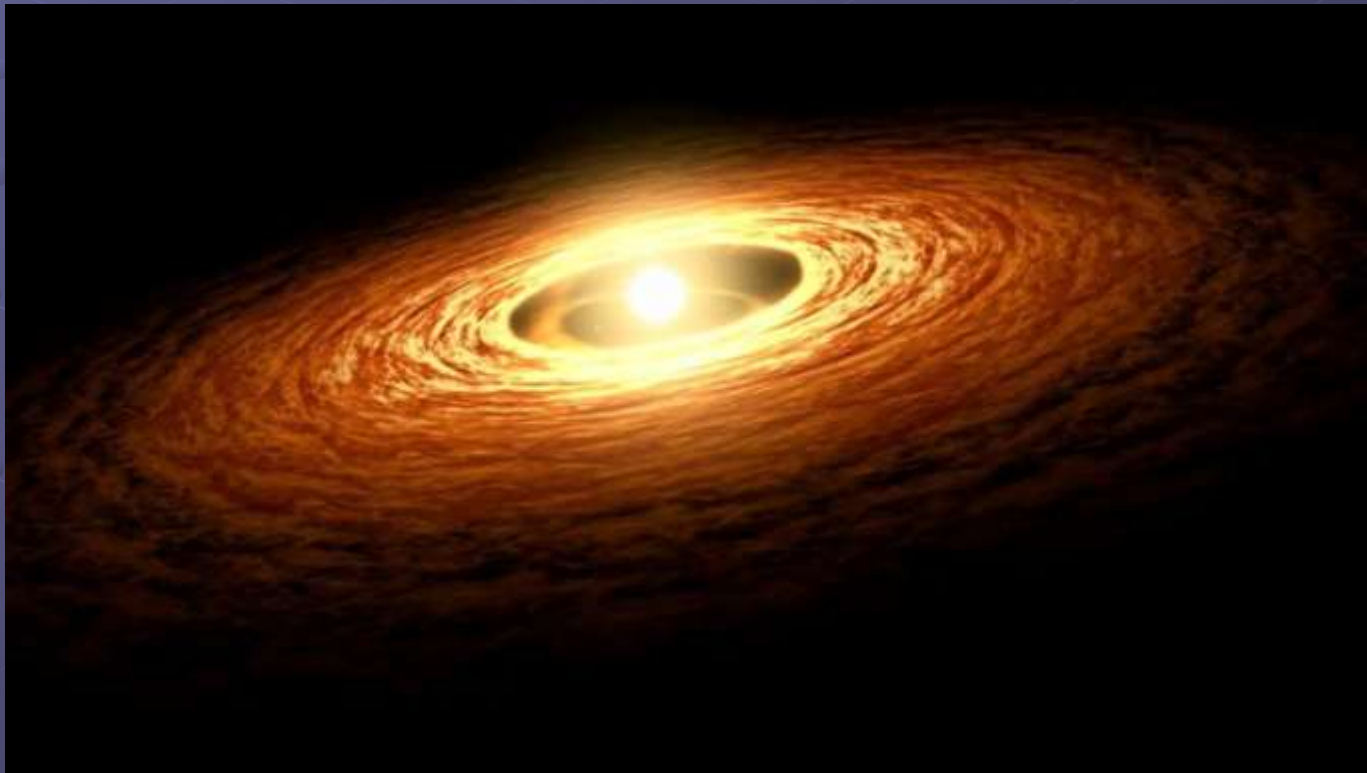


H B																He B					
Li c	Be c															B c	C s L	N s L	O s L	F L	Ne s L
Na L	Mg L															Al s L	Si s L	P L	S s L	Cl L	Ar L
K L	Ca L	Sc L	Ti s L	V s L	Cr L	Mn L	Fe s L	Co s	Ni s	Cu L	Zn L	Ga s	Ge s	As L	Se s	Br s	Kr s				
Rb s	Sr L	Y L	Zr L	Nb L	Mo s L	Tc L	Ru s L	Rh s	Pd s L	Ag s L	Cd s L	In s L	Sn s L	Sb s	Te s	I s	Xe s				
Cs s	Ba L	Hf s L		Ta s L	W s L	Re s	Os s	Ir s	Pt s	Au s	Hg s L	Tl s L	Pb s	Bi s	Po s	At s	Rn s				
Fr s	Ra s																				
		La L	Ce L	Pr s L	Nd s L	Pm s L	Sm s L	Eu s	Gd s	Tb s	Dy s	Ho s	Er s	Tm s	Yb s L	Lu s					
		Ac s	Th s	Pa s	U s	Np s	Pu s	Am M	Cm M	Bk M	Cf M	Es M	Fm M	Md M	No M	Lr M					

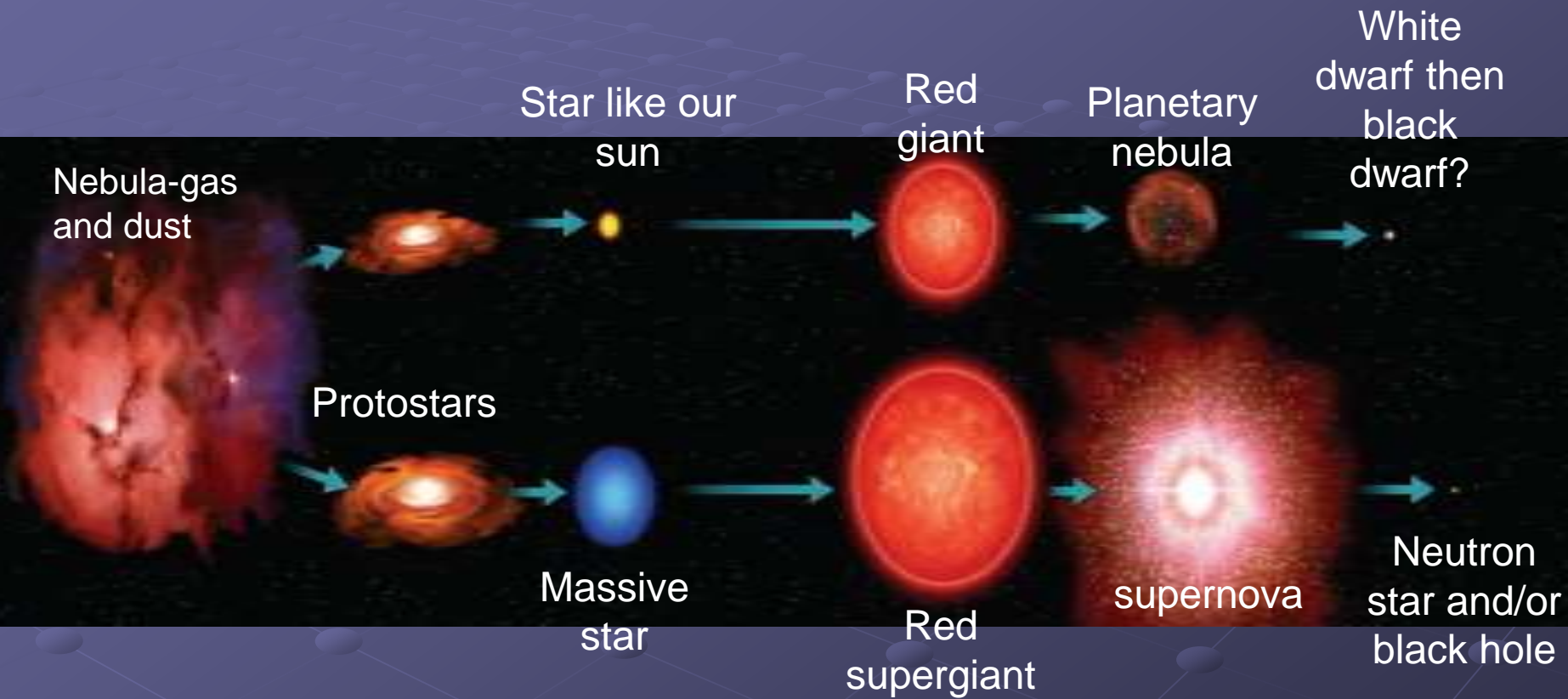
B Big Bang	L Large stars	s Super-novae
c Cosmic rays	s Small stars	M Man-made

11

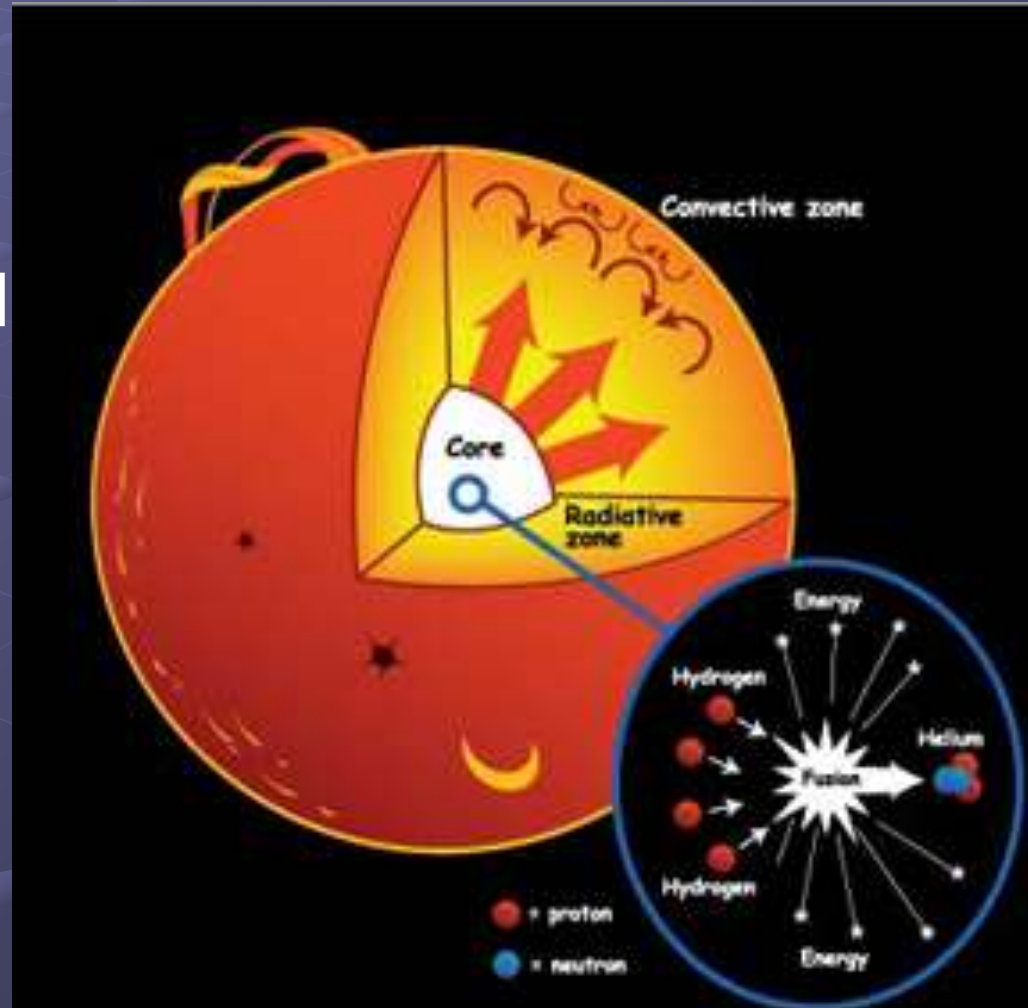
- What is important about the onset of fusion?
 - It marks the birth of a star.



Life Cycle of Stars by MASS

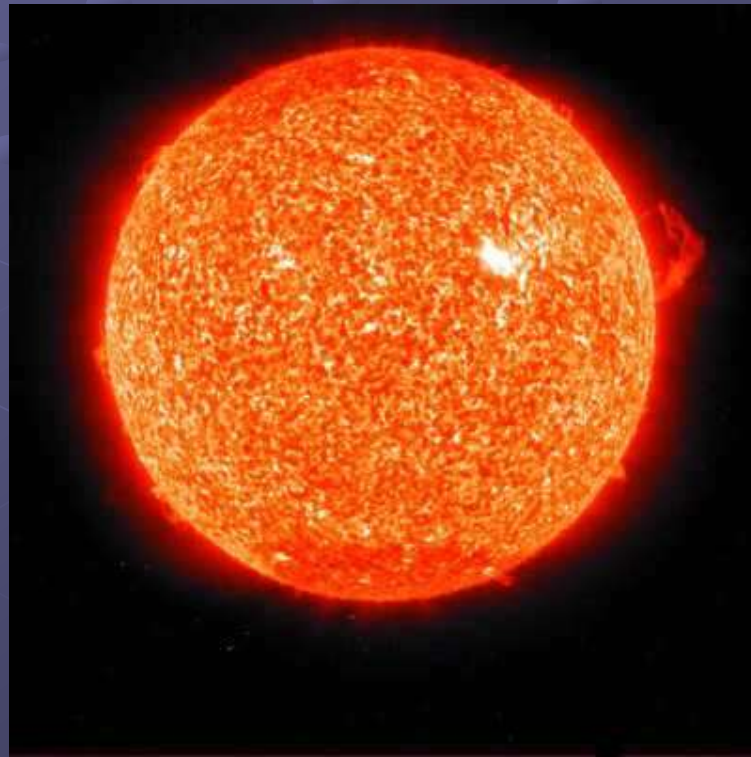


- What happens during the main sequence stage?
 - Energy is generated as hydrogen fuses into helium



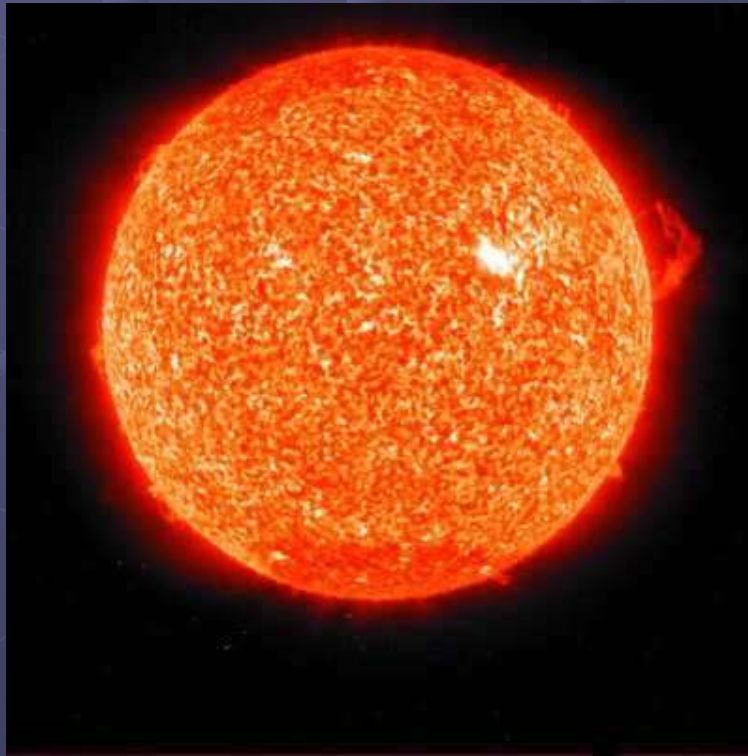
13

- What is the second and longest stage in the life of a star?
 - C: The main-sequence stage.

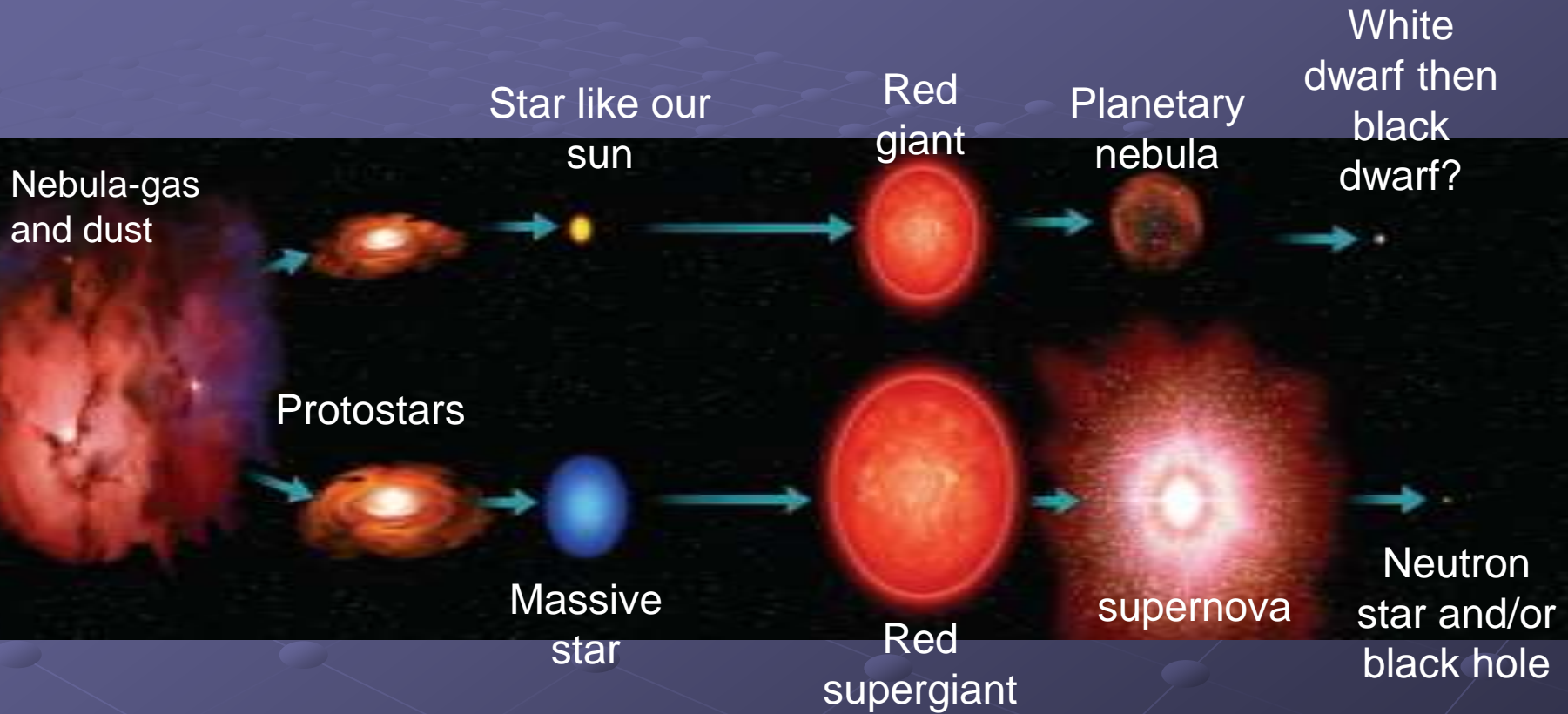


14

- A star that has the same mass as the sun's mass:
 - B: Stays on the main sequence for about 10 billion years.

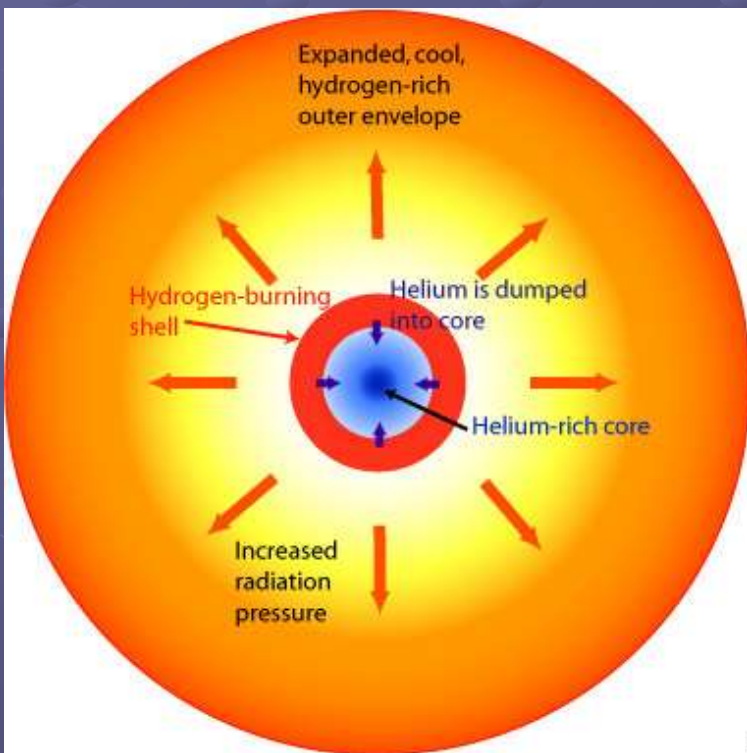


Life Cycle of Stars by MASS



15

- When does a star enter its third stage?
 - When almost all of the hydrogen atoms in its core have fused into helium atoms.

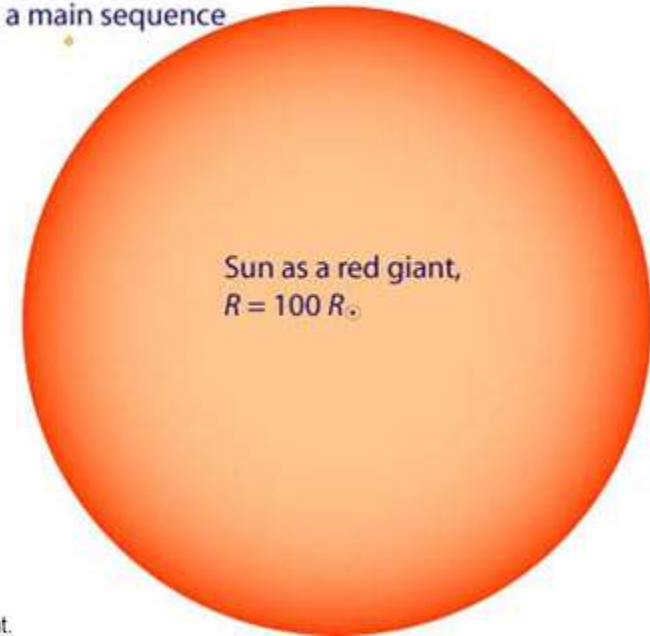


Hydrogen Shell Burning on the Red Giant Branch

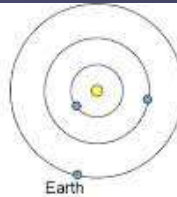


Comparison in size of Sun as a main sequence star and a red giant

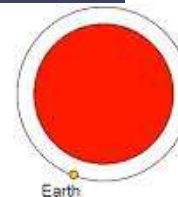
Sun as a main sequence star



Sun as a red giant,
 $R = 100 R_{\odot}$



Now: hot core + warm surface; small size.



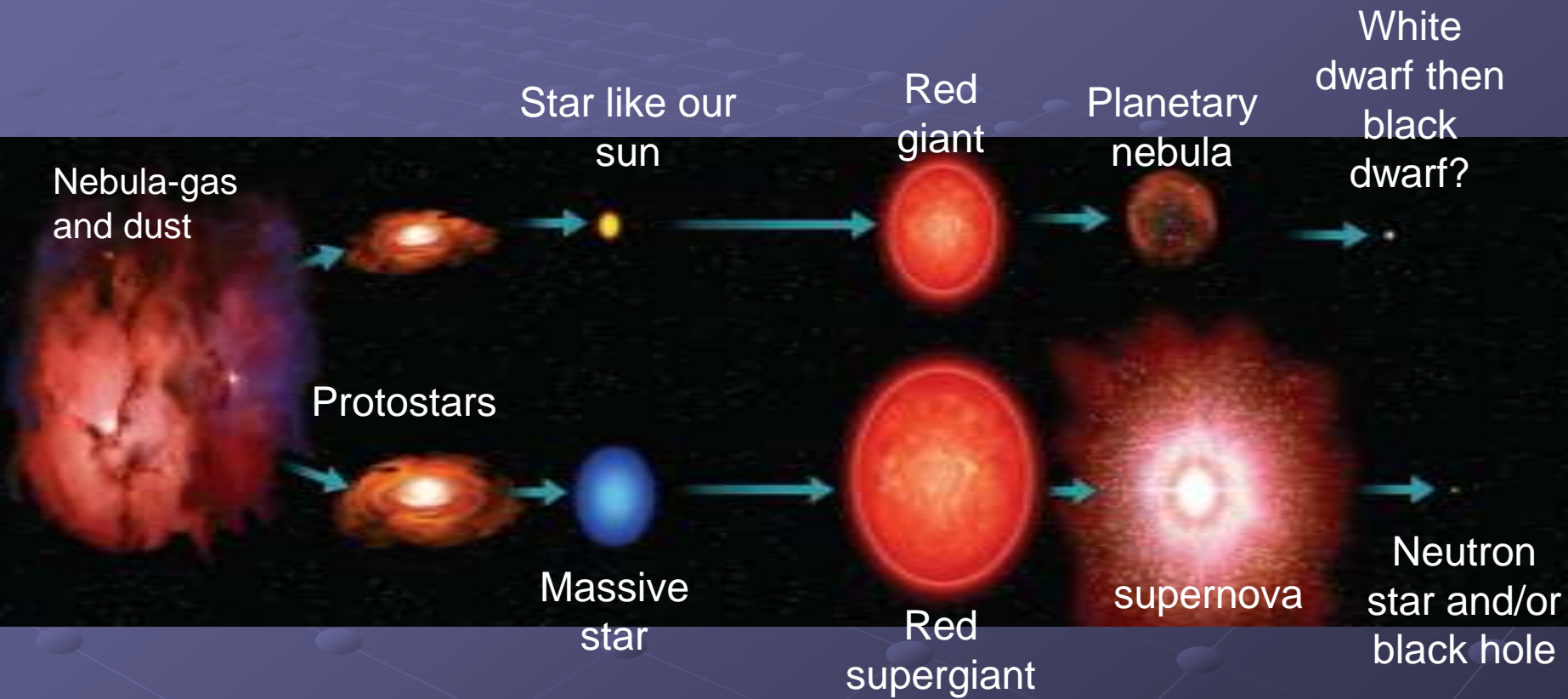
Future: very hot core + cool surface. Large size but less mass; very bright.

16

- In the evolution of a medium-sized star, when will fusion in the star stop?
 - After the helium atoms have fused into carbon and oxygen.



Life Cycle of Stars by MASS



17

- What is a planetary nebula?
 - A cloud of gas that forms around a sun like star that is dying.



18

● What is a white dwarf?

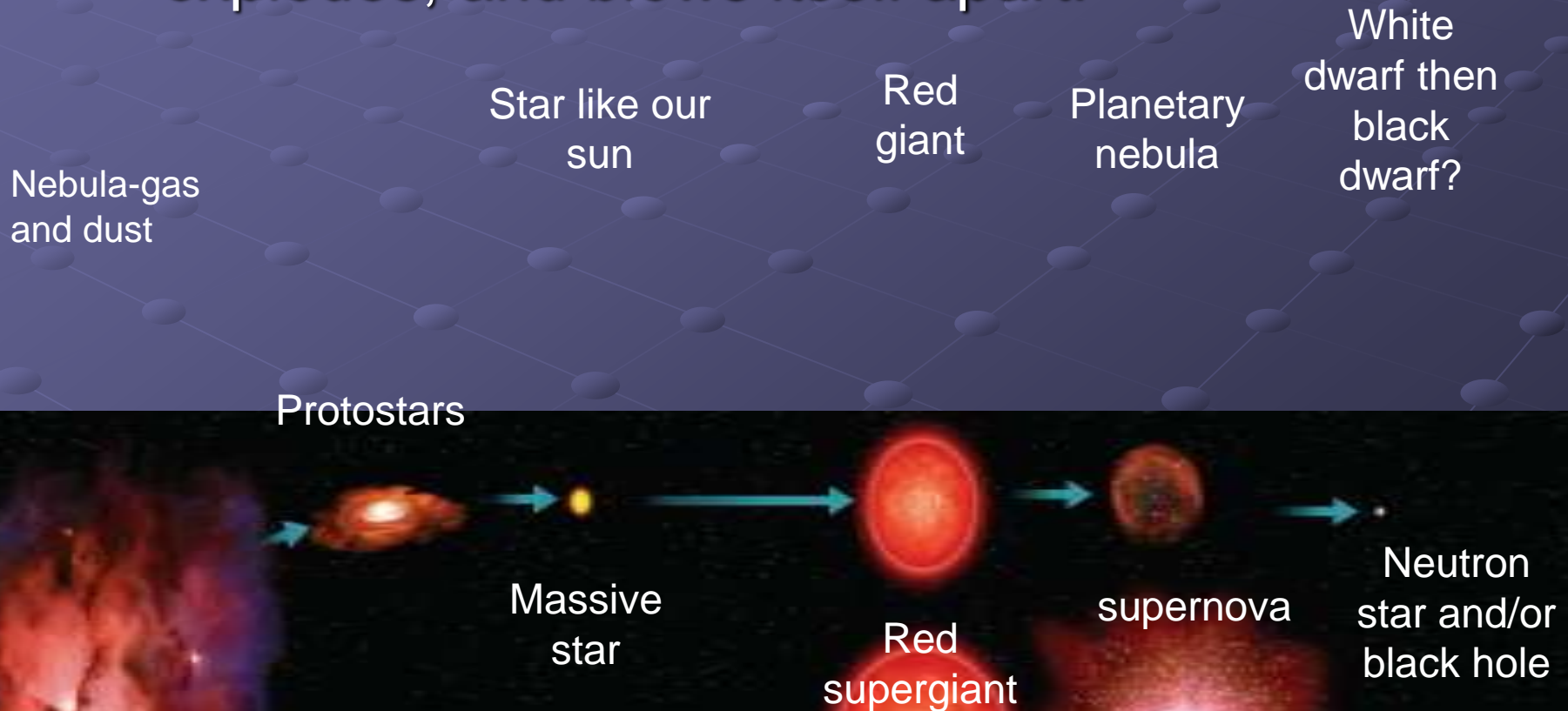
- C: A hot, extremely dense core of matter leftover from an old star.



19

● Describe a supernova.

- A supernova is a star that collapses, explodes, and blows itself apart.



20

● What happens to the carbon atoms in a collapsing Massive Star as temperatures rise and fusion begins again?

- The carbon atoms in the core of the massive star fuse into heavier elements such as oxygen, magnesium, or silicon.

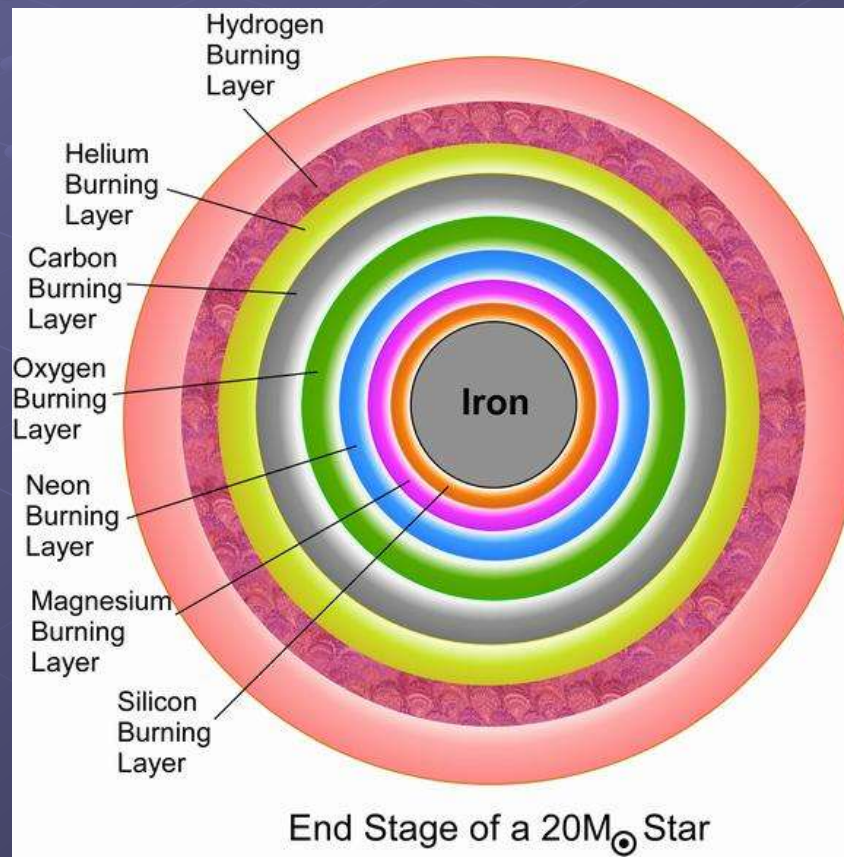
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Legend:

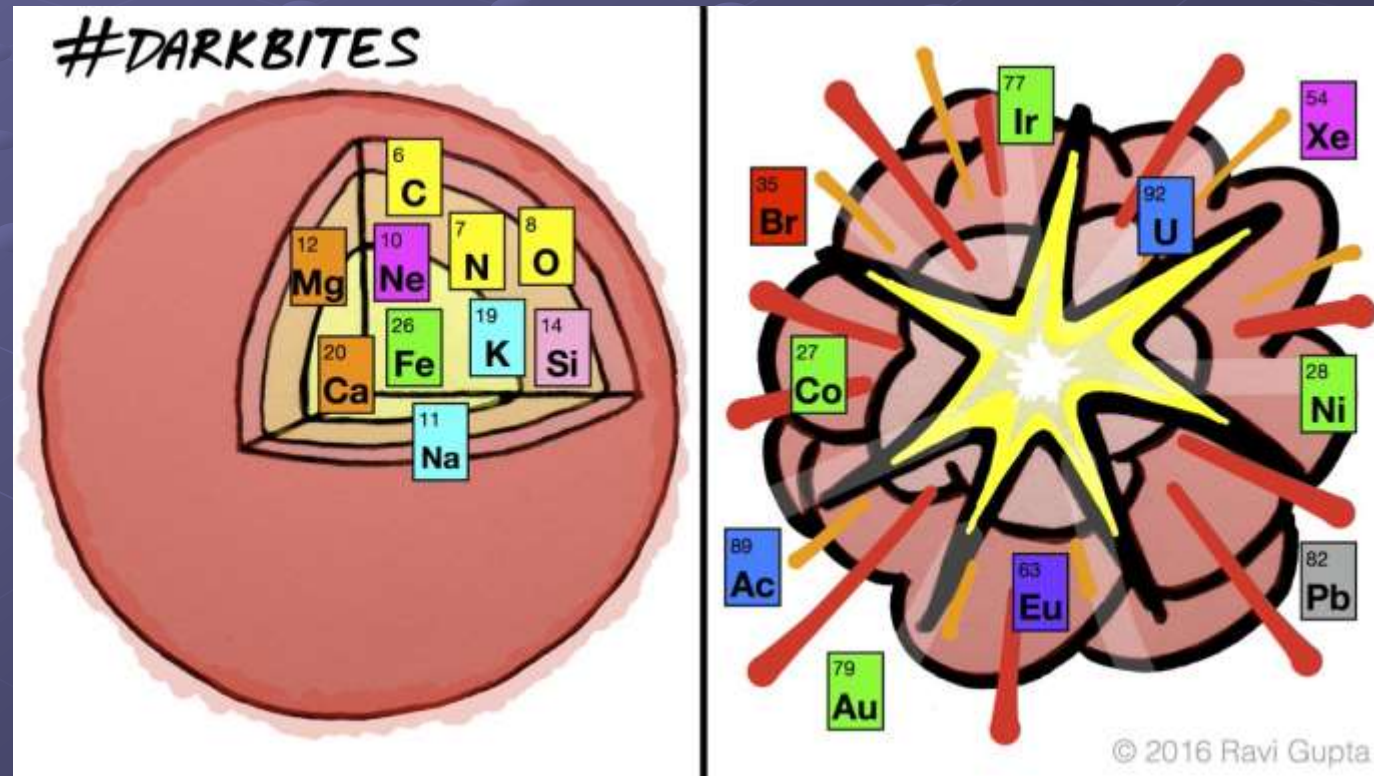
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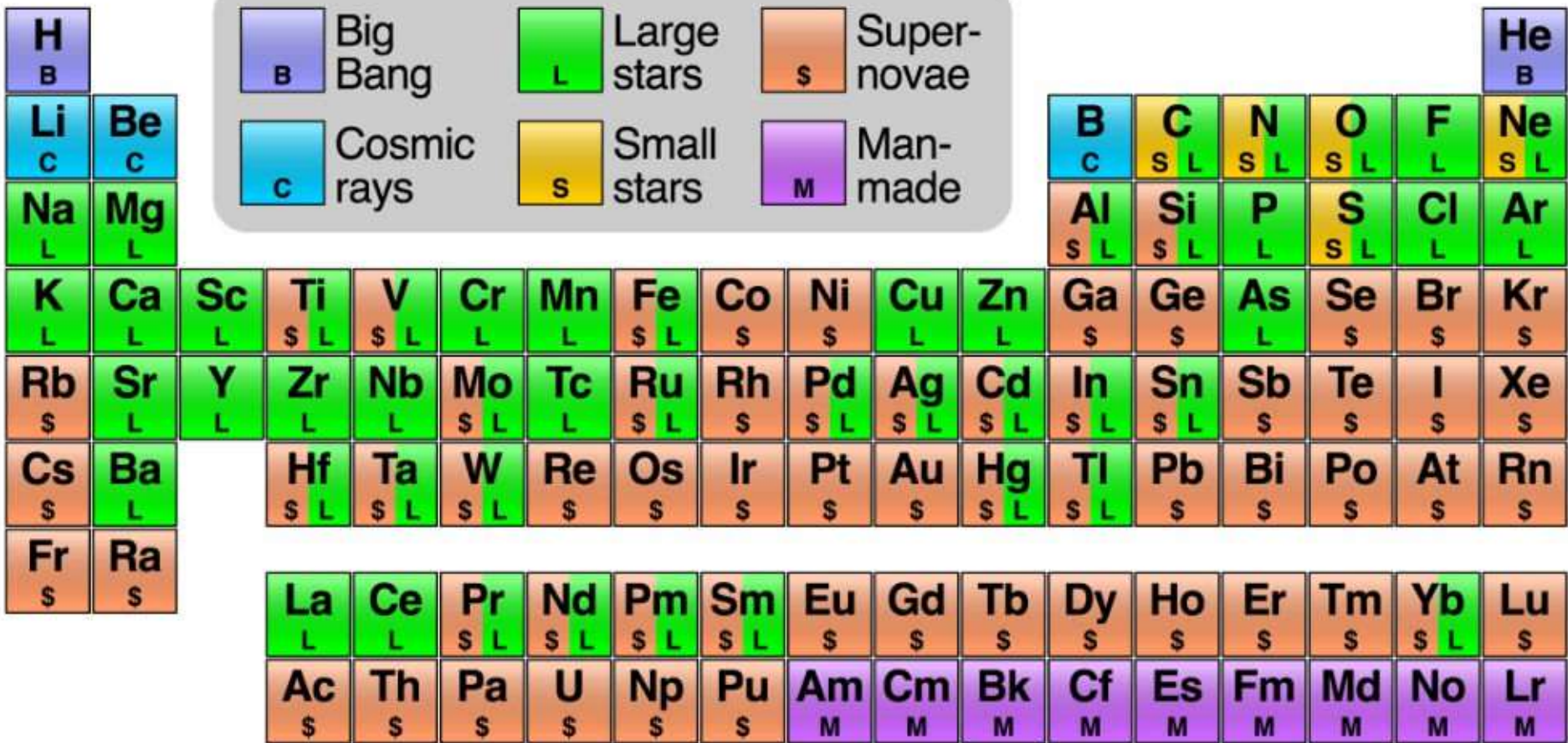
21

- Fusion continues until the core is almost entirely made of iron.



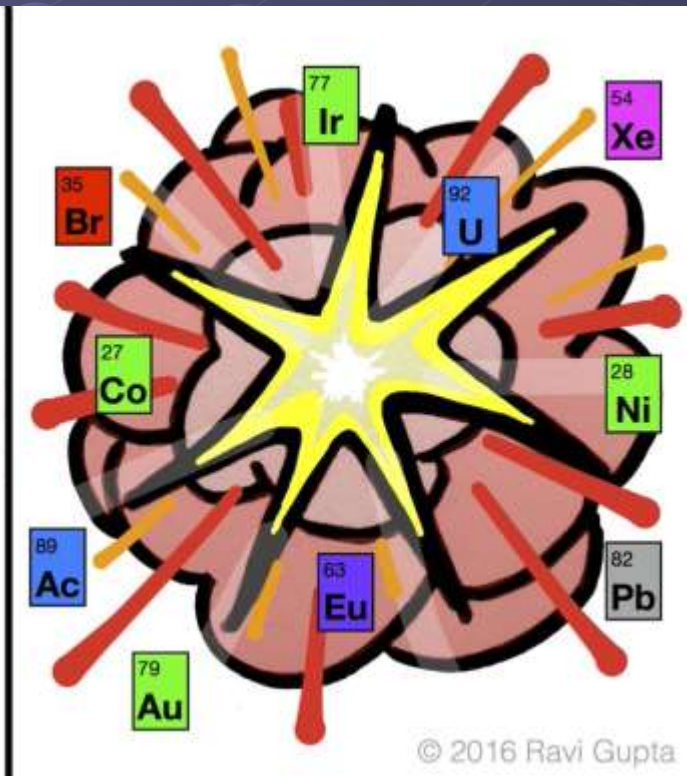
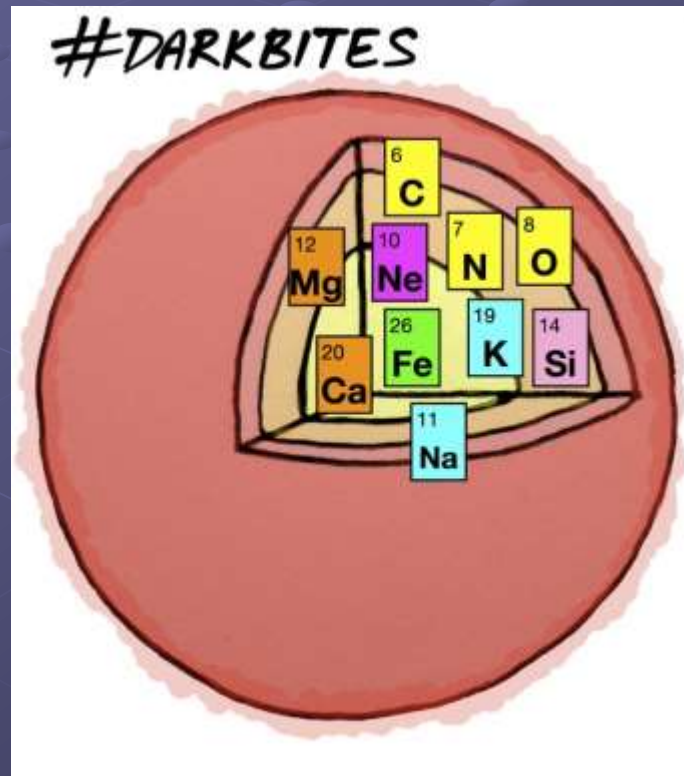
- Fusion of iron into heavier elements takes
 - Energy from the star, rather than giving off energy.





23

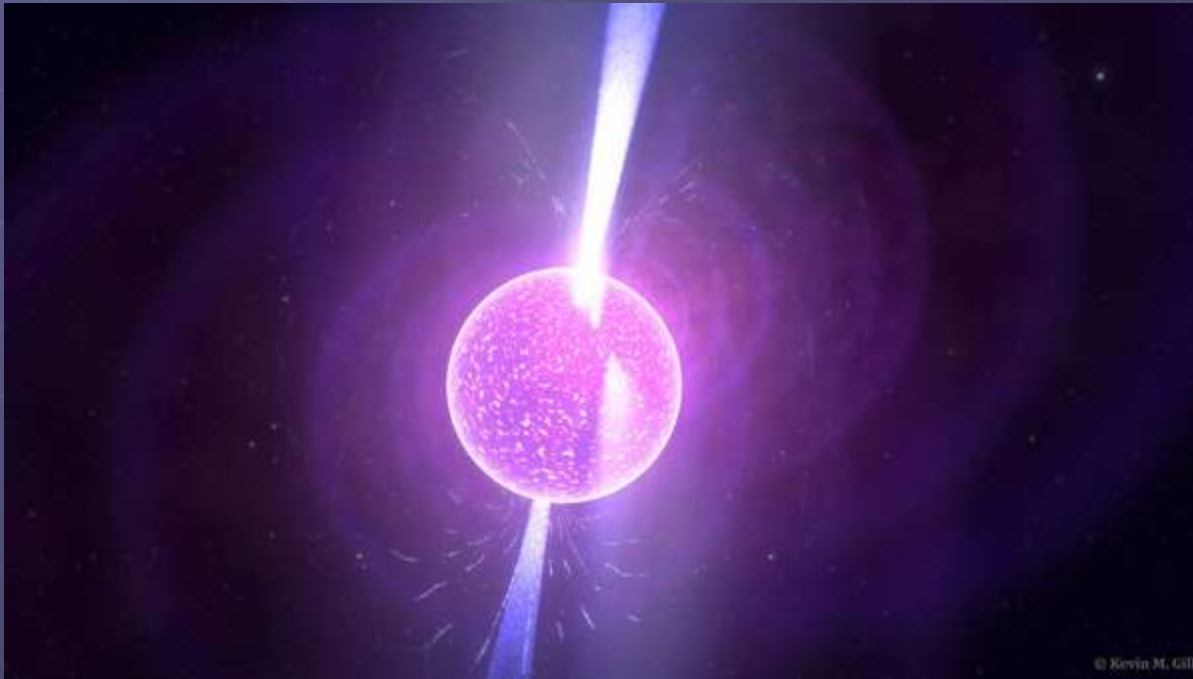
- What is released as the core of the star collapses?
 - Energy



24

● What is a neutron star?

- A star that has collapsed under gravity to the point that the electrons and protons have smashed together to form neutrons.



● What is a black hole?

- An object so massive and dense that even light cannot escape its gravity.



The End?

