

SUPERNOVA!



What is a supernova?

How dangerous are they to life on Earth?

How would the universe be different without supernovae?

RECENT HEADLINES

Astronomer predicts that a red supergiant star nearby could go supernova very soon

Betelgeuse's Brightening Raises Hopes for a Supernova Spectacle

Is the puzzling star Betelgeuse going to explode in our lifetime after all?

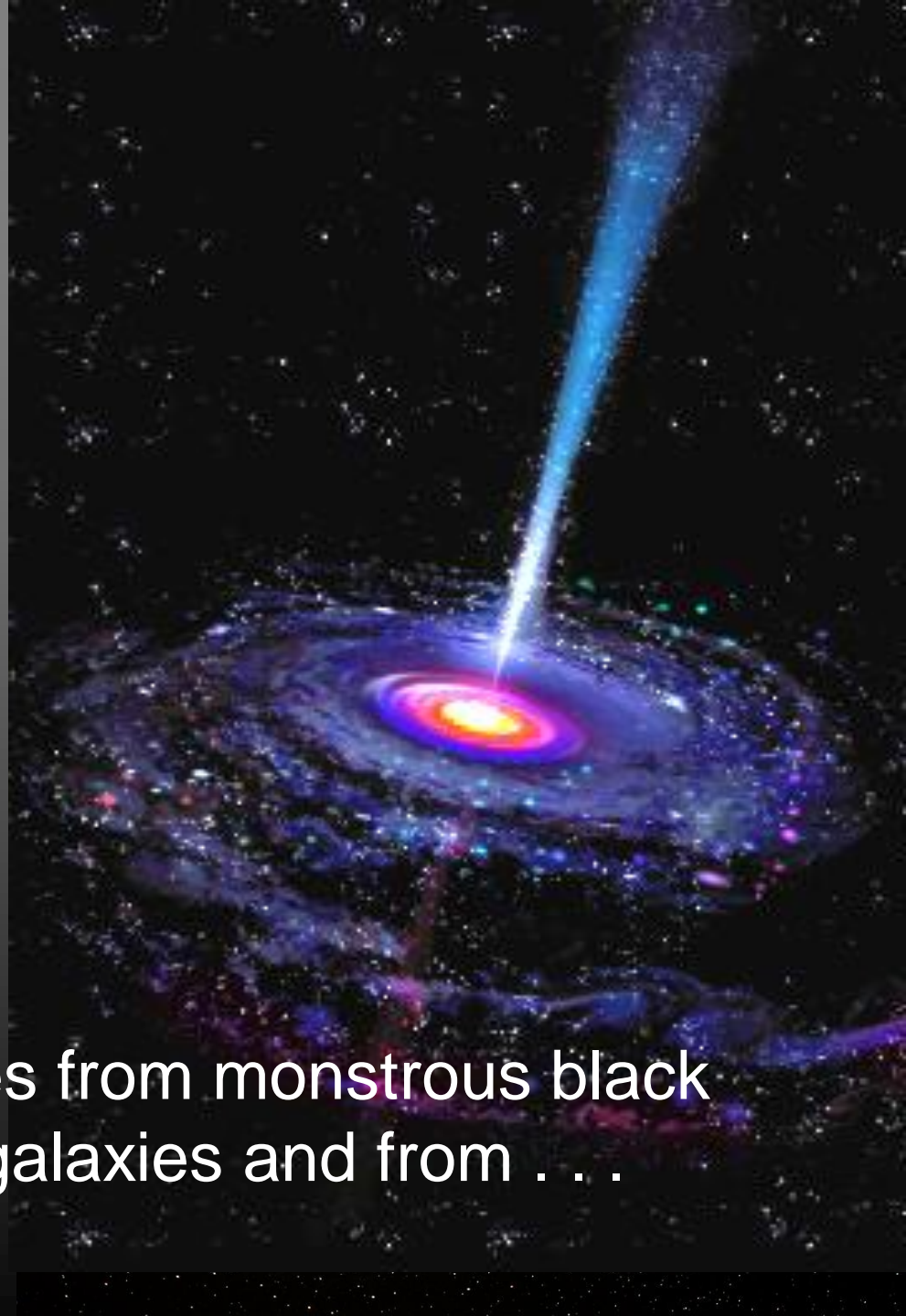
A hundred years
ago, we believed
we lived in a quiet,
safe universe . . .



Today we know the universe is filled with powerful cosmic radiation our eyes cannot see:

- Gamma-rays
- X-Rays
- Fast-moving atomic particles (“Cosmic Rays”)

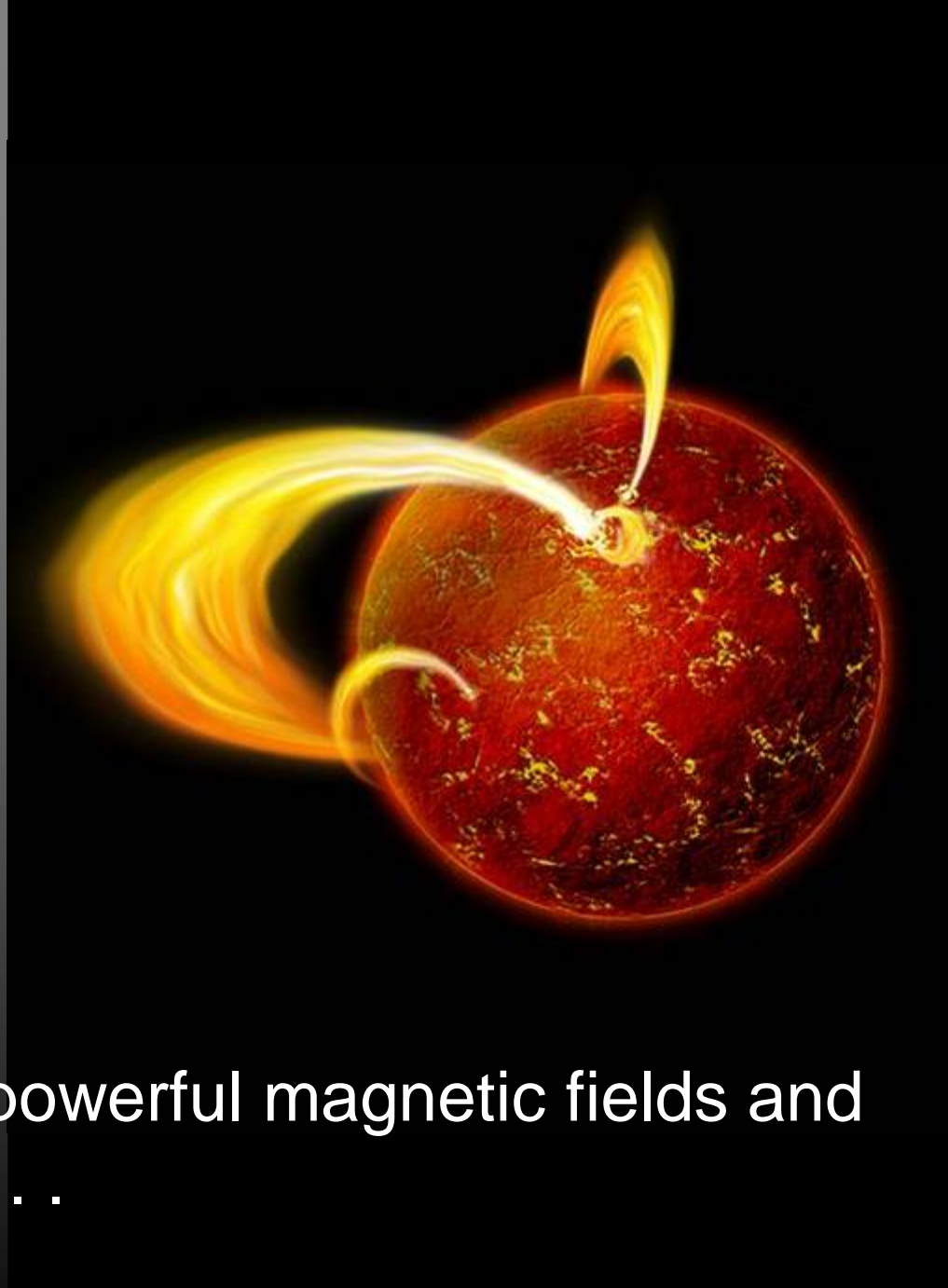
Much of which originates from monstrous black holes in the centers of galaxies and from . . .



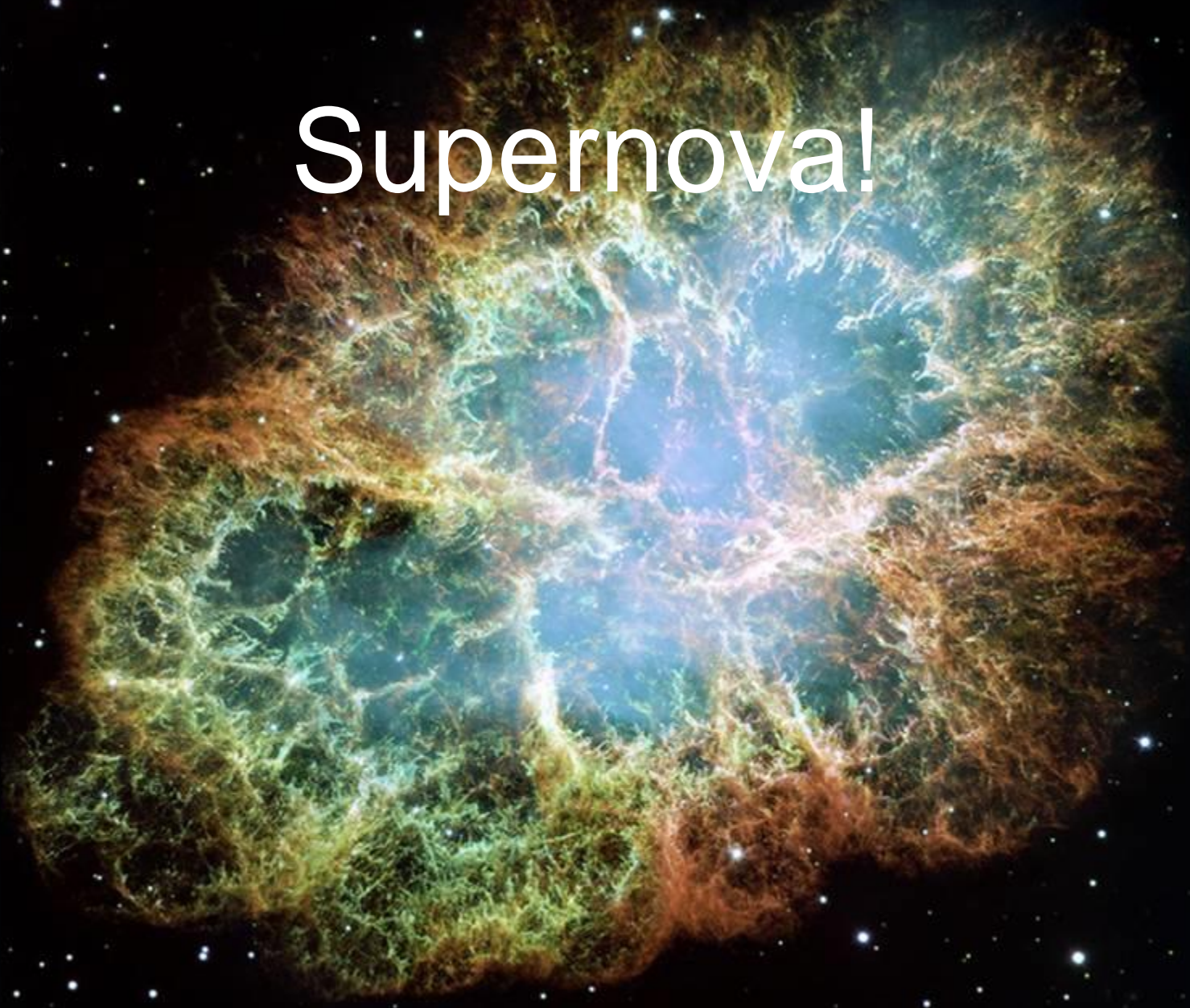
Today we know the universe is filled with powerful cosmic radiation our eyes cannot see:

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. . . neutron stars with powerful magnetic fields and more commonly from . . .



Supernova!



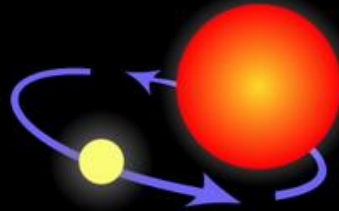
Types of Supernova

- Type IA – White dwarf experiencing thermal runaway after absorbing material from a companion star
- Type IB – White dwarf experiencing core collapse after absorbing material from a companion star
- Type II – Supermassive star undergoing core collapse

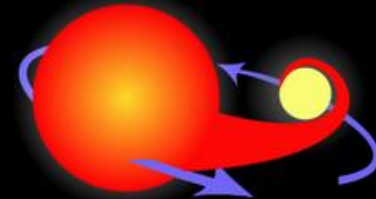
The progenitor of a Type Ia supernova



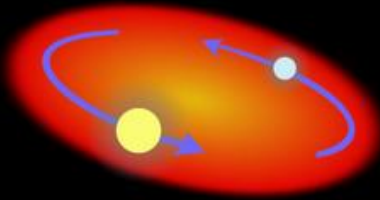
Two normal stars are in a binary pair.



The more massive star becomes a giant...



...which spills gas onto the secondary star, causing it to expand and become engulfed.



The secondary, lighter star and the core of the giant star spiral toward within a common envelope.



The common envelope is ejected, while the separation between the core and the secondary star decreases.



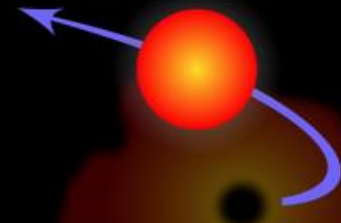
The remaining core of the giant collapses and becomes a white dwarf.



The aging companion star starts swelling, spilling gas onto the white dwarf.

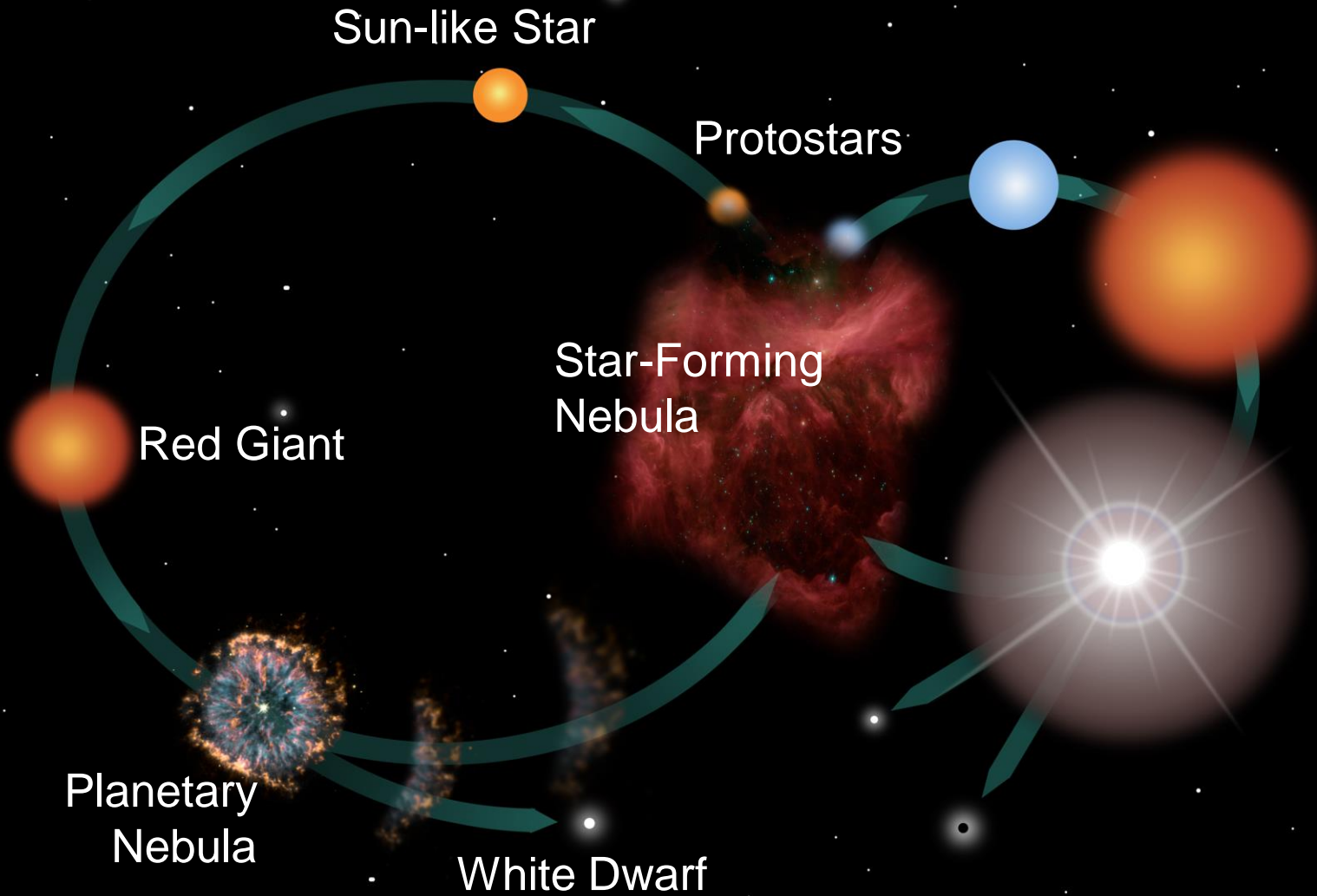


The white dwarf's mass increases until it reaches a critical mass and explodes...

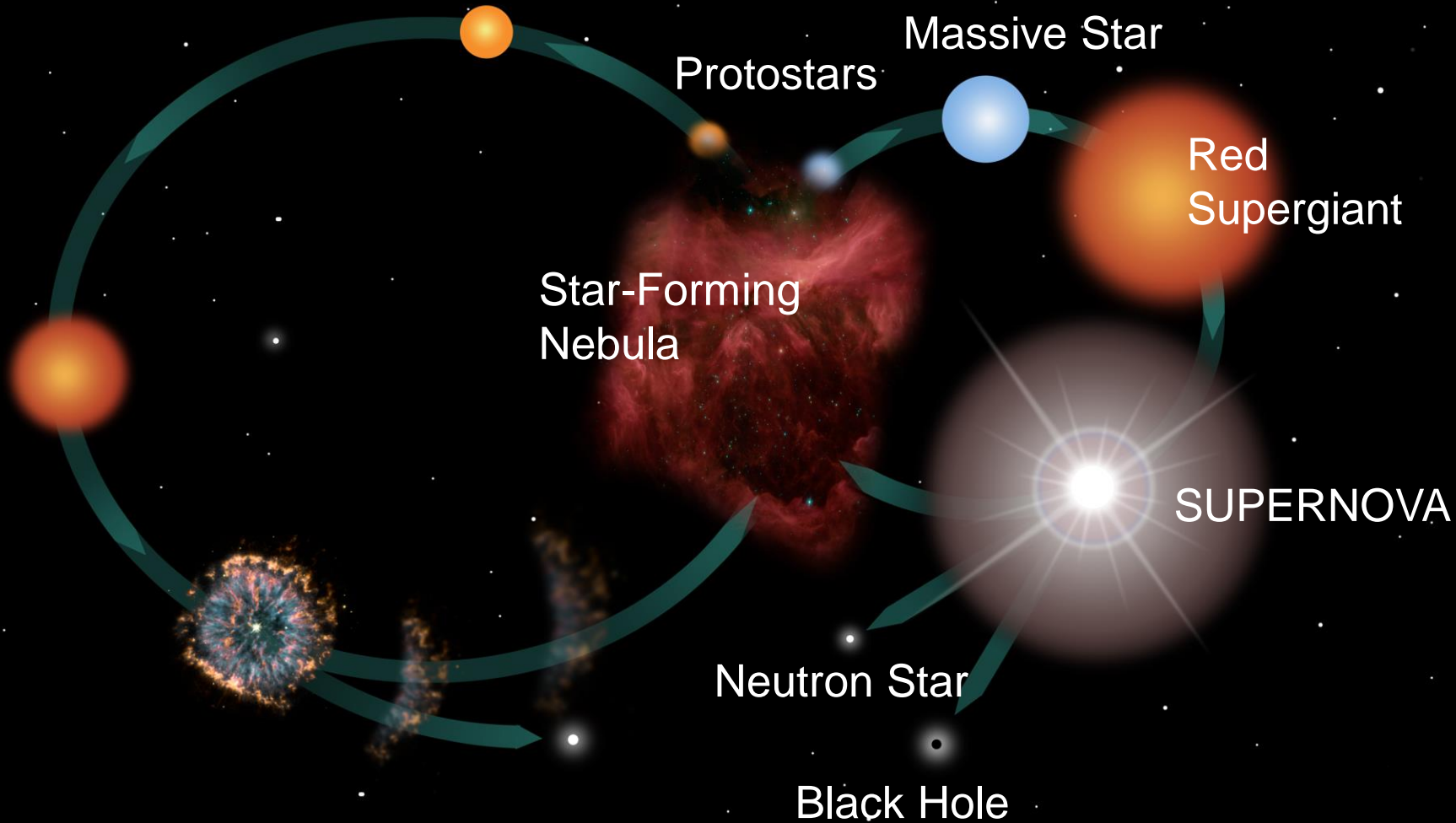


...causing the companion star to be ejected away.

Life of a Sun-like Star



Life of a Massive Star

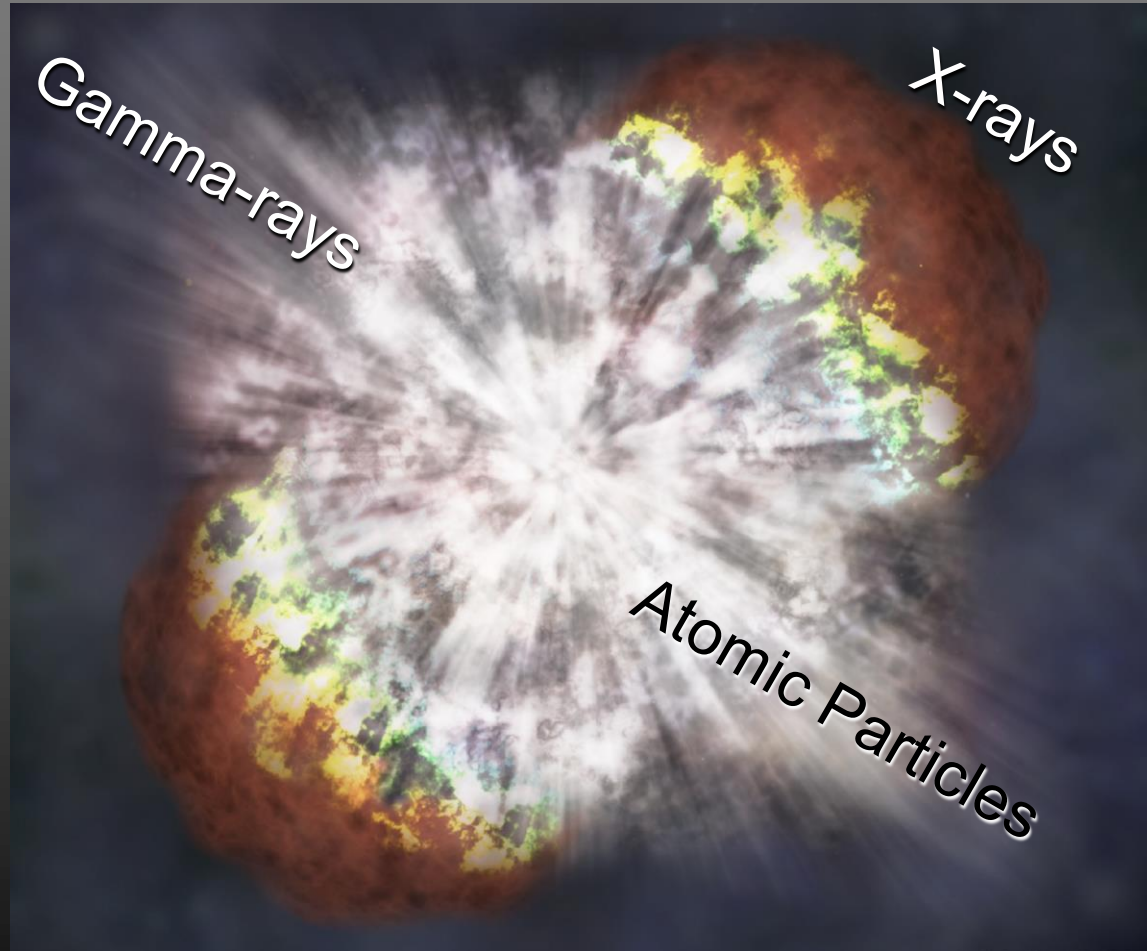


A composite image of Earth and a bright star or supernova in space. The Earth is shown in the lower right, with a colorful, fiery atmosphere. The star is in the upper left, with a bright yellow and white core and a blue, glowing outer shell. The background is a dark blue space filled with stars.

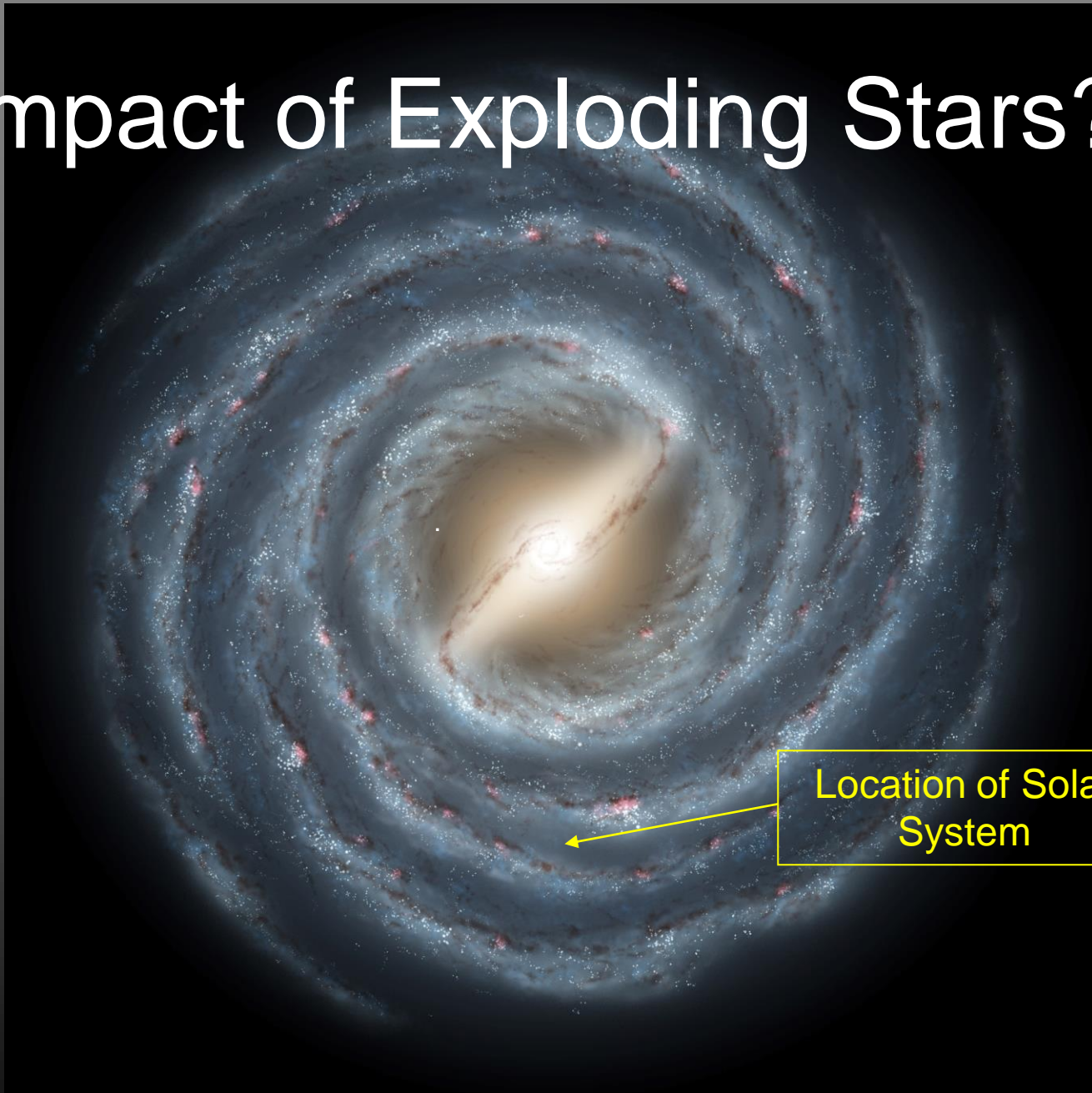
Is radiation from supernovae
and GRB sources
dangerous to Earth?

How close would they have to be?

Radiation from exploding stars



Impact of Exploding Stars?!




Artist's
Conception
of the Milky
Way Galaxy

How close would a Supernova have to be dangerous?



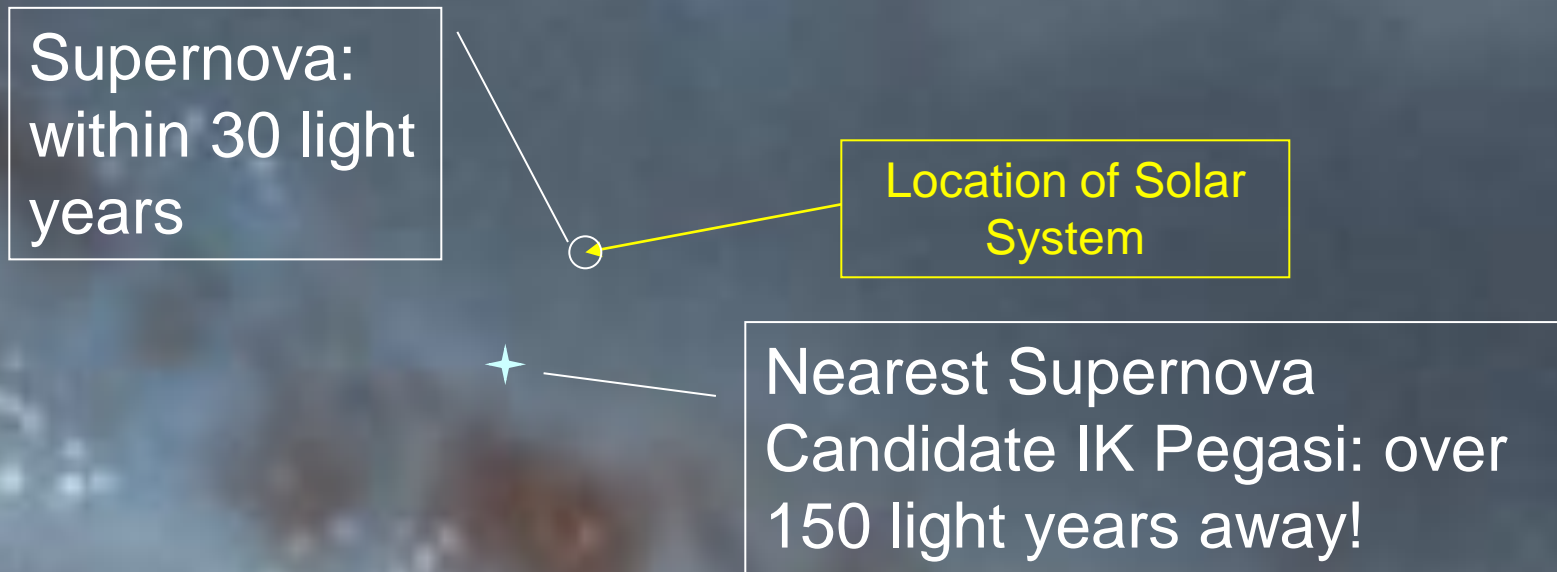
Location of Solar System

How close would a Supernova have to be dangerous?

A detailed illustration of a spiral galaxy, showing its characteristic spiral arms and central core. The galaxy is rendered in shades of blue, white, and red, with numerous stars and dust clouds visible. A yellow box with a yellow arrow points to a specific location within the galaxy, labeled "Location of Solar System".

Location of Solar System

How close would a Supernova have to be to be dangerous?




Gamma-Ray Burst (GRB)!



Formed from the collapse of
a supernova into a black hole

How close would a
Gamma-Ray Burst (GRB) have
to be to be dangerous?




Location of Solar
System

How close would a Gamma-Ray Burst (GRB) have to be to be dangerous?



**GRB Danger Zone:
within 8,000 light years**



**Location of Solar
System**

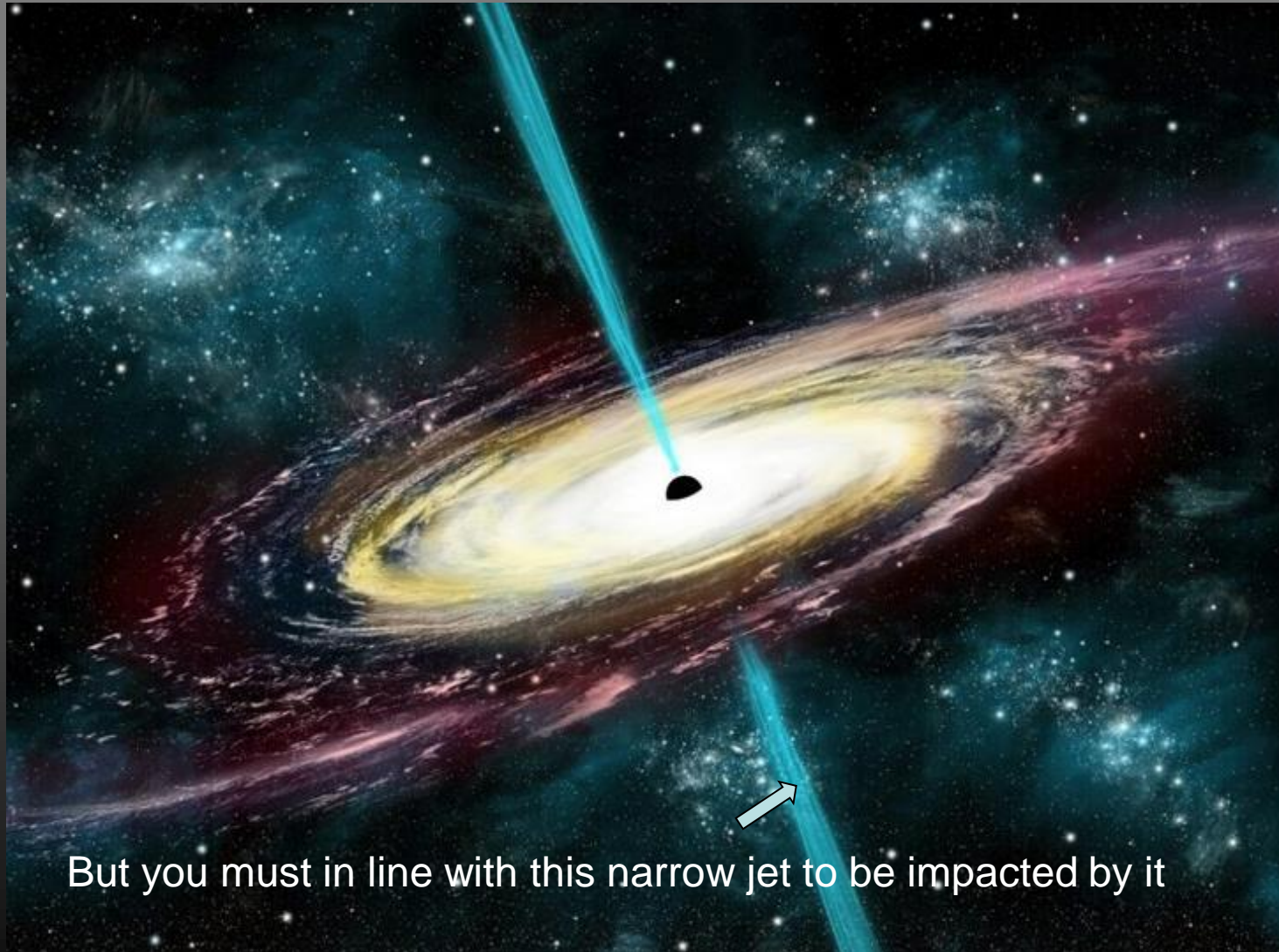
How close is the nearest Gamma-Ray Burst (GRB) source ?

Nearest detected GRB source:
over a Billion light years away!

Our galaxy is about 100,000 light years across

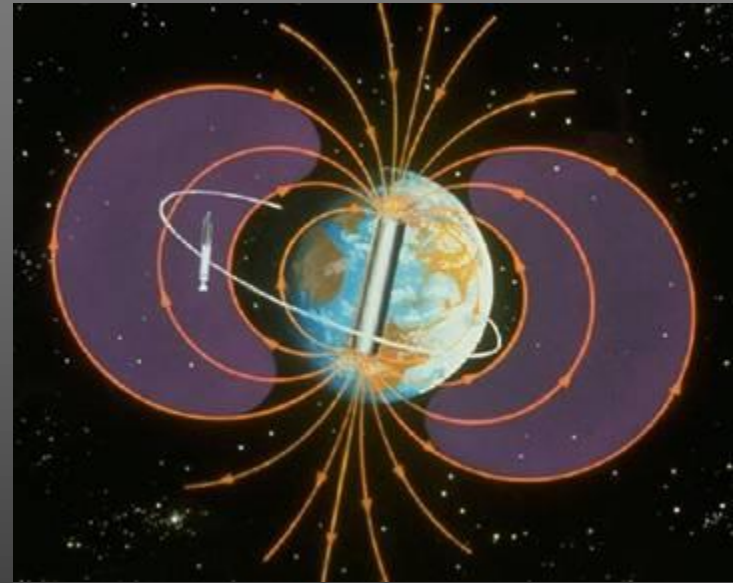


There may be some closer



But you must in line with this narrow jet to be impacted by it

Earth's Atmosphere & Magnetic Field



Protect Earth from most high-energy
radiation . . .

But prevent us from detecting it here on Earth

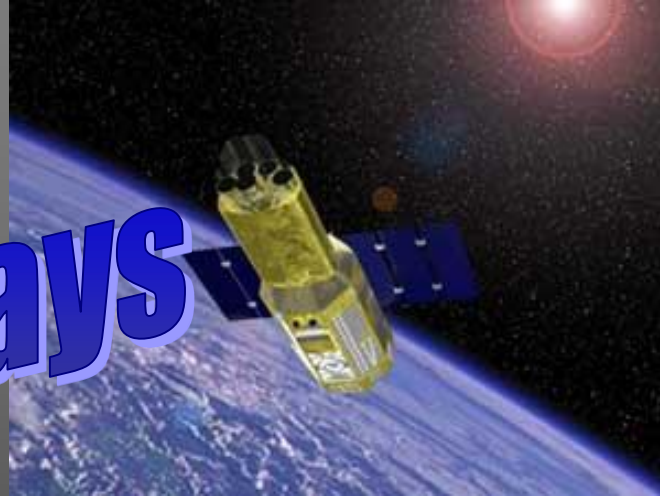
The high view: getting a better look

XMM-Newton



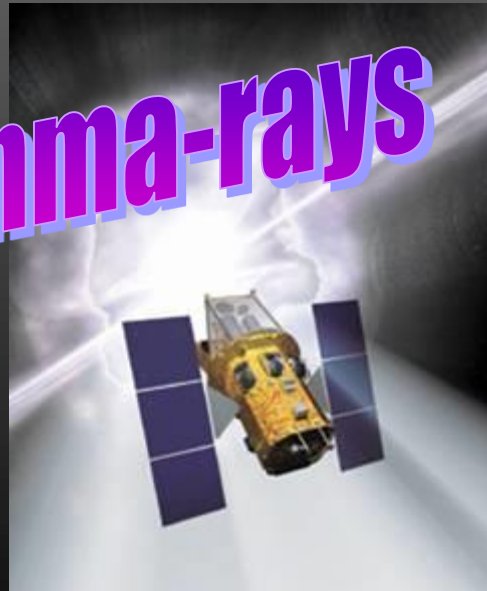
X-rays

Suzaku



GLAST

Gamma-rays



Swift

Life from Exploding Stars!

The image features a periodic table of elements as a background. At the top center is a bright yellow sun with rays. In the center, a stylized Earth is shown with a city of purple buildings on the left, a person with blonde hair sitting at a computer on the right, a brown dog on the bottom right, and a diamond ring on the right side. A purple ring surrounds the Earth. A grey callout box with a black border is positioned on the right, containing the text: "Scientists have discovered that most of the heavy elements in the universe are dispersed from stars that go supernova." Two orange arrows originate from the top corners of this box and point towards the Oxygen element (O) in the periodic table, which is highlighted in a grey box. The periodic table includes elements from Hydrogen (H) to Lanthanum (La) and Actinium (Ac).

Oxygen

Scientists have discovered that most of the heavy elements in the universe are dispersed from stars that go supernova.

Life from Exploding Stars!

The image features a periodic table of elements as a background. A cartoon illustration of Earth is overlaid on the left side. The Earth is depicted with green continents and blue oceans. On the Earth, there are several buildings, a person with blonde hair sitting at a computer, a brown dog, and a diamond ring. A bright sun is positioned above the Earth. A grey box with the word "Silicon" is placed over the Silicon element (Si) in the periodic table. A red arrow points from this box to the Silicon element in the table.

1	H									2	He																						
3	Li	4	Be							5	B	6	C	7	N	8	O	9	F	10	Ne												
11	Na									12	Al	13	Si	14	P	15	S	16	Cl	17	Ar	18	Kr										
19	K									25	Fe	26	Co	27	Ni	28	Cu	29	Zn	30	Ga	31	Ge	32	As	33	Se	34	Br	35	Kr	36	Xe
37	Rb									41	Ru	42	Rh	43	Pd	44	Ag	45	Cd	46	In	47	Sn	48	Sb	49	Te	50	I	51	Xe	52	Rn
53	Cs									75	Os	76	Ir	77	Pt	78	Au	79	Hg	80	Tl	81	Pb	82	Bi	83	Po	84	At	85	Rn	86	Rn
87	Fr									107	Hs	108	Mt	109	--	110	--	111	--	112	--	113	--	114	--	115	--	116	--	117	--	118	--
89										61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu	72	Hf
91										93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr	104	Rf

Life from Exploding Stars!

Diagram illustrating the periodic table of elements with a focus on the origin of life from exploding stars. The sun is shown above the table. An illustration of Earth shows a city, a person using a computer, and a dog, with a red arrow pointing from the word 'Gold' (Au) in the periodic table to the Earth, highlighting the presence of gold and other elements from stars on our planet.

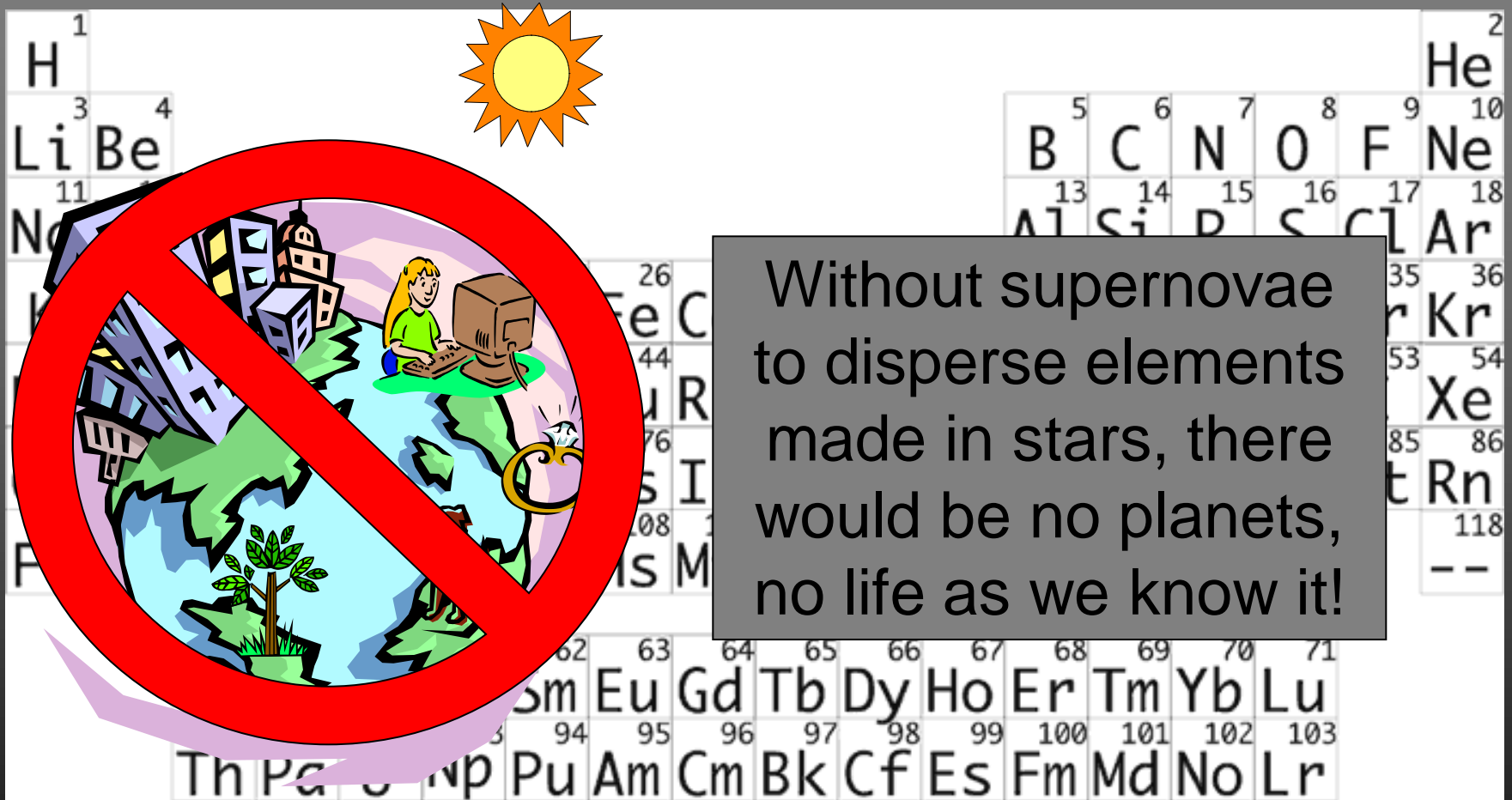
1																	2		
H																	He		
3	4													5	6	7	8	9	10
Li	Be													B	C	N	O	F	Ne
11	12													13	14	15	16	17	18
Na	Mg													Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
87	88	89	104	105	106	107	108	109	110	111	112		114		116		118		
Fr	Ra	Ac	Rf	Mn	Ht	Rft	Hs	Mt											
			122	123	124	125	126	127	128	129	130	131	132	133	134	135	136		
			La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
			94	95	96	97	98	99	100	101	102	103							
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

Life from Exploding Stars!

The diagram shows a central globe representing Earth with a city, a person at a computer, a dog, and a tree. Lines connect these elements to the periodic table. A sun is positioned above the table, and the word "Iron" is highlighted in a grey box. The periodic table includes elements from Hydrogen (H) to Oganesson (Og), with atomic numbers indicated in small numbers above the element symbols.

1																	2															
H																	He															
3	4												5	6	7	8	9	10														
Li	Be												B	C	N	O	F	Ne														
11	12														13	14	15	16	17	18												
Na	Mg														Al	Si	P	S	Cl	Ar												
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36															
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Cobalt	Iron	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr														
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54															
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe															
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71																
Cs	Ba	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu																
79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103								
Fr	Ra	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	

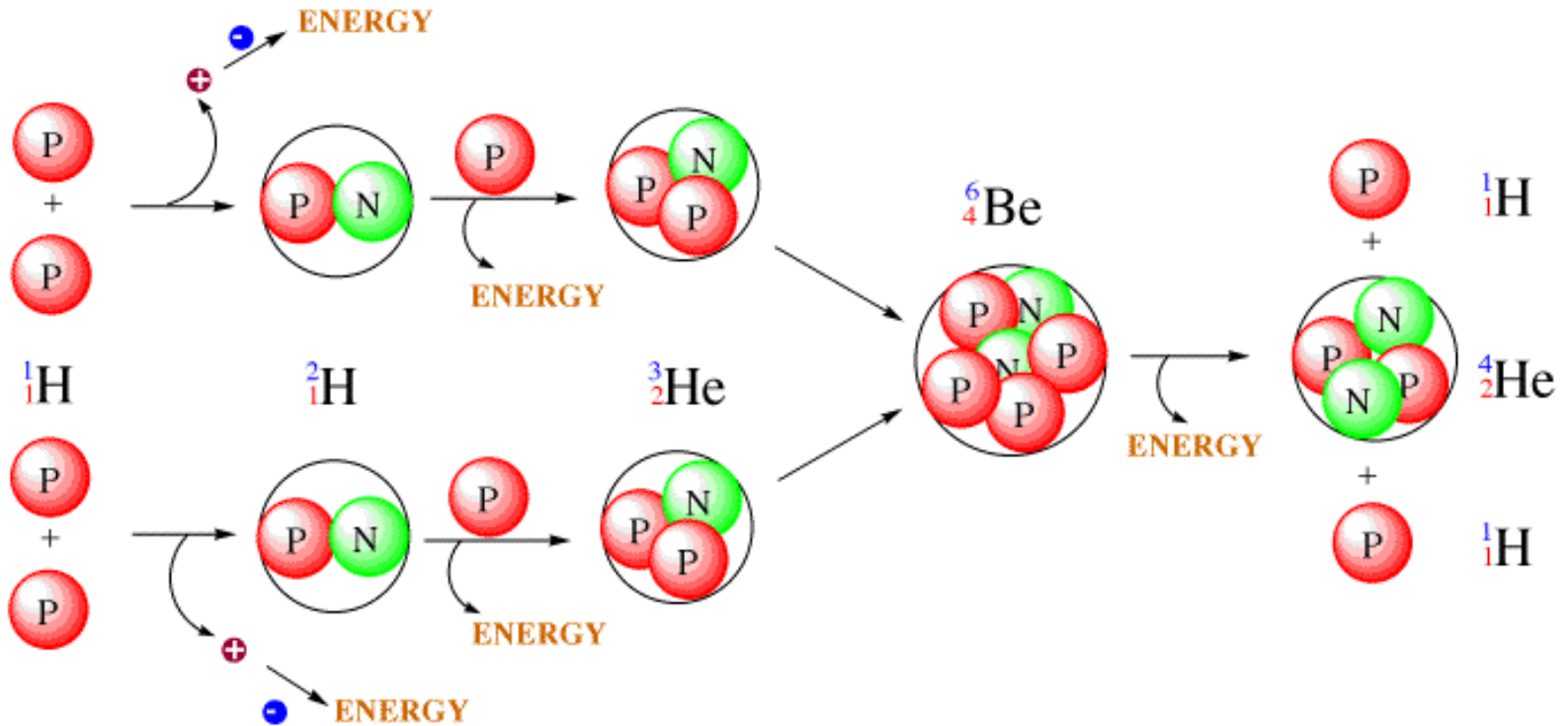
Life from Exploding Stars!



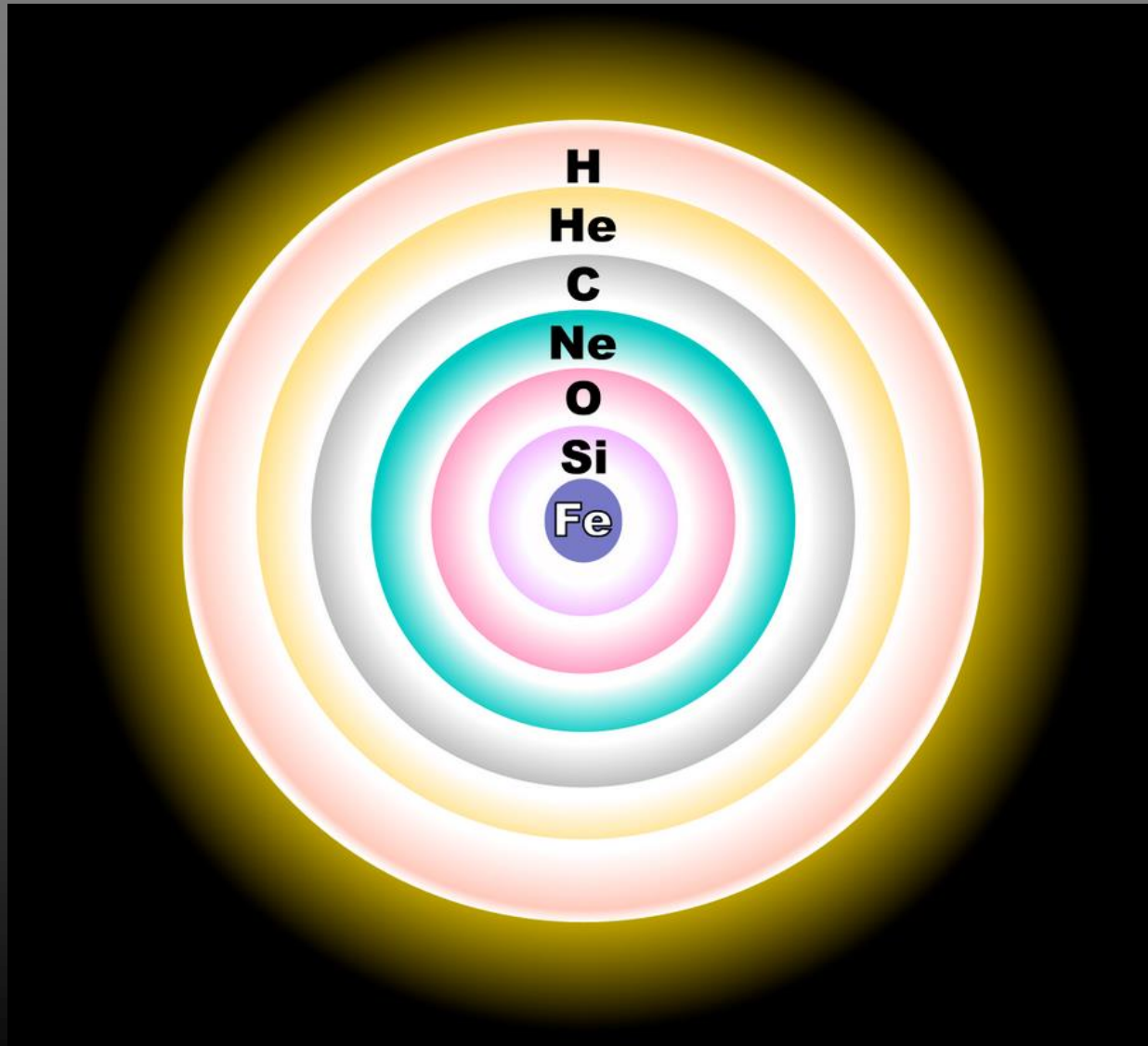
The image features a periodic table of elements in the background. A bright yellow sun with rays is positioned at the top center. A large red prohibition sign (a circle with a diagonal slash) is overlaid on the left side of the table. Inside the circle is a colorful illustration of a planet with green land, blue water, a tree, a person sitting at a computer, and a city with buildings. A text box on the right side of the table contains the following text:

Without supernovae to disperse elements made in stars, there would be no planets, no life as we know it!

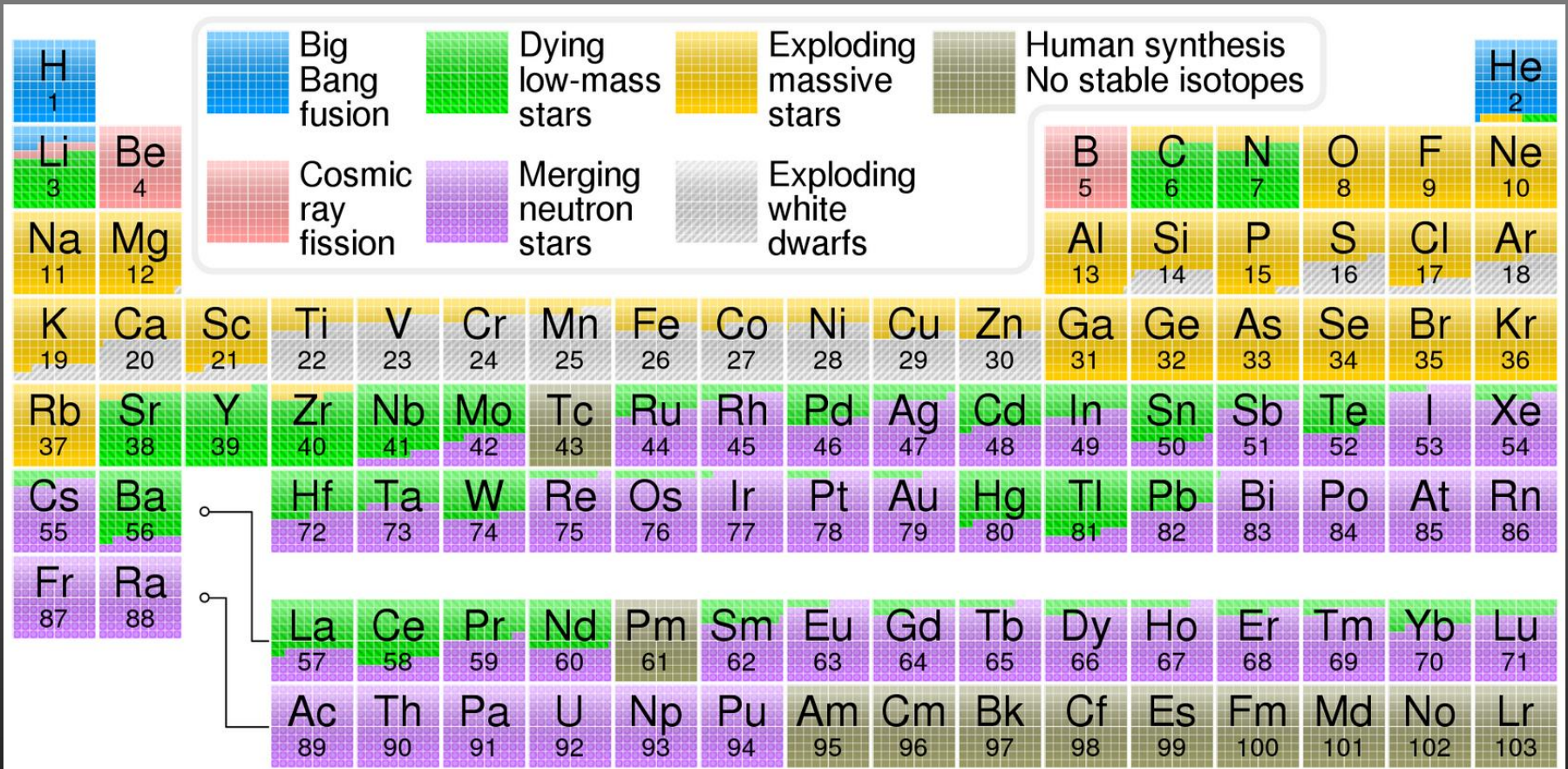
How are elements produced?



Fusion Sequence within Stars



Formation of the Elements



So aren't you
glad we live in a
universe where
stars explode?

Which stars?

Orion's stars likely to
go supernova!





Betelgeuse is 650 light years away

The last naked eye supernova in our galaxy was in Kepler's Supernova in 1604

Messier 1, the Crab Nebula, is a supernova remnant that was observed by Chinese astronomers in the year 1054 (6500 ly away)