



Universidad  
Industrial de  
Santander



GRUPO HALLEY DE ASTRONOMÍA Y  
CIENCIAS AEROSPAZIALES

# Astronomía Planetaria

## Clase 20 – Estrellas Masivas

Mauricio Suárez Durán

Escuela de Física

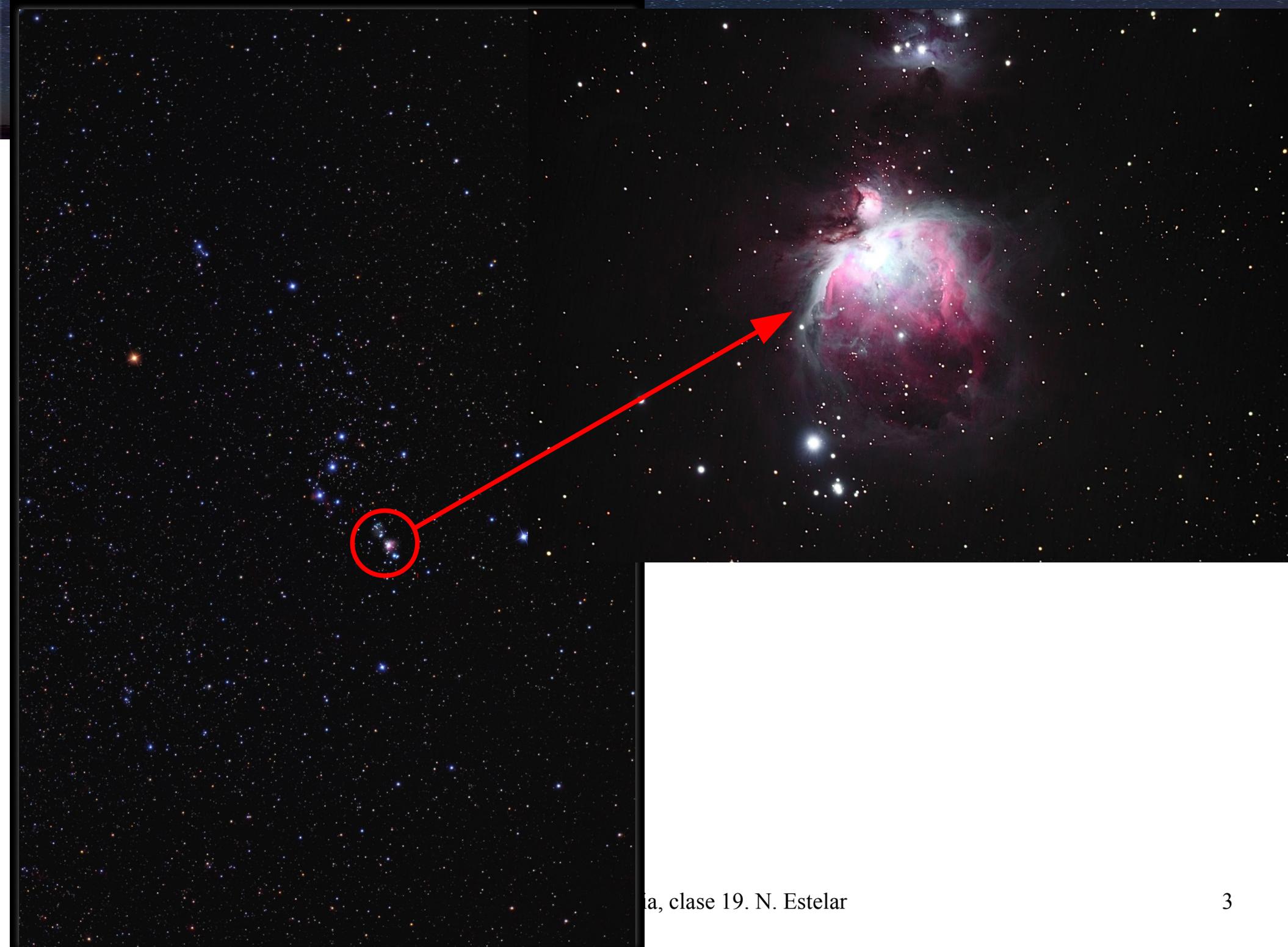
Grupo Halley de Astronomía y Ciencias Aeroespaciales

Universidad Industrial de Santander

Bucaramanga, II semestre de 2013

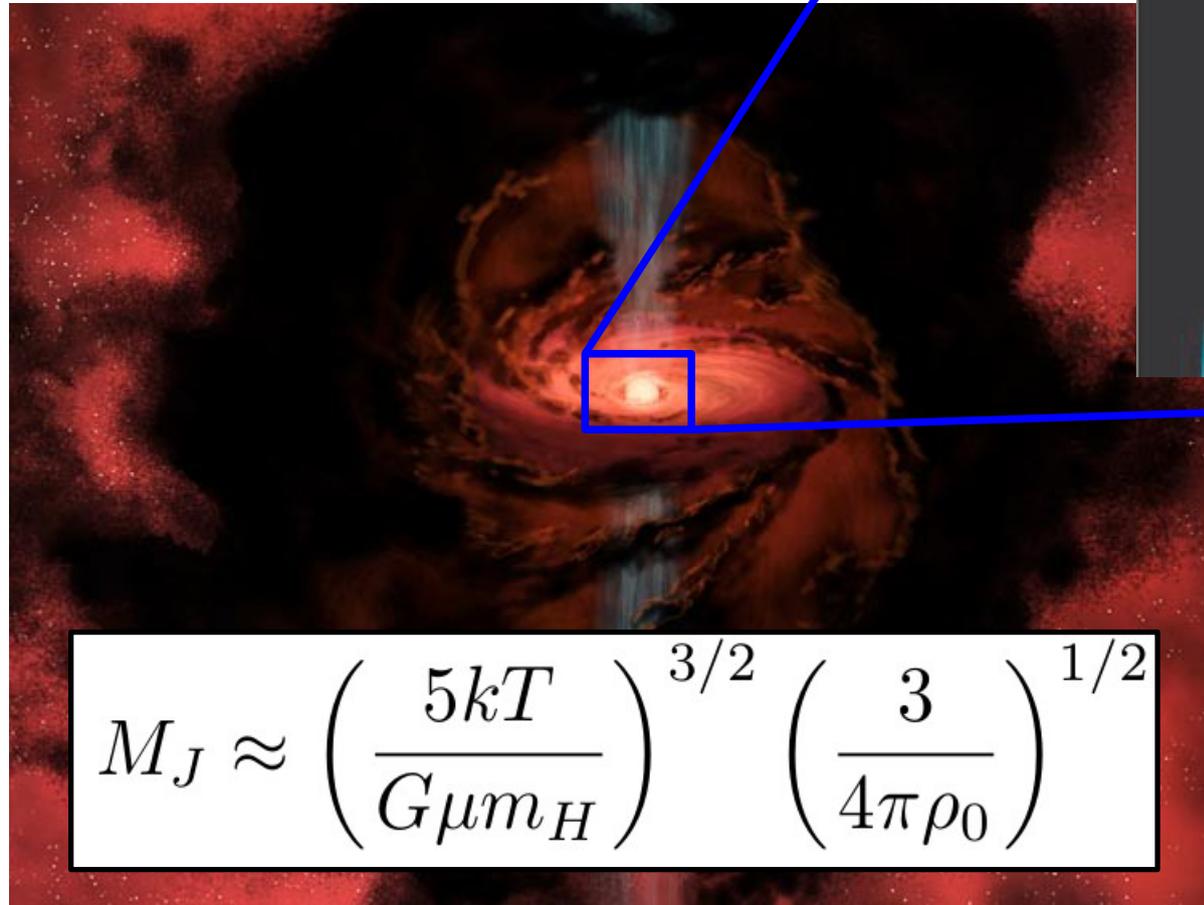
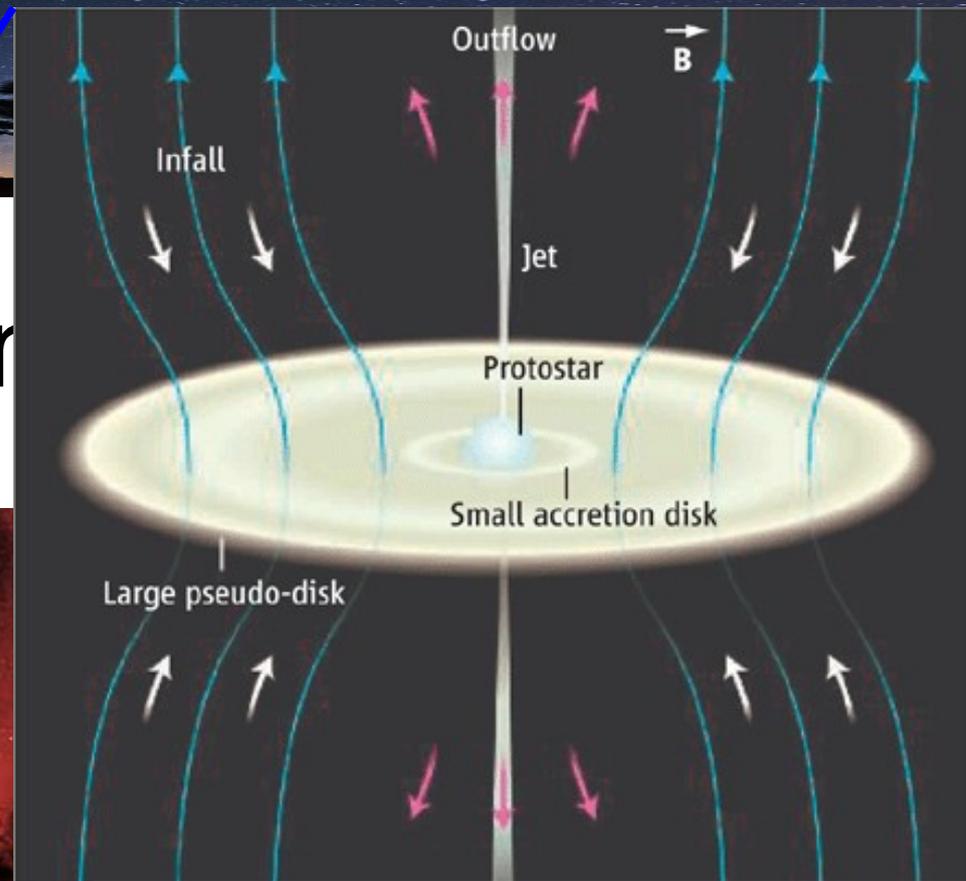


# En nuestro capítulo anterior



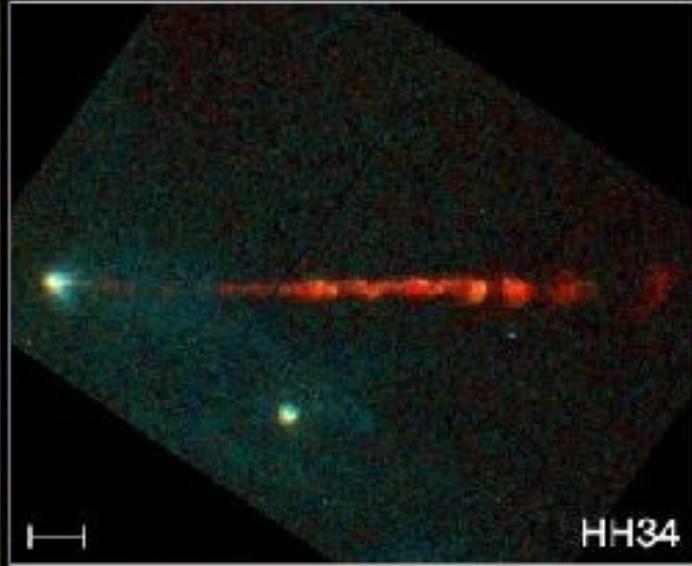
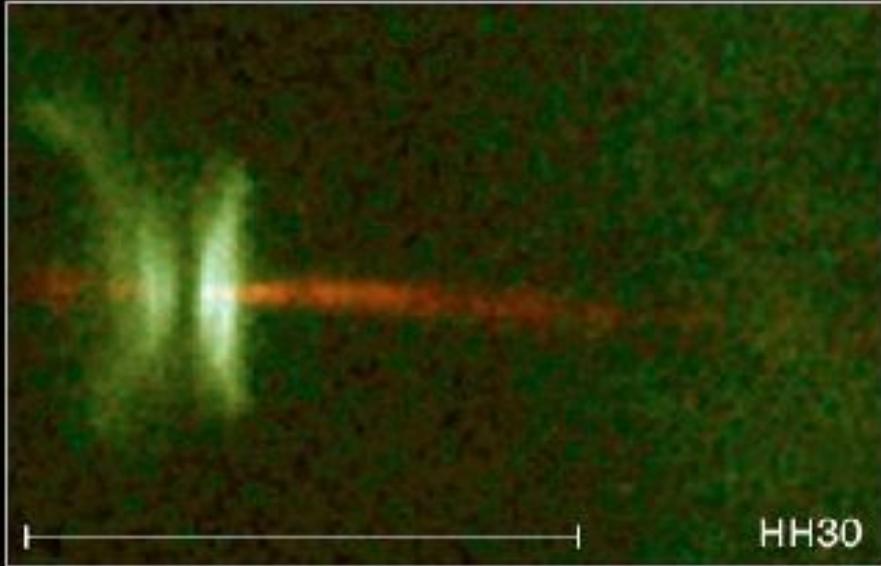
...a, clase 19. N. Estelar

# ¿Cómo se forman



$$M_J \approx \left( \frac{5kT}{G\mu m_H} \right)^{3/2} \left( \frac{3}{4\pi\rho_0} \right)^{1/2}$$

$$R_J \approx \left( \frac{15kT}{4\pi G\mu m_H \rho_0} \right)^{1/2}$$



?

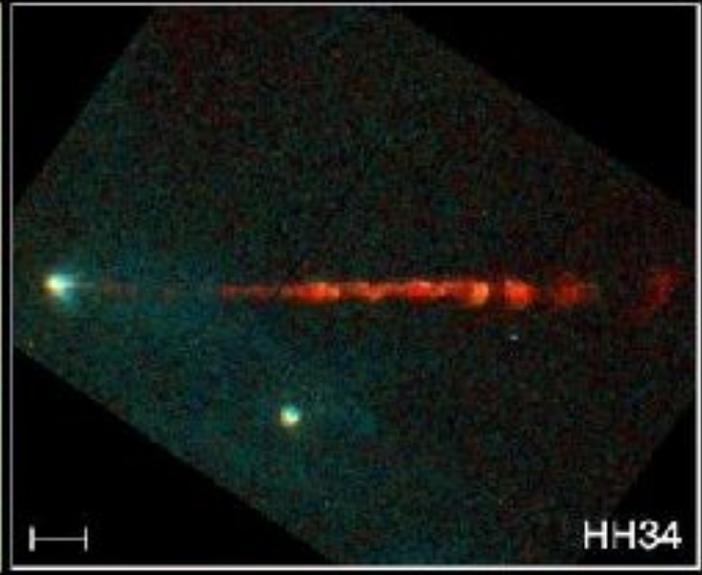
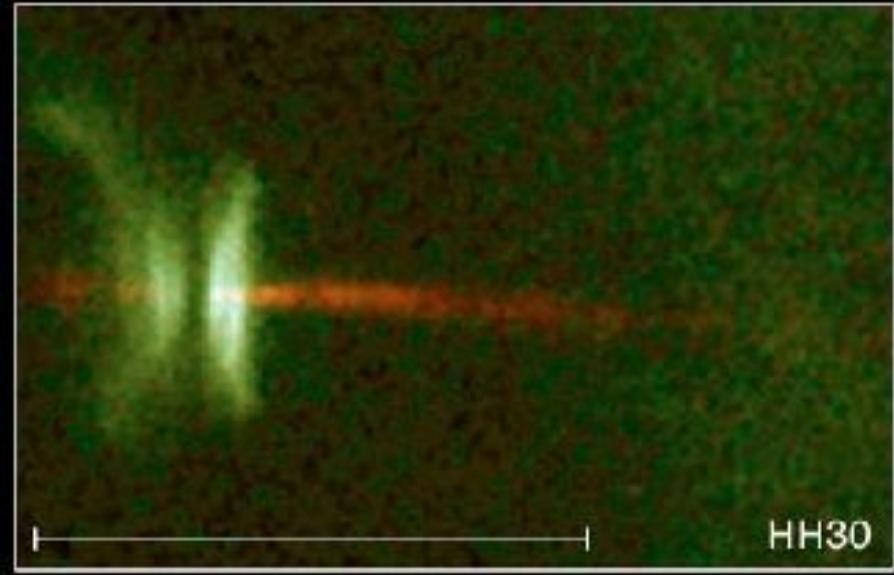


### Jets from Young Stars

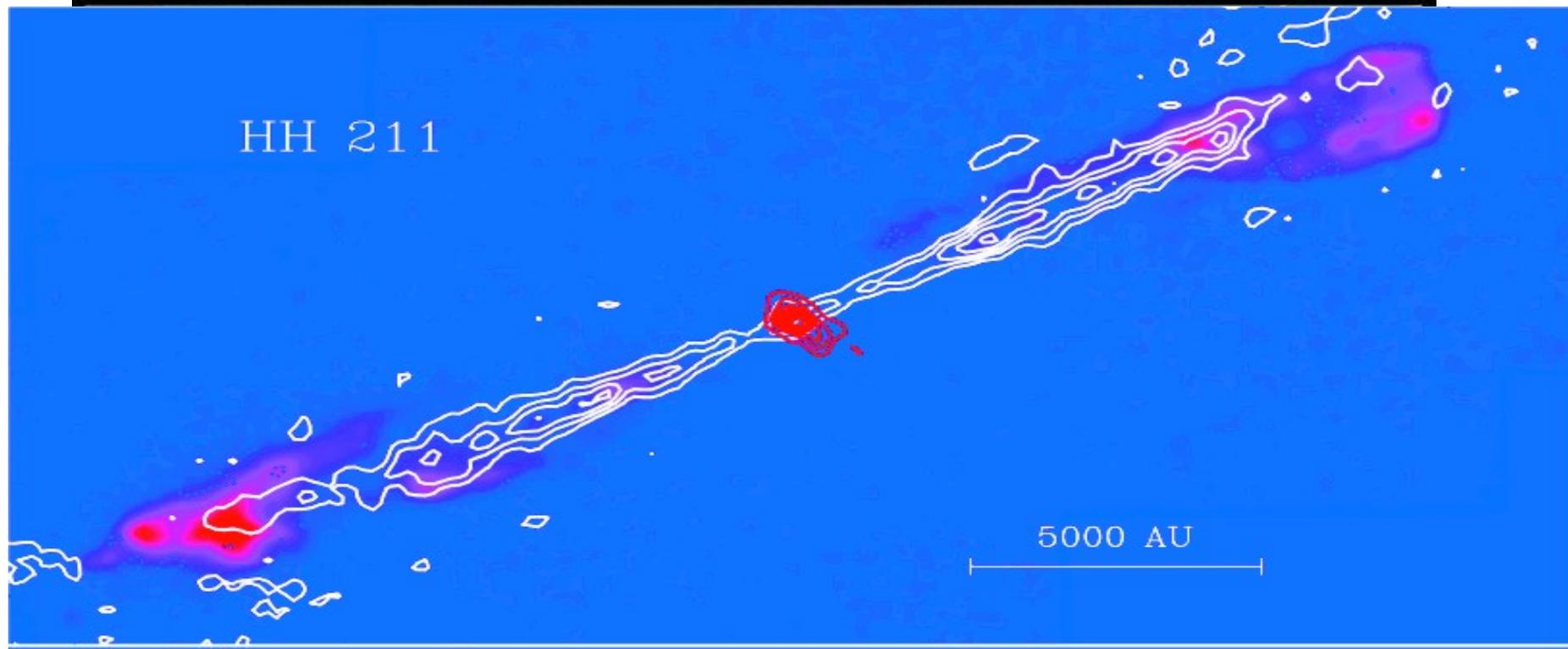
HST · WFPC2

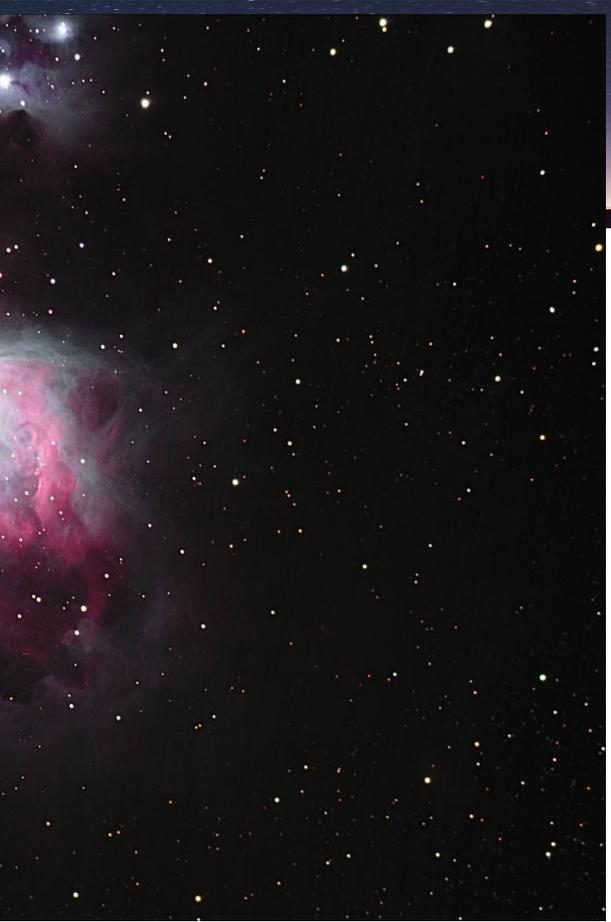
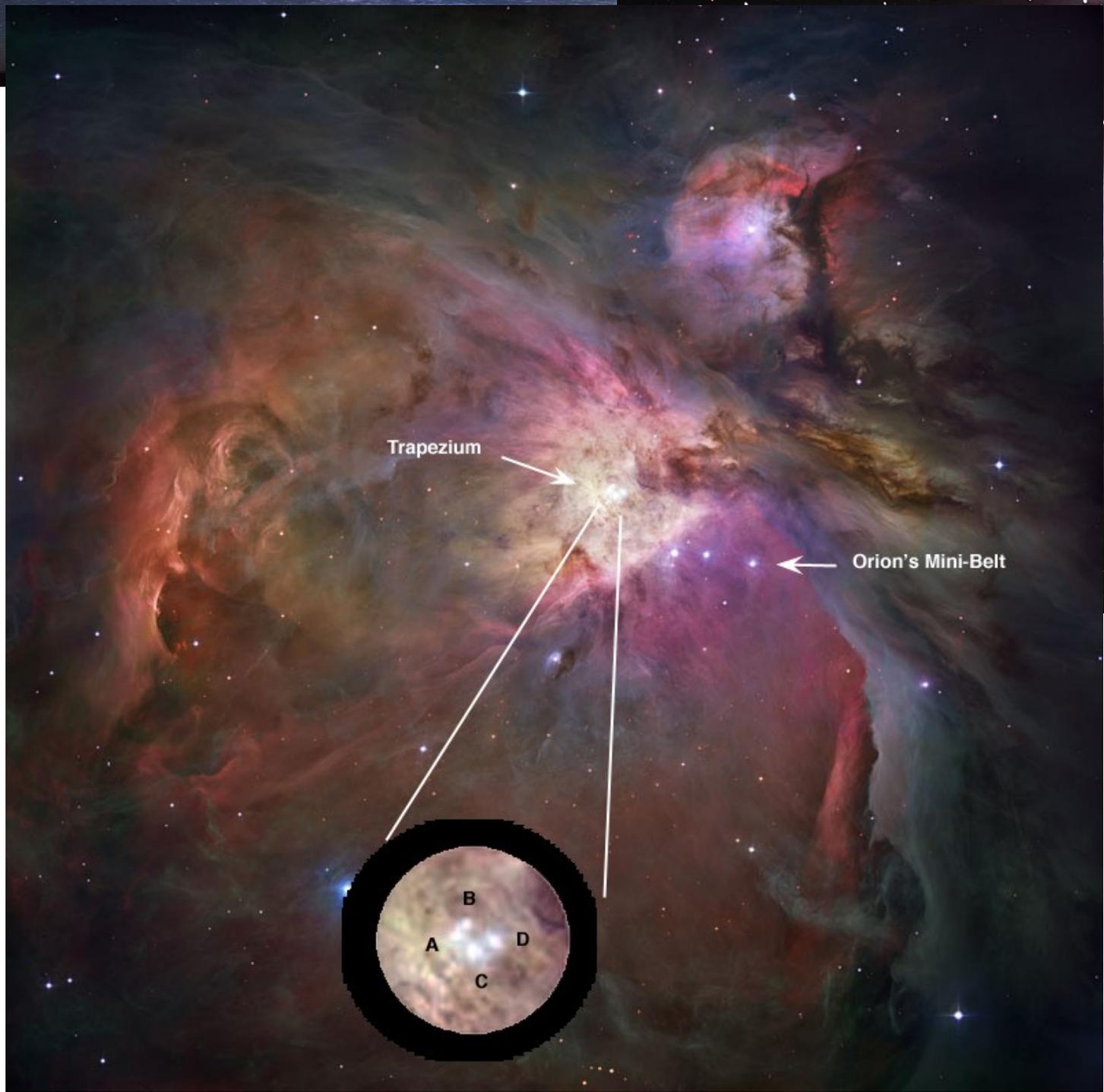
PRC95-24a · ST ScI OPO · June 6, 1995

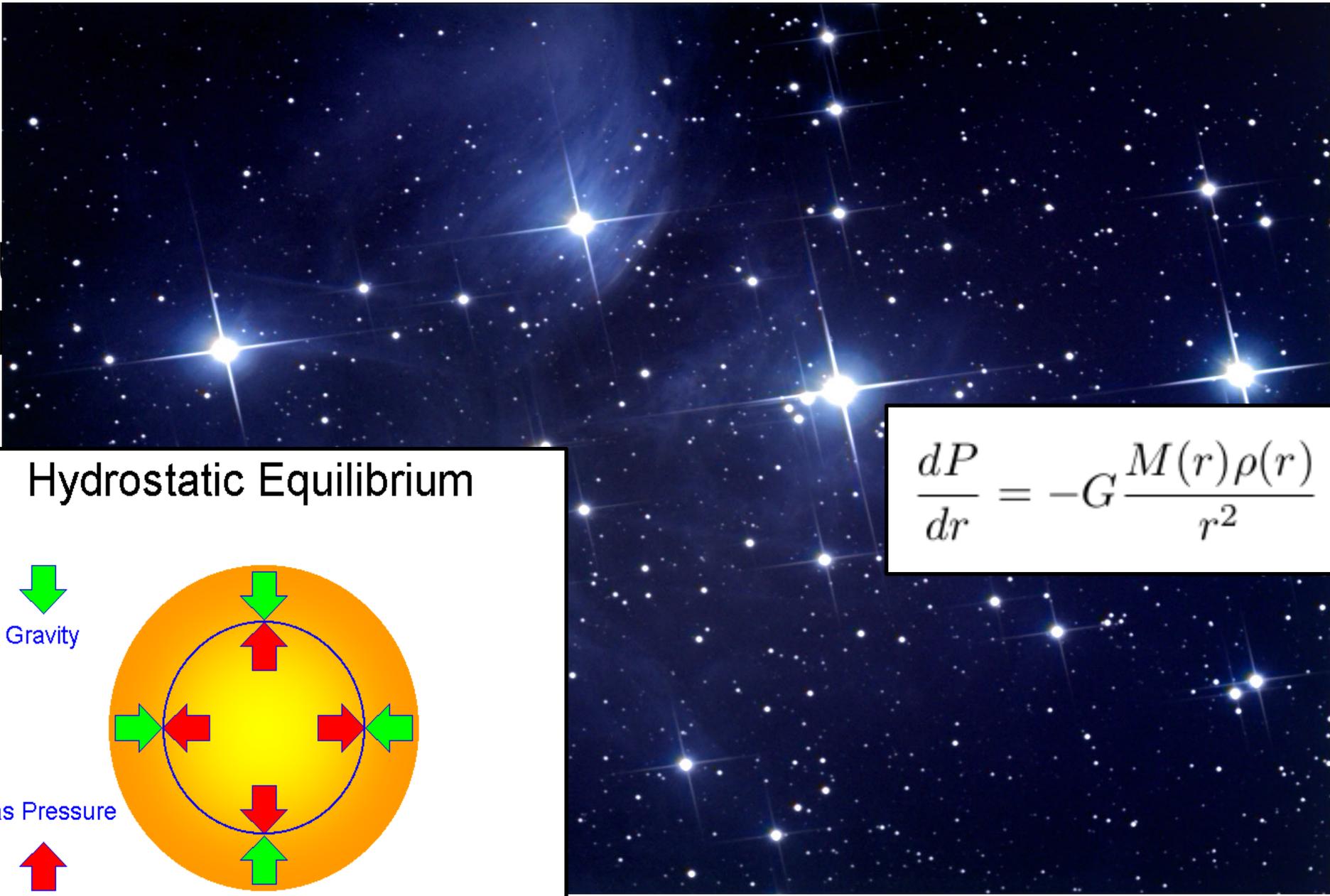
C. Burrows (ST ScI), J. Hester (AZ State U.), J. Morse (ST ScI), NASA



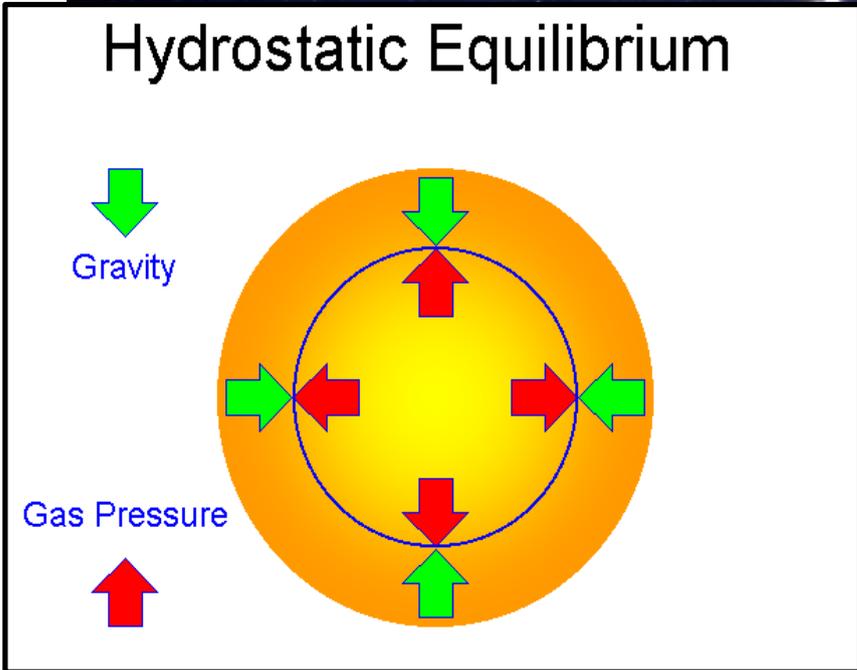
?





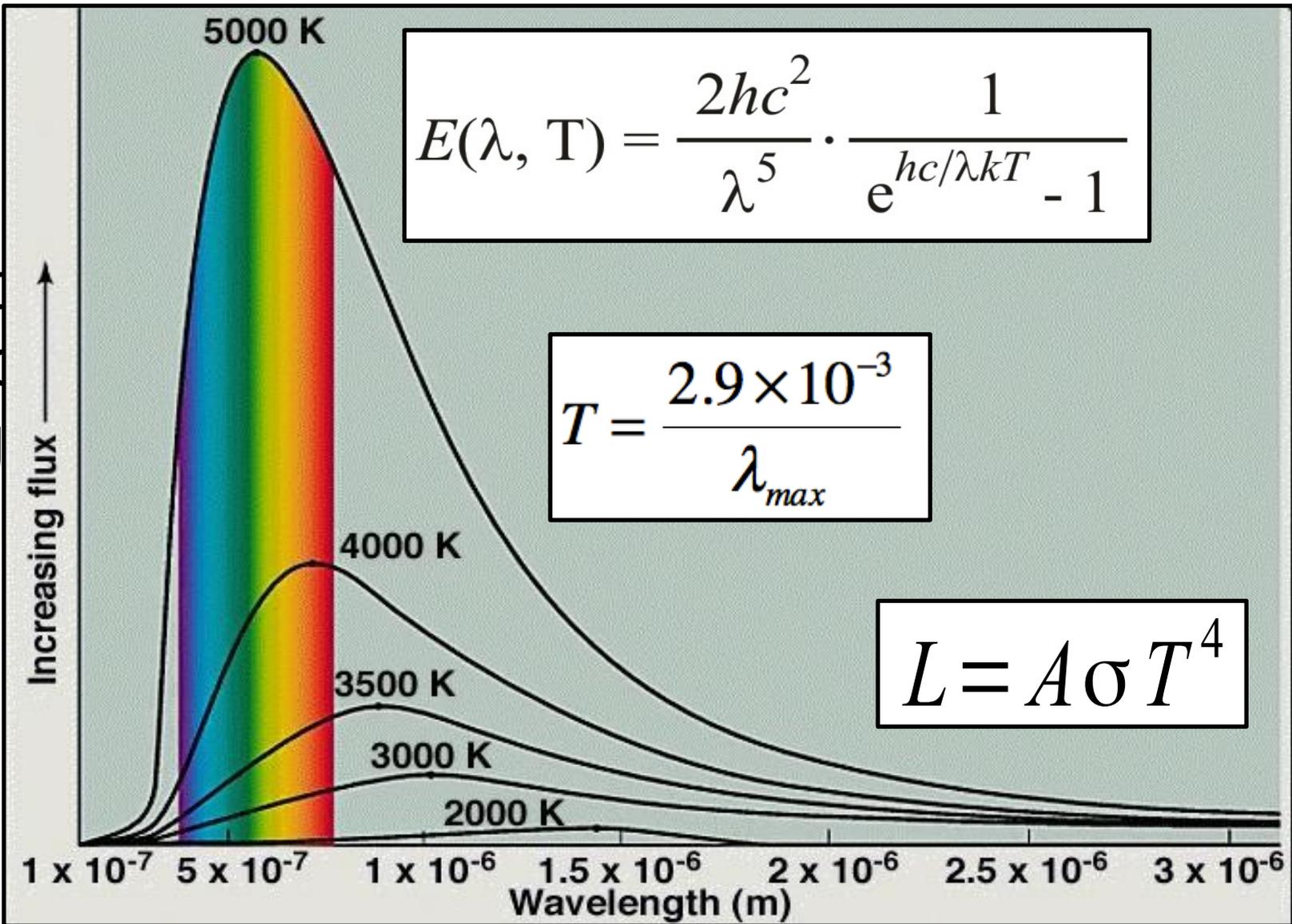


$$\frac{dP}{dr} = -G \frac{M(r)\rho(r)}{r^2}$$



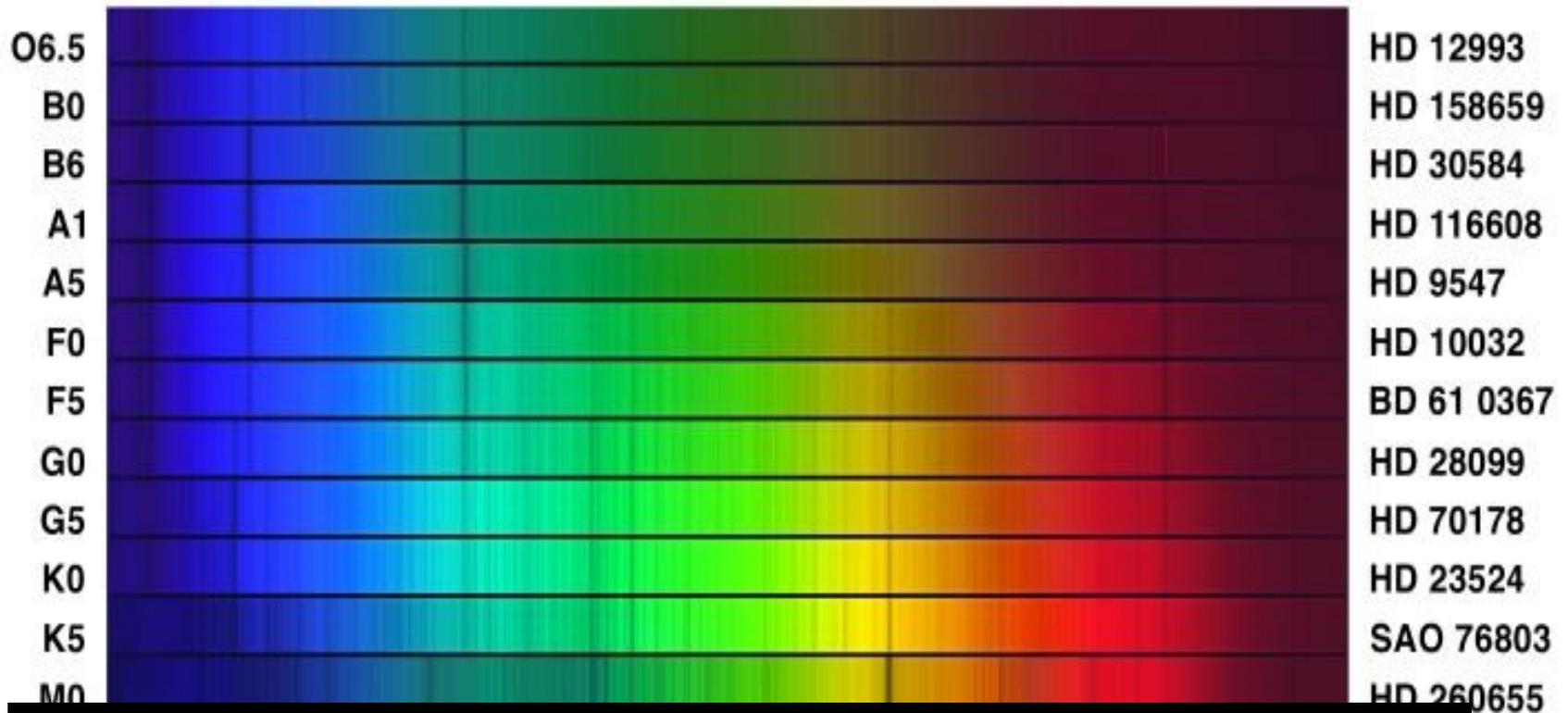


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# Clasificación estelar



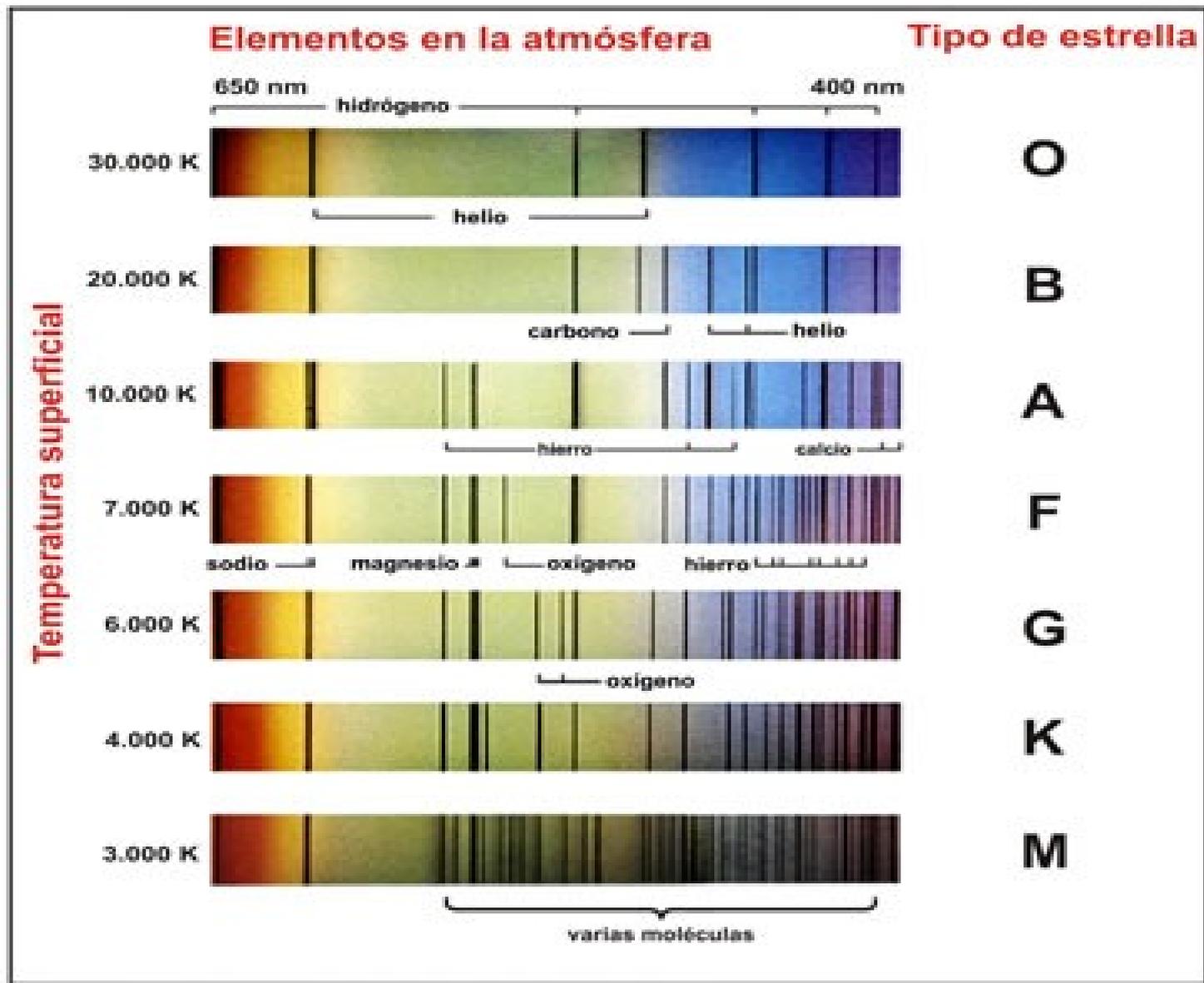
Spectral Class Types for Stars

F4 metal  
M4.5 emis  
B1 emis



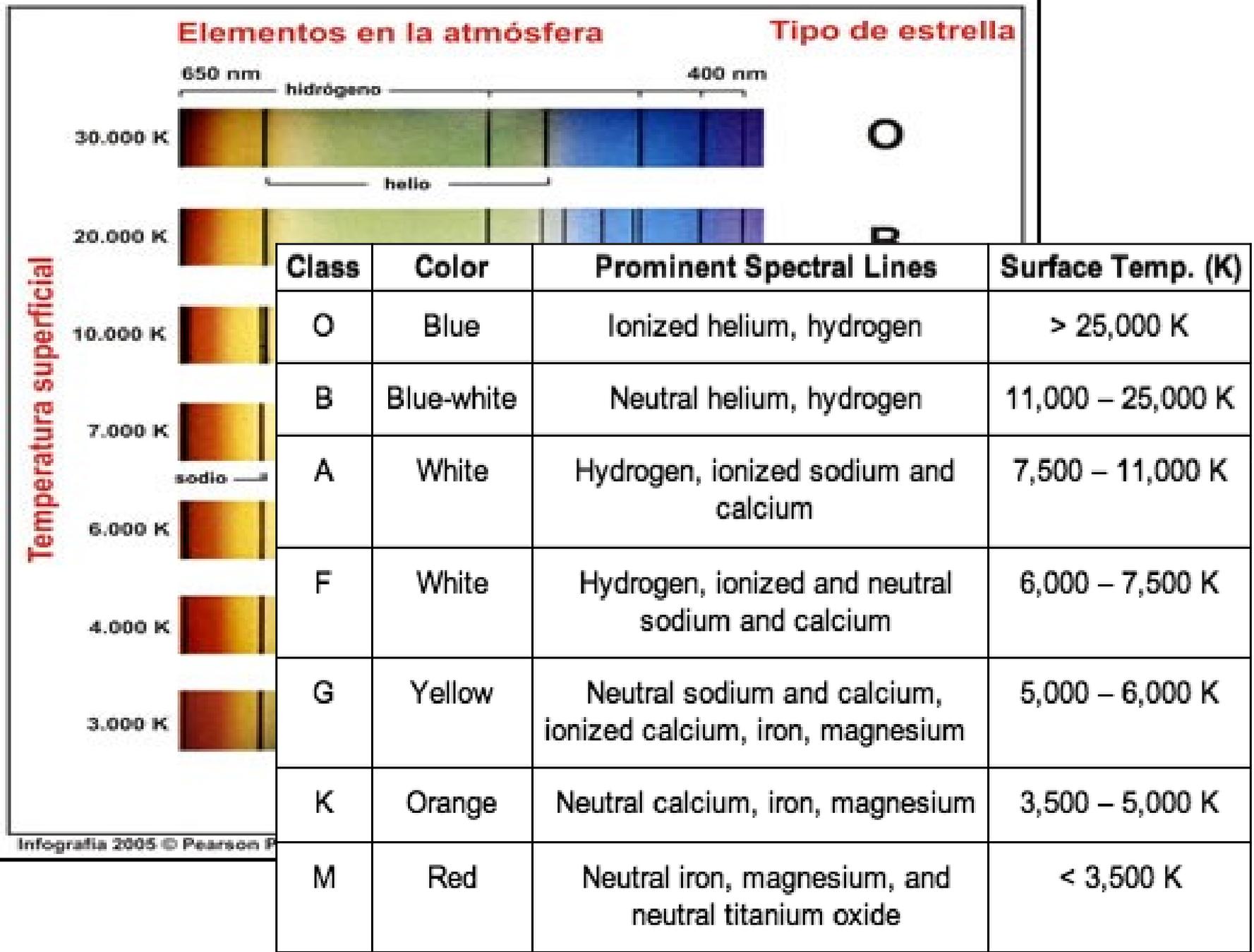
755  
028  
1292  
256

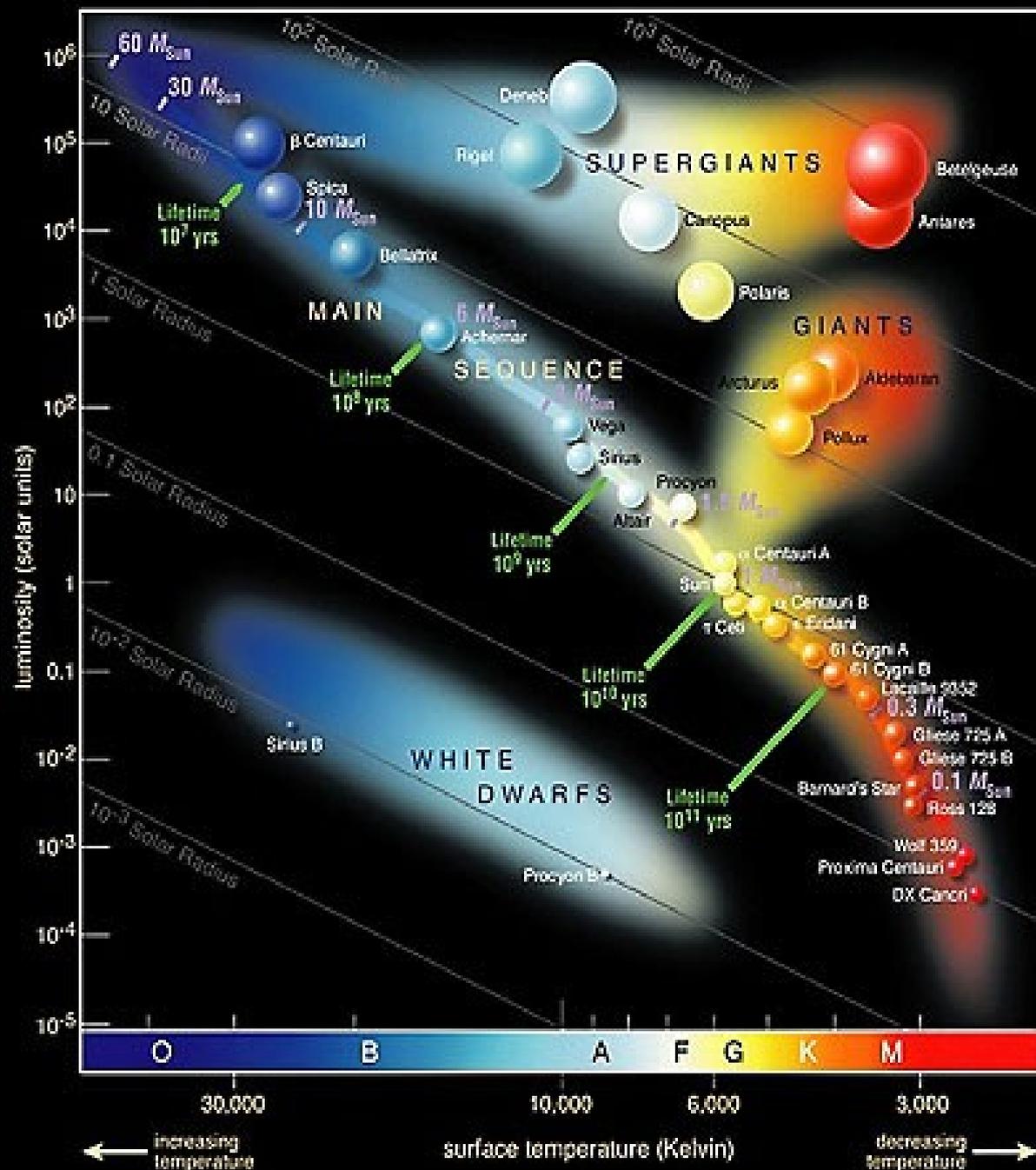
# CLASIFICACIÓN ESPECTRAL DE LAS ESTRELLAS



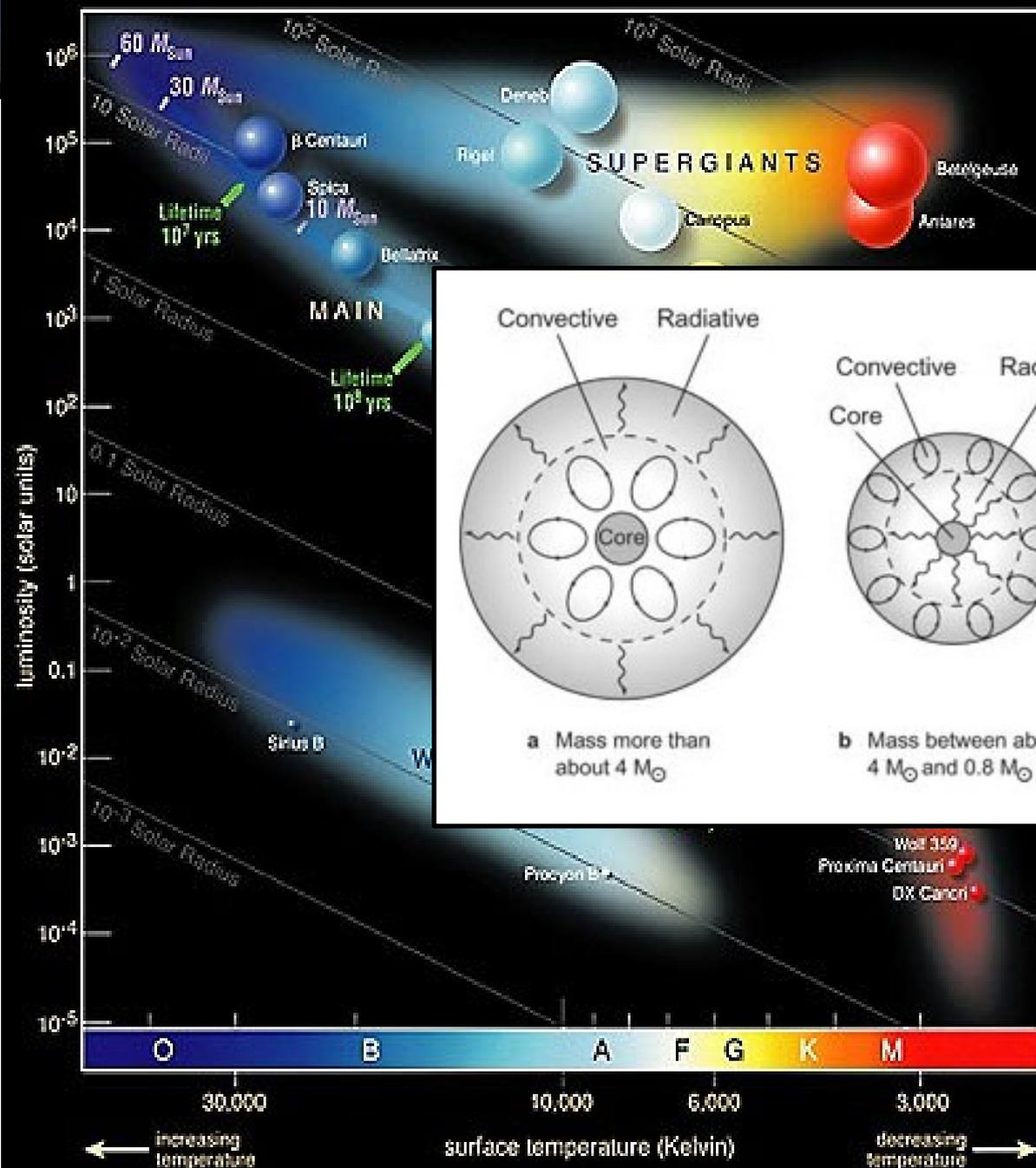
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# CLASIFICACIÓN ESPECTRAL DE LAS ESTRELLAS

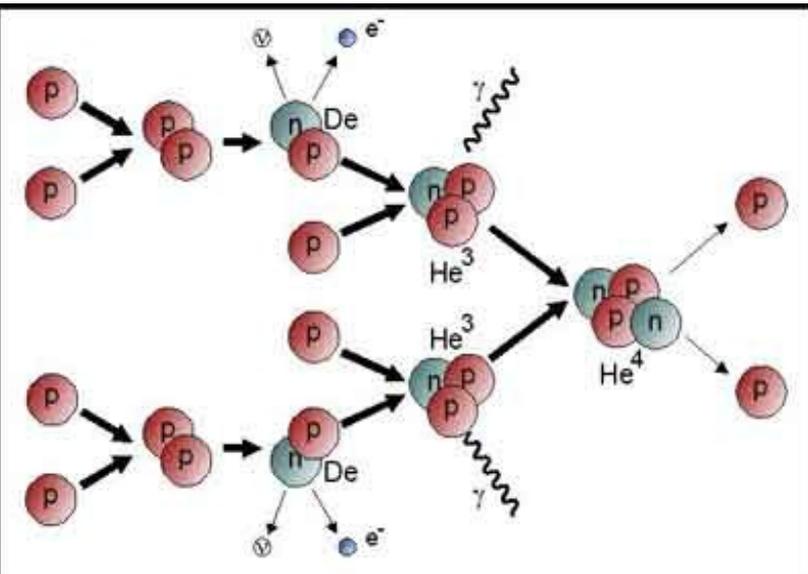




Clase	Temperatura	Color
<b>O</b>	30.000 – 60.000 K	Azul
<b>B</b>	10.000 – 30.000 K	Azul-Blanco
<b>A</b>	7.500 – 10.000 K	Blanco
<b>F</b>	6.000 – 7.500 K	Amarillo Blanco
<b>G</b>	5.000 – 6.000 K	Amarillo
<b>K</b>	3.000 – 5.000 K	Amarillo Naranja
<b>M</b>	2.000 – 3.500 K	Rojo

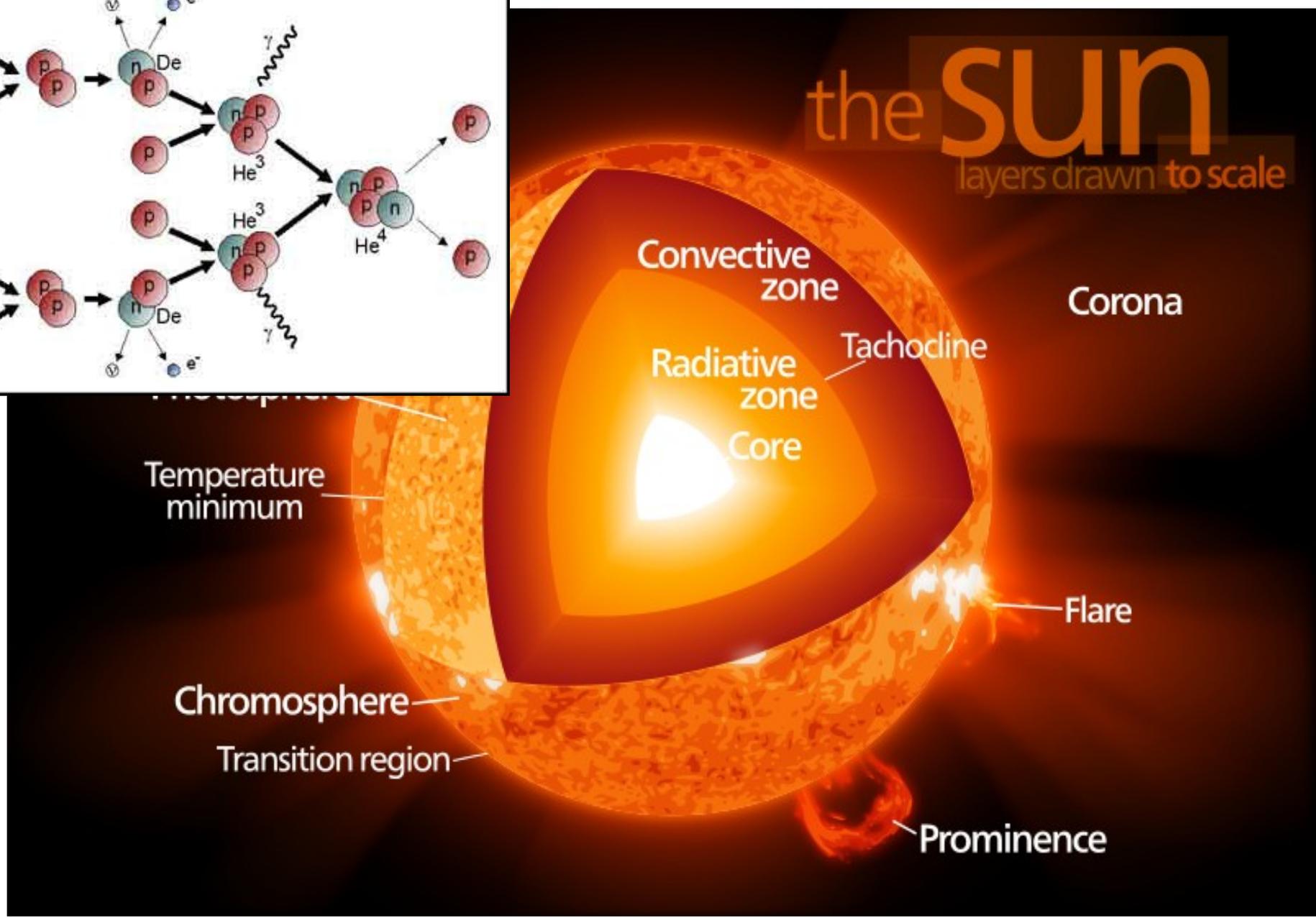


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O	30.000 – 60.000 K	Azul
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F	6.000 – 7.500 K	Amarillo Blanco
G	5.000 – 6.000 K	Amarillo
K	3.000 – 5.000 K	Amarillo Naranja
M	2.000 – 3.500 K	Rojo



# the sun

layers drawn to scale



# Periodic Table of the Elements

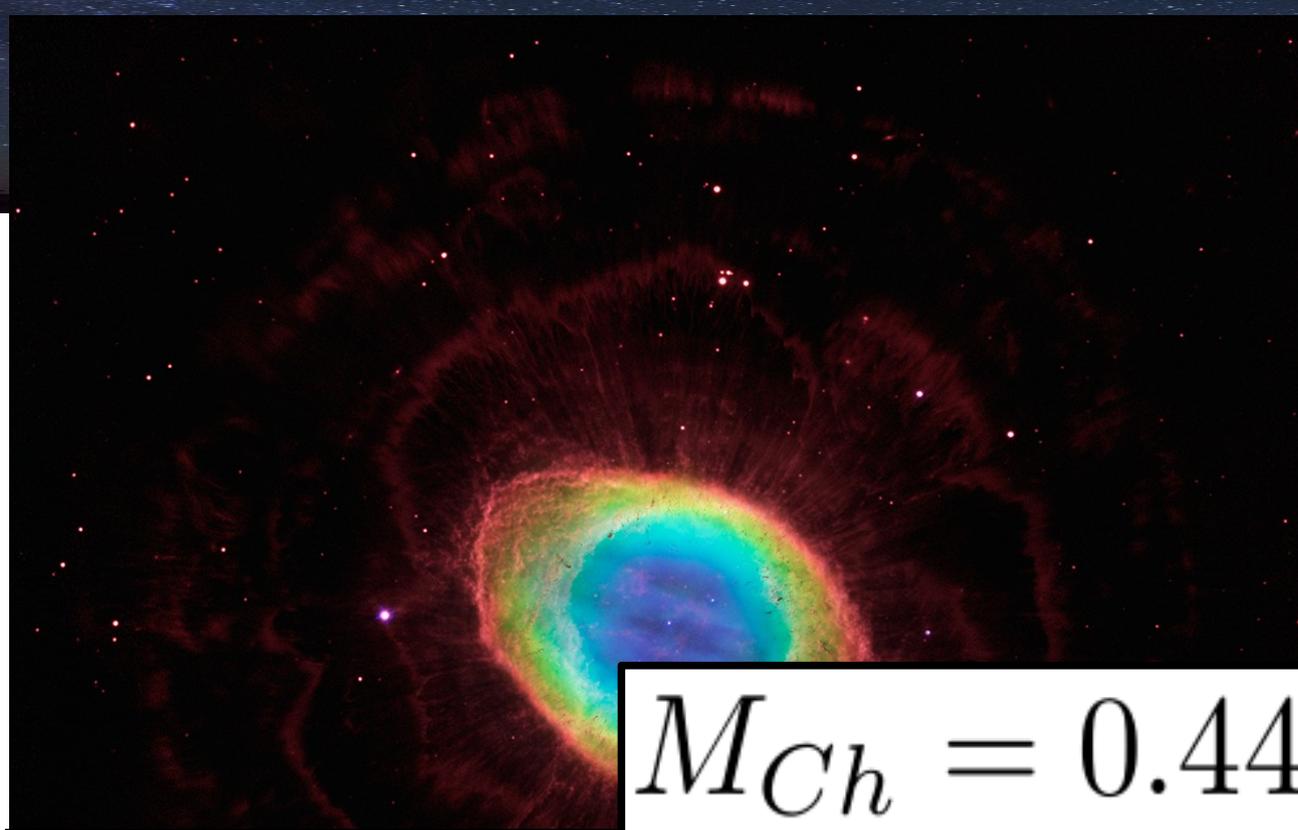
1	IA	1	H	1A																0	2	He															
2		2	Li	3A	4	Be							5	6	7	8	9	10																			
3		11	Na	12	Mg	IIIB	IVB	VB	VIB	VIB	VIB	VII	VIII	IB	IIIB	13	14	15	16	17	18																
4		19	K	20	Ca	21	Sc	22	Ti	23	Y	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
5		37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
6		55	Cs	56	Ba	*La	Hf	72	Ta	73	W	74	Re	75	Os	76	Ir	77	Pt	78	Au	79	Hg	80	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn	
7		87	Fr	88	Ra	+Ac	Hf	104	Ha	105	Sg	106	Ns	107	Hs	108	Mt	109	110	111	112	113															

\* Lanthanide Series

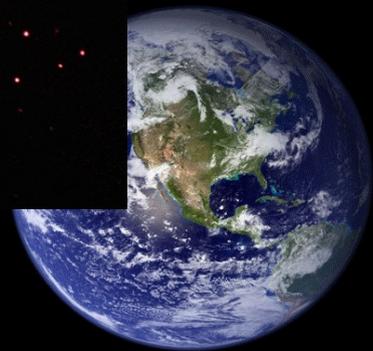
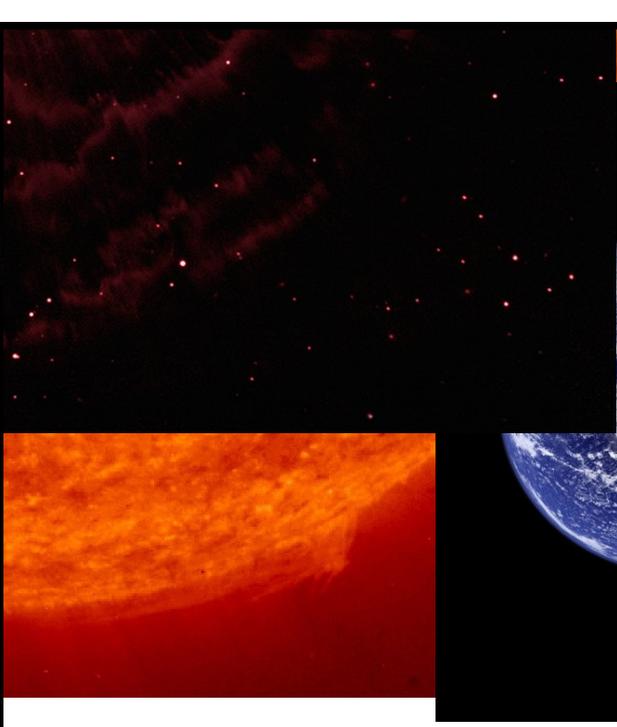
58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

\* Actinide Series

90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr



$$M_{Ch} = 0.44M_{\odot}$$



$M \approx 1.0 M_{\text{sun}}$   
 $R \approx 5800 \text{ km}$   
 $V_{\text{esc}} \approx 0.02c$

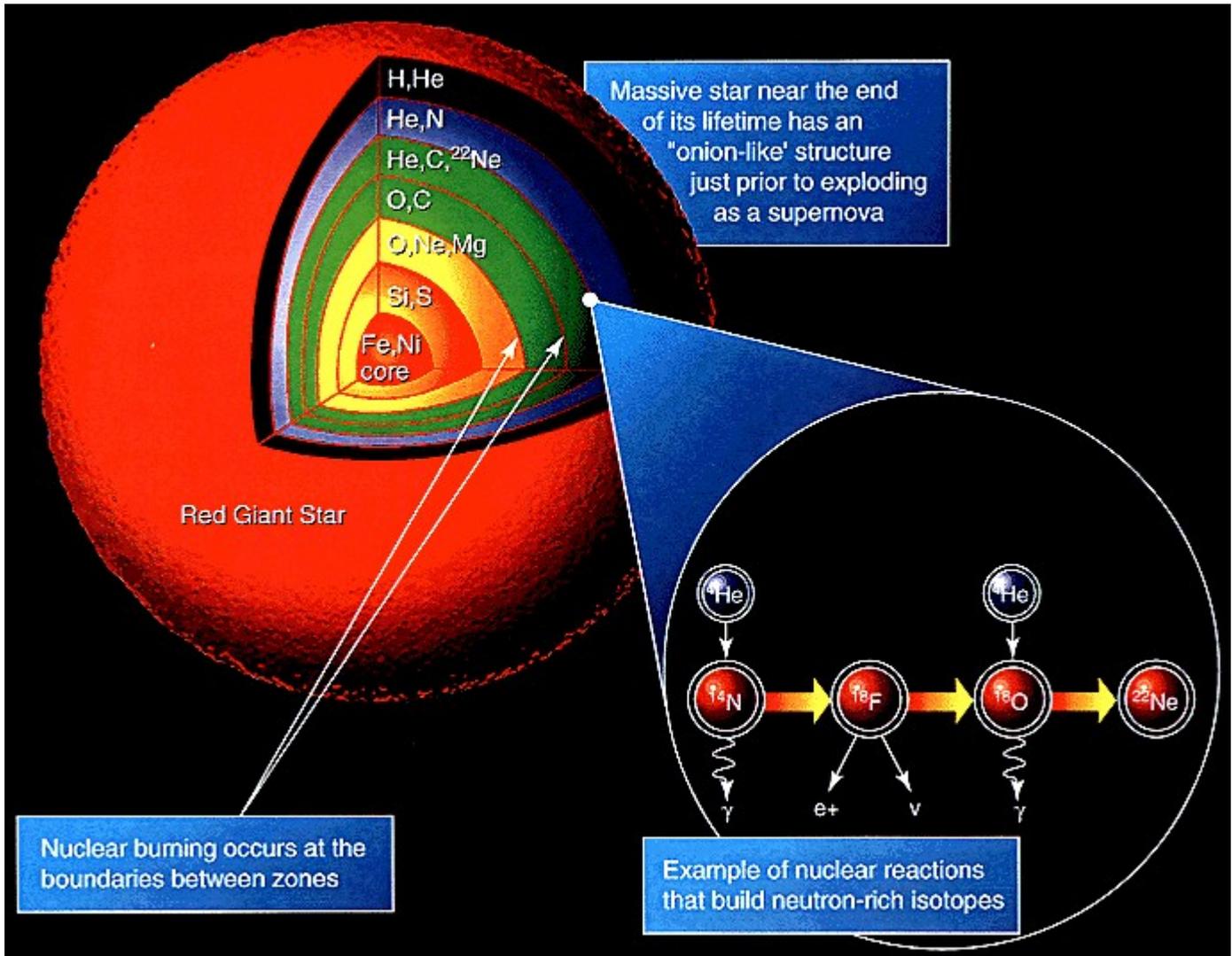


# El objetivo para hoy

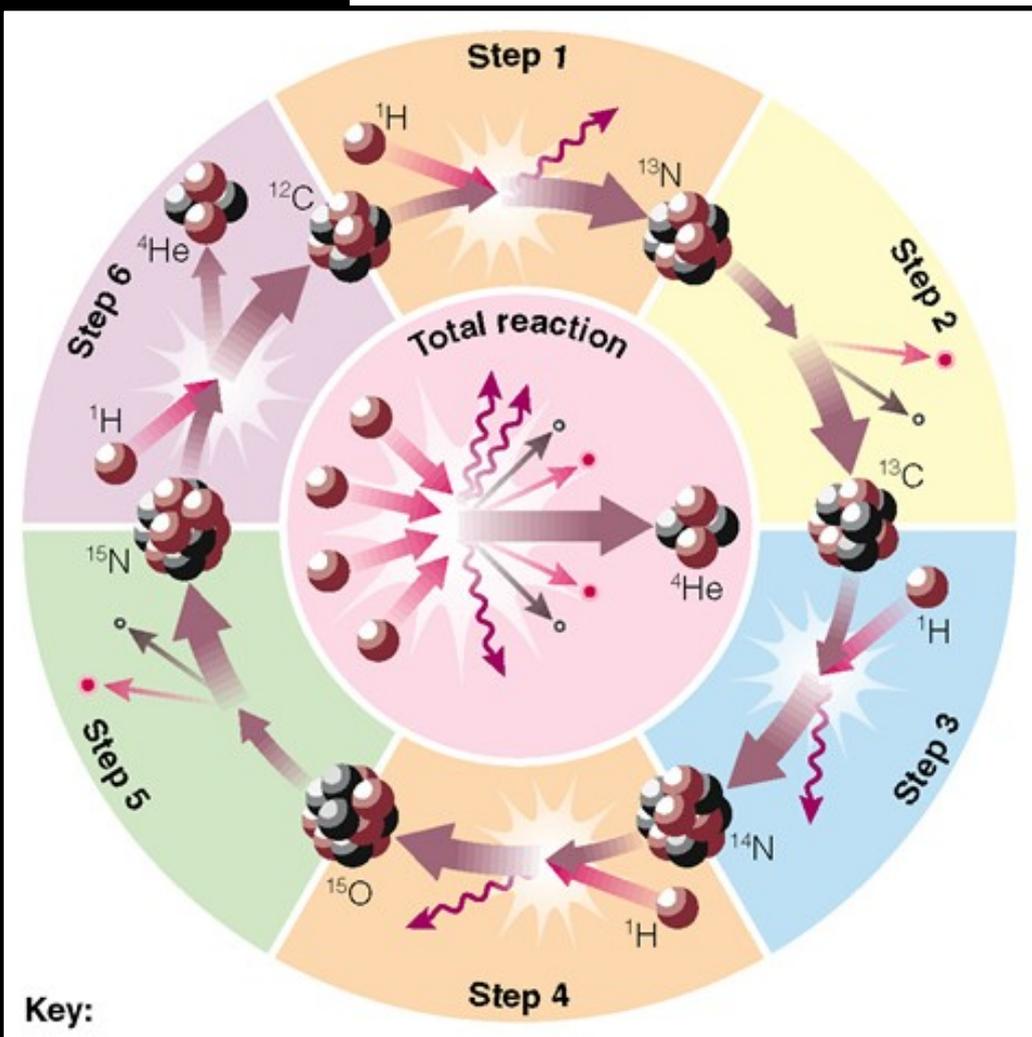
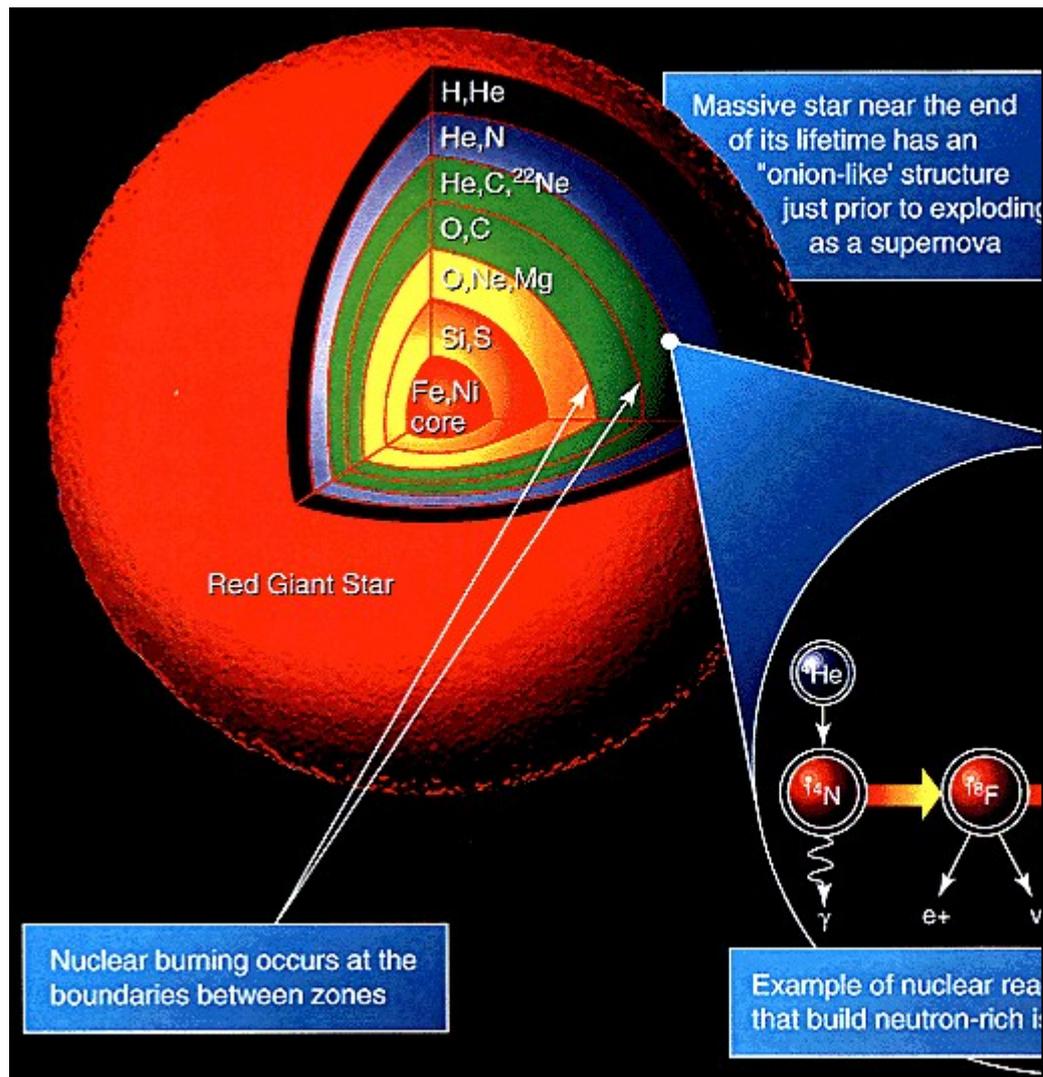
- **Mostrar la evolución para estrellas masivas.**



# Estrellas de Alta masa ( $>10M_{\text{sol}}$ )



( $>10M_{\text{sol}}$ )



- Key:**
- neutron
  - proton
  - positron
  - neutrino
  - ⤴ gamma ray



# Estrellas de Alta masa ( $>10M_{\text{sol}}$ )

# Periodic Table of the Elements

1	IA	1	H	1A																0	2	He															
2		2	Li	3A	3	Be								5	5A	6	C	7	N	8	O	9	F	10	Ne												
3		11	Na	12	Mg	IIIB		IVB	VB	VIB	VIB	VII	VIII	IB	IIIB	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar										
4		19	K	20	Ca	21	Sc	22	Ti	23	Y	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
5		37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
6		55	Cs	56	Ba	*La	Hf	72	Ta	73	W	74	Re	75	Os	76	Ir	77	Pt	78	Au	79	Hg	80	Tl	81	Pb	82	Bi	83	Po	84	At	85	Rn		
7		87	Fr	88	Ra	+Ac	Hf	104	Ha	105	Sg	106	Ns	107	Hs	108	Mt	109	110	111	112	113															

\* Lanthanide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

\* Actinide Series

90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

# Periodic Table of the Elements

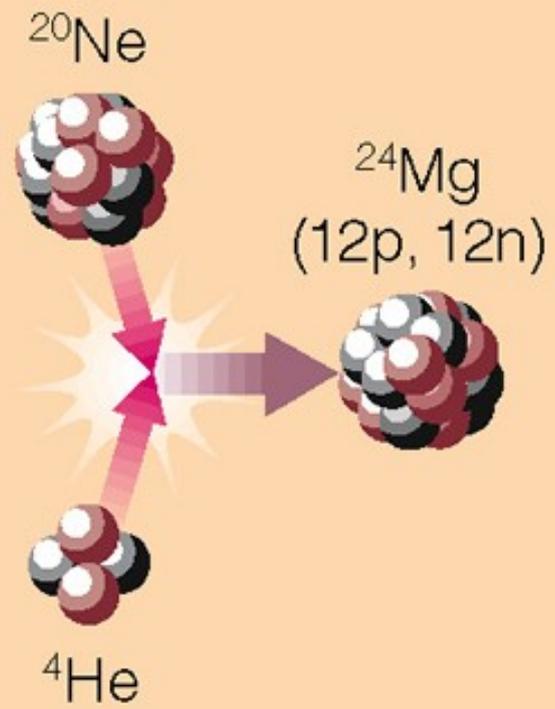
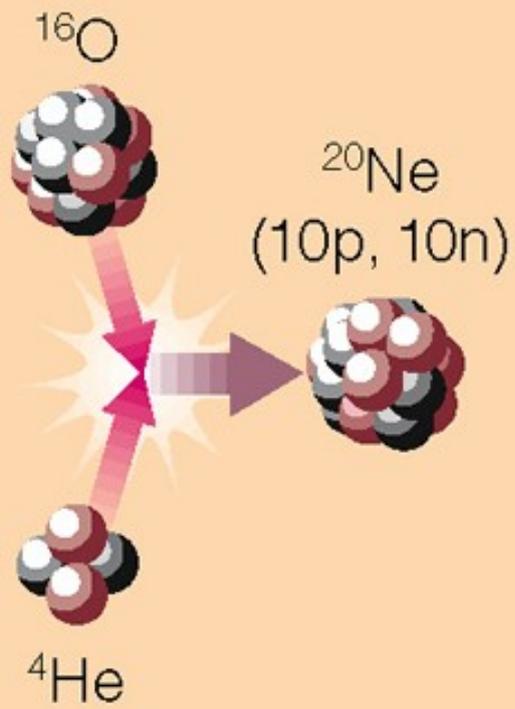
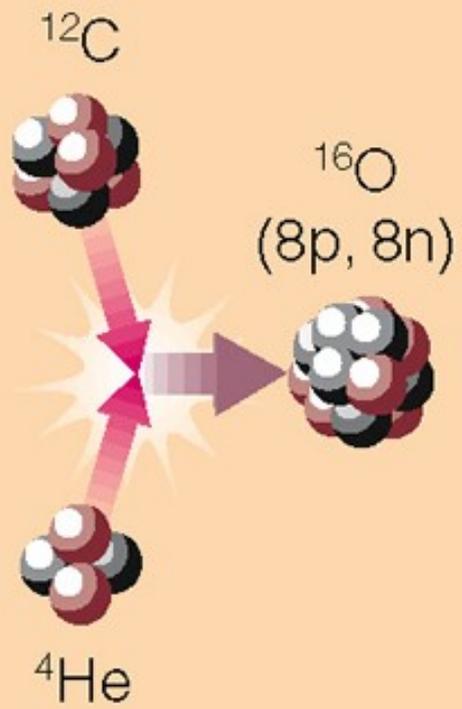
1	1A	1	H	1A																0	2	He															
2		2	Li	3A	3	Be						5	5A	6	C	7	N	8	O	9	6A	F	10	7A	Ne												
3		11	Na	12	Mg	IIIB	IVB	VB	VIB	VIB	VIB	VII	VII	IB	11B	13	Al	14	Si	15	P	16	S	17	Cl	18	Ar										
4		19	K	20	Ca	21	Sc	22	Ti	23	Y	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
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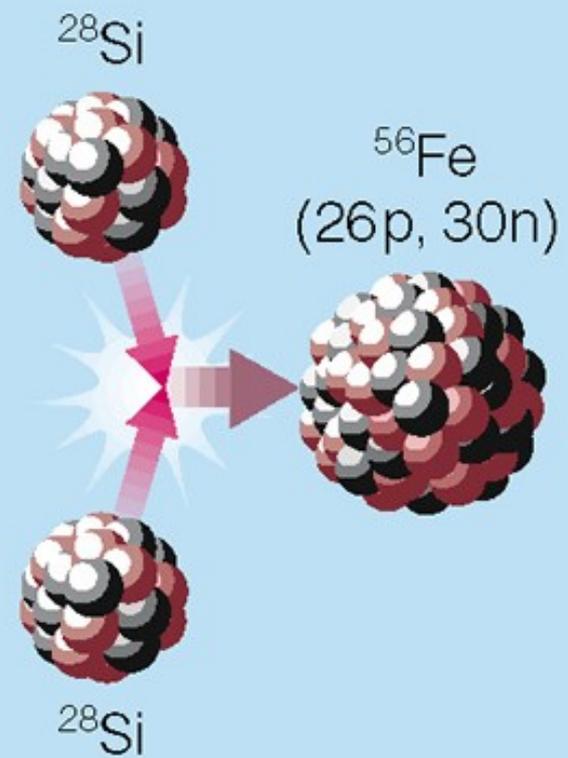
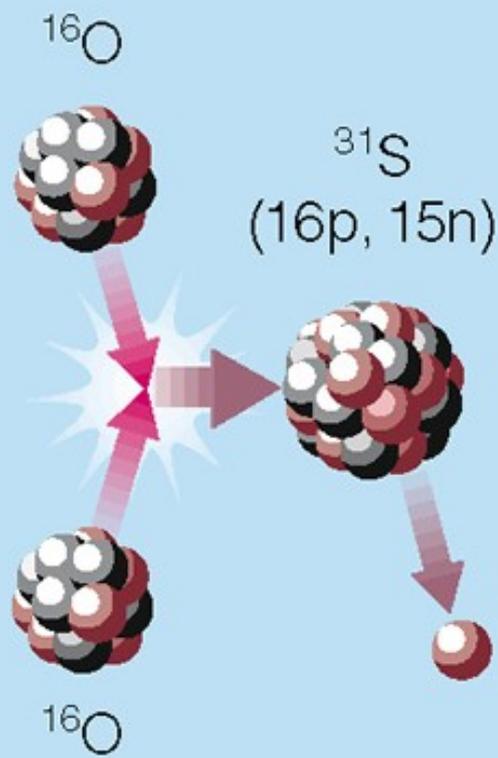
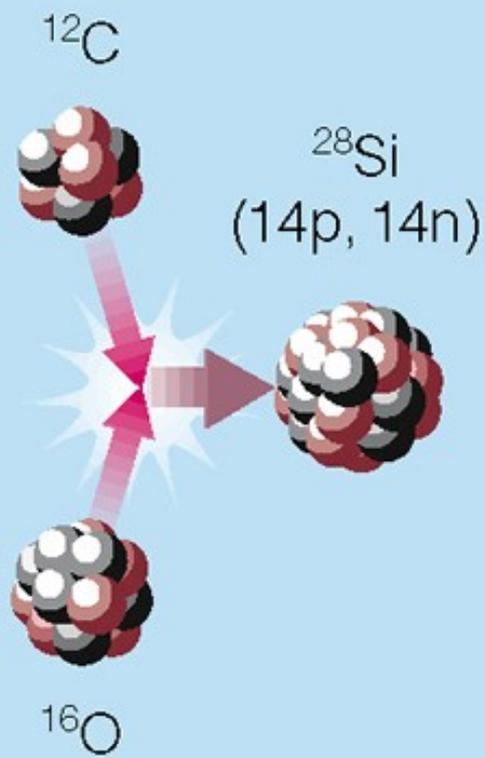
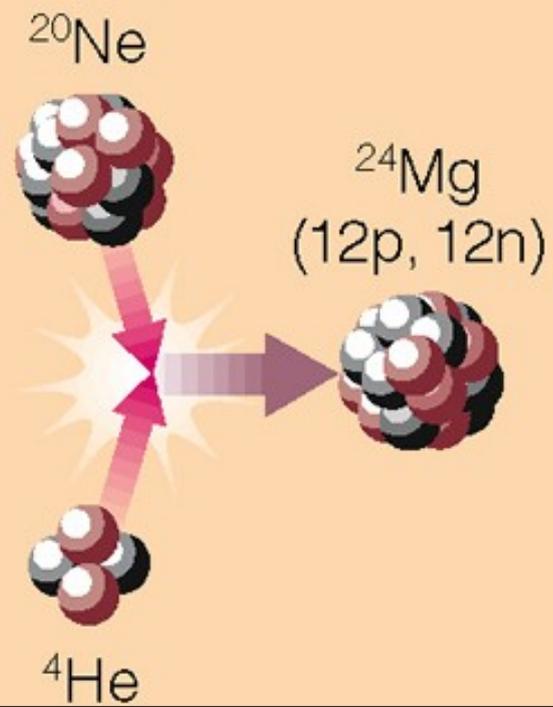
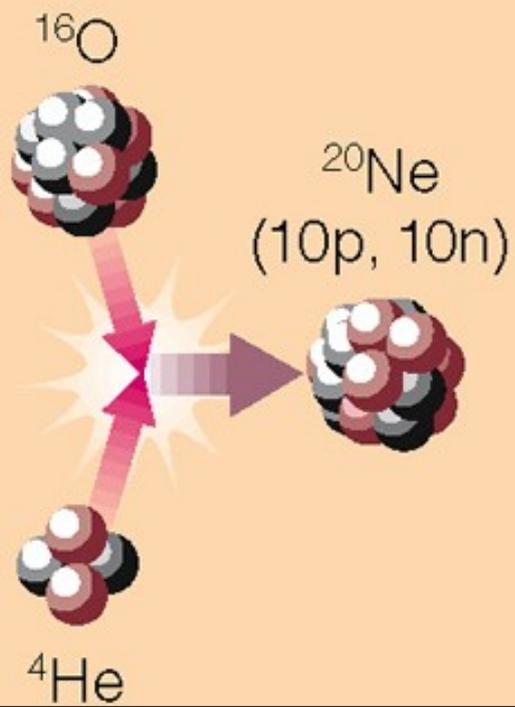
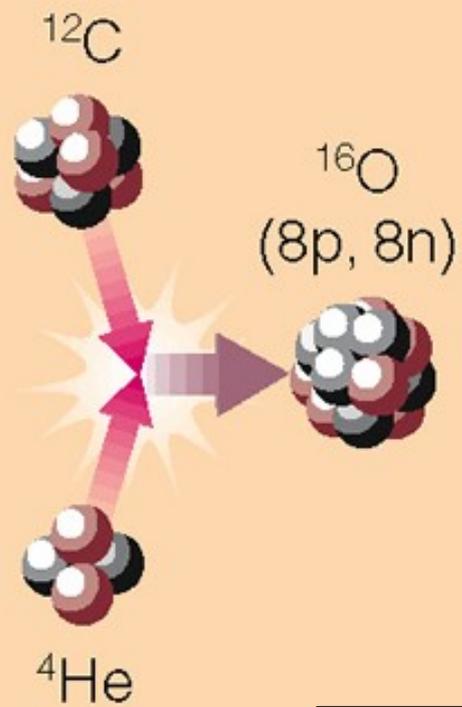
\* Lanthanide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
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90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr





# Periodic Table of the Elements

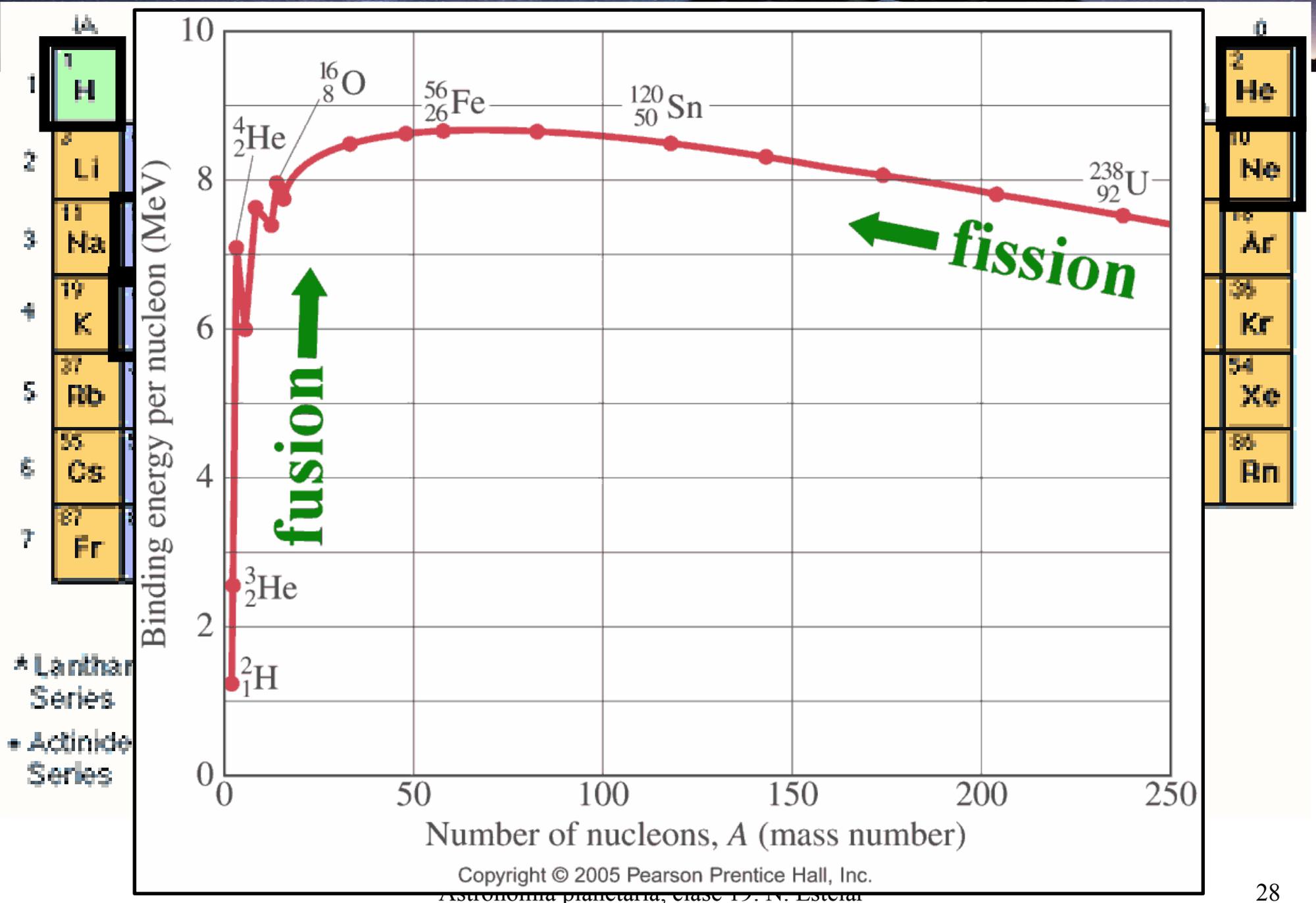
1	1A 1 H	2A											3A 5 B	4A 6 C	5A 7 N	6A 8 O	7A 9 F	8A 10 Ne	
2	3 Li	4 Be											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
3	11 Na	12 Mg	III B	IV B	V B	VI B	VII B	VIII		IX	X	XI B	XII B	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba	*57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
7	87 Fr	88 Ra	+89 Ac	104 Rf	105 Ha	106 Sg	107 Nh	108 Hs	109 Mt	110	111	112	113						

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58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

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90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

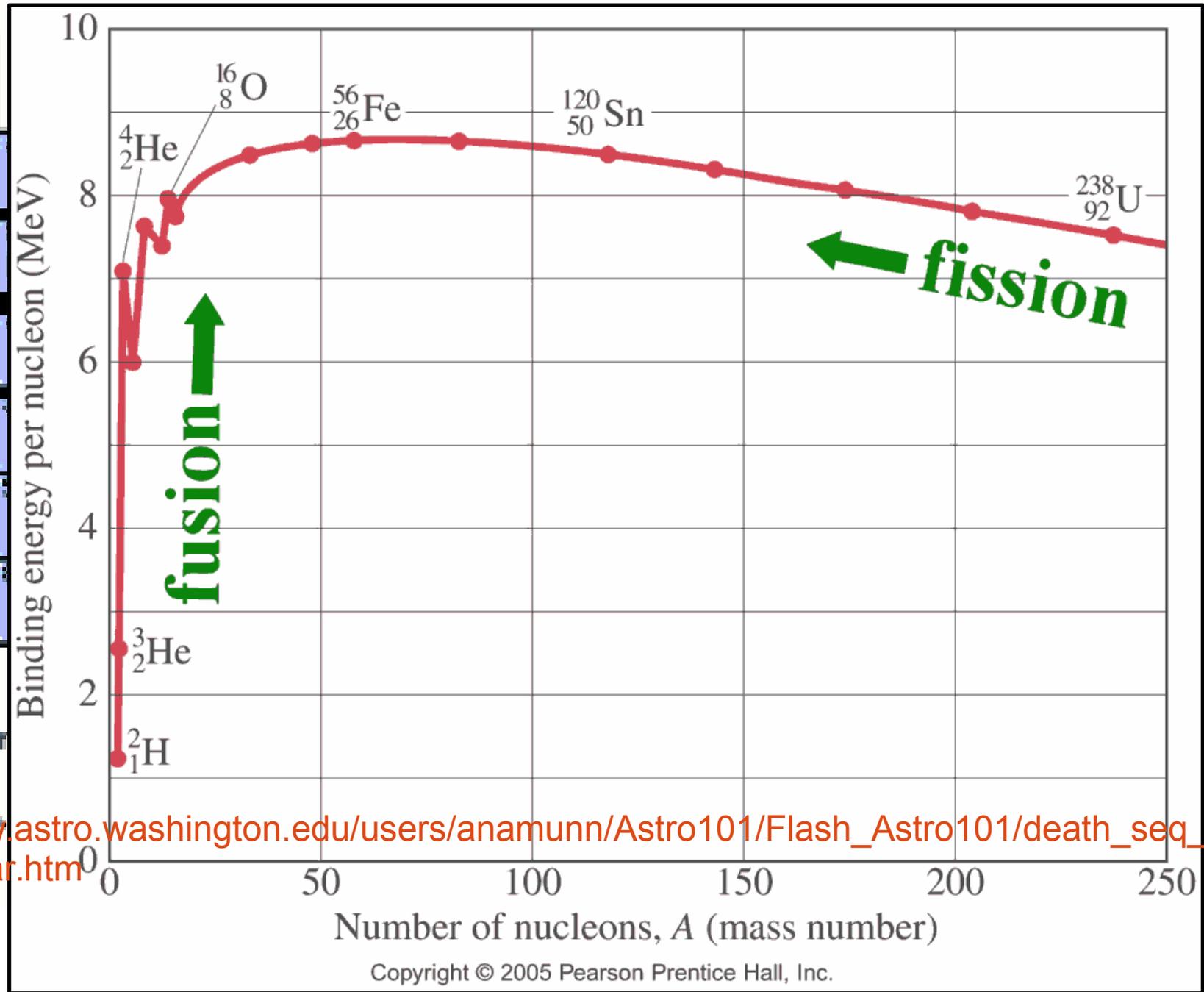


1	1	H
2	2	Li
3	11	Na
4	19	K
5	37	Rb
6	55	Cs
7	87	Fr

\* Lanthan Series

\* Actin Series

2	2	He
10	10	Ne
18	18	Ar
36	36	Kr
54	54	Xe
86	86	Rn



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[http://www.astro.washington.edu/users/anamunn/Astro101/Flash\\_Astro101/death\\_seq\\_of\\_high-mass\\_star.htm](http://www.astro.washington.edu/users/anamunn/Astro101/Flash_Astro101/death_seq_of_high-mass_star.htm)