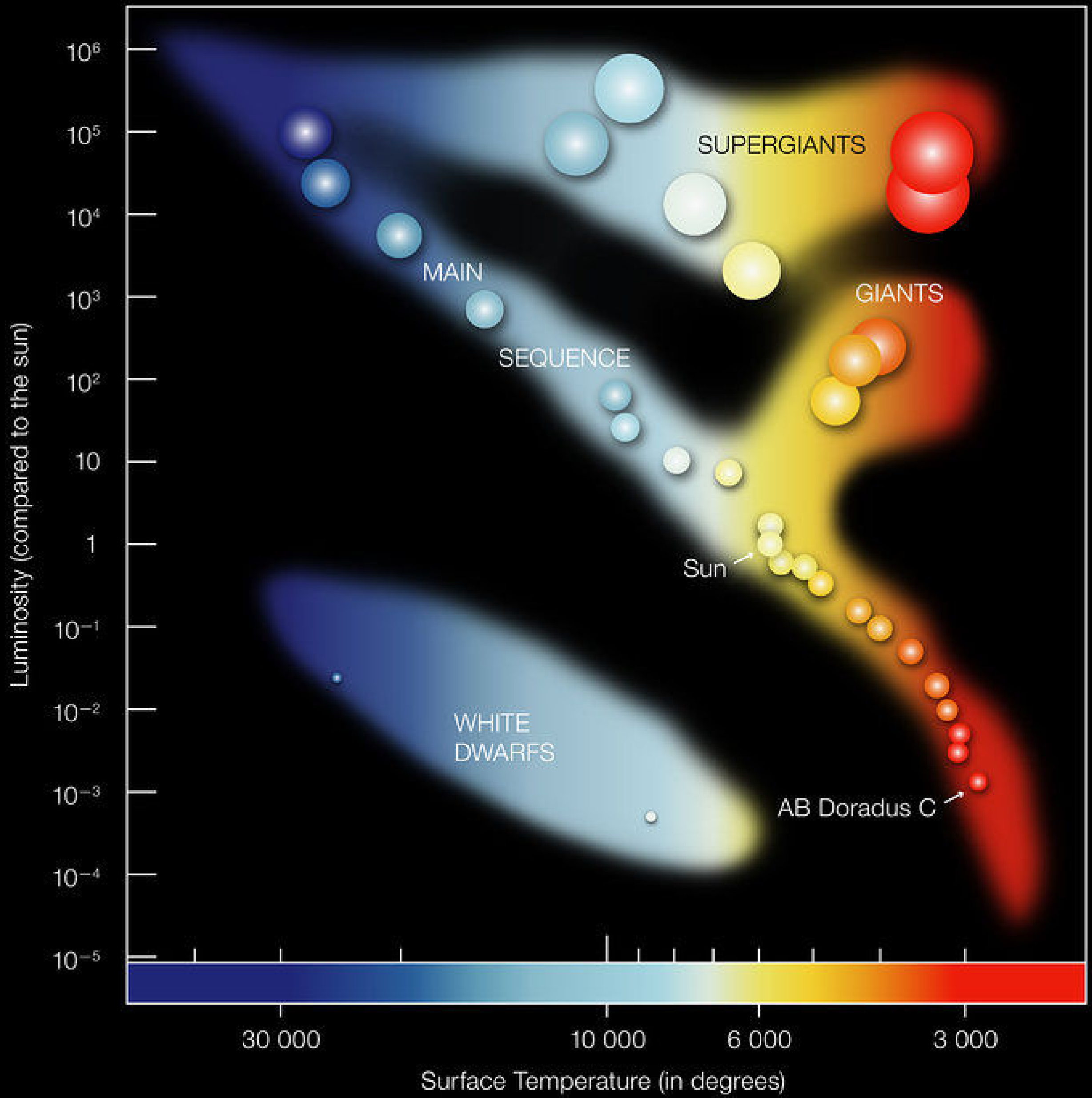
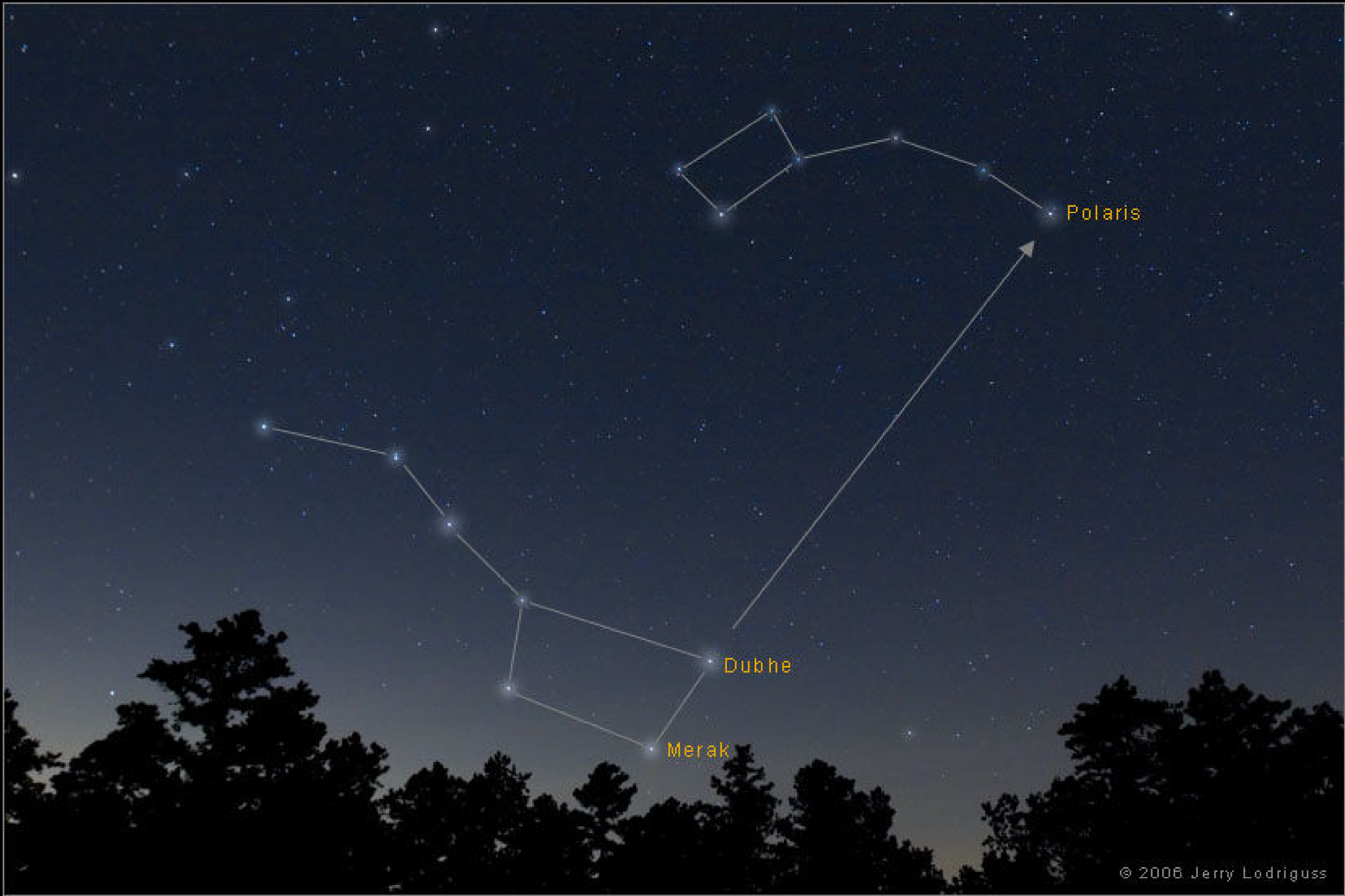


Csillagfejlődés

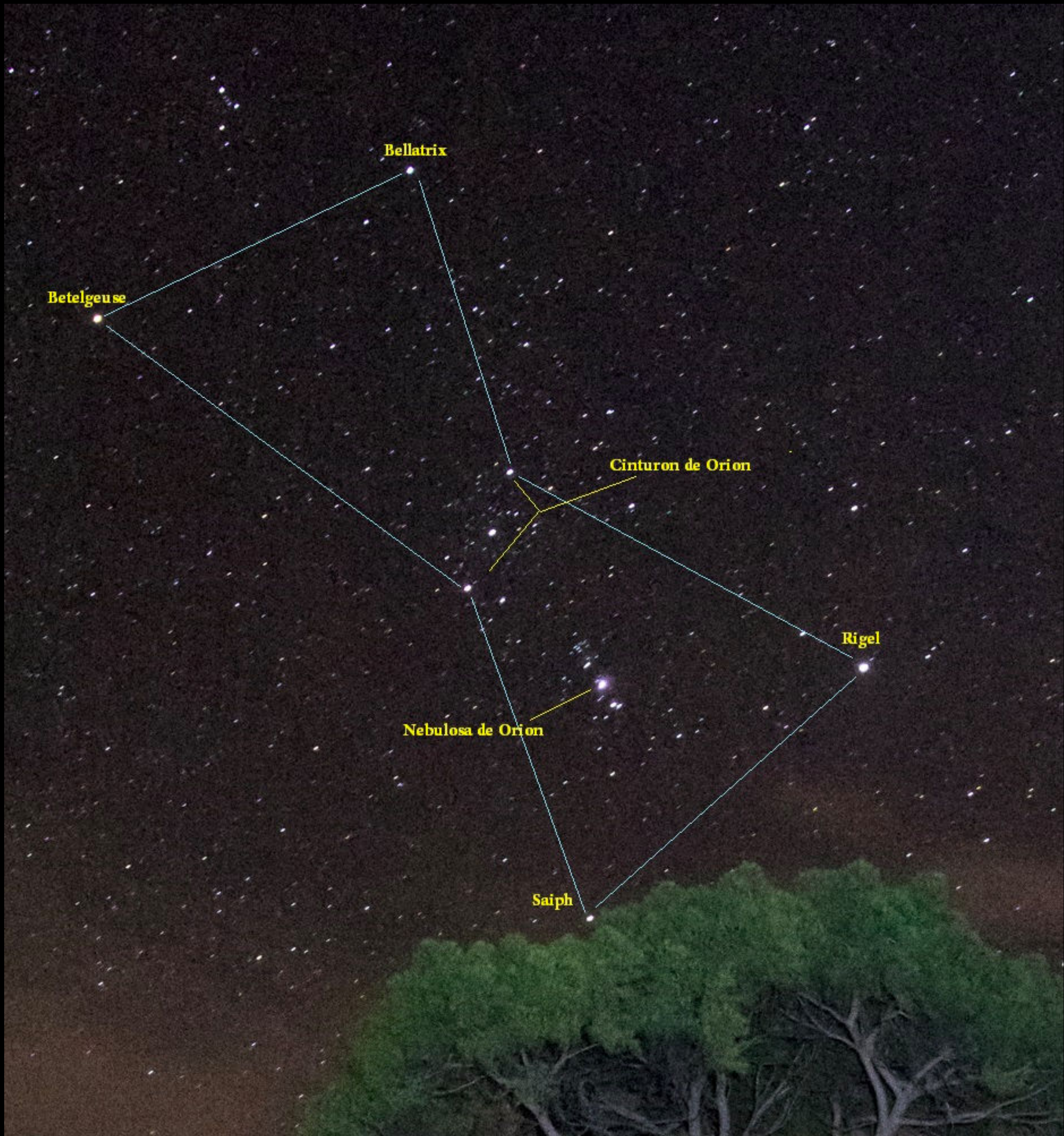
Kiss Miklós

Gyöngyösi
Berze Nagy János
Gimnázium

1.



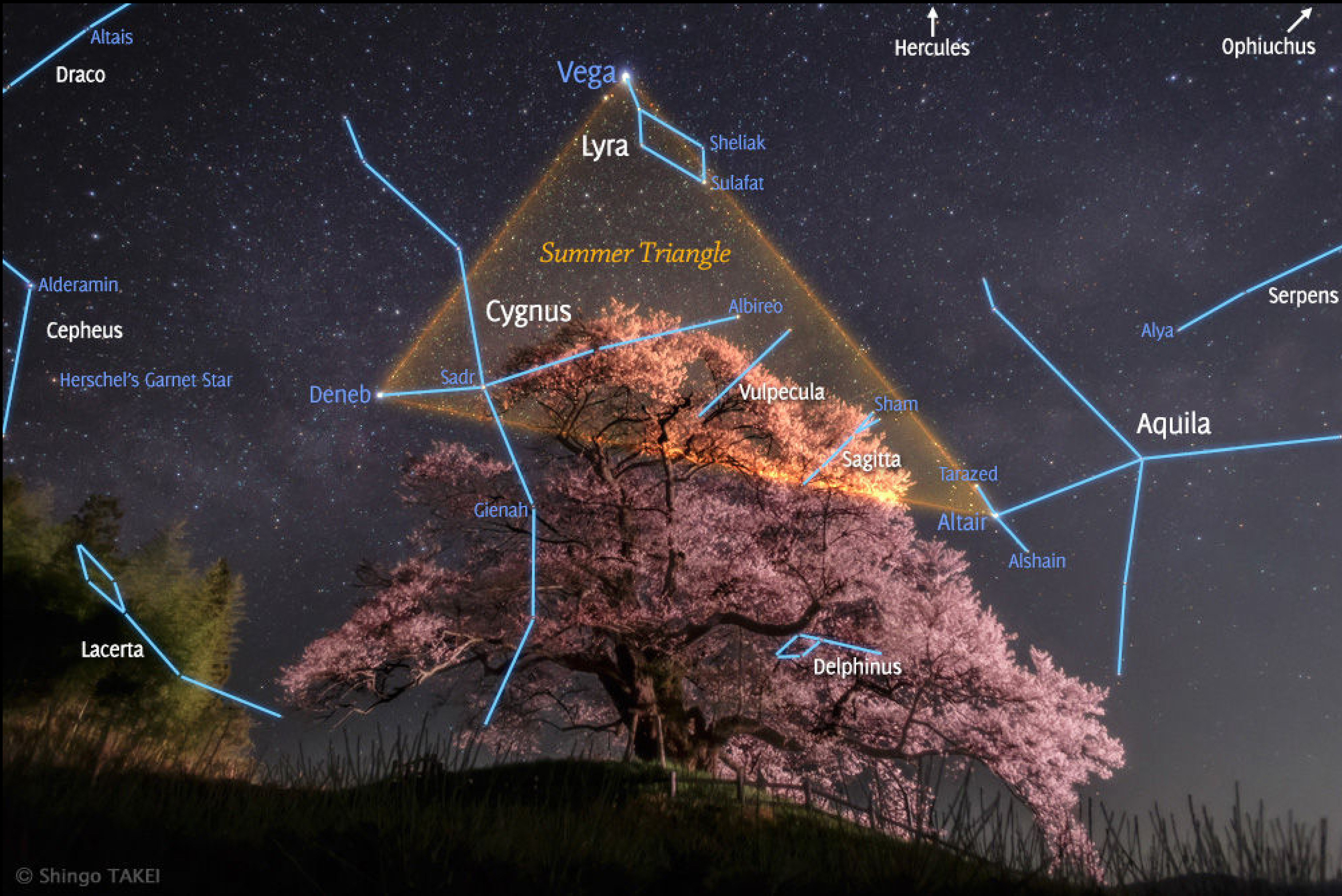
2.



Az Orion csillagai

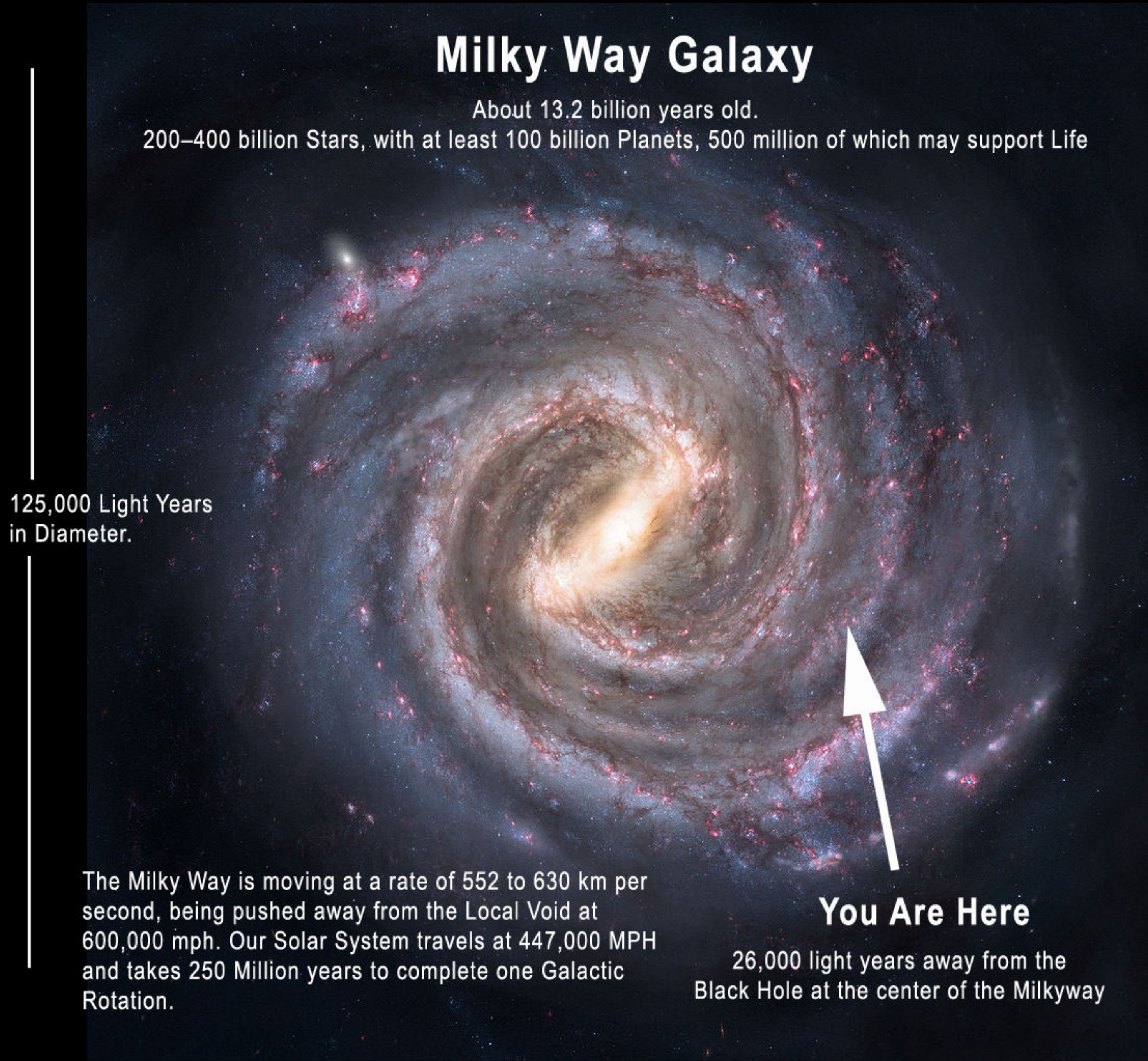
Orion

3.

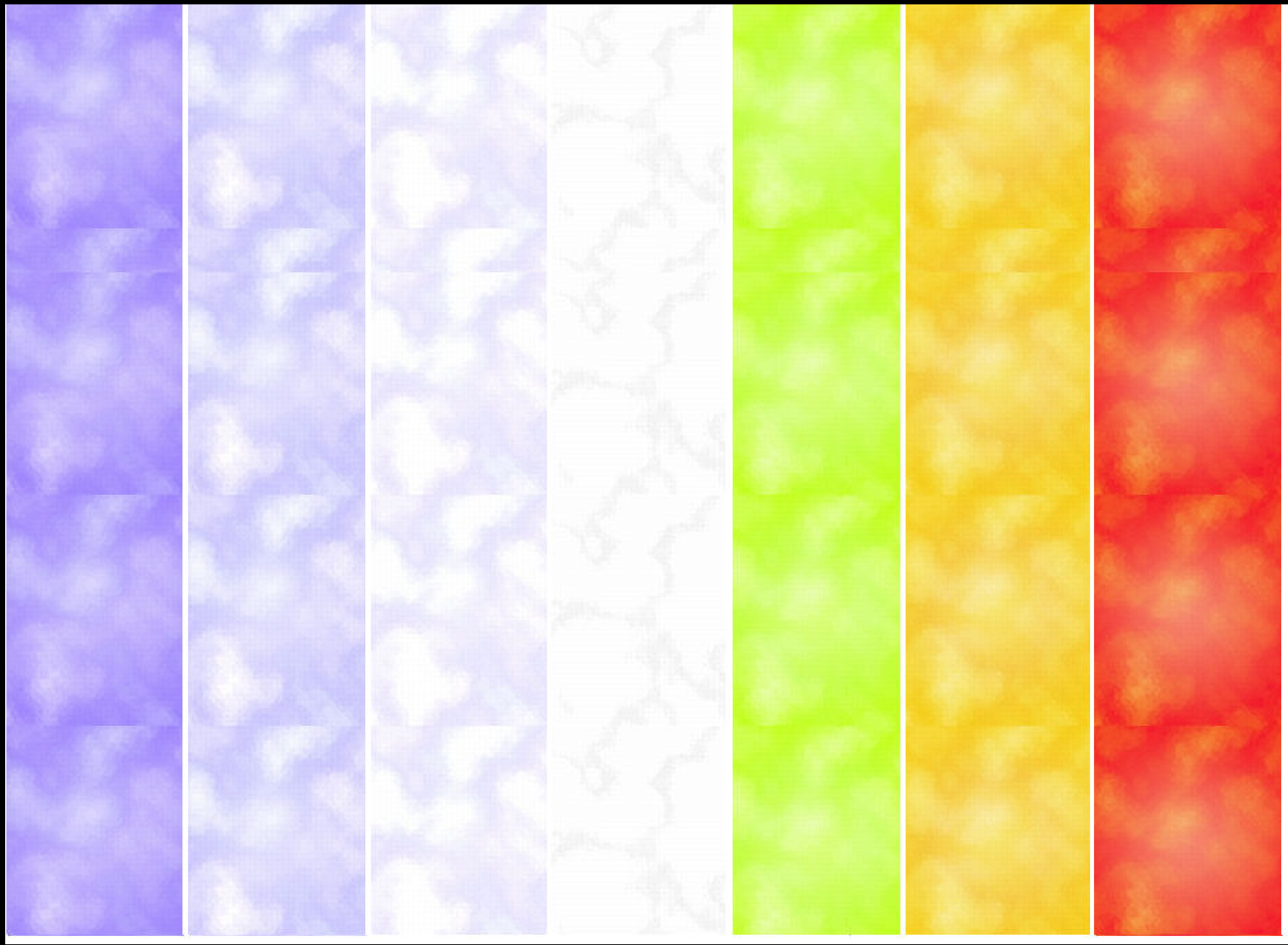

Altais
Draco
Vega
Hercules
Ophiuchus
Lyra
Sheliak
Sulafat
Summer Triangle
Alderamin
Cepheus
Cygnus
Albireo
Serpens
Alya
Herschel's Garnet Star
Sadr
Deneb
Vulpecula
Sham
Aquila
Sagitta
Tarazed
Gienah
Altair
Alshain
Lacerta
Delphinus
© Shingo TAKEI

A nyári háromszög

4.

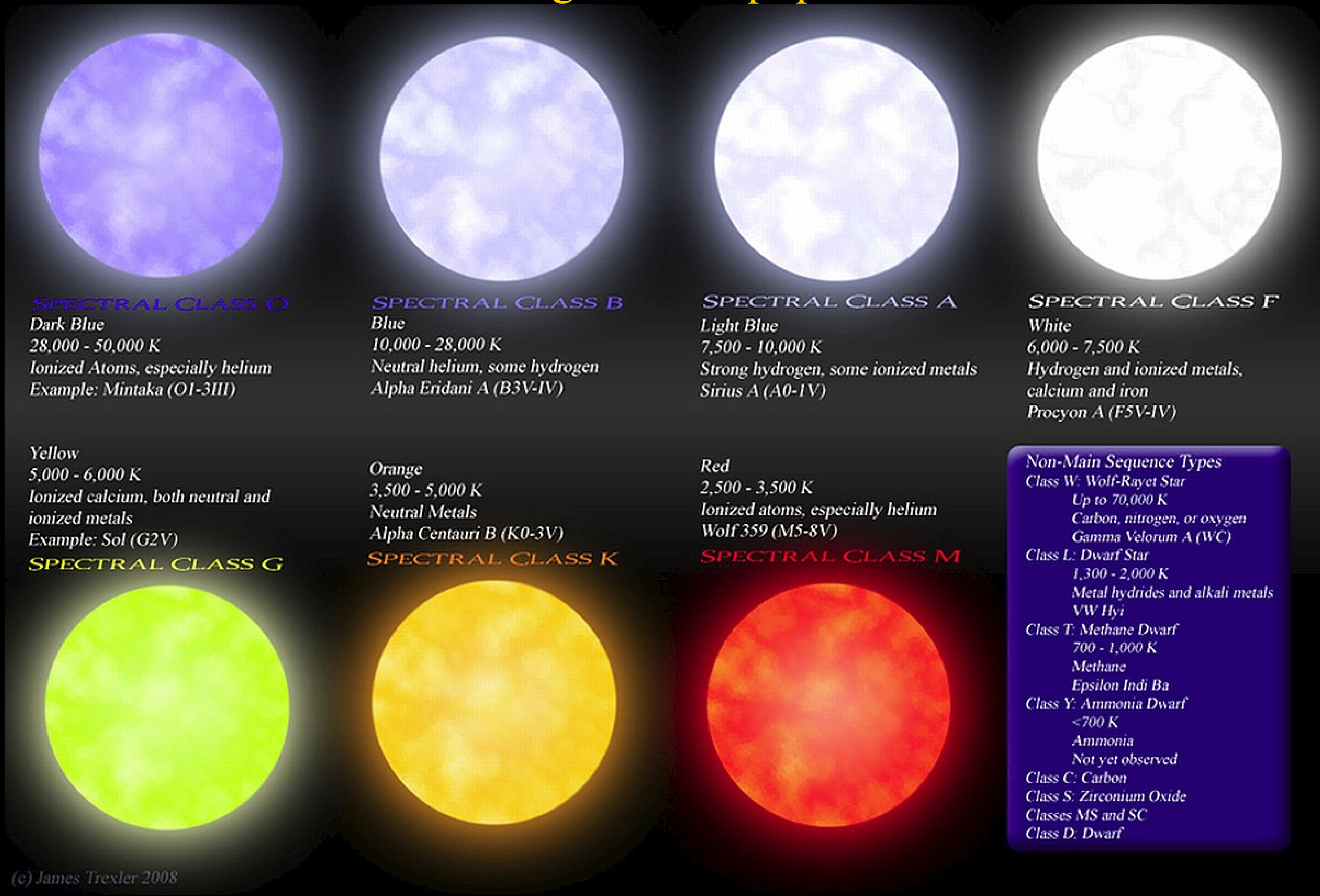

Milky Way Galaxy
About 13.2 billion years old.
200–400 billion Stars, with at least 100 billion Planets, 500 million of which may support Life
125,000 Light Years in Diameter.
The Milky Way is moving at a rate of 552 to 630 km per second, being pushed away from the Local Void at 600,000 mph. Our Solar System travels at 447,000 MPH and takes 250 Million years to complete one Galactic Rotation.
You Are Here
26,000 light years away from the Black Hole at the center of the Milkyway

Mi ez? 1.



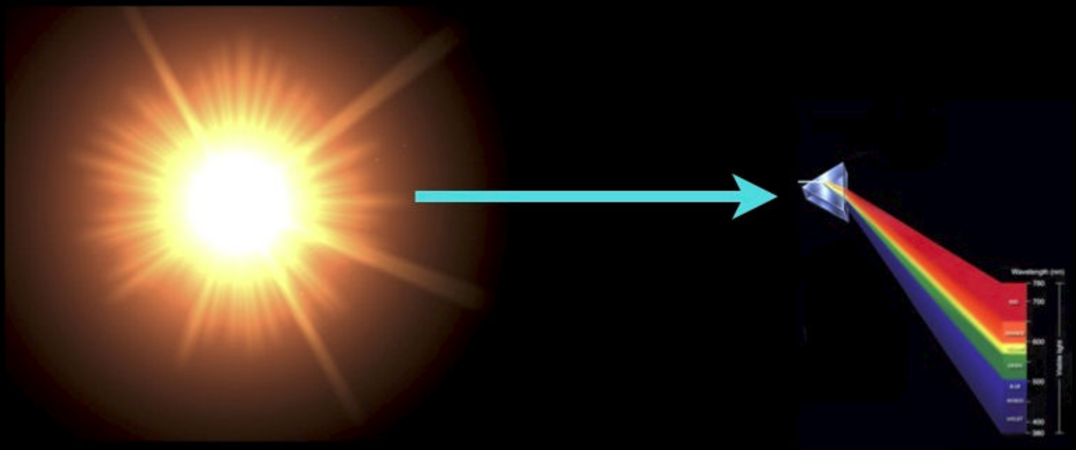
Mi ez? 2.

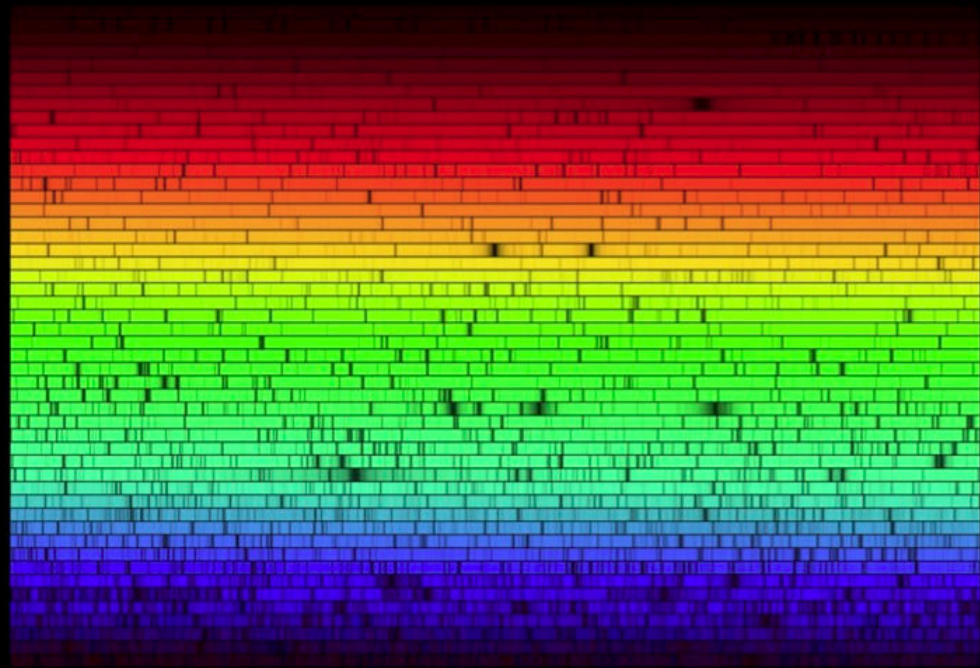
Csillagok színképtípusa

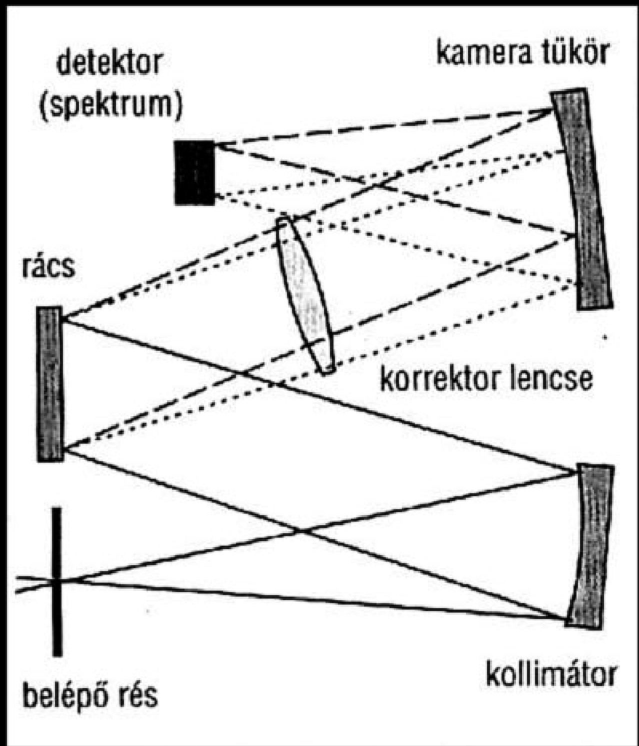


http://www.khadley.com/courses/Astronomy/ph_206/topics/stars/

A csillagok színképének elemzése





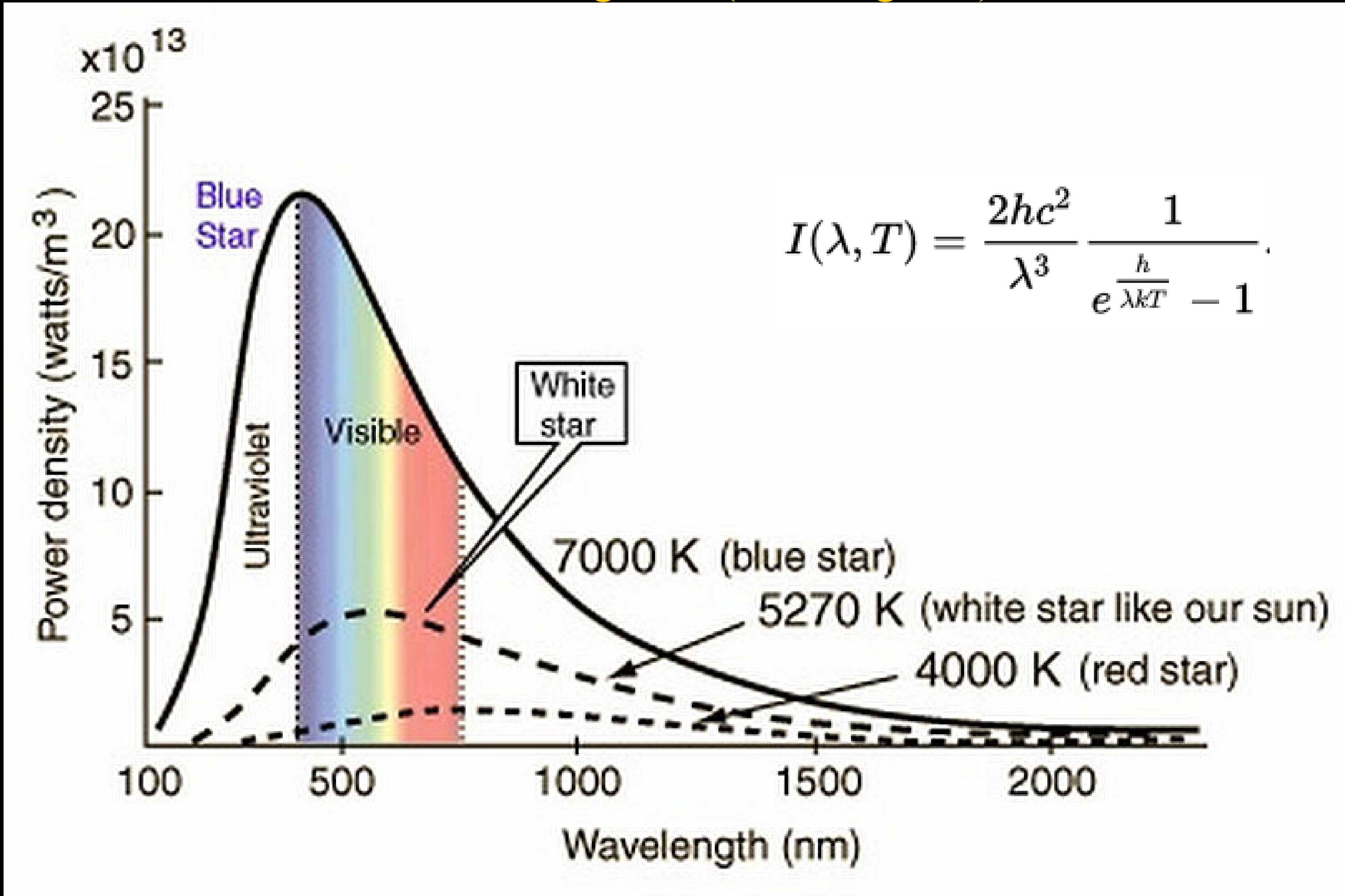


Otthoni lehetőség:

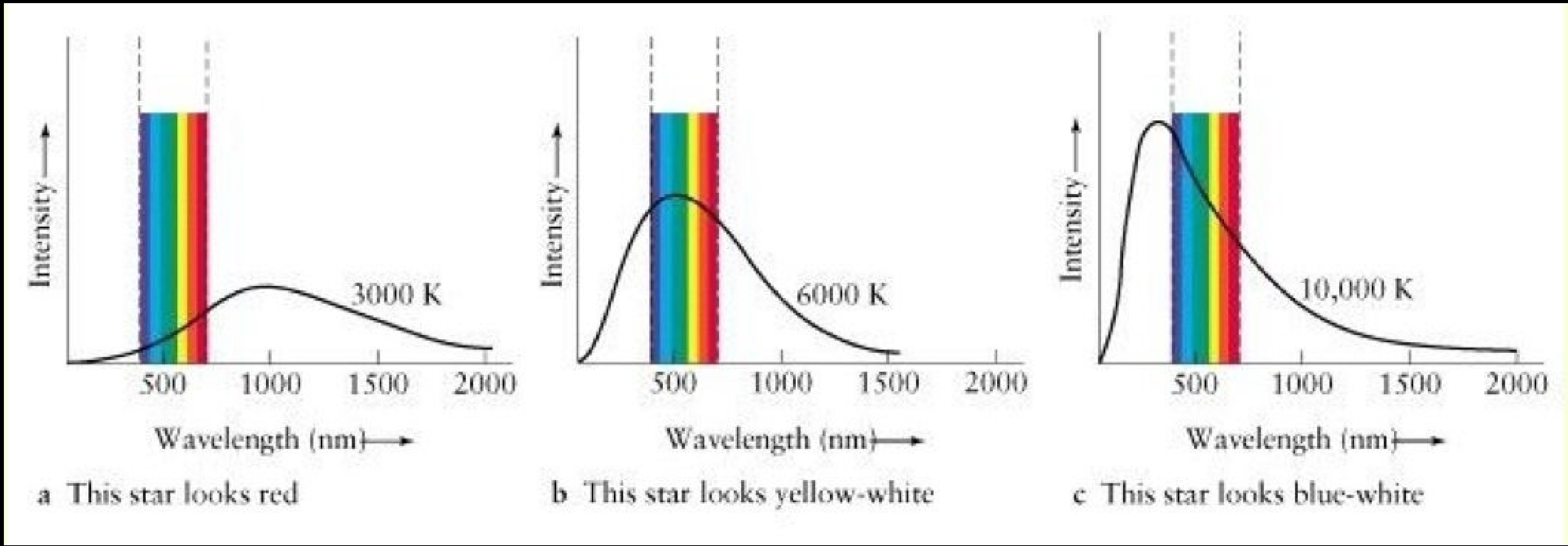
SCOPE
STELLAR CLASSIFICATION ONLINE
PUBLIC EXPLORATION

A Citizen Science Project
http://scope.pari.edu/

Feketetest sugárzás (Planck-görbe)



Feketetest sugárzás és színek



Wien-féle eltolódási törvény:

$$\lambda_{max} = \frac{0{,}29\ \text{cm}}{T(K)}$$

Színképosztályok

Spectral classification

Astronomers have classified stars according to their spectra into **spectral classes** (also called **spectral type**).

The major spectral classes are type **O, B, A, F, G, K, M** where the O-class is the most luminous (and hottest) and the M-class is the faintest (and coolest). Each type is subdivided into 10 finer divisions (0-9), as A8 or F0.

This picture shows standard spectra for each class.

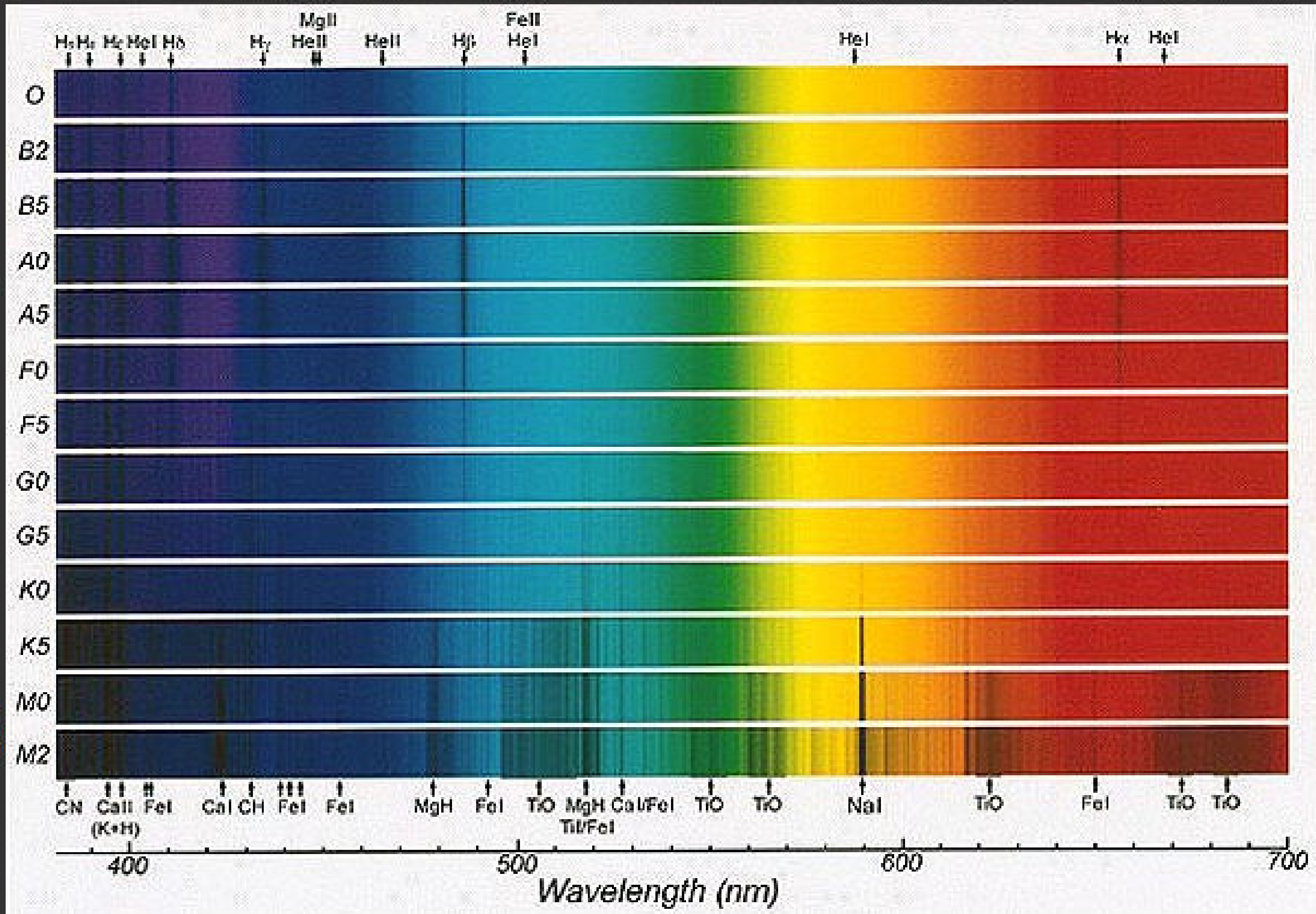


Image from odin.physastro.mnsu.edu

The historical reason why this sequences seems arbitrary, is that initially the classes were defined alphabetically according to strength of the spectral lines. Later it was discovered that this is not directly related to temperature. So the original sequence was re-arranged according to temperature.

Annie Jump Cannon

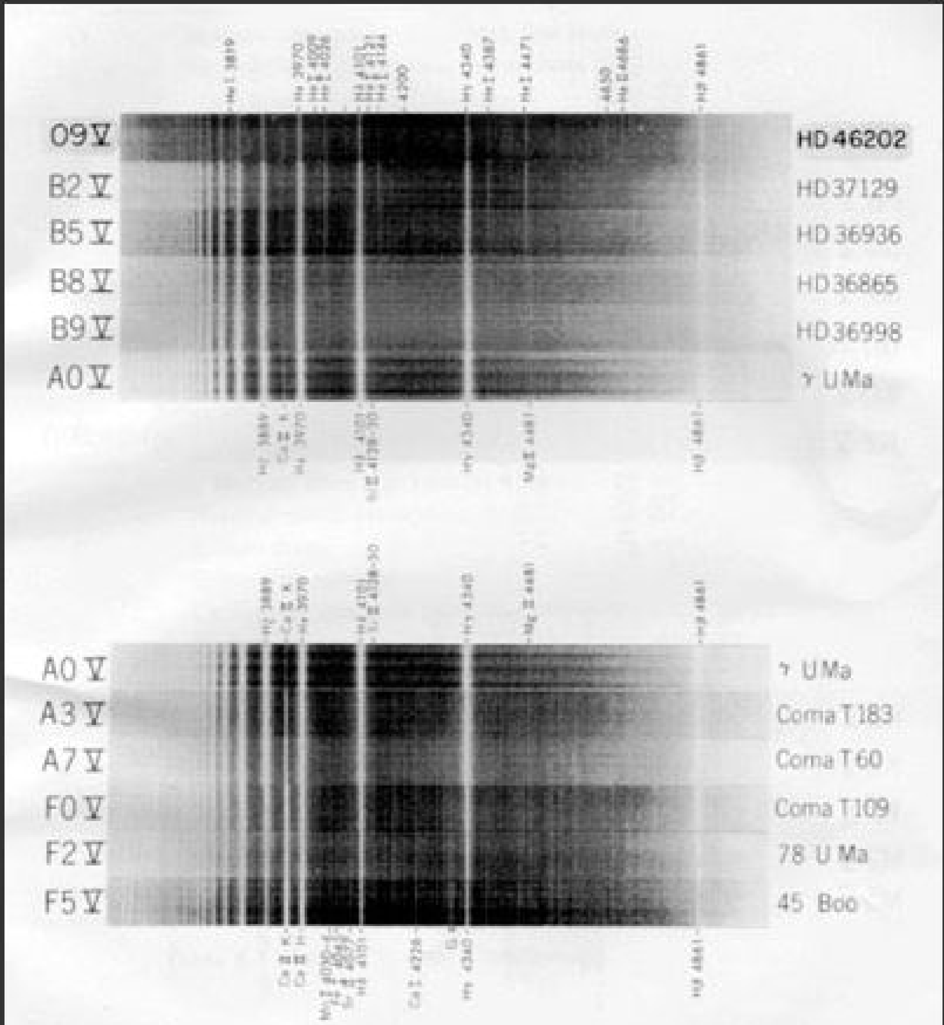


Figure 8.2 Stellar spectra for main-sequence classes B0–F5. (Figure from Abt et al., *An Atlas of Low-Dispersion Grating Stellar Spectra*, Kitt Peak National Observatory, Tucson, AZ, 1968.)

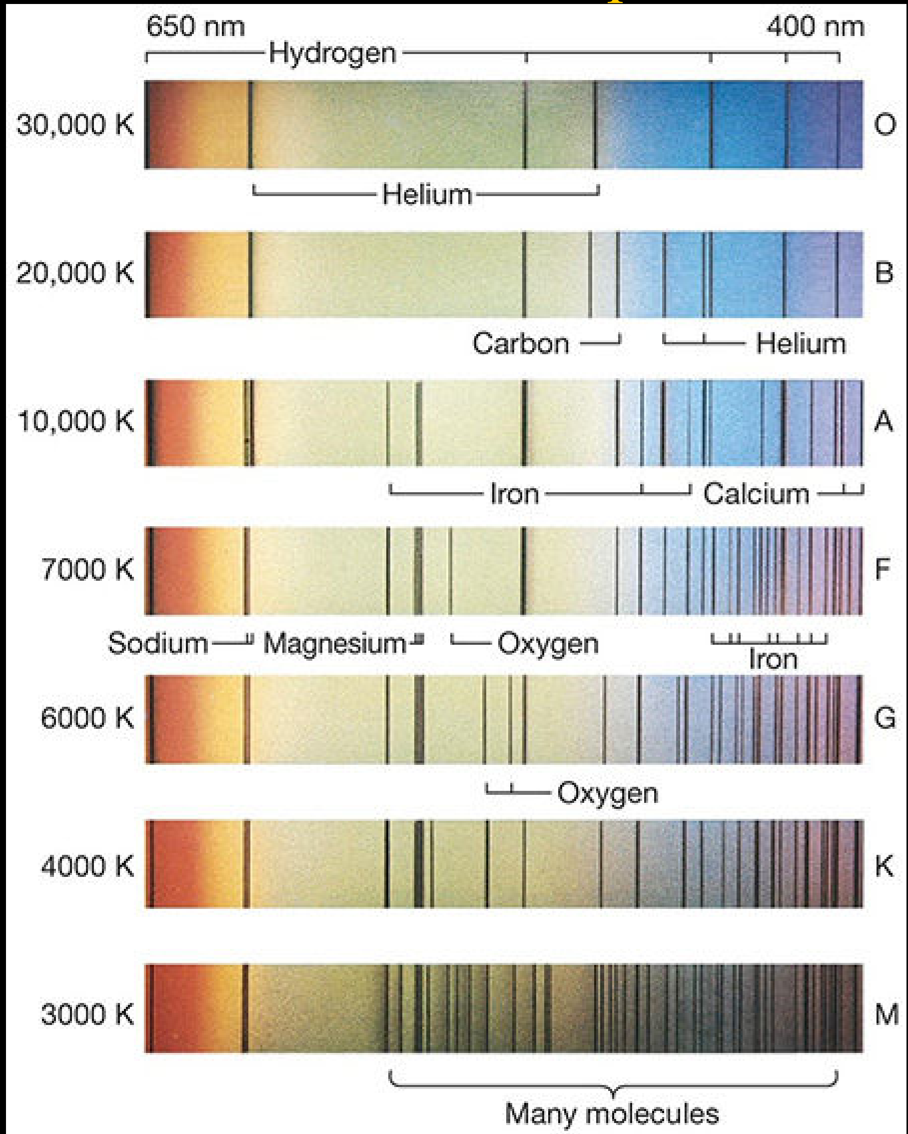
Classifying stars used to be something of an art form that comes with practice. Each spectral class is defined by the spectrum of a standard star (above), against which the other stars are compared. The classifier eventually memorizes the standards and can classify the spectrum of a random star very quickly.

Astronomer **Annie Cannon** classified well over 300,000 stars in her lifetime.
Modern classifiers are now using automated systems with computers and complex software, that will give more objective results.

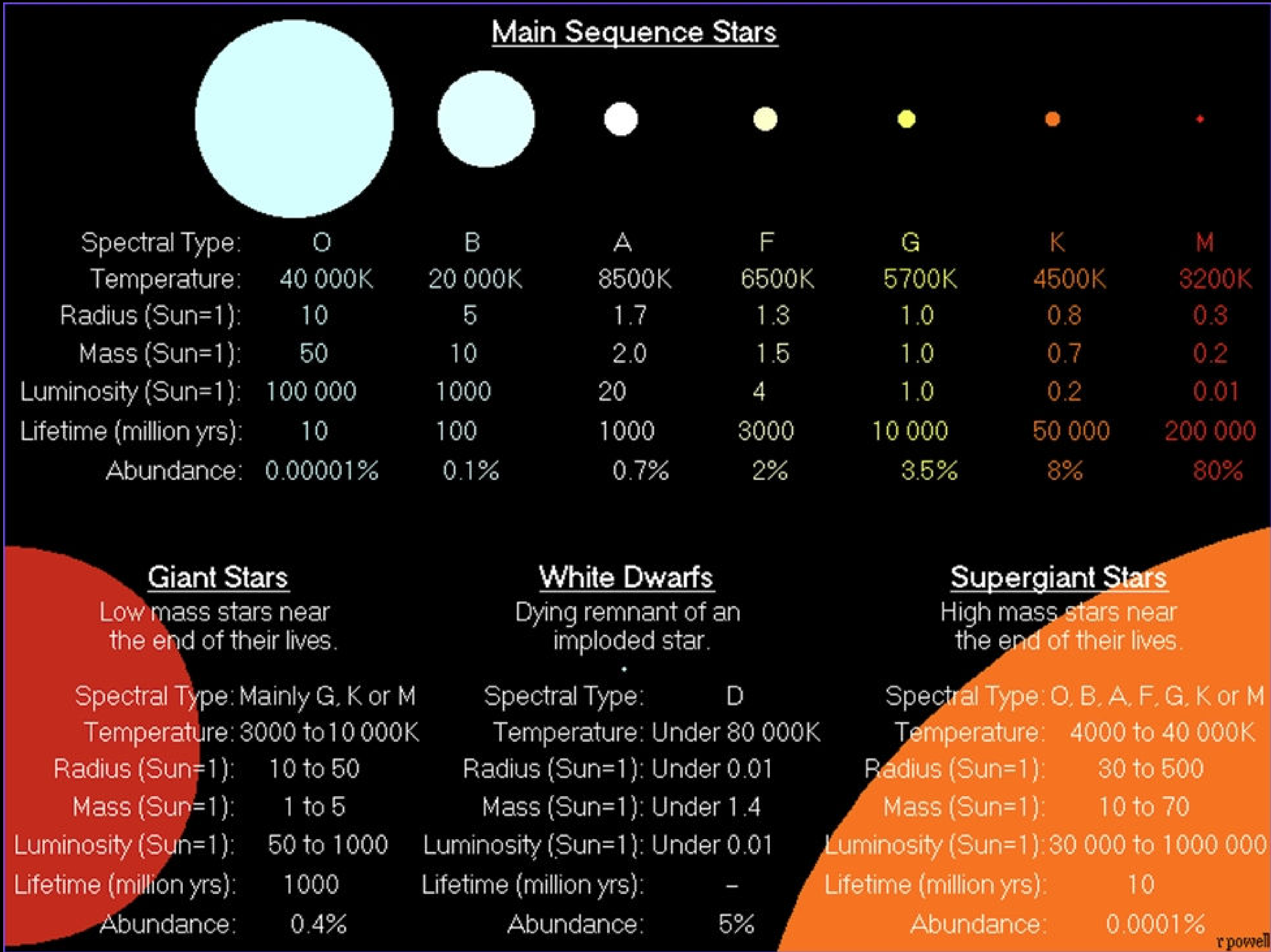
Annie Jump Cannon at work. Photo from www.twu.edu/dsc

Collection of photographic spectra. Image Wellesley Women in Science www.wellesley.edu

Szín, hőmérséklet, spektrum



W, O, B A, F. G, K, M, R, N, S, L, T, Y



Main Sequence Stars

Spectral Type:	O	B	A	F	G	K	M
Temperature:	40 000K	20 000K	8500K	6500K	5700K	4500K	3200K
Radius (Sun=1):	10	5	1.7	1.3	1.0	0.8	0.3
Mass (Sun=1):	50	10	2.0	1.5	1.0	0.7	0.2
Luminosity (Sun=1):	100 000	1000	20	4	1.0	0.2	0.01
Lifetime (million yrs):	10	100	1000	3000	10 000	50 000	200 000
Abundance:	0.00001%	0.1%	0.7%	2%	3.5%	8%	80%

Giant Stars

Low mass stars near the end of their lives.

Spectral Type:	Mainly G, K or M
Temperature:	3000 to 10 000K
Radius (Sun=1):	10 to 50
Mass (Sun=1):	1 to 5
Luminosity (Sun=1):	50 to 1000
Lifetime (million yrs):	1000
Abundance:	0.4%

White Dwarfs

Dying remnant of an imploded star.

Spectral Type:	D
Temperature:	Under 80 000K
Radius (Sun=1):	Under 0.01
Mass (Sun=1):	Under 1.4
Luminosity (Sun=1):	Under 0.01
Lifetime (million yrs):	–
Abundance:	5%

Supergiant Stars

High mass stars near the end of their lives.

Spectral Type:	O, B, A, F, G, K or M
Temperature:	4000 to 40 000K
Radius (Sun=1):	30 to 500
Mass (Sun=1):	10 to 70
Luminosity (Sun=1):	30 000 to 1000 000
Lifetime (million yrs):	10
Abundance:	0.0001%

r powell

Fényesség

Hipparkhosz

(i. e. 180? 160-125)

Hipparkhosz nevéhez fűződik az első csillagkatalógus, amely 1022 állócsillagot tartalmaz. A katalógust Ptolemaiosz közölte az Almagesztben. A katalógus elkészítésének valószínűleg az volt az oka, hogy Kr. e. 134-ben új csillag jelent meg a Skorpió csillagképben, amely feltehetőleg egy szupernóva volt. Hipparkhosz vezette be a csillagok fényességskáláját (magnitudóskála). A csillagokat hat fényrendbe sorolta. Az első fényrendbe a legfényesebbek, a másodikba a kevésbé fényesek tartoztak stb. A hatodik fényrend tagjait a szabad szemmel még éppen észrevehető csillagok jelentették.

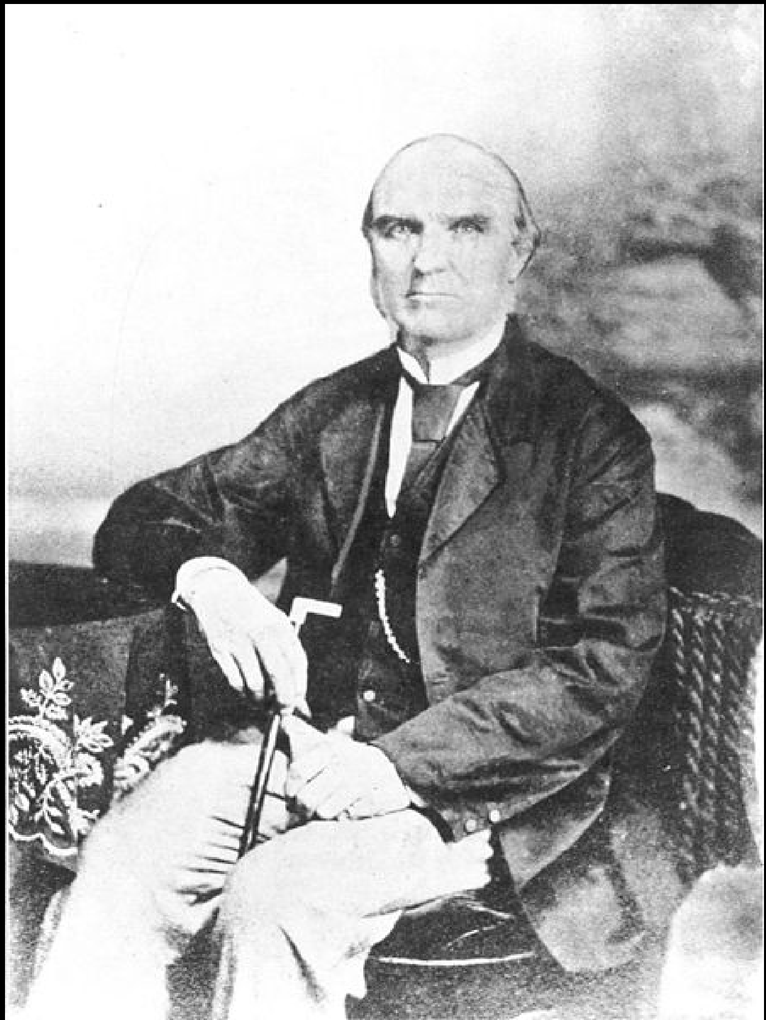
(http://tudasbazis.sulinet.hu/hu/termeszettudomanyok/foldrajz/csillagaszat/csillagaszat-az-okori-gorogorszagban-arisztarkhosztol-ptolemaioszig/hipparkhosz-munkassaga)

Csillagkatalógus i. e. 129.

1022 állócsillag

Csillagok fényessége: 1-6

Látszólagos fényesség (magnitúdó)



,

Norman Robert Pogson, (1829 –1891)

1856

$$I_1 = 100 \cdot I_6$$

$$I_1 = q^5 \cdot I_6$$

$$q = \sqrt[5]{100} = 2{,}5119 \approx 2{,}52$$

$$5 = 6 - 1$$

$$I' = 2{,}52^{(m-m')} \cdot I$$

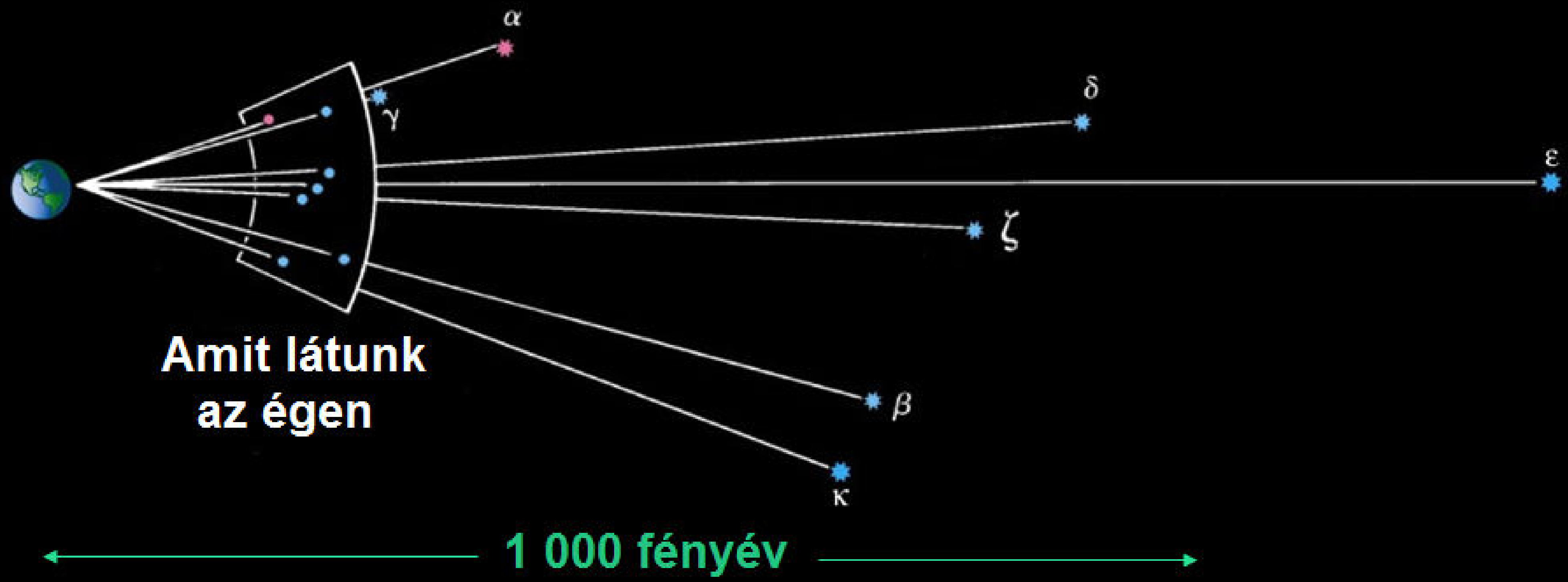
$$\lg I' = \lg(2{,}52^{(m-m')} \cdot I)$$

$$\lg I' = (m - m') \cdot \lg 2{,}52 + \lg \cdot I$$

$$\lg I' = 0{,}4 \cdot (m - m') + \lg \cdot I$$

$$\lg \frac{I'}{I} = -0{,}4 \cdot (m' - m)$$

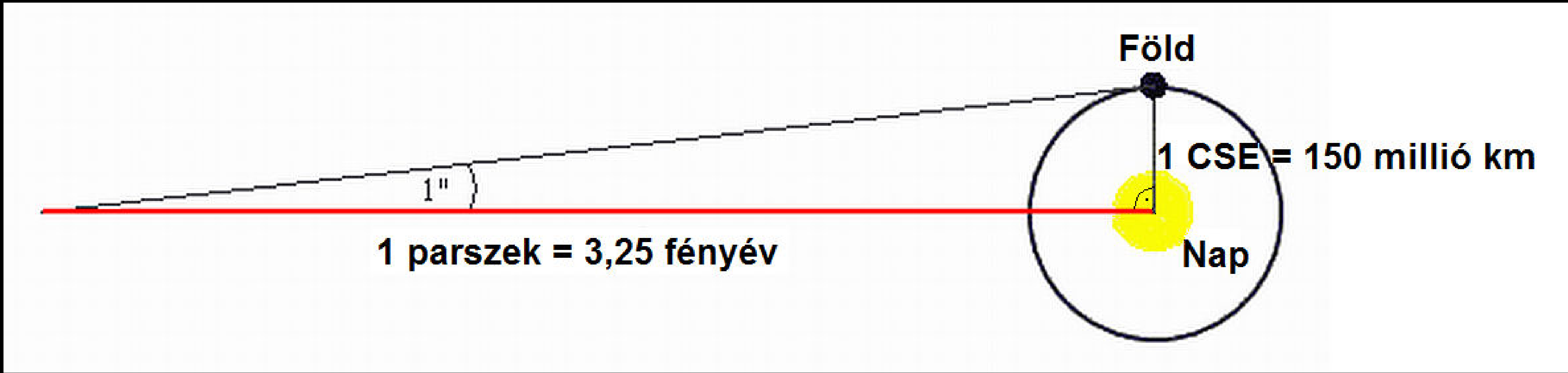
Abszolút fényesség (magnitúdó) I.



http://www.khadley.com/courses/Astronomy/ph_206/topics/stars/

Alnitak, Alnilam és Mintaka az öv három csillaga.
Mindhárom kék szuperóriás.
Közel egyforma fényesek, de a középső (Alnilam) 500 fényévvel távolabb van.

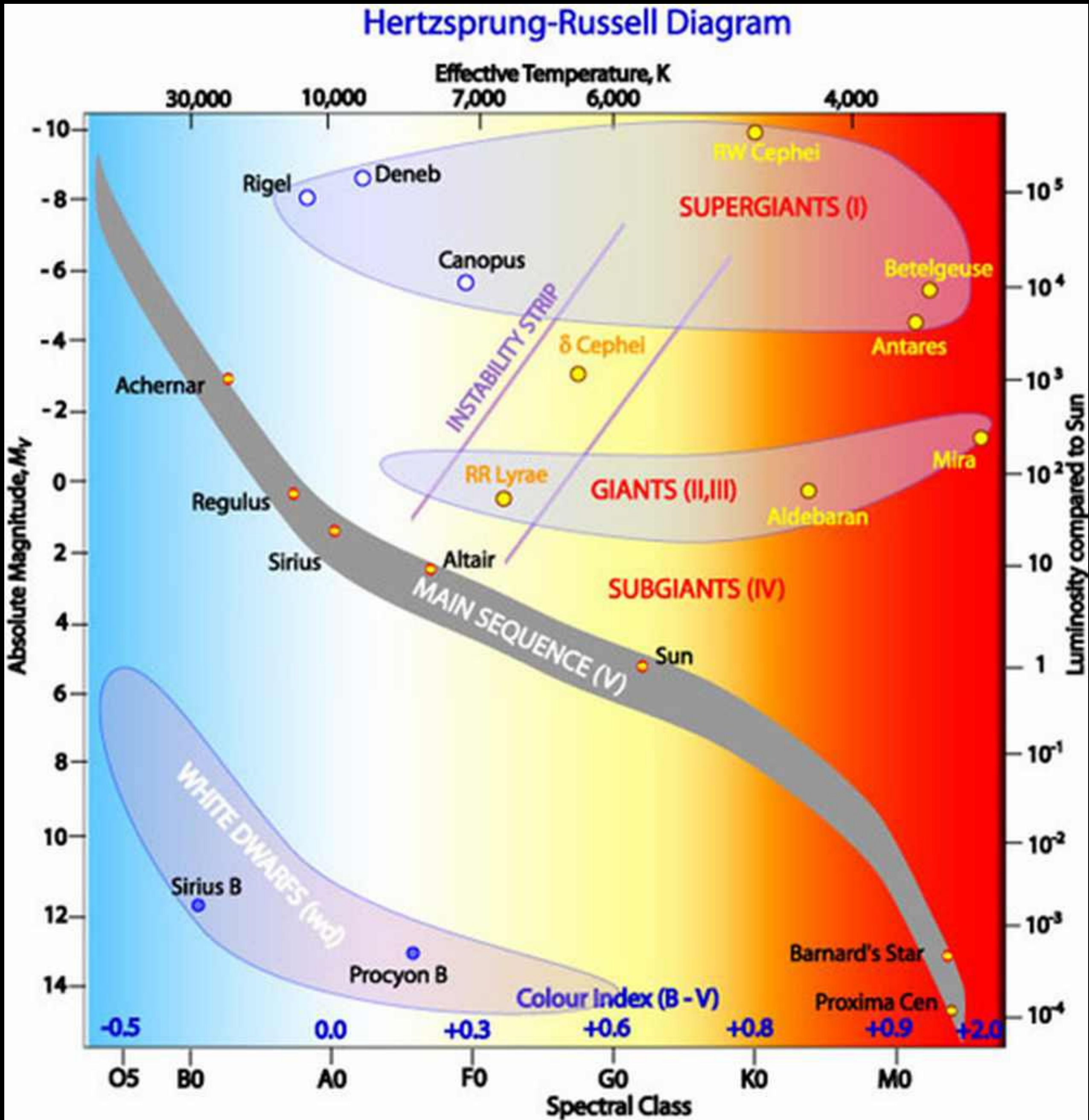
Abszolút fényesség (magnitúdó) II.



Abszolút magnitúdó: a csillag fényessége 10 parszek távolságból.

$$M = m + 5(\lg p + 1)$$

$$p = \frac{1}{d(\text{parszekben})}$$

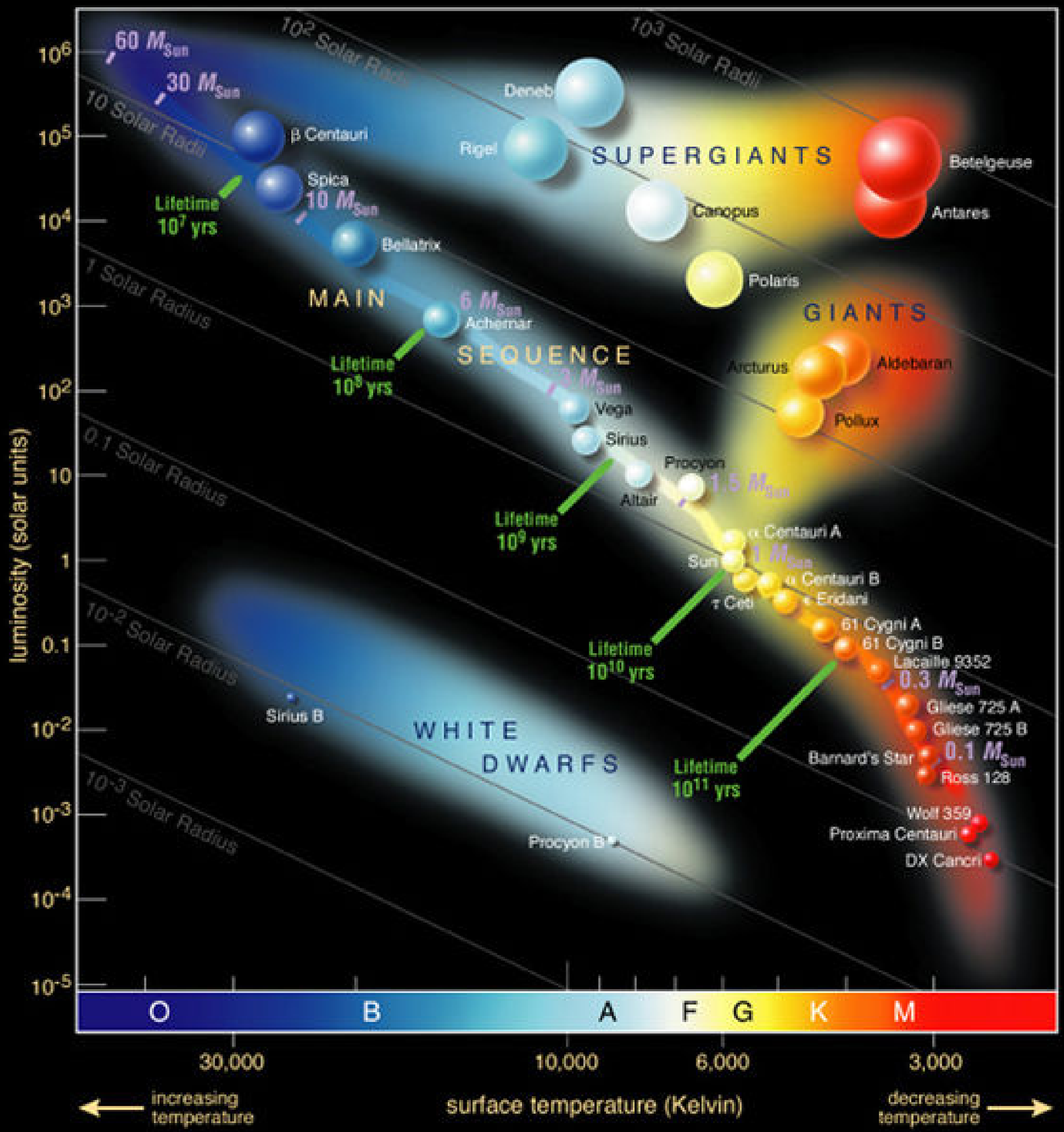


HRD

1905-1913 között

Fősorozat:

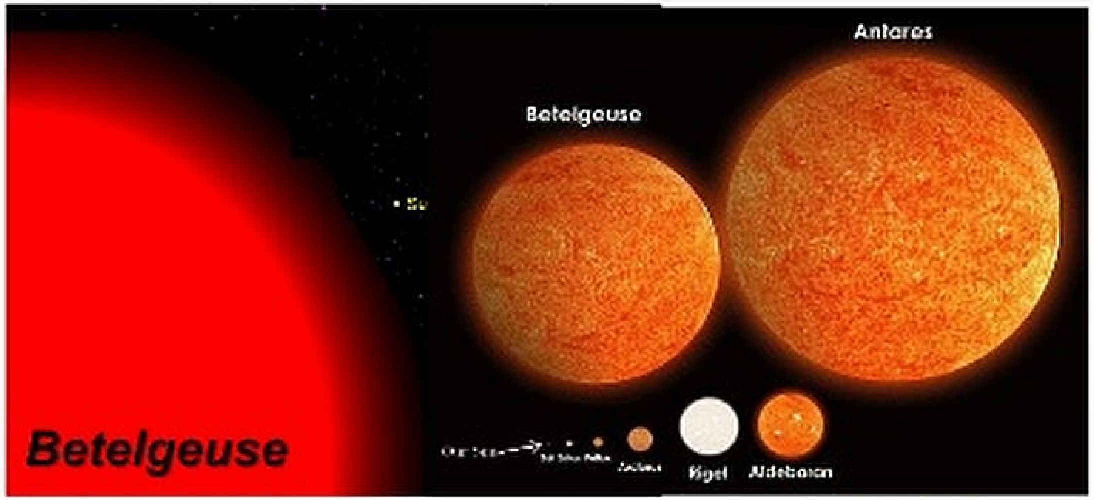
$0{,}08\ M_{\odot} < M < 60\ M_{\odot}$



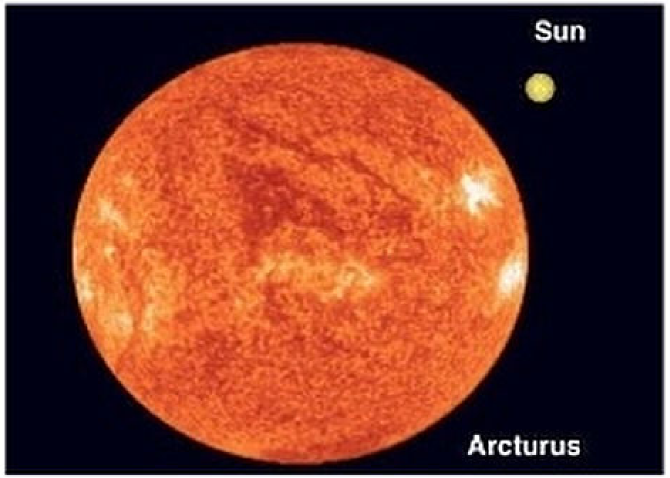
Ejnar Herzsprung (1873-1967)

Henry Norris Russell (1877-1957)

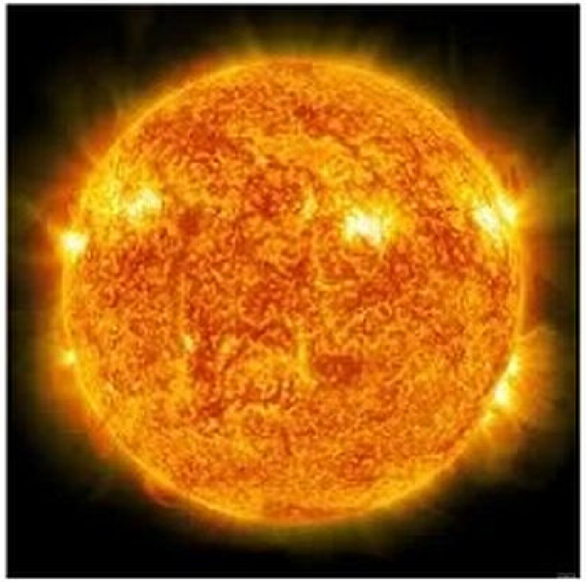
Betelgeuse (Red Star in the night Sky)



Arcturus



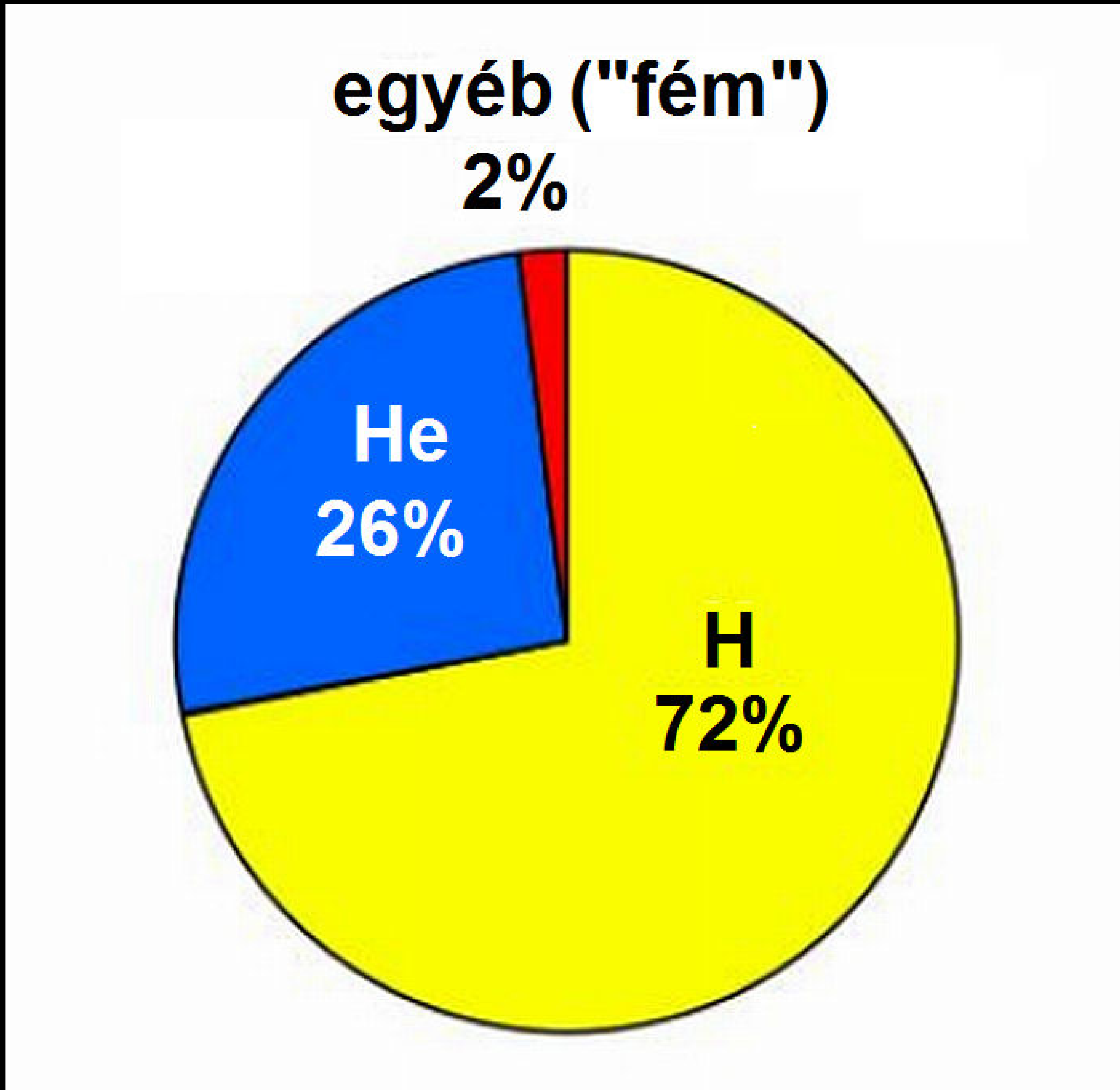
Sun



Sirius
(Brighest star in the sky)

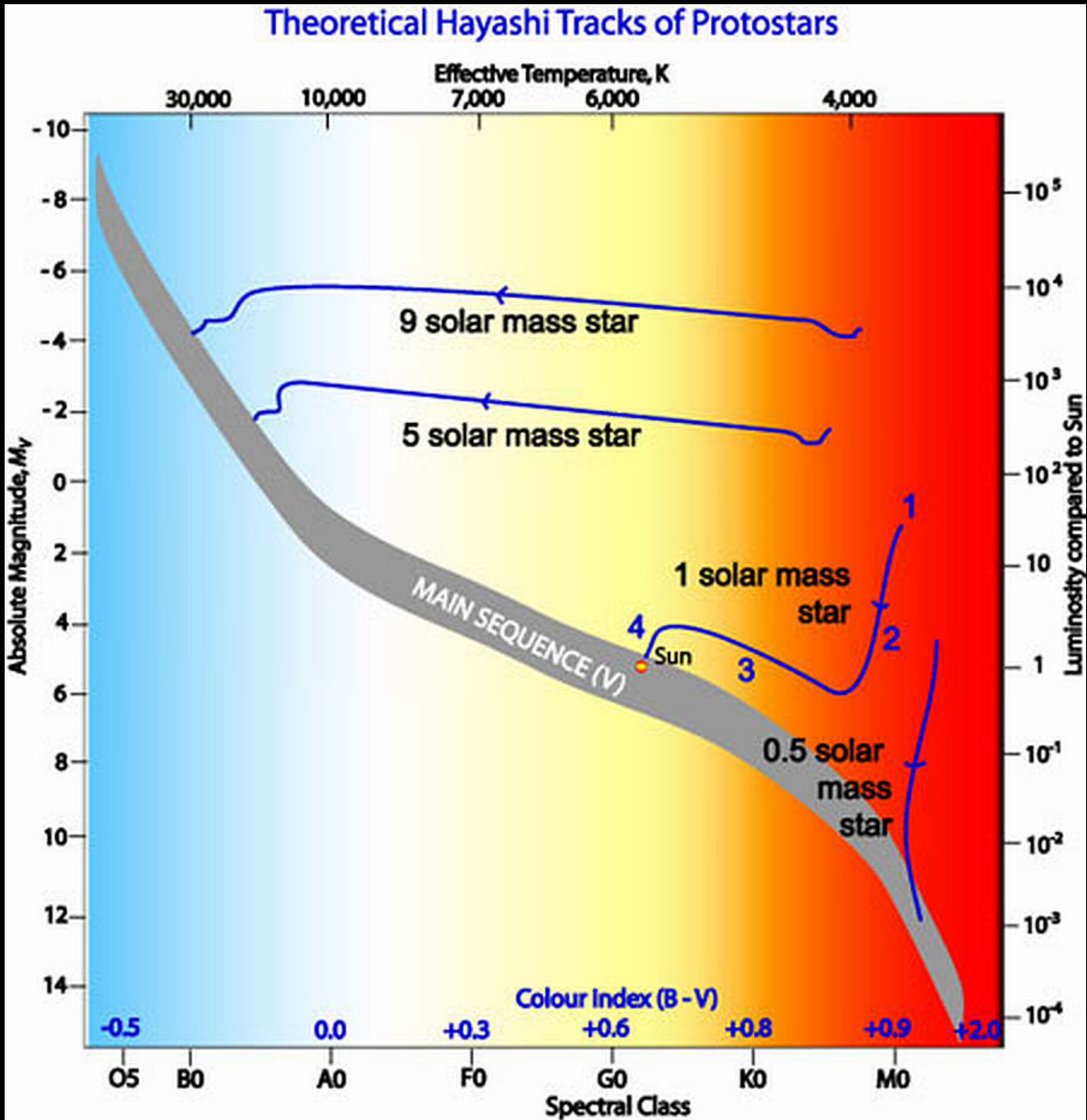
Rigel

Kozmikus elemgyakoriság

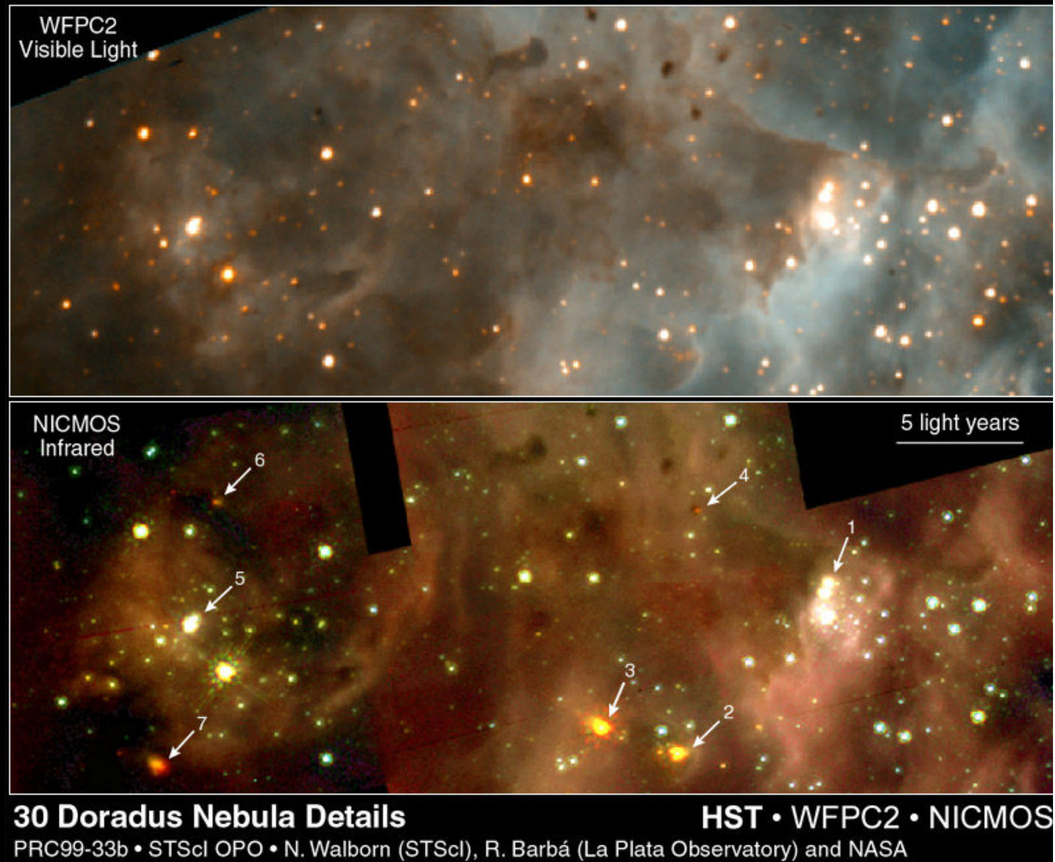


http://astronomy.swin.edu.au/sao/downloads/HET603-M05A01.pdf alapján

Csillagszületés

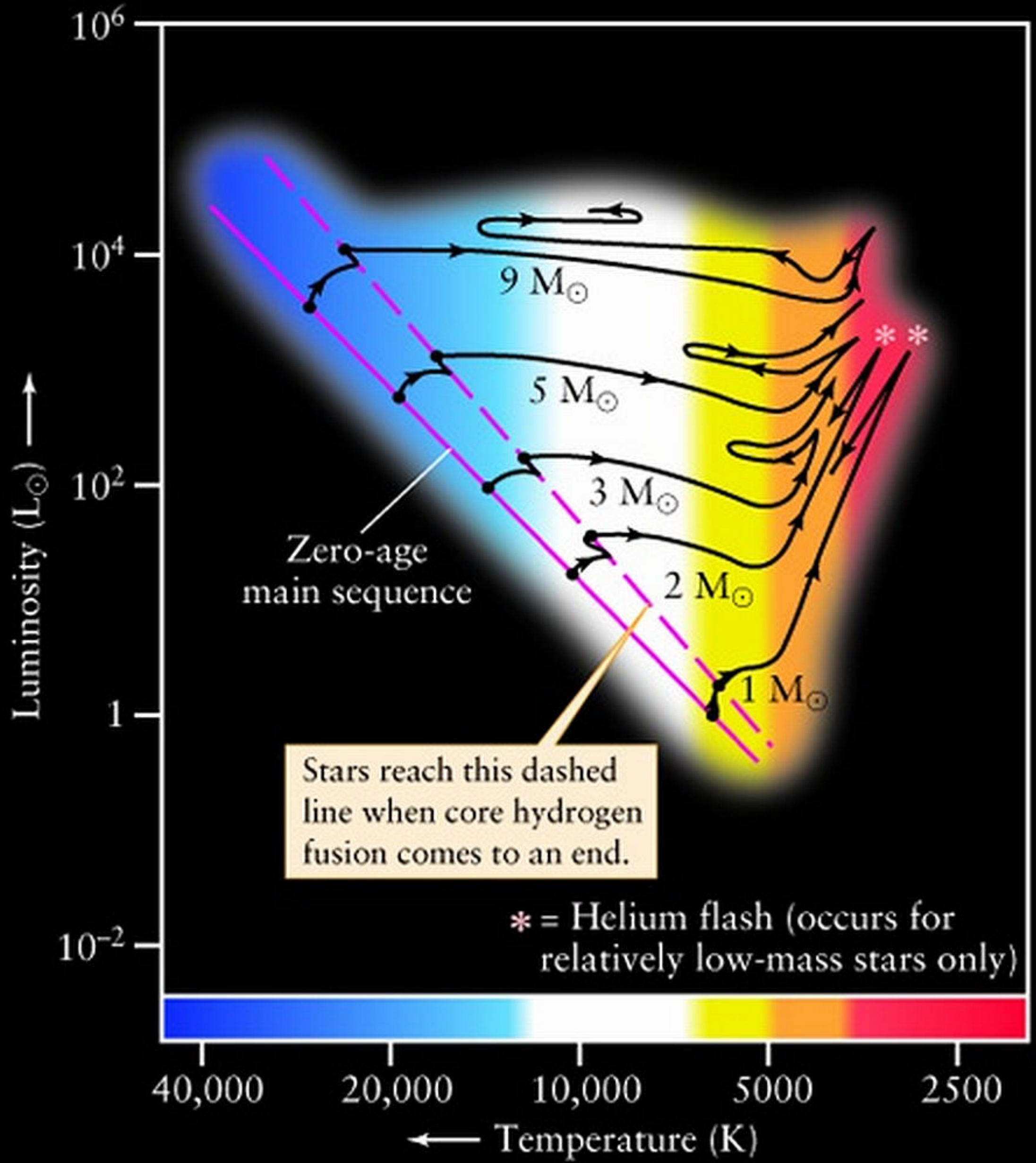


látható fény



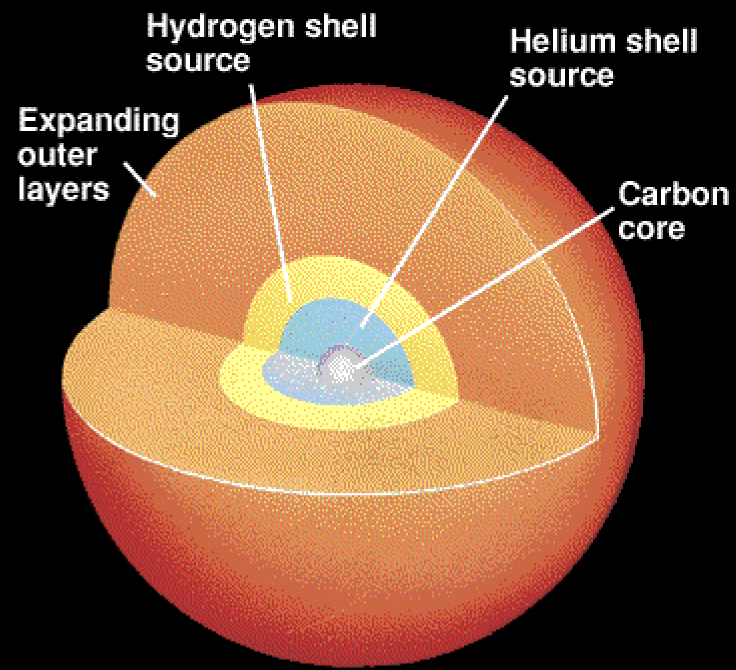
in Large Magellanic Cloud

infravörös



AGB

https://sites.ualberta.ca/~pogosyan/teaching/ASTRO_122/lect17/lecture17.html



Mitől forró a csillag?

A gravitációs összehúzódás miatt!

Mi a fúzió szerepe:

1. késlelteti az összeomlást
2. magszintézis, elemkeletkezés

Csillag és tömeg

Kezdet: gravitáció ->felmelegedés -> egyensúly

$0{,}0125\ M_{\odot} < M < 0{,}08\ M_{\odot}$ barna törpe Li, D fúzió

$0{,}08\ M_{\odot} < M < 0{,}5\ M_{\odot}$ vörös törpe -> He fehér törpe

$0{,}5\ M_{\odot} < M < 8\ M_{\odot}$ -> C-O fehér törpe

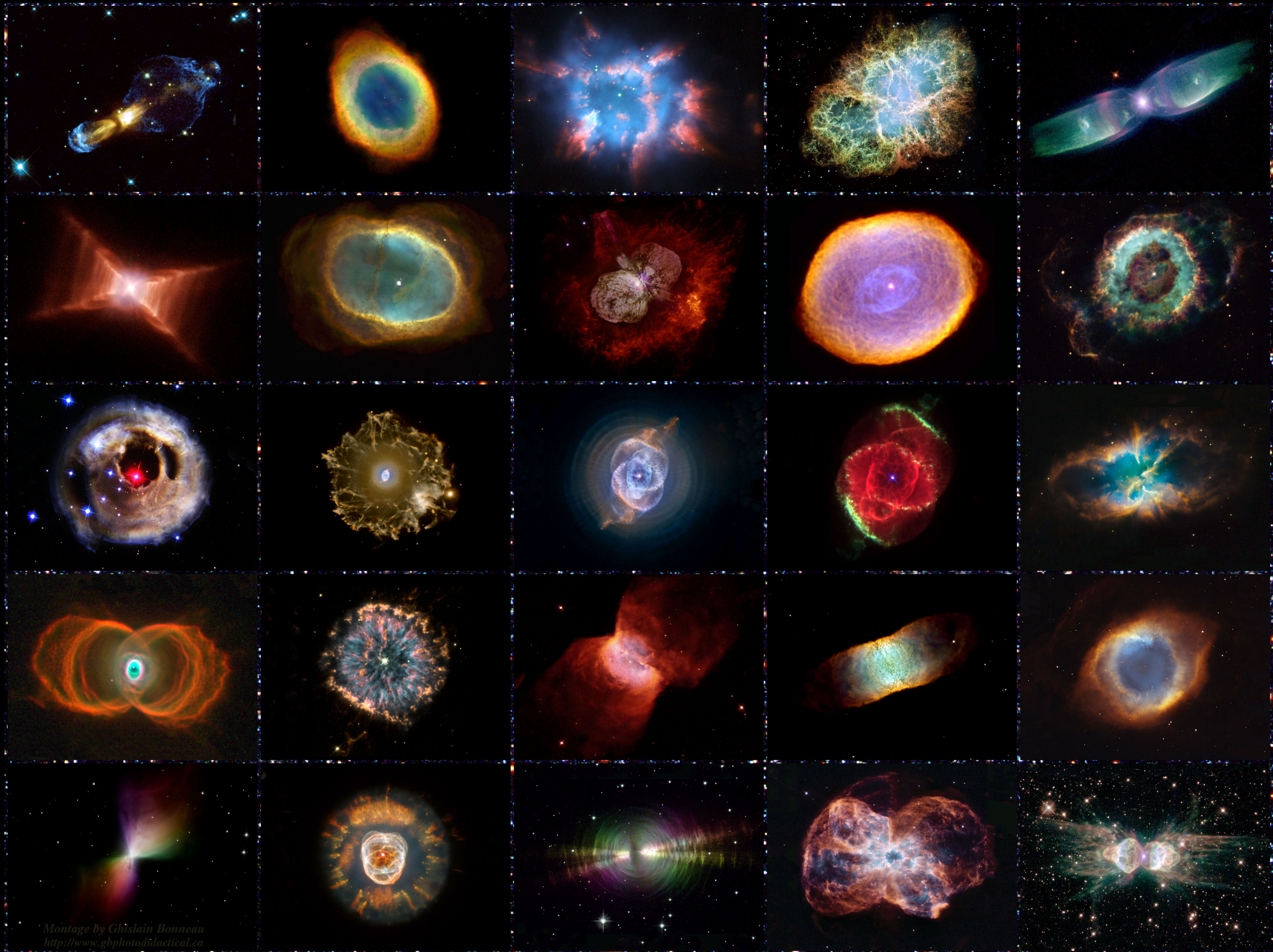
$8\ M_{\odot} < M < 10\ M_{\odot}$ -> O-Ne-Mg fehér törpe vagy nova

fúzió a vasig 3 alfa folyamat

fehér törpe: $M < 1{,}4\ M_{\odot}$ (Chandrasekar-limit)

Anyagvesztés: fehér törpe és planetáris köd

Planetáris ködök



Macskaszem-köd I.

William Herschel 1786.

Macskaszem-köd II.

Gyűrűs-köd

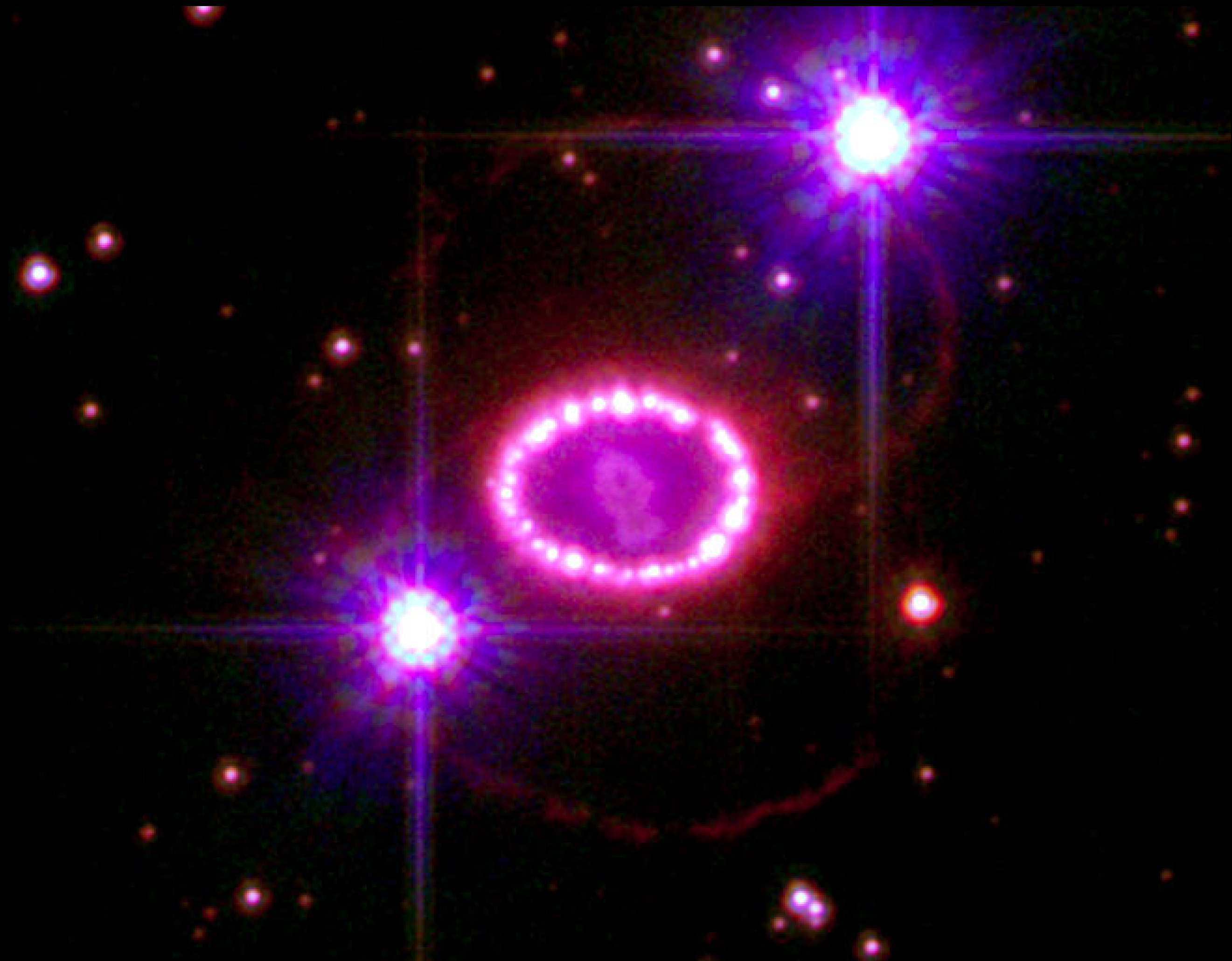
Charles Messier 1779.

Szupernóva

SN előtt

SN után

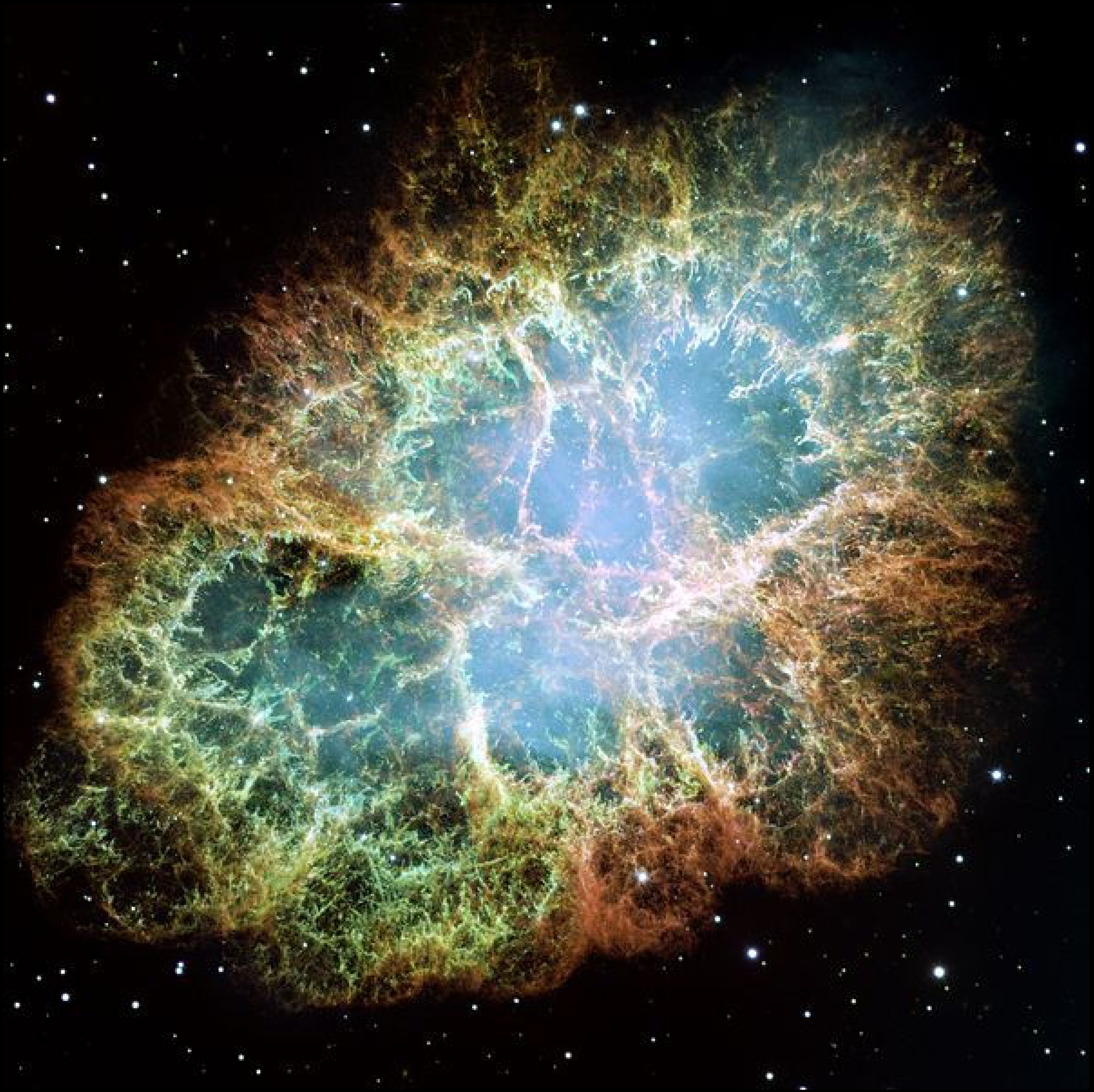
SNII
8-9 $M_\odot$ < M



SN 1987a

Approximately two to three hours before the visible light from SN 1987A reached Earth, a burst of neutrinos was observed at three separate neutrino observatories. This is likely due to neutrino emission, which occurs simultaneously with core collapse, but preceding the emission of visible light. Transmission of visible light is a slower process that occurs only after the shock wave reaches the stellar surface.[12] At 07:35 UT, **Kamiokande II detected 12 antineutrinos**; IMB, 8 antineutrinos; and Baksan, 5 antineutrinos; in a burst lasting less than 13 seconds. Approximately three hours earlier, the Mont Blanc liquid scintillator detected a five-neutrino burst, but this is generally not believed to be associated with SN 1987A

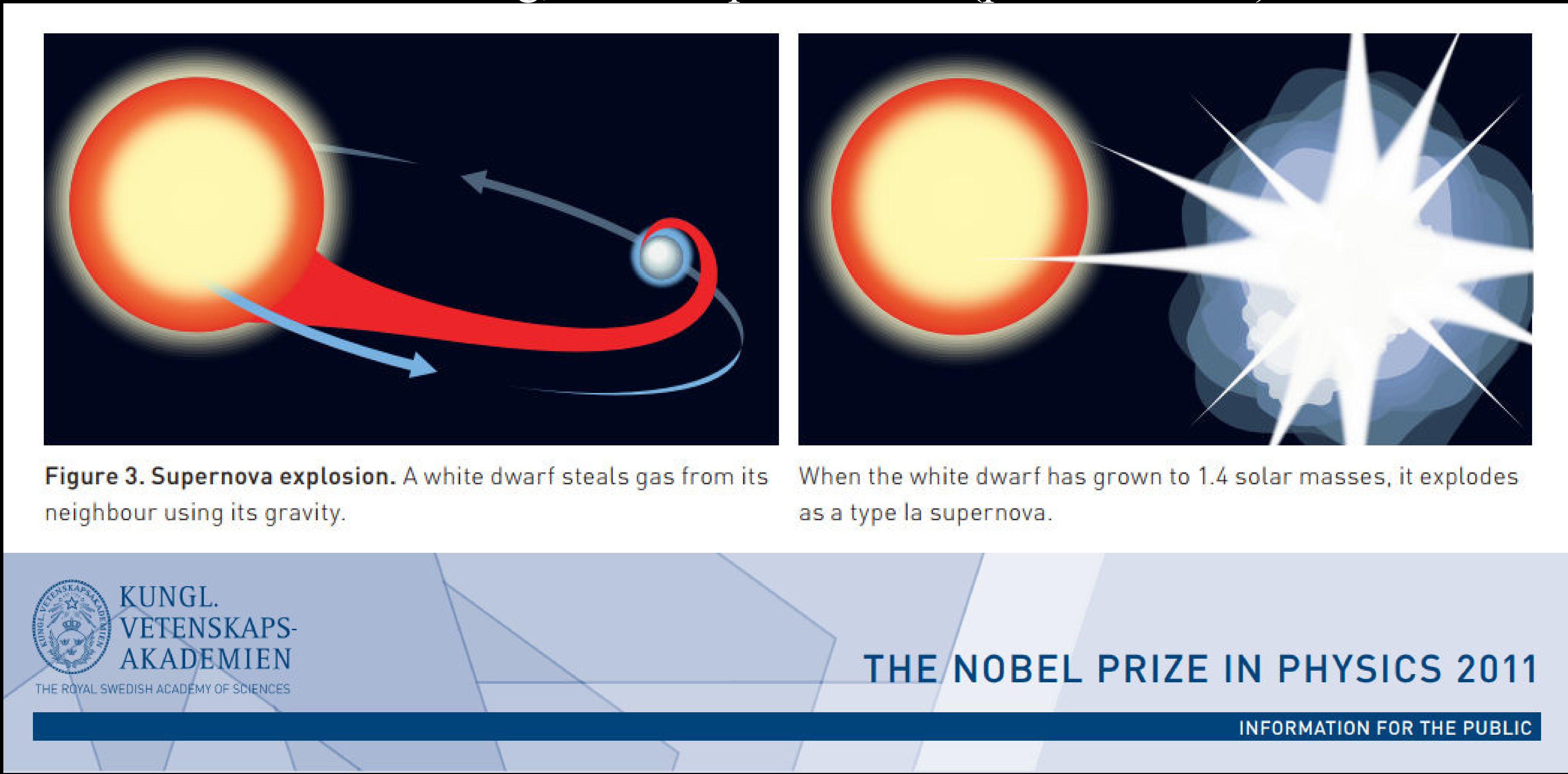
Rák-köd: SN 1054



Távolság: 6500 fényév
középén pulzár
-> SN II

SNIa

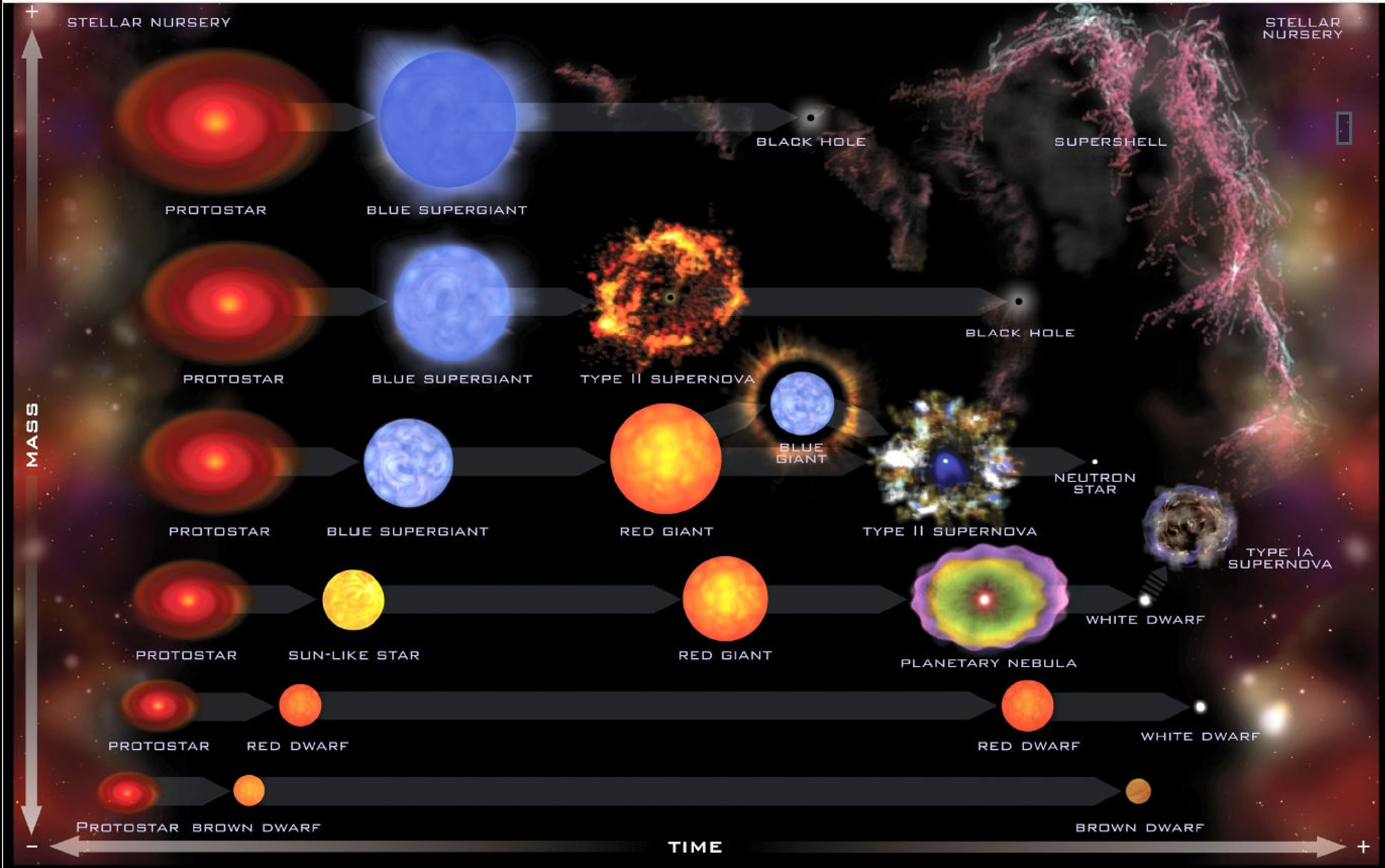
kettőscsillag, fehér törpe és kísérő (pl. vörös óriás)



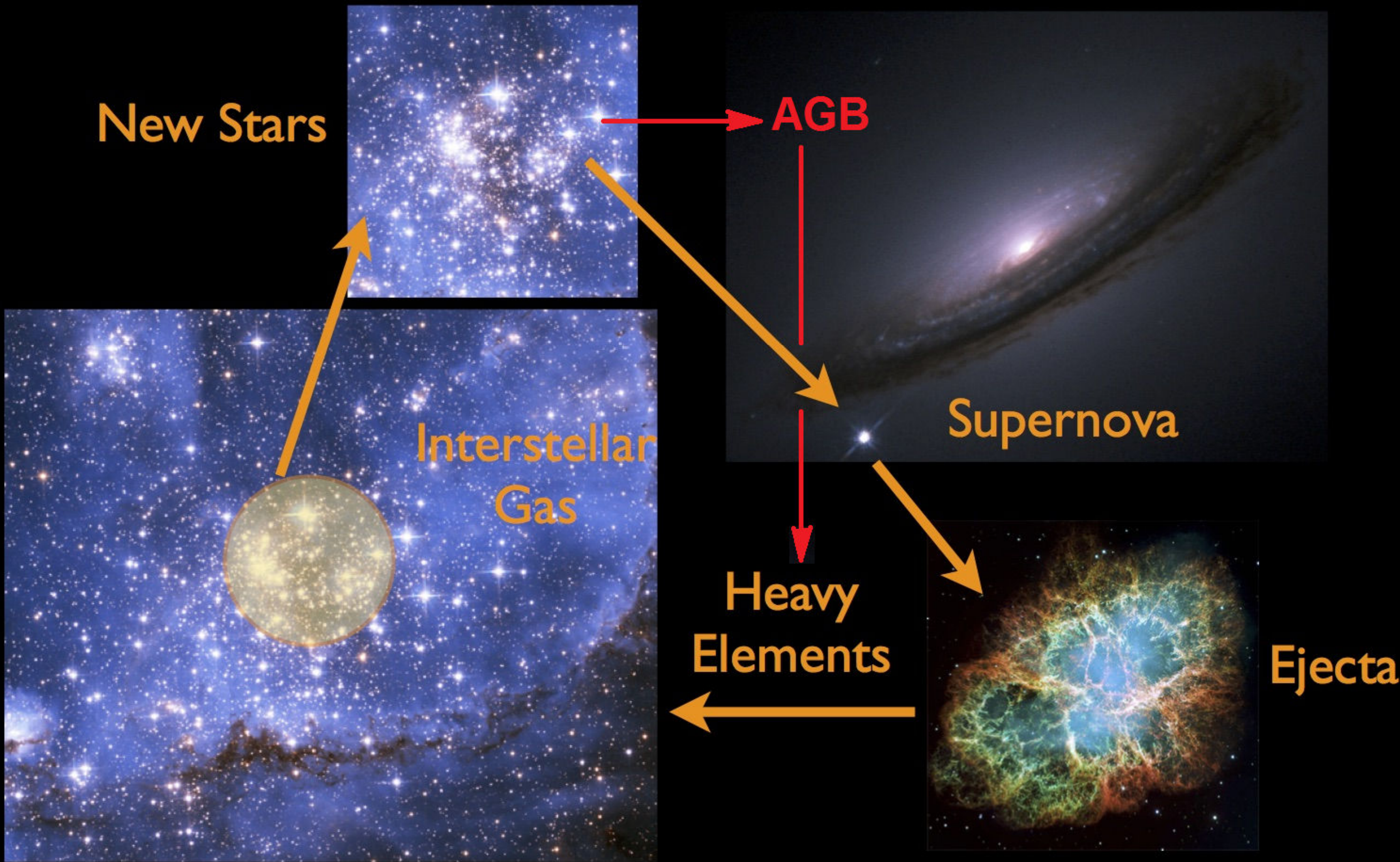
Supernovae – star explosions – became the new standard candles.

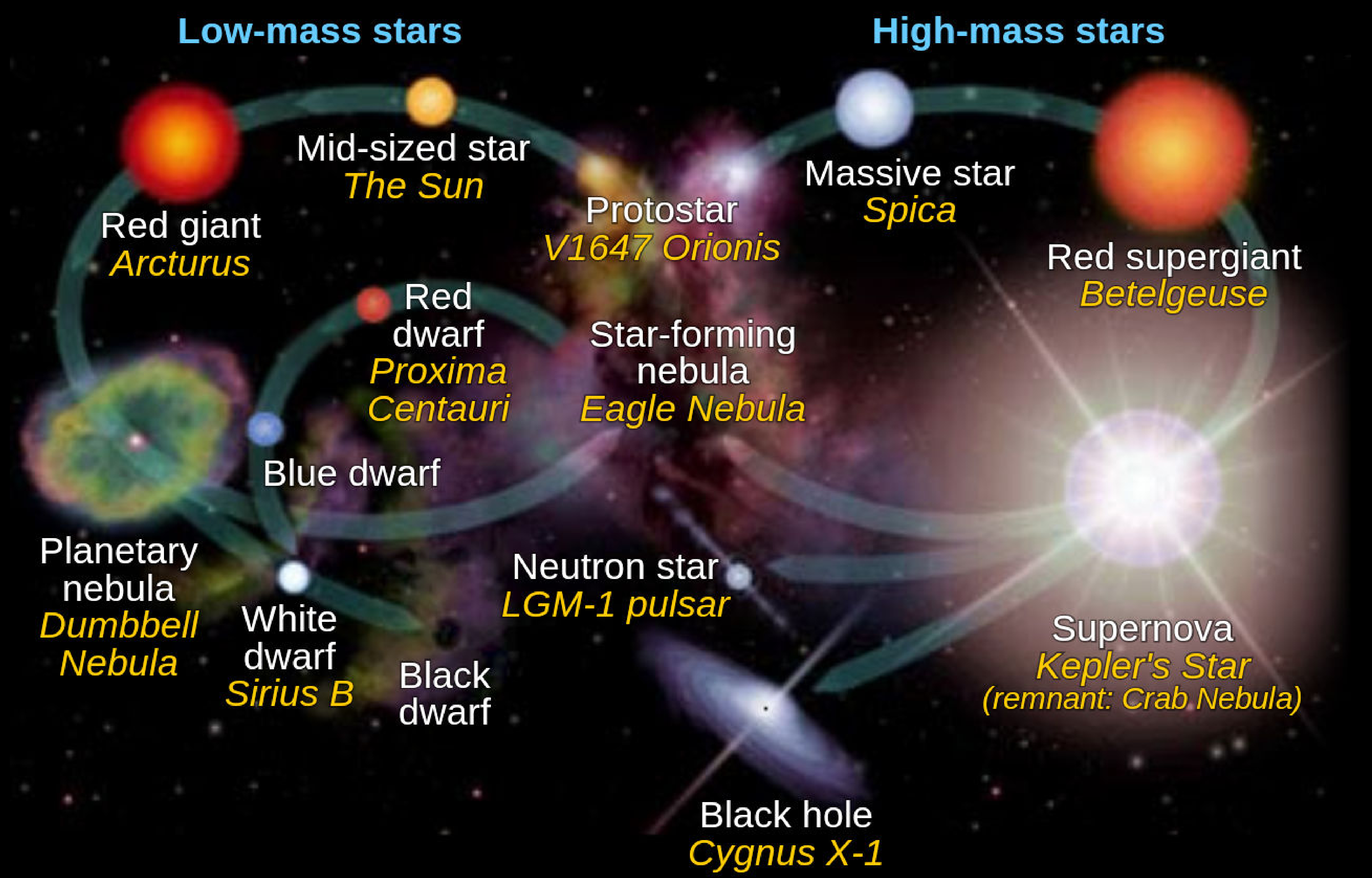
http://www.nobelprize.org/nobel_prizes/physics/laureates/2011/popular-physicsprize2011.pdf

Csillag, tömeg és életút



The Cycle of Star Formation




Low-mass stars
High-mass stars
Mid-sized star
The Sun
Red giant
Arcturus
Protostar
V1647 Orionis
Massive star
Spica
Red supergiant
Betelgeuse
Red
dwarf
Proxima
Centauri
Star-forming
nebula
Eagle Nebula
Blue dwarf
Planetary
nebula
Dumbbell
Nebula
White
dwarf
Sirius B
Black
dwarf
Neutron star
LGM-1 pulsar
Supernova
Kepler's Star
(remnant: Crab Nebula)
Black hole
Cygnus X-1

Köszönöm a figyelmet!