We are Starstuff

The Cosmic Origins
of the
Chemical Elements

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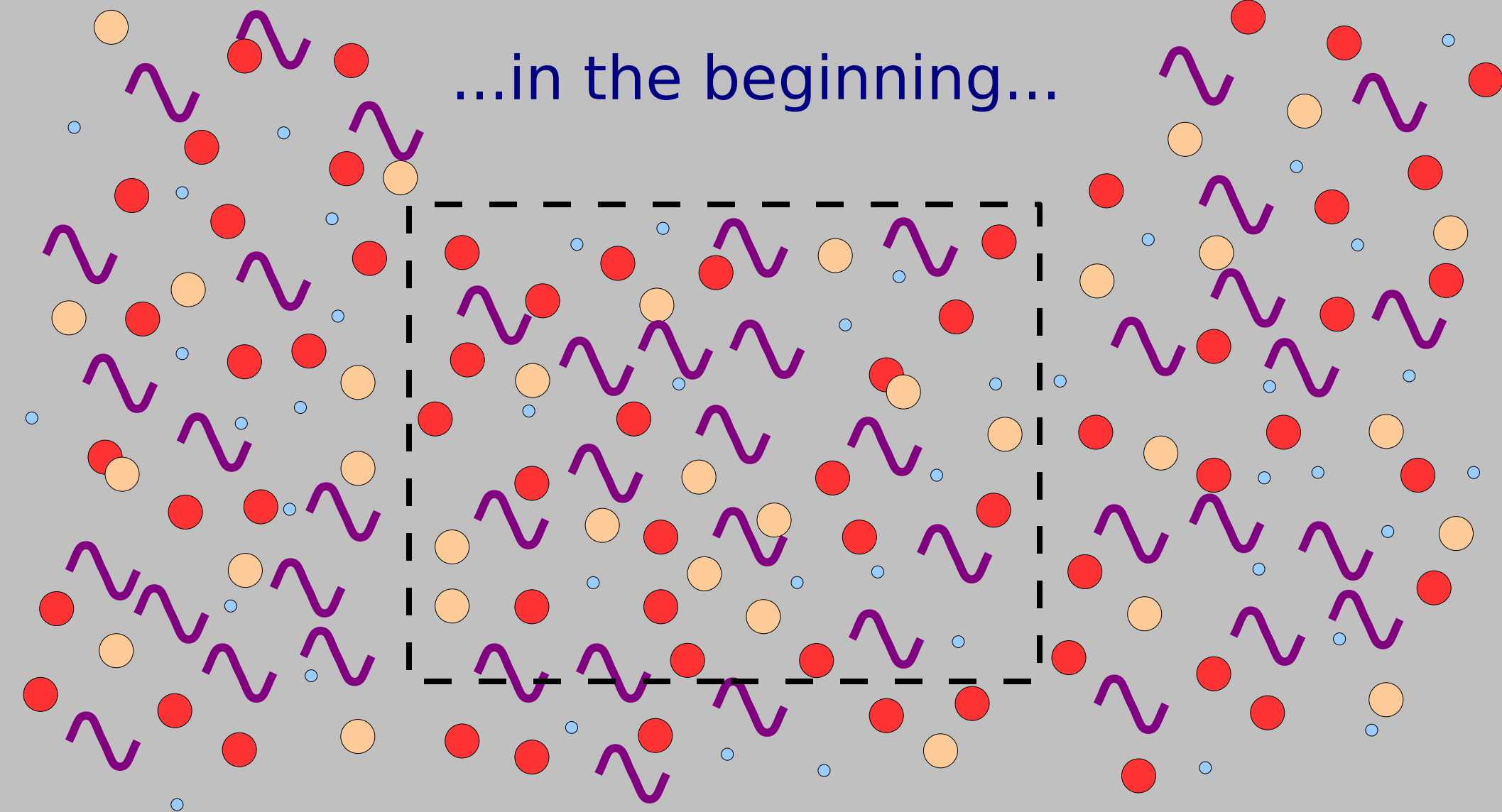
MICA public talk (www.mica-vw.org)

Second Life

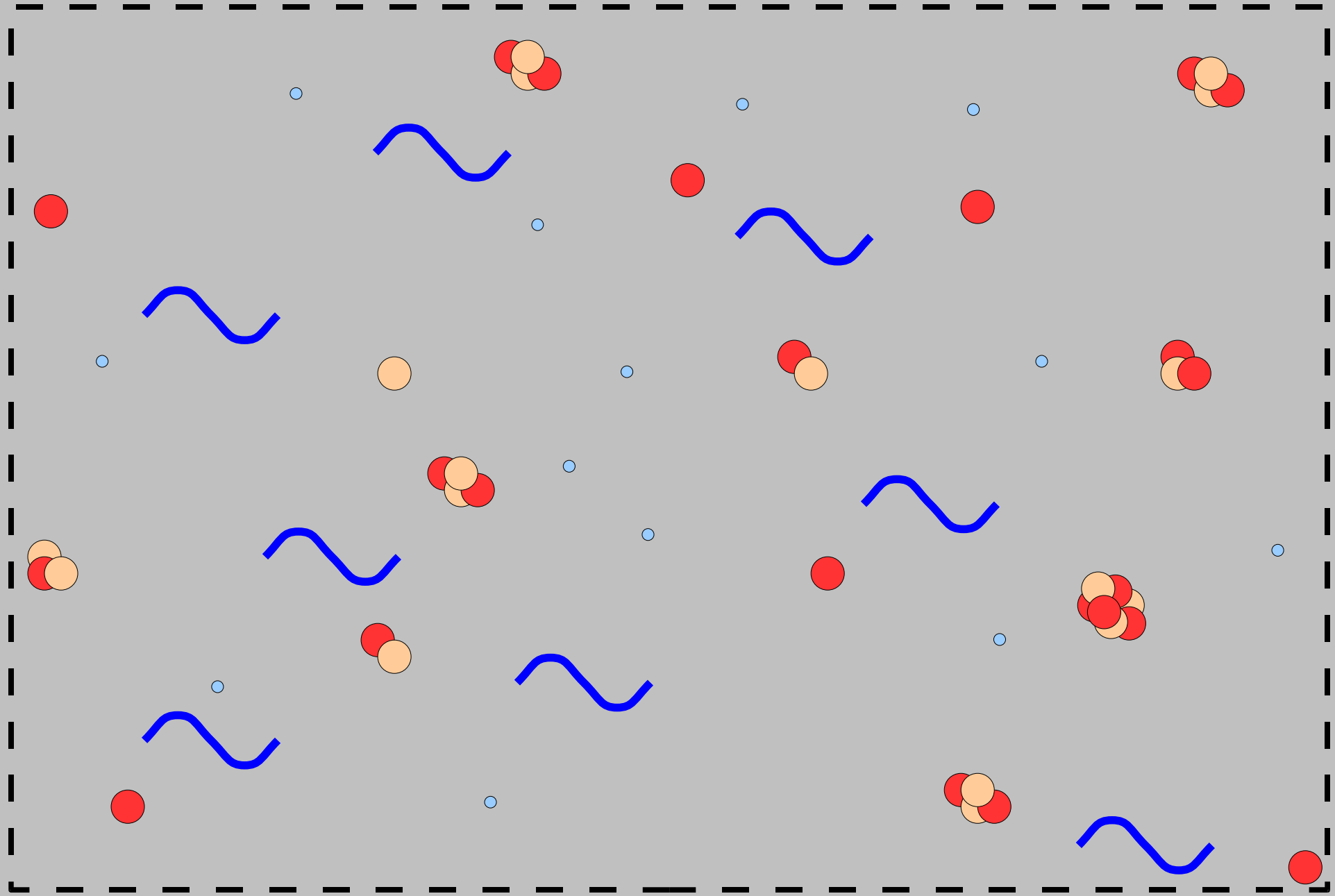
2008-10-10

...in the beginning...



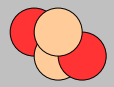
2 minutes after the Big Bang, the Universe is a soup of dark matter, plus protons, neutrons, electrons, positrons, and photons.

20 minutes after the big bang:



When the Big Bang is done making elements, what is left?

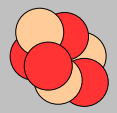
- Hydrogen : 75% (by mass)
- Deuterium : tiny
- Tritium : tiny



Helium : 25% (by mass)

Helium-3 : tiny

Lithium : tiny



Beryllium : tiny

...AND THAT'S IT!!!

That's what the Big Bang theory predicts...
...is there data to support it?

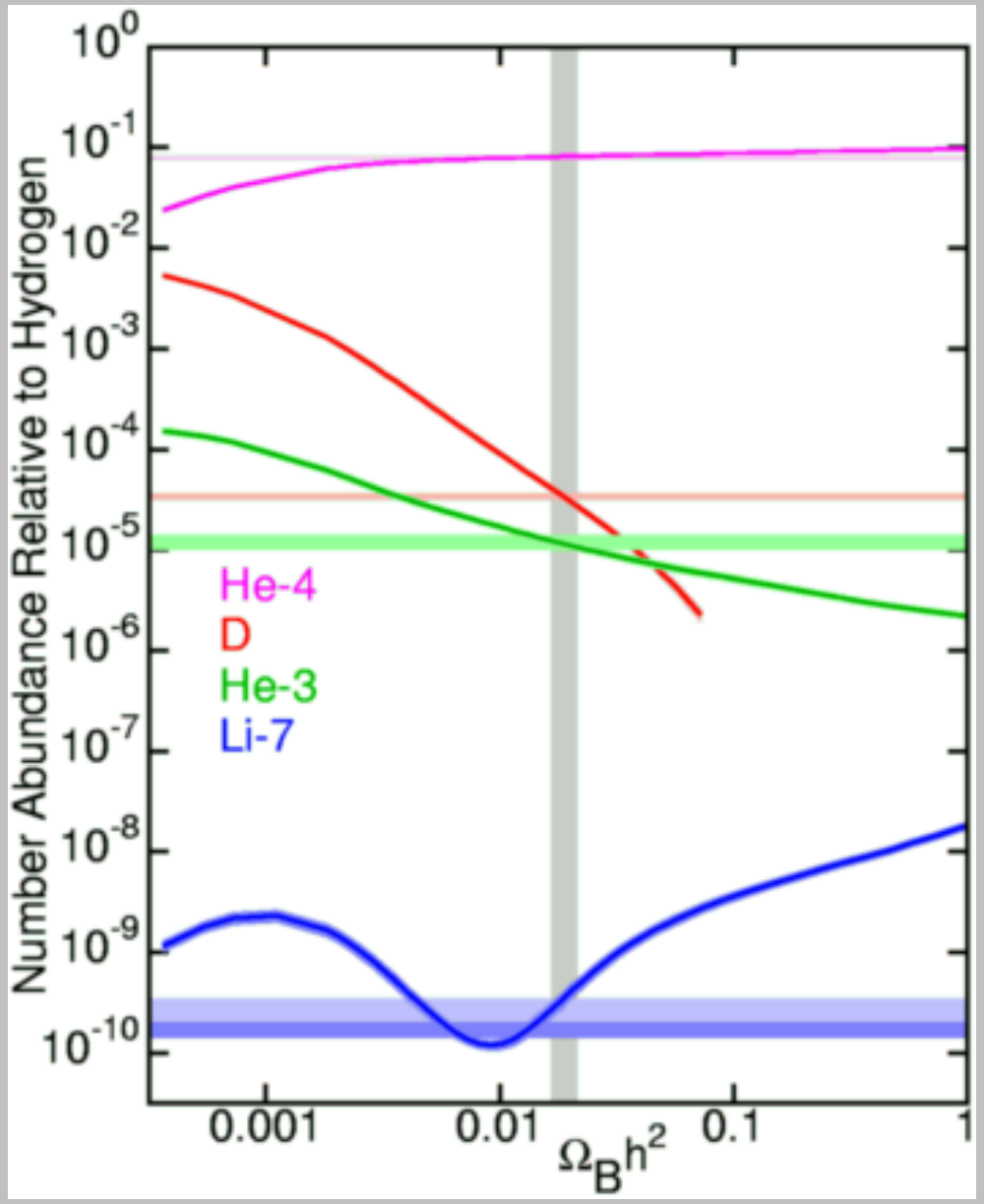
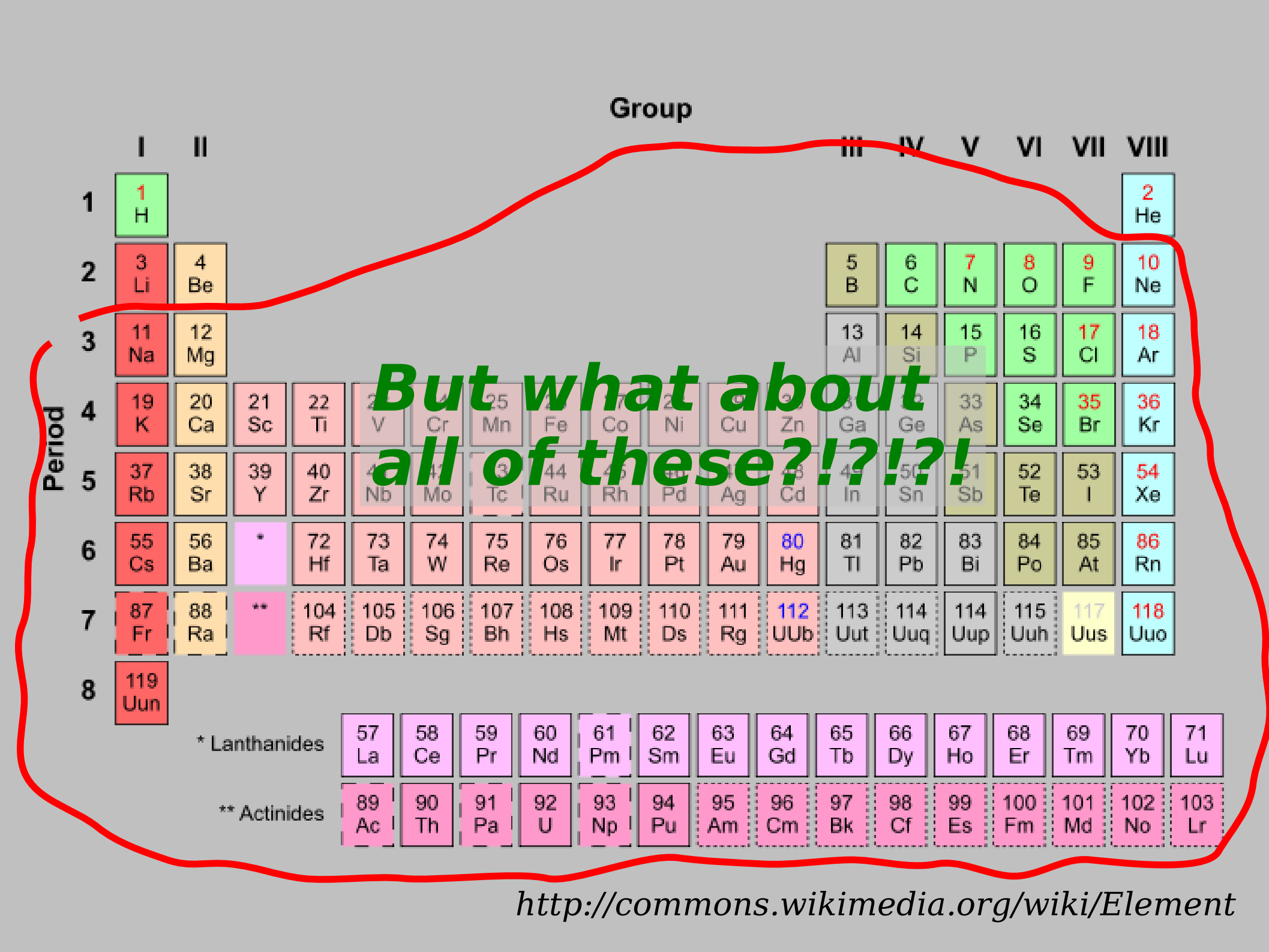


Image: Ned Wright http://www.astro.ucla.edu/~wright/BBNS.html


Group
I II III IV V VI VII VIII
Period
1 2 3 4 5 6 7 8
1 H
2 He
3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne
11 Na 12 Mg 13 Al 14 Si 15 P 16 S 17 Cl 18 Ar
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
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
55 Cs 56 Ba * 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
87 Fr 88 Ra ** 104 Rf 105 Db 106 Sg 107 Bh 108 Hs 109 Mt 110 Ds 111 Rg 112 UUb 113 Uut 114 Uuq 114 Uup 115 Uuh 117 Uus 118 Uuo
119 Uun
* Lanthanides 57 La 58 Ce 59 Pr 60 Nd 61 Pm 62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho 68 Er 69 Tm 70 Yb 71 Lu
** Actinides 89 Ac 90 Th 91 Pa 92 U 93 Np 94 Pu 95 Am 96 Cm 97 Bk 98 Cf 99 Es 100 Fm 101 Md 102 No 103 Lr
But what about all of these?!?!?!
http://commons.wikimedia.org/wiki/Element

Composition of the Sun

Hydrogen	71%
Helium	27%
Oxygen	1%
Carbon	0.4%
Iron	0.14%
Nitrogen	0.1%
Silicon	0.1%
Magnesium	0.08%
Neon	0.06%
Sulfur	0.04%

Powering Stars: ~~Nuculer~~ Nuclear Fusion
(Making heavier elements from lighter ones)

- Main Sequence Star : fusing Hydrogen to Helium at its core. (90% of a star's life)

Red Giant : an inert, very dense Helium core with a shell fusing Hydrogen to Helium around it.

Later : Helium fusing to Carbon at the core.

Stars are element factories!

BUT

- All of the action is at the core!
- Most of the stars that have contributed elements dredge up very little

So how do we get the elements out?

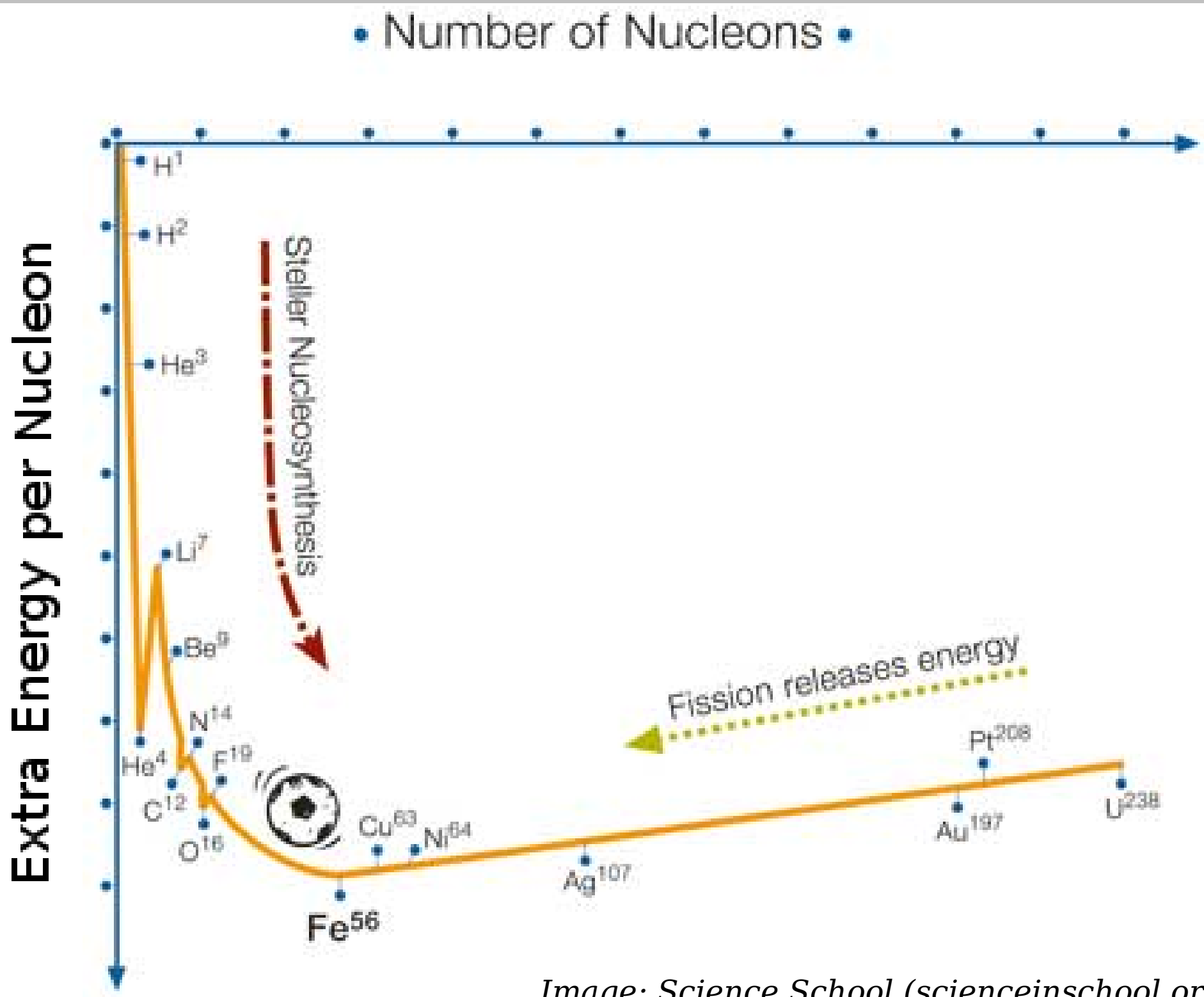


Image: Science School (scienceinschool.org)

Very massive stars can fuse all the way up to iron at their cores.

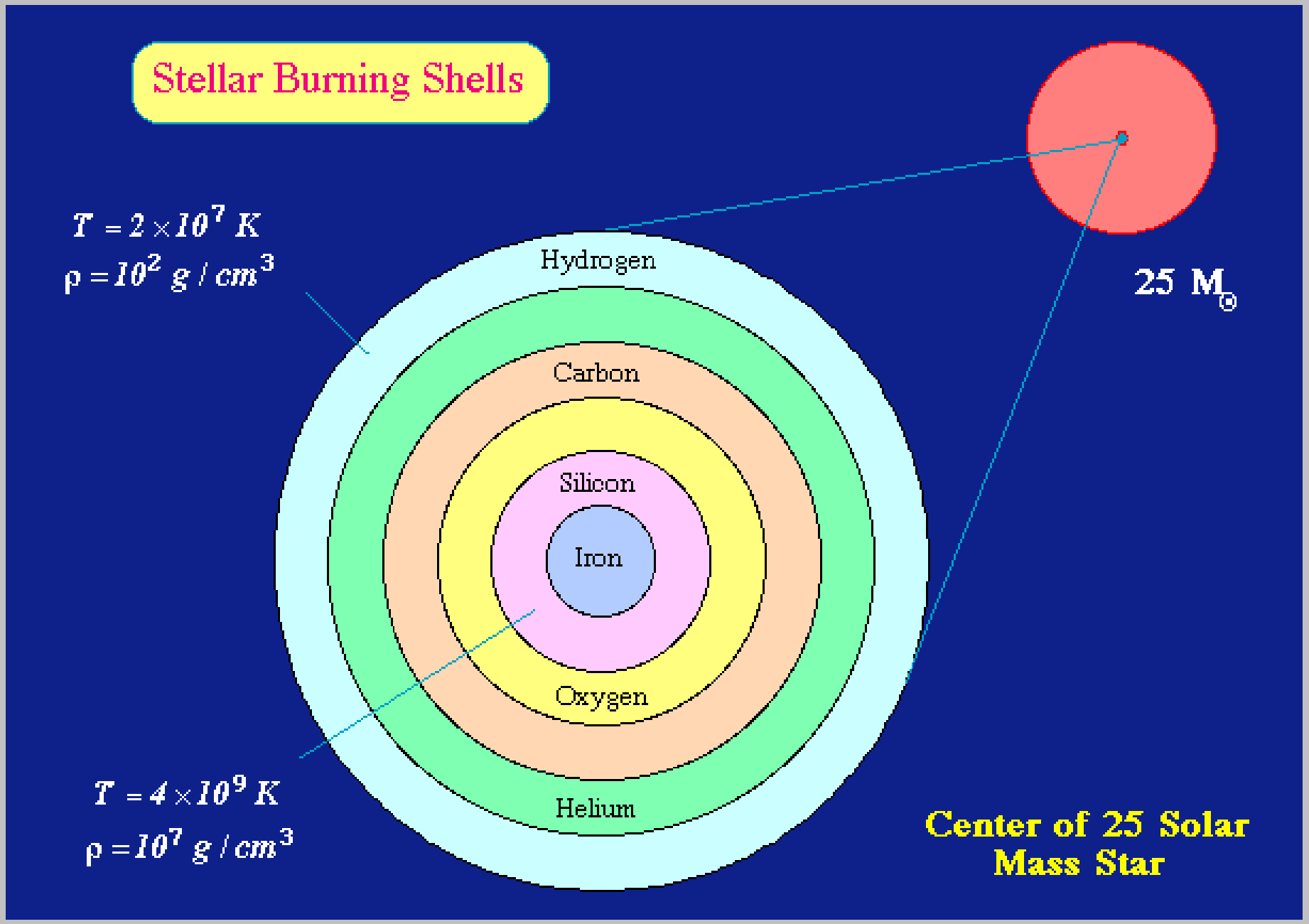
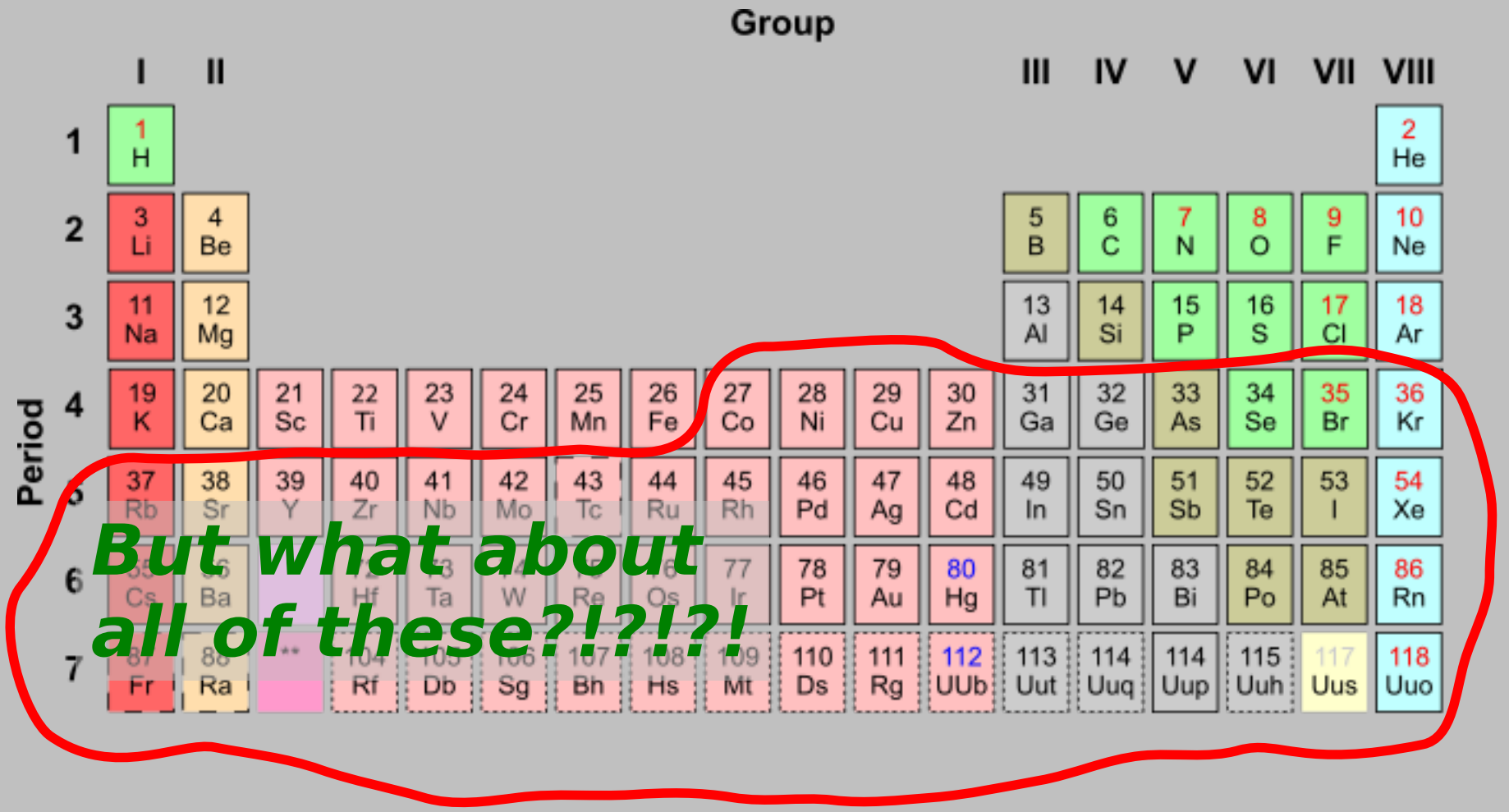


Image: Mike Guidry



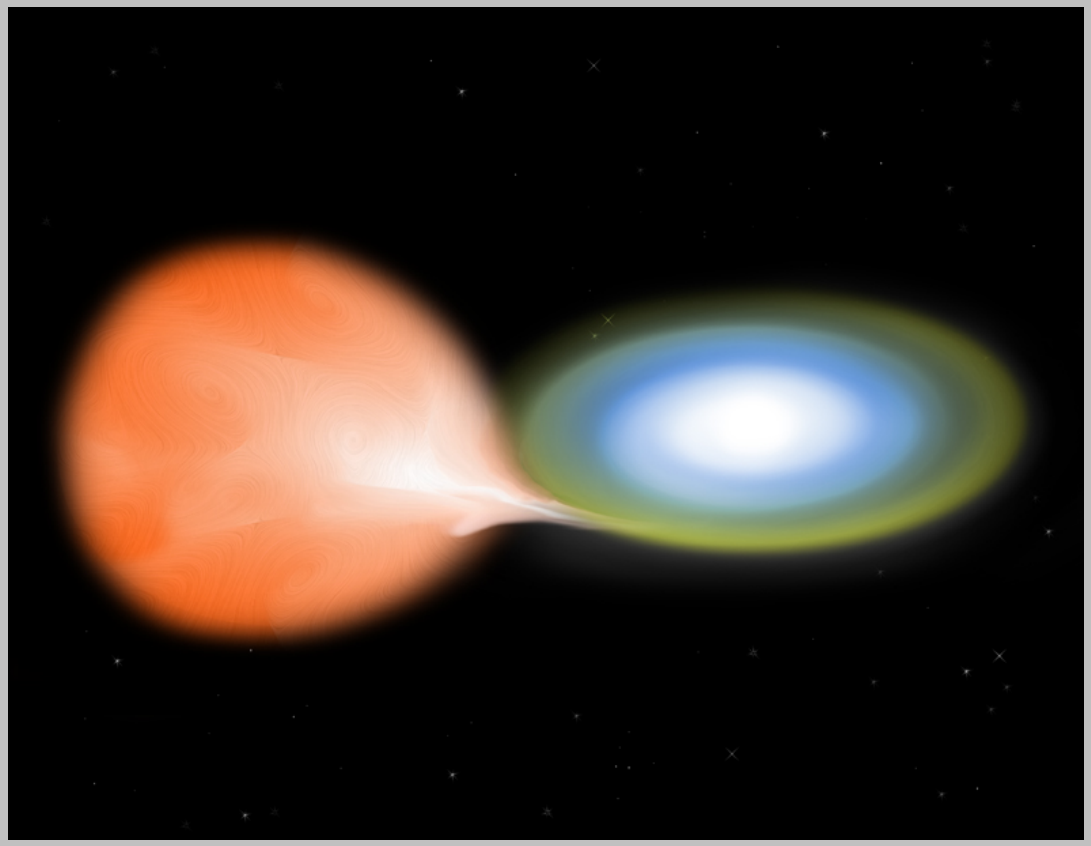
And how are you going to get all that junk out of the cores of those massive stars anyway??

Core Collapse Supernova

The inert iron core of a massive star (few thousand km across) collapses under gravity down to a neutron star (10km across); the outer layers bounce and are thrown off in a tremendous explosion.

- Fling!! Lots of elements are spewed forth
- BOOM! Lots of extra energy created all of a sudden... enough to do wasteful things like make heavy elements!

The other type of supernova: Thermonuclear Supernova



(Image credit: CXC/M. Weiss)

- A white dwarf accretes matter from a companion.
- It reaches a critical mass and undergoes runaway fusion.
- Fling!! The entire white dwarf star is blown away.
- BOOM! Lots of extra energy to do wasteul things like make heavy elements.

We are not just star stuff...

...we are *exploding-star stuff!*

You can be sure that at least some of the atoms in your body have been through a supernova before, because *that's where the heavier elements come from!*