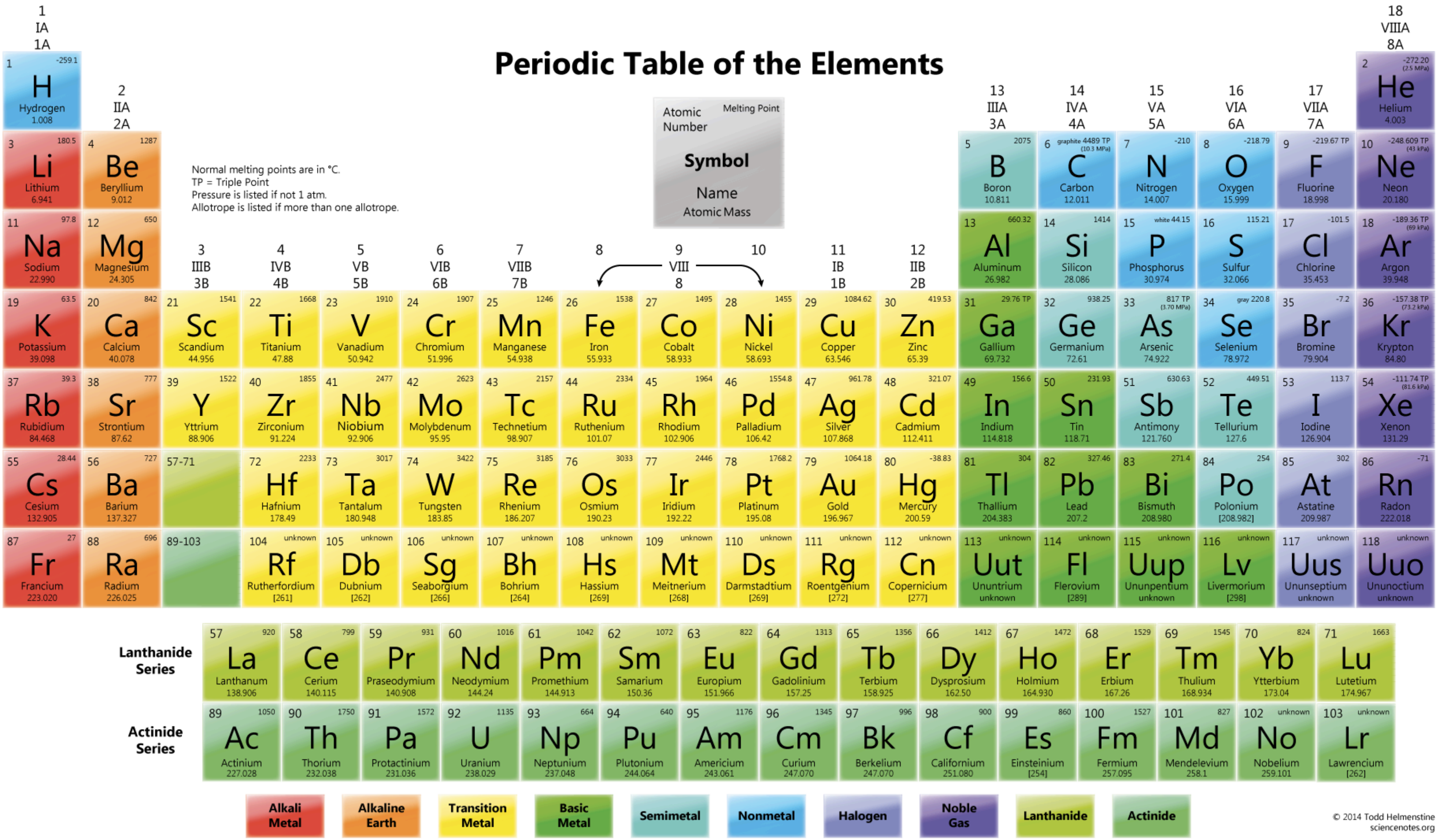
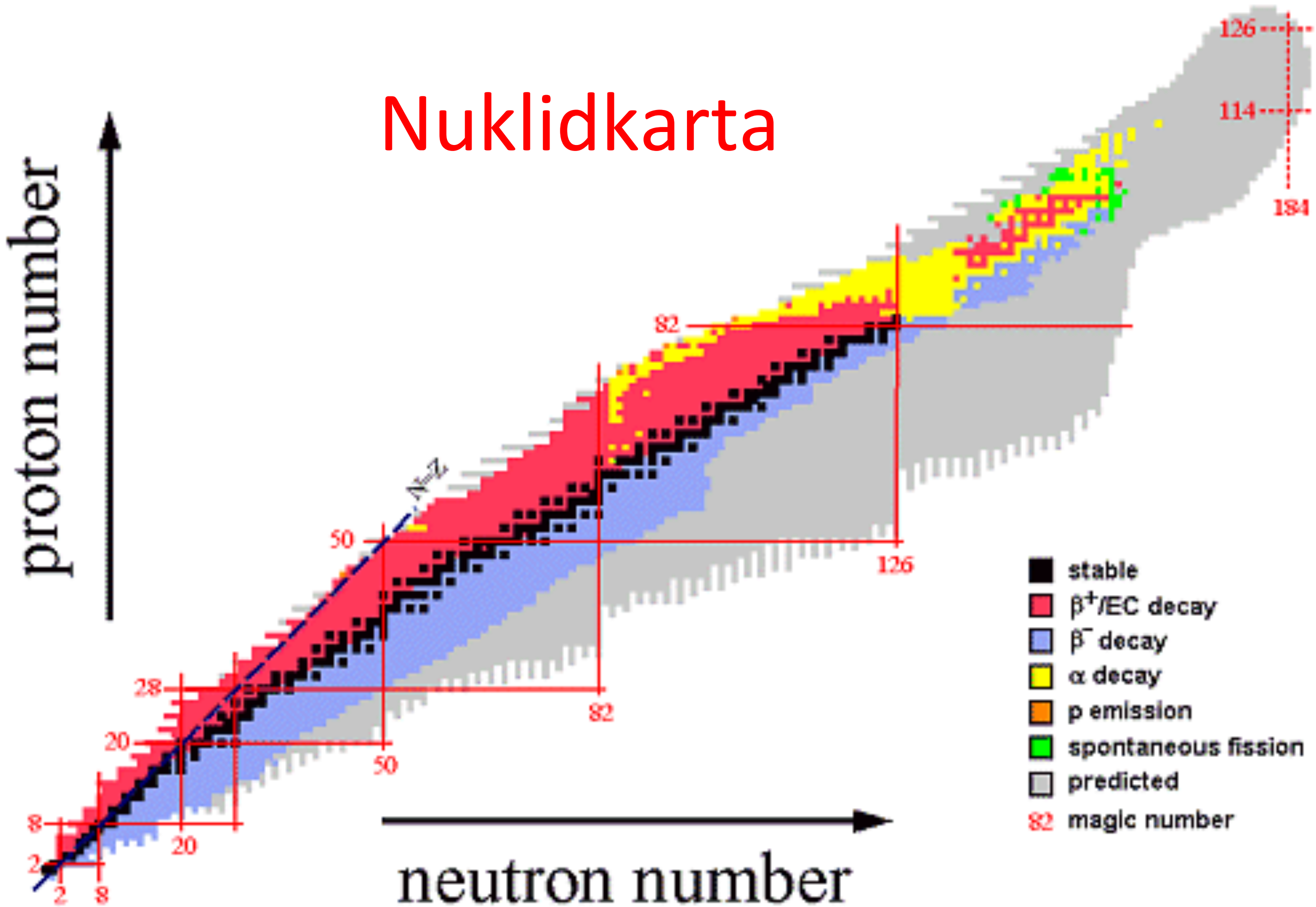


Antalet elektroner bestämmer kemiska egenskaper

Nuklidkarta

Z



N

300+ naturliga; <300 stabila, >3000 totalt – varje nuklid är unik!

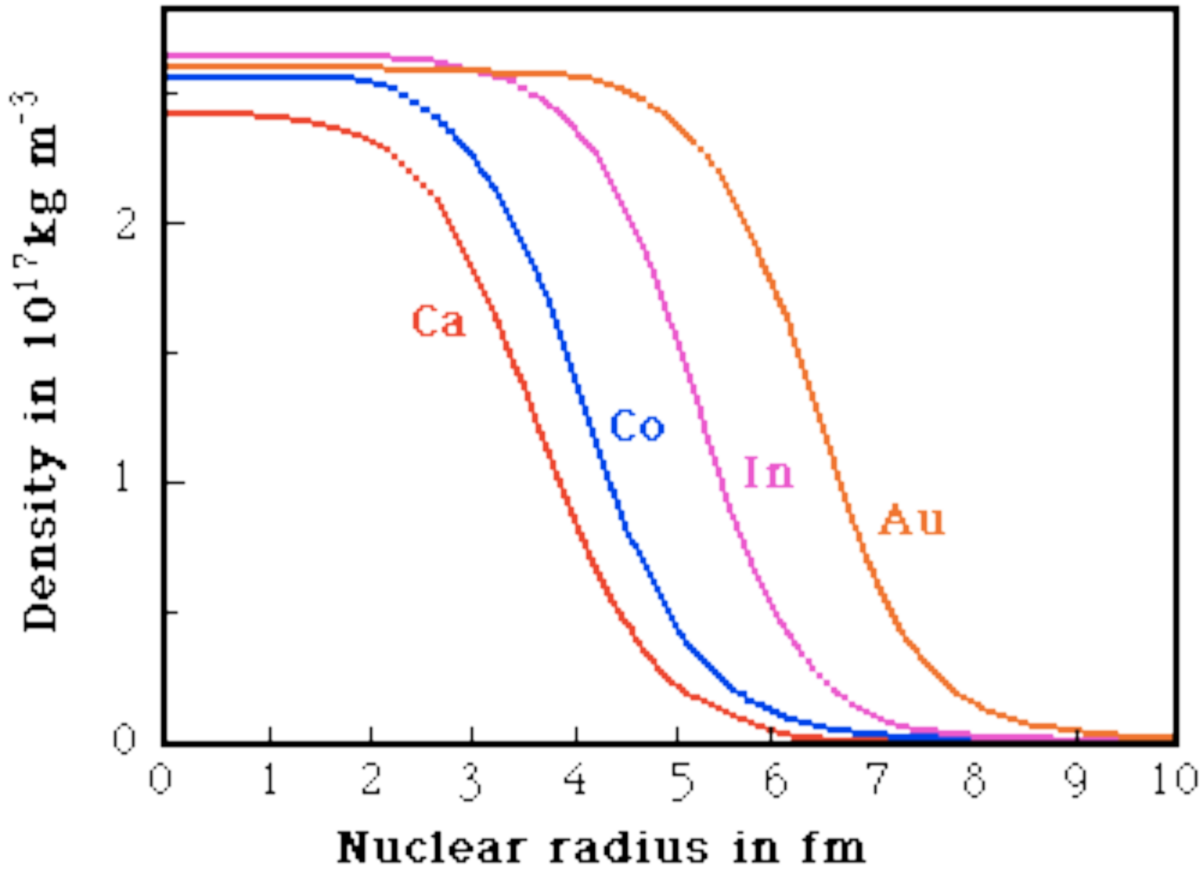
Lätta: stabila kring Z=N; Tyngre: Z<N, upp till ^{208}Pb

Table 43.2 Neutral Atomic Masses for Some Light Nuclides

Element and Isotope	Atomic Number, Z	Neutron Number, N	Atomic Mass (u)	Mass Number, A
Hydrogen ($^{1}_{1}H$)	1	0	1.007825	1
Deuterium ($^{2}_{1}H$)	1	1	2.014102	2
Tritium ($^{3}_{1}H$)	1	2	3.016049	3
Helium ($^{3}_{2}He$)	2	1	3.016029	3
Helium ($^{4}_{2}He$)	2	2	4.002603	4
Lithium ($^{6}_{3}Li$)	3	3	6.015122	6
Lithium ($^{7}_{3}Li$)	3	4	7.016004	7
Beryllium ($^{9}_{4}Be$)	4	5	9.012182	9
Boron ($^{10}_{5}B$)	5	5	10.012937	10
Boron ($^{11}_{5}B$)	5	6	11.009305	11
Carbon ($^{12}_{6}C$)	6	6	12.000000	12
Carbon ($^{13}_{6}C$)	6	7	13.003355	13
Nitrogen ($^{14}_{7}N$)	7	7	14.003074	14
Nitrogen ($^{15}_{7}N$)	7	8	15.000109	15
Oxygen ($^{16}_{8}O$)	8	8	15.994915	16
Oxygen ($^{17}_{8}O$)	8	9	16.999132	17
Oxygen ($^{18}_{8}O$)	8	10	17.999160	18

Source: A. H. Wapstra and G. Audi, *Nuclear Physics* **A595,** 4 (1995).

Kärn-densitet/täthet



Det diagram som betyder mest för våra livsbetingelser…

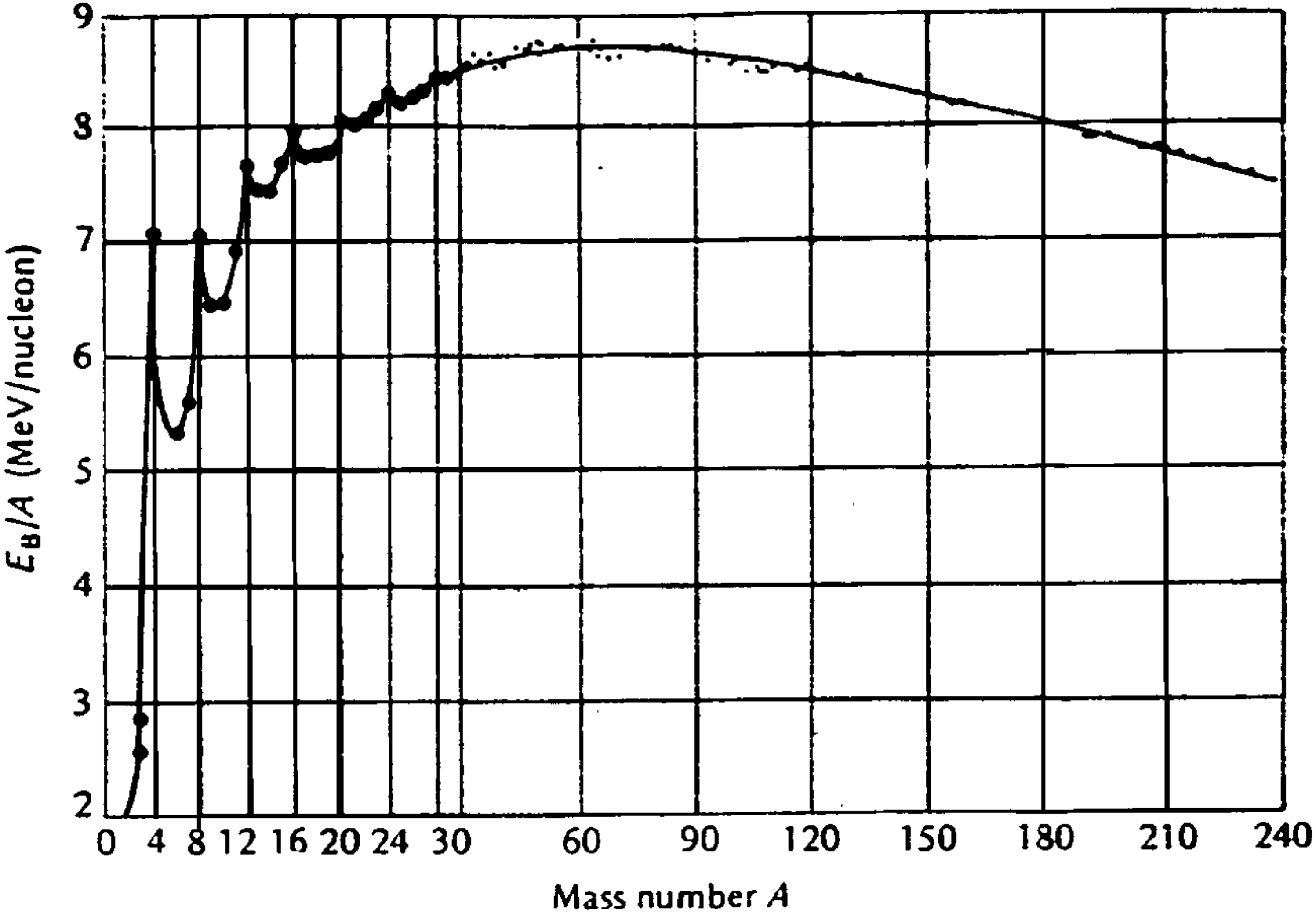
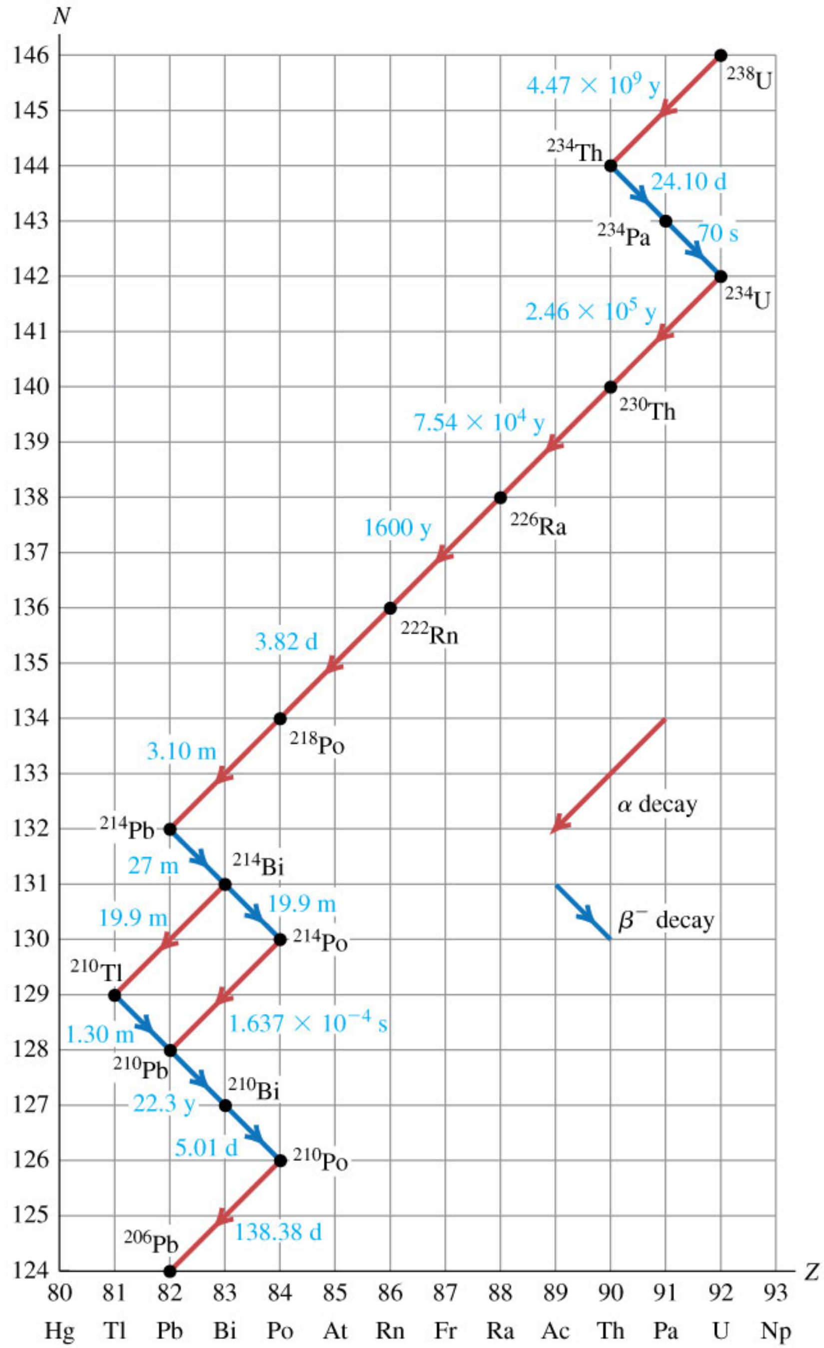


Figure 43.7

Uranium series



4 series in nature

Uranium
Actinium
Thorium
Neptunium

All end in Pb isotope

Figure 43.5

Potentialbarriär > Q => tunneleffekt behövs

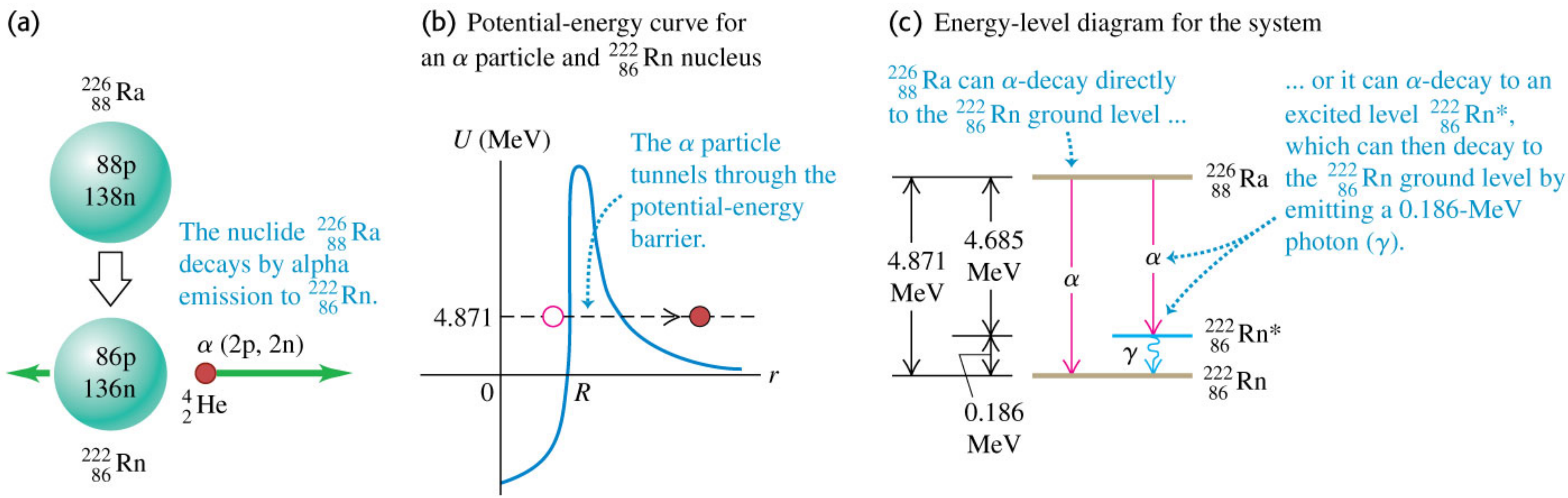
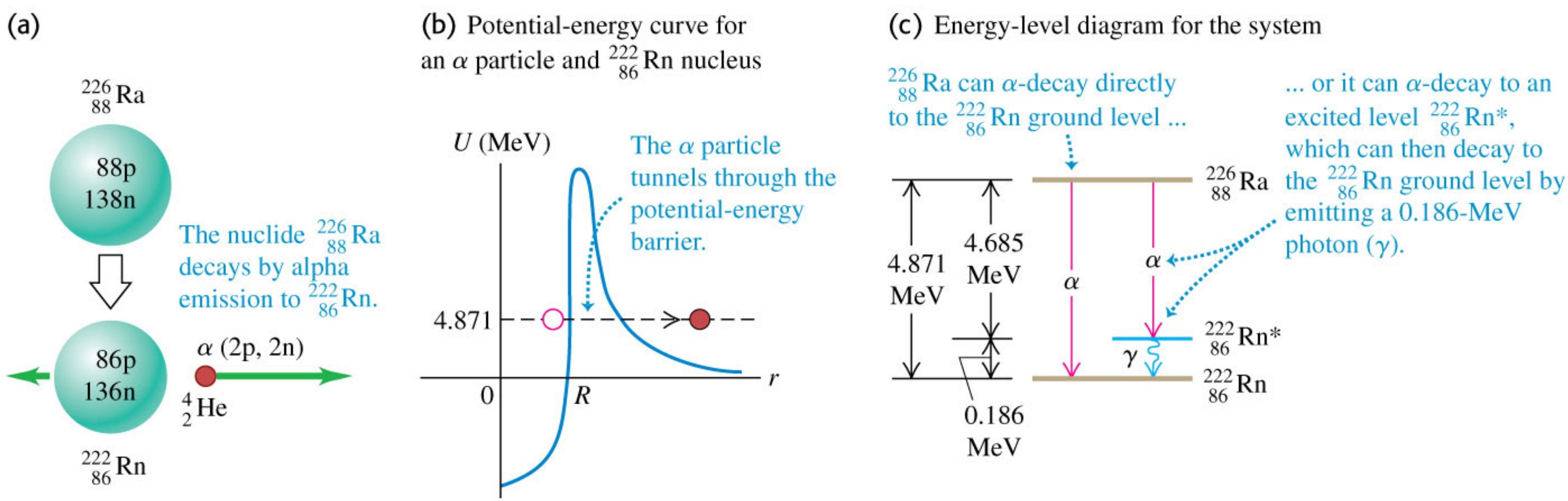


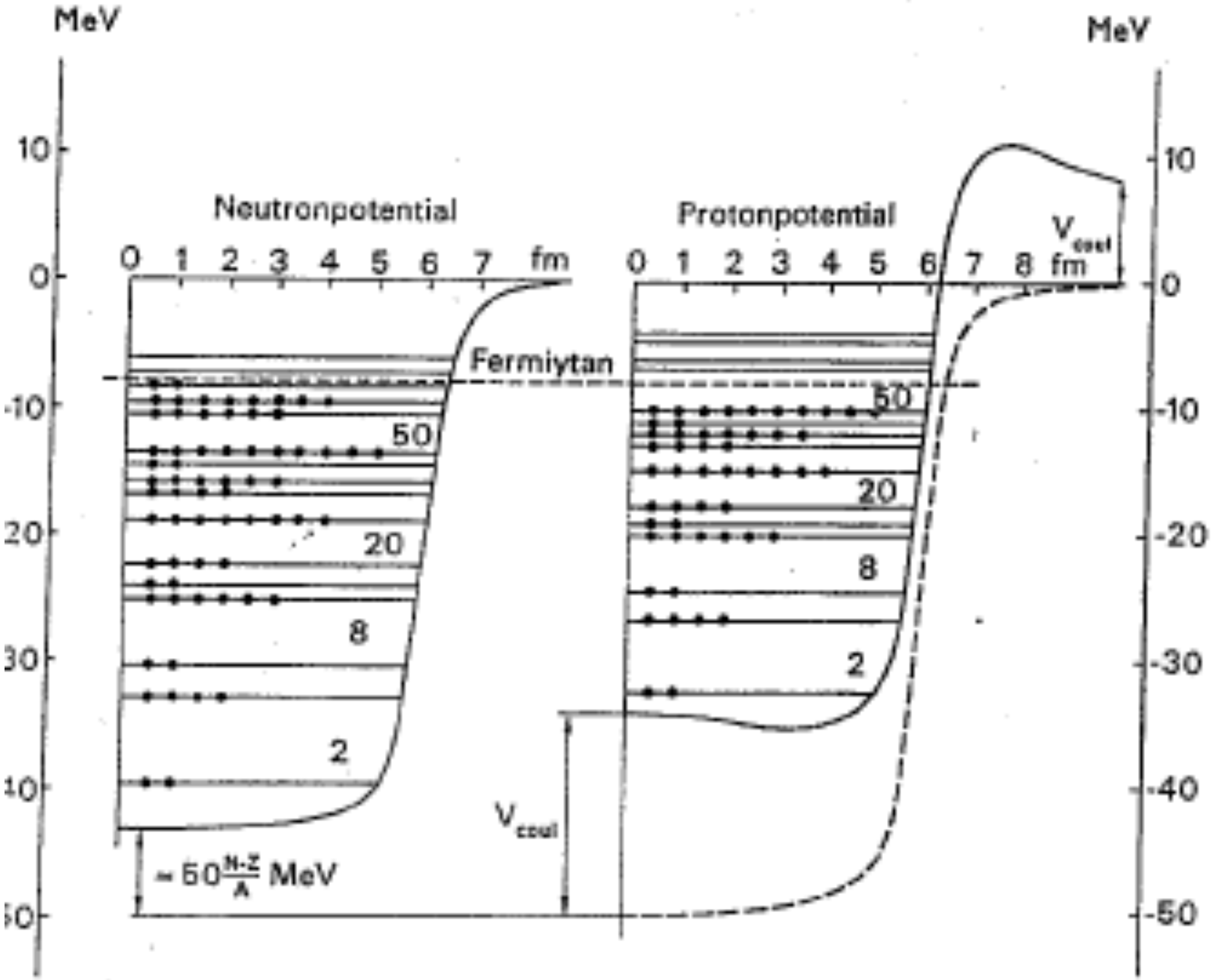
Figure 43.5

Shell model / Skal modell

Många olika energitillstånd i kärnor
Mer komplicerat kvantmekaniskt än atomfysiks skalmodell: kommer mer i senare kurser…



Level scheme ^{116}Sn



Gamma energies from ^{61}Zn

$^{40}Ca + ^{24}Mg \rightarrow ^{61}Zn + p + p + n + \gamma$

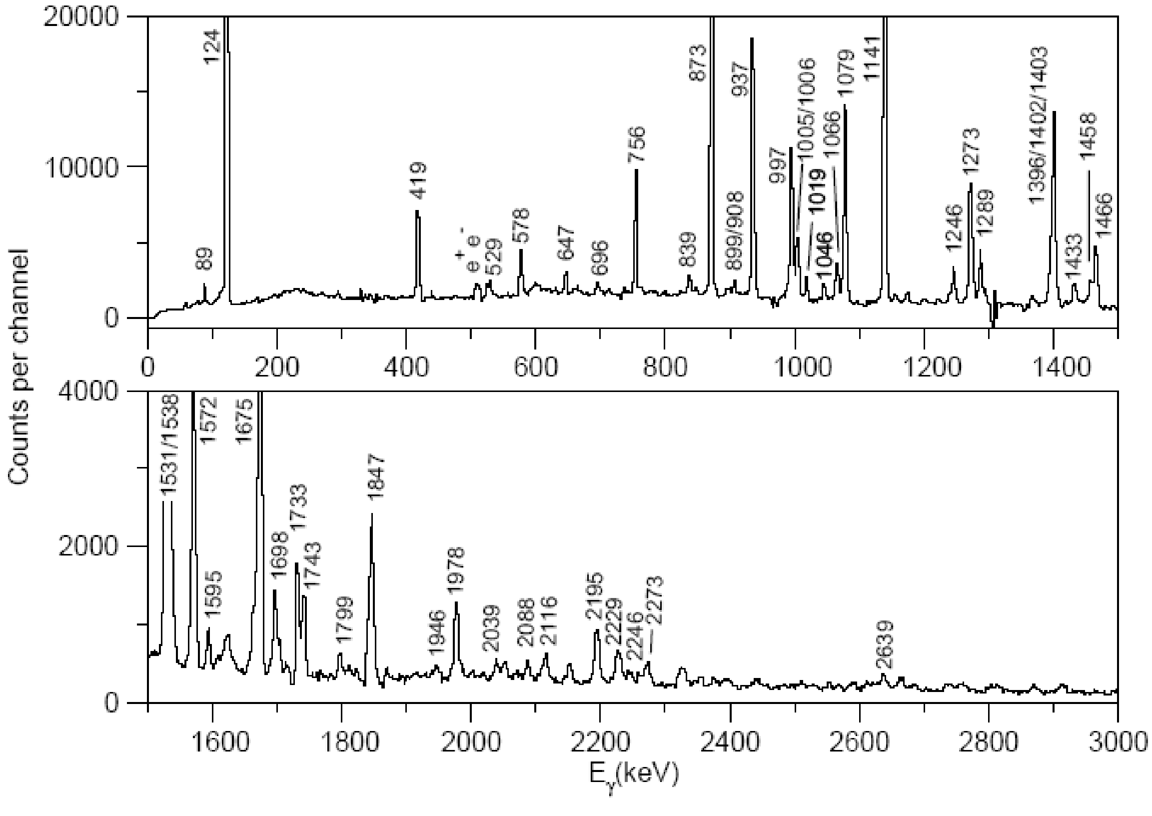
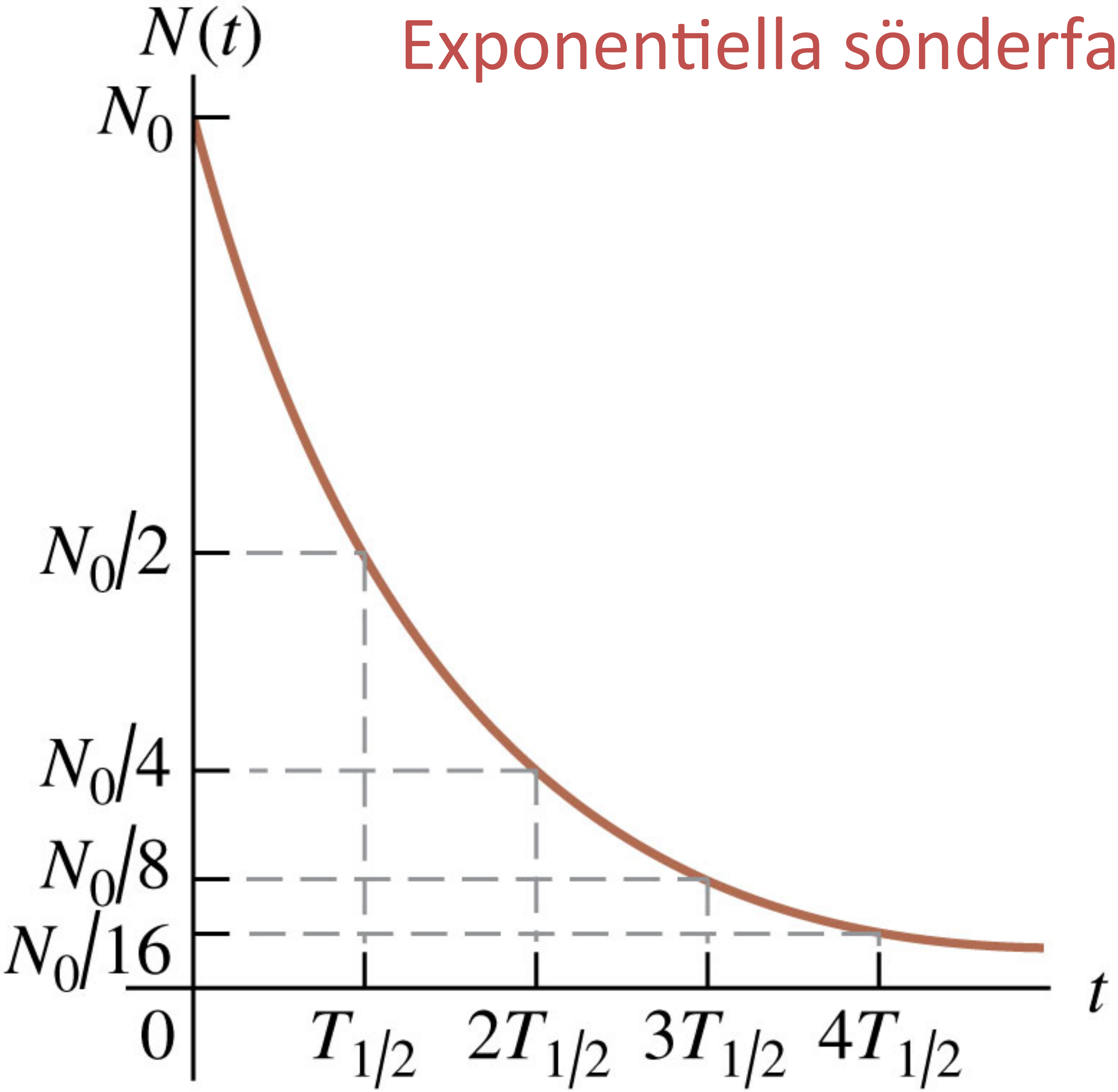
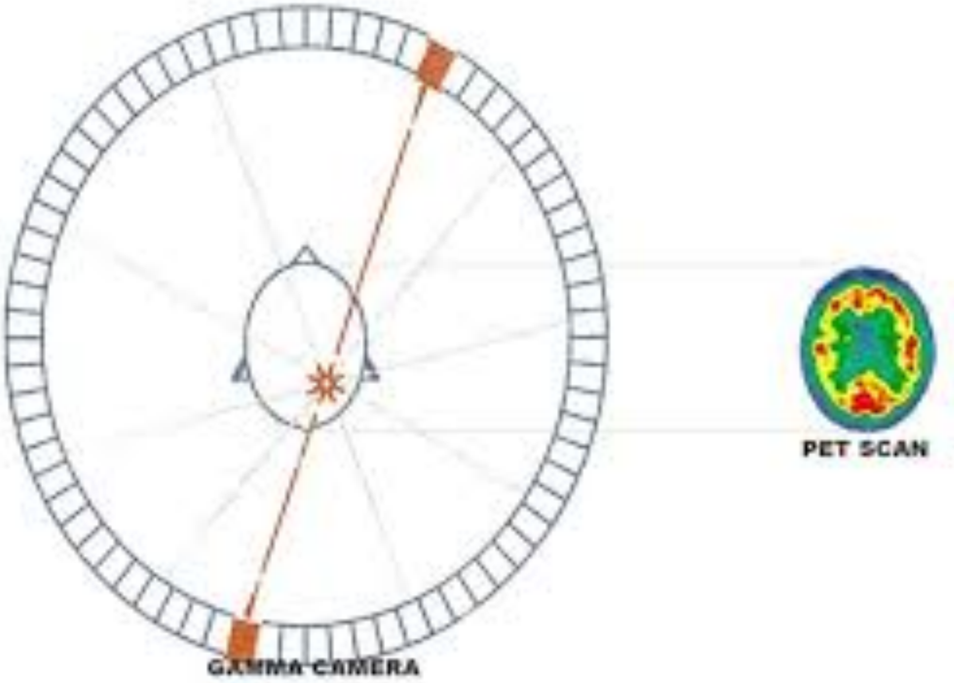


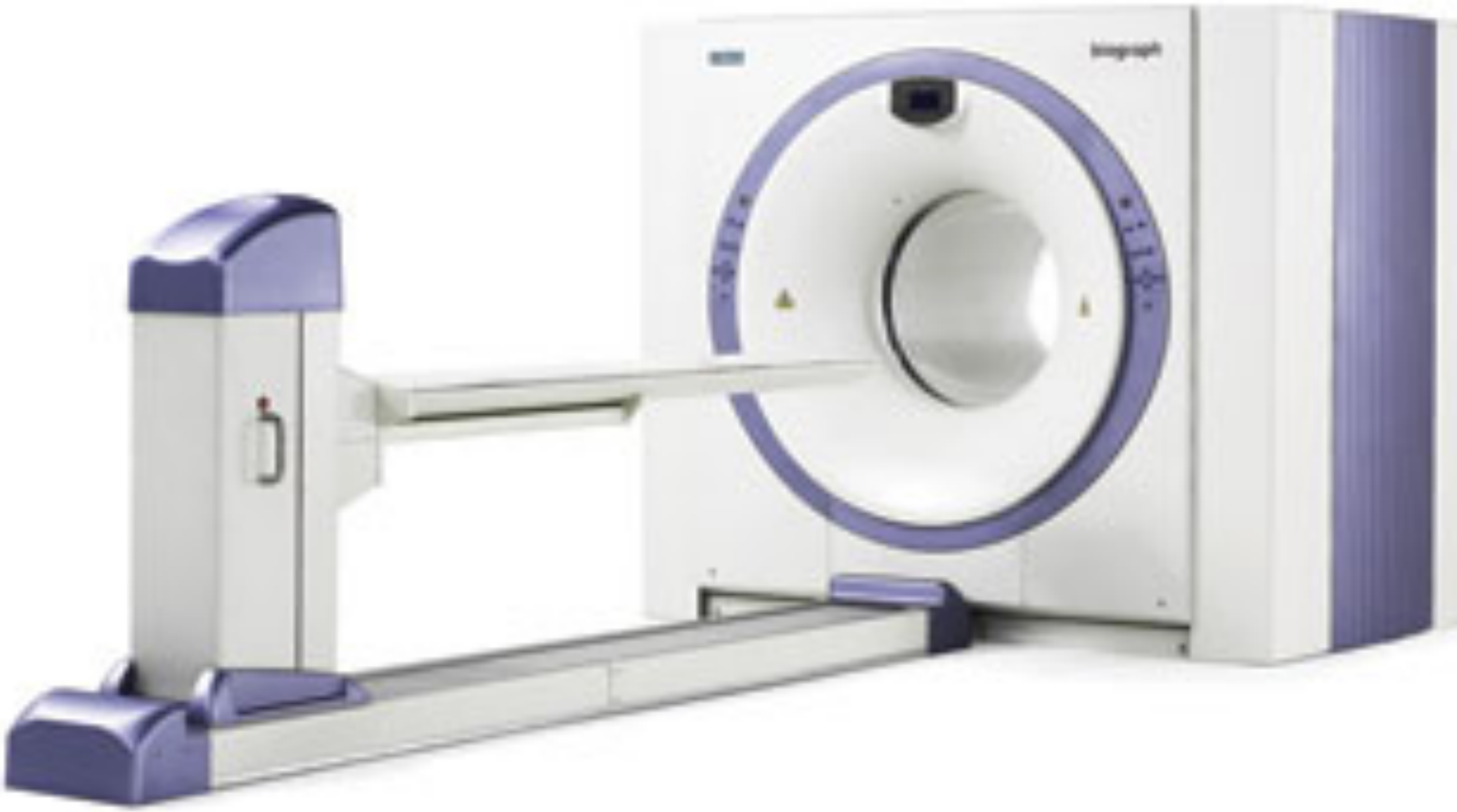
Figure 43.8

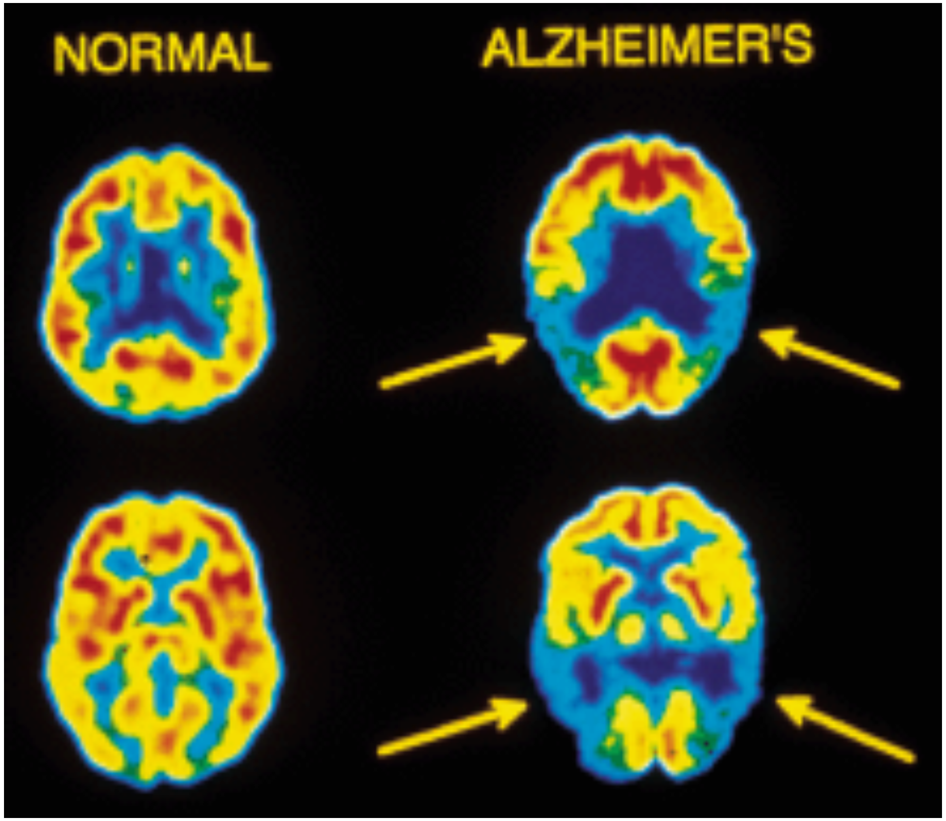
Exponentiella sönderfallslagen



PET Imaging

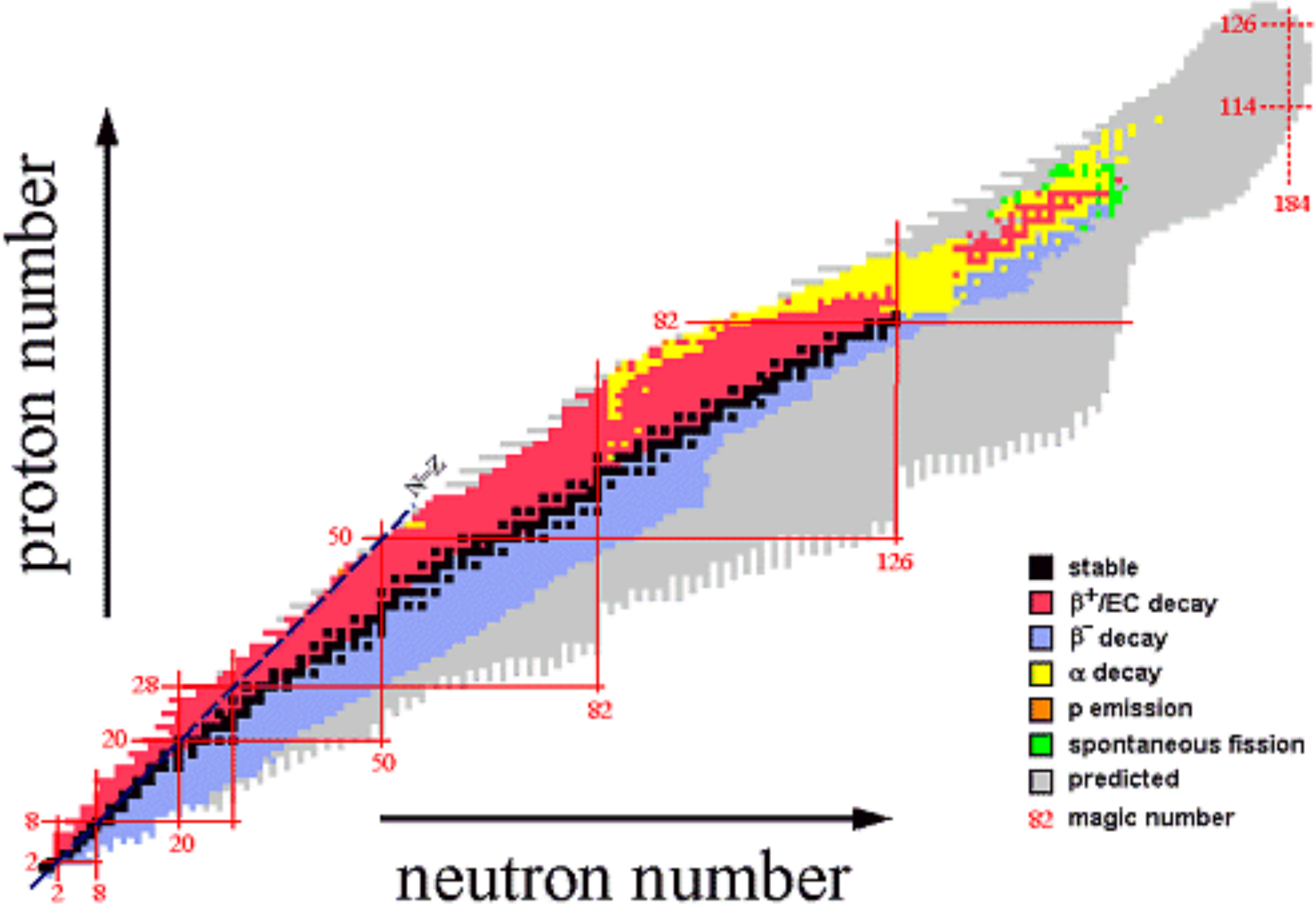





NORMAL
ALZHEIMER'S

β^+ exempel for PET

Isotope	reaction	Halflife (min)
^{18}F	$^{18}O(p,n)^{18}F$	110
^{11}C	$^{14}N(p,\alpha)^{11}C$	20,4
^{15}O	$^{14}N(d,n)^{15}O$	2,1
^{13}N	$^{16}O(p,\alpha)^{13}N$	10


proton number
neutron number
N=Z
2
8
20
28
50
82
126
114
184
stable
β+/EC decay
β- decay
α decay
p emission
spontaneous fission
predicted
82 magic number

Q= $BE_{efter} - BE_{före}$

Fördelaktigt att gå mot max BE

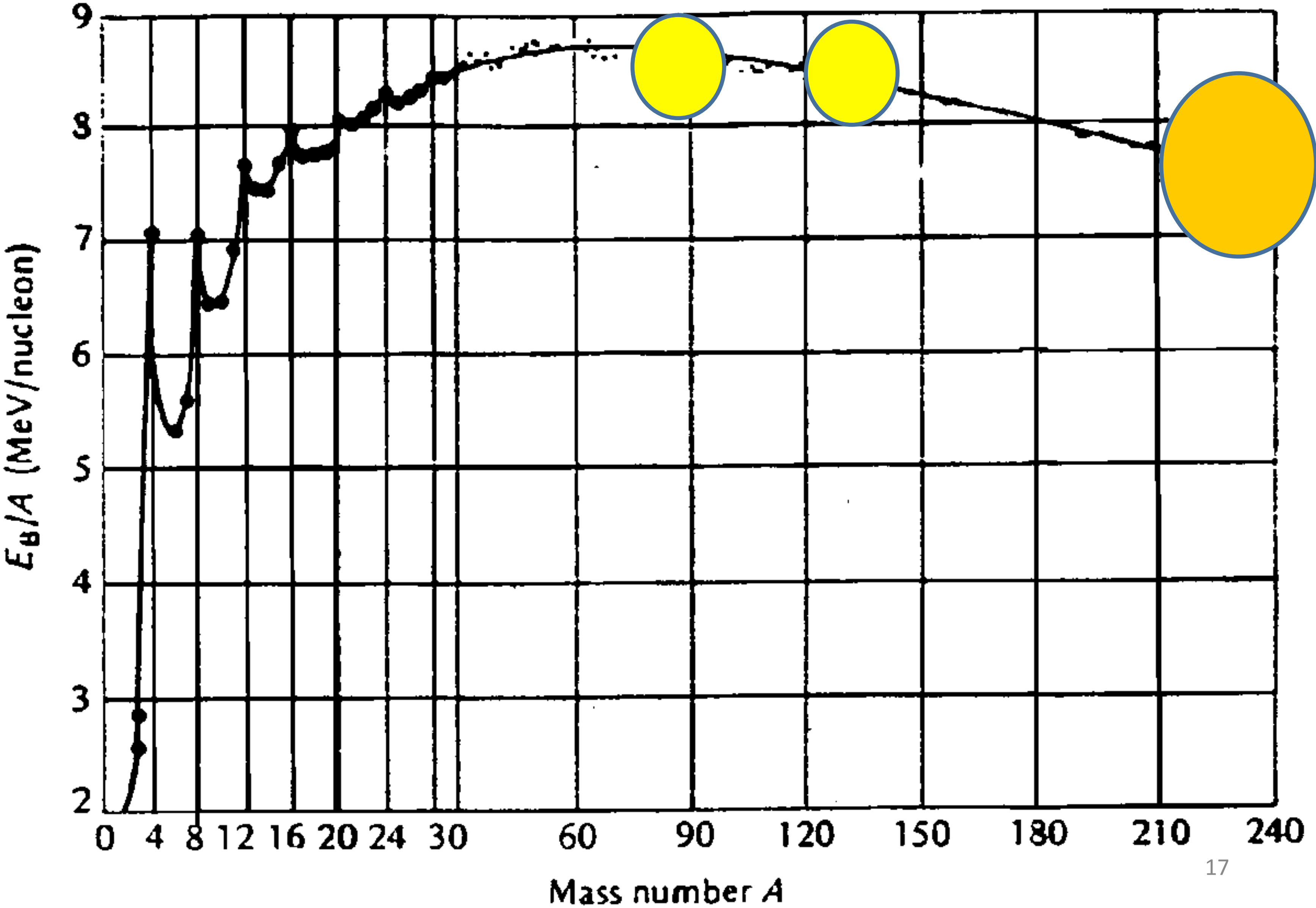


Figure 43.11

Massfördelning av fissionsfragment från ^{235}U

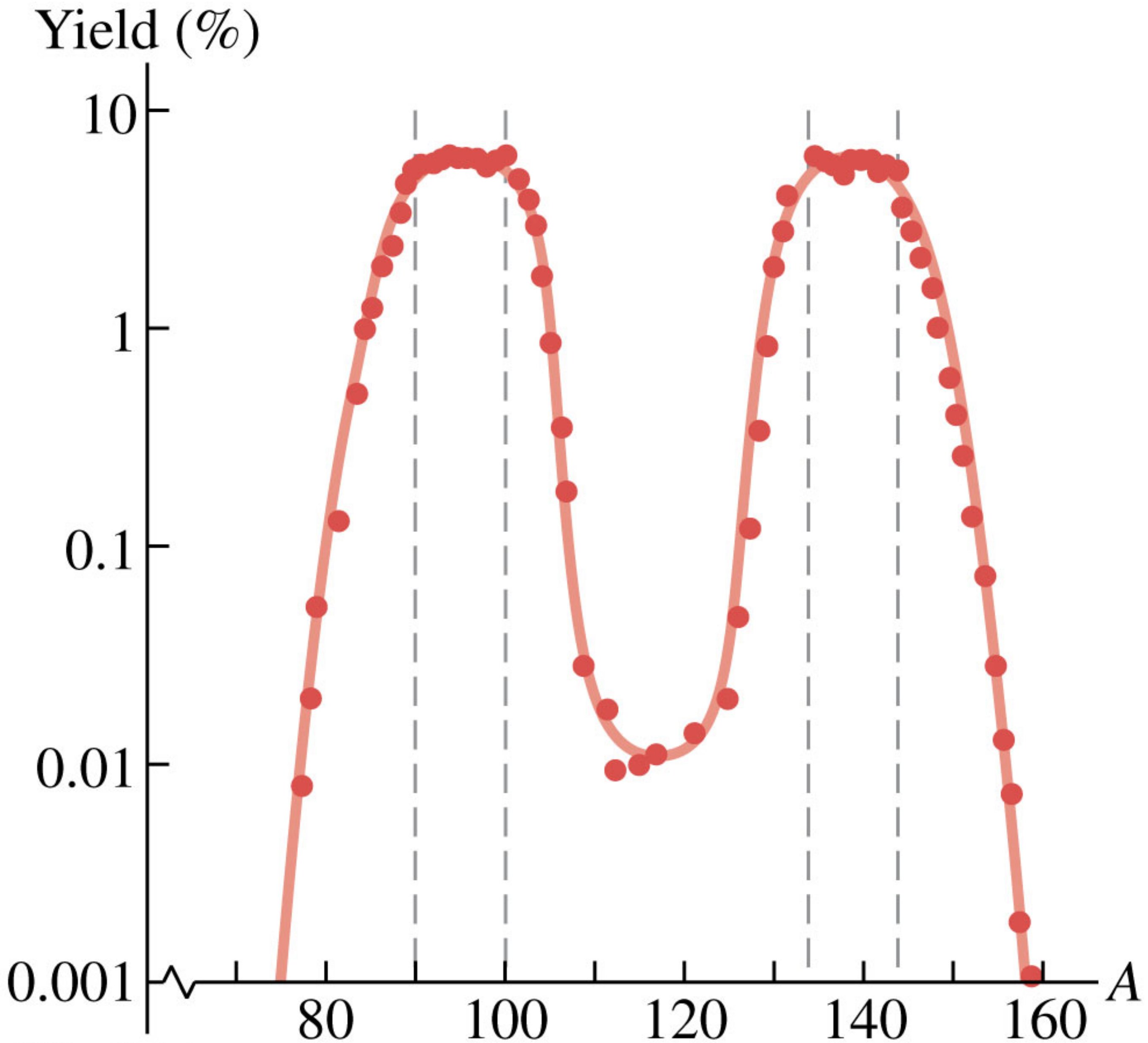
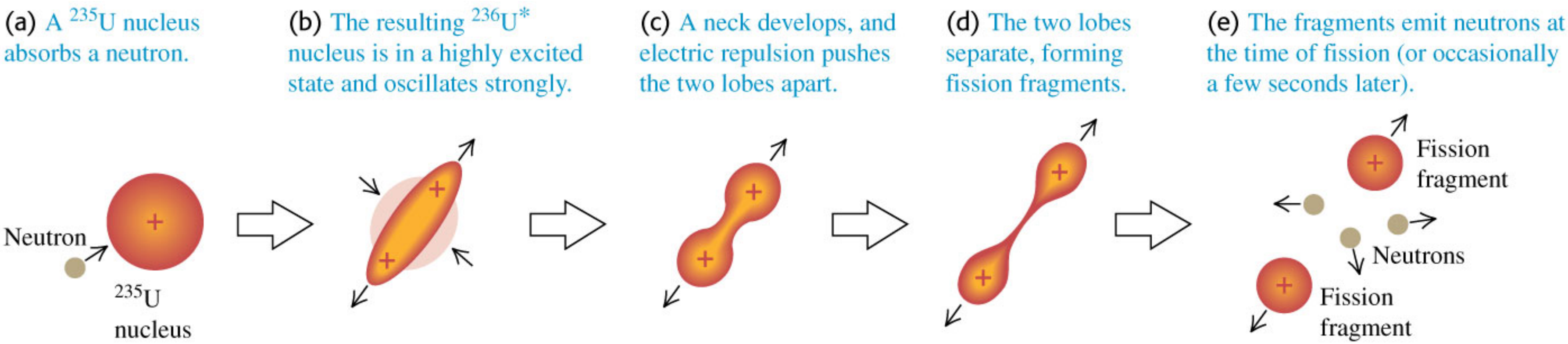


Figure 43.12

Fission



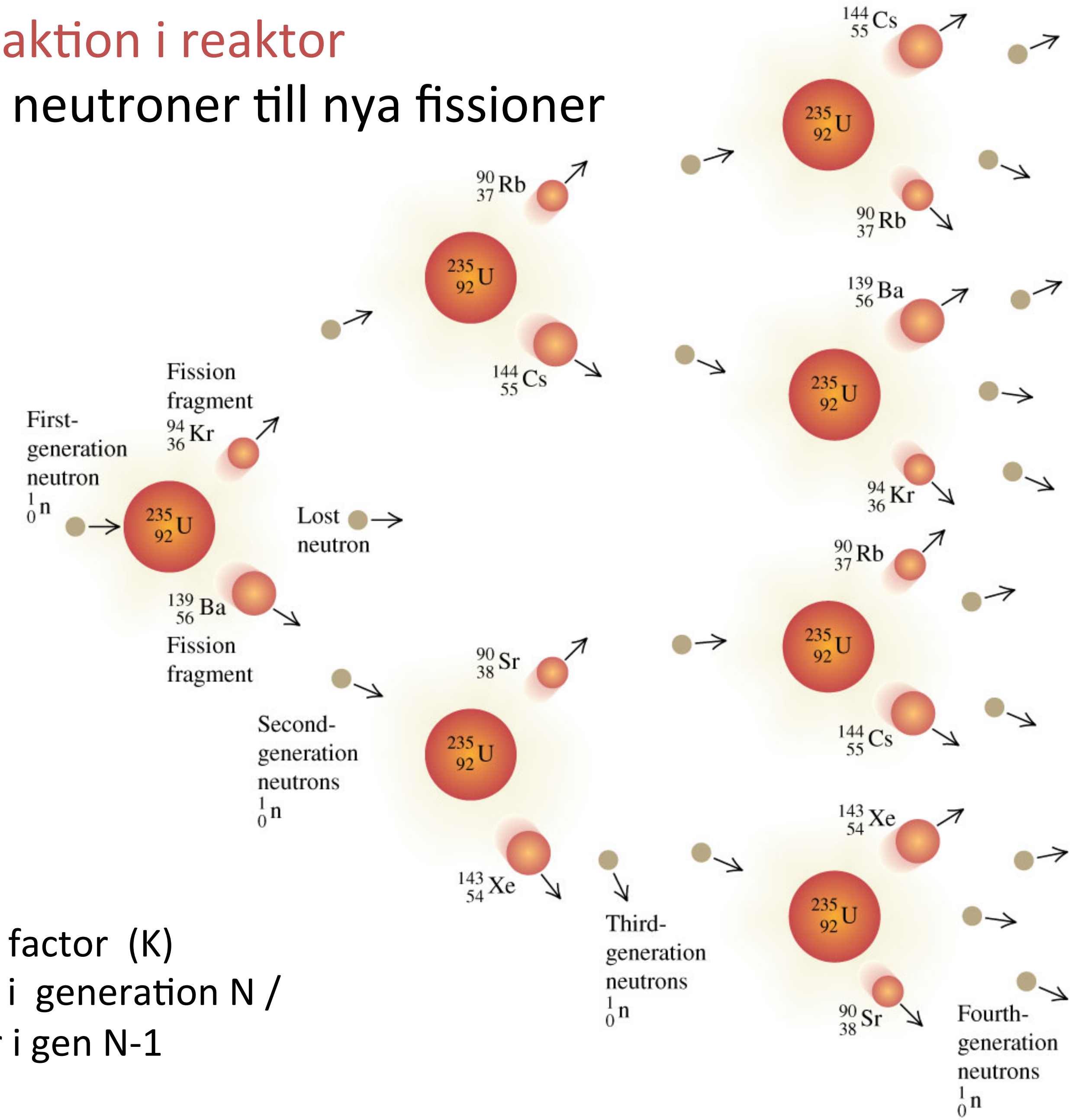
$$^{235}U + n \rightarrow \ldots \rightarrow {}^{90}Sr + {}^{143}Xe + 3\ m_n$$

$$Q = [m_n + m(^{235}U) - m(^{90}Sr) - m(^{143}Xe) - 3m_n]c^2$$

Figure 43.14

Kedjereaktion i reaktor

Använd neutroner till nya fissioner

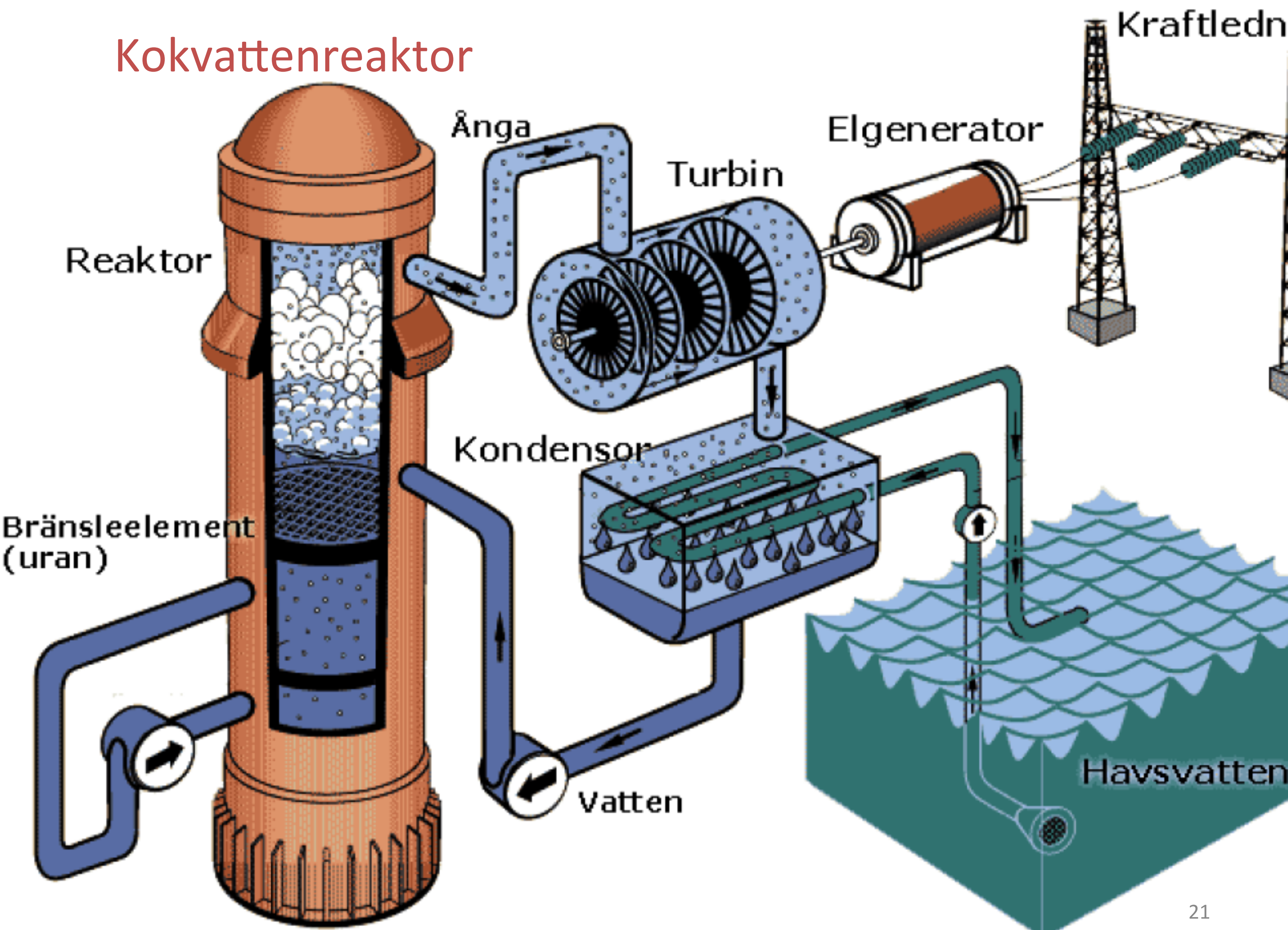


Multiplication factor (K)

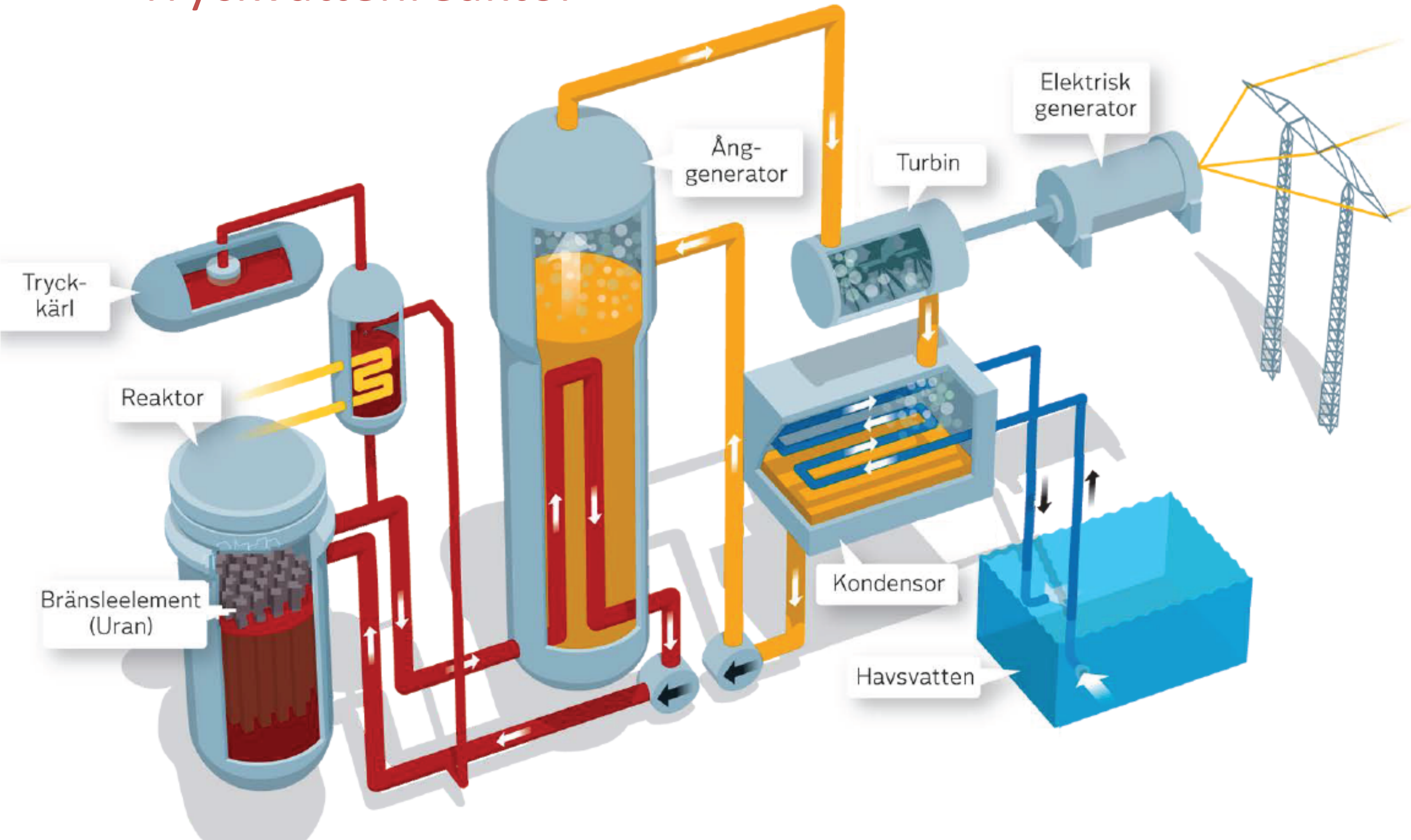
K: #neutroner i generation N /

neutroner i gen N-1

Kokvattenreaktor



Tryckvattenreaktor



FAQ

KTH/SKC har allmän info ang. kärnkraft/bränsle etc
https://www.kth.se/sci/centra/skc/omkarnkraft/
Ska samla ytterligare länkar på
http://www.hep.lu.se/staff/silvermyr/fysa01/

Uran bryts mestadels i Australien och Kanada (även afrikanska länder och Ryssland), anrikas (centrifugering, tidigare diffusion) i bl.a. Frankrike, Holland. Svenskt kärnbränsle, urankutsar, tillverkades i Västerås.
MOX fuel (med plutonium) används i bl.a. Frankrike. Bridreaktorer har varit testanläggningar i bl.a. Frankrike (drivs ej längre)

Andra möjligheter

- Använd neutroner från accelerator typ ESS
- Kan då använda ^{232}Th, som det finns gott om
- Mindre farligt kärnavfall.
- Utvecklingsstudier sedan 60-talet. Mer komplicerat än U cykeln

- Transmutering
- Använd kärnreaktioner för att utvinna energi ur existerande kärnavfall, och göra det mindre farligt.

- Inte så kostnadseffektivt som fission. På utvecklingsstadie – behöver bättre accelerator teknologi

Neutroner från reaktorer används även för radioaktiva tracer-nuklider för medicinska ändamål

Det diagram som betyder mest för våra livsbetingelser…

Fusion av lätta kärnor
Q > 0
Exoterm reaktion

Fission av tunga kärnor
Q > 0
Exoterm reaktion

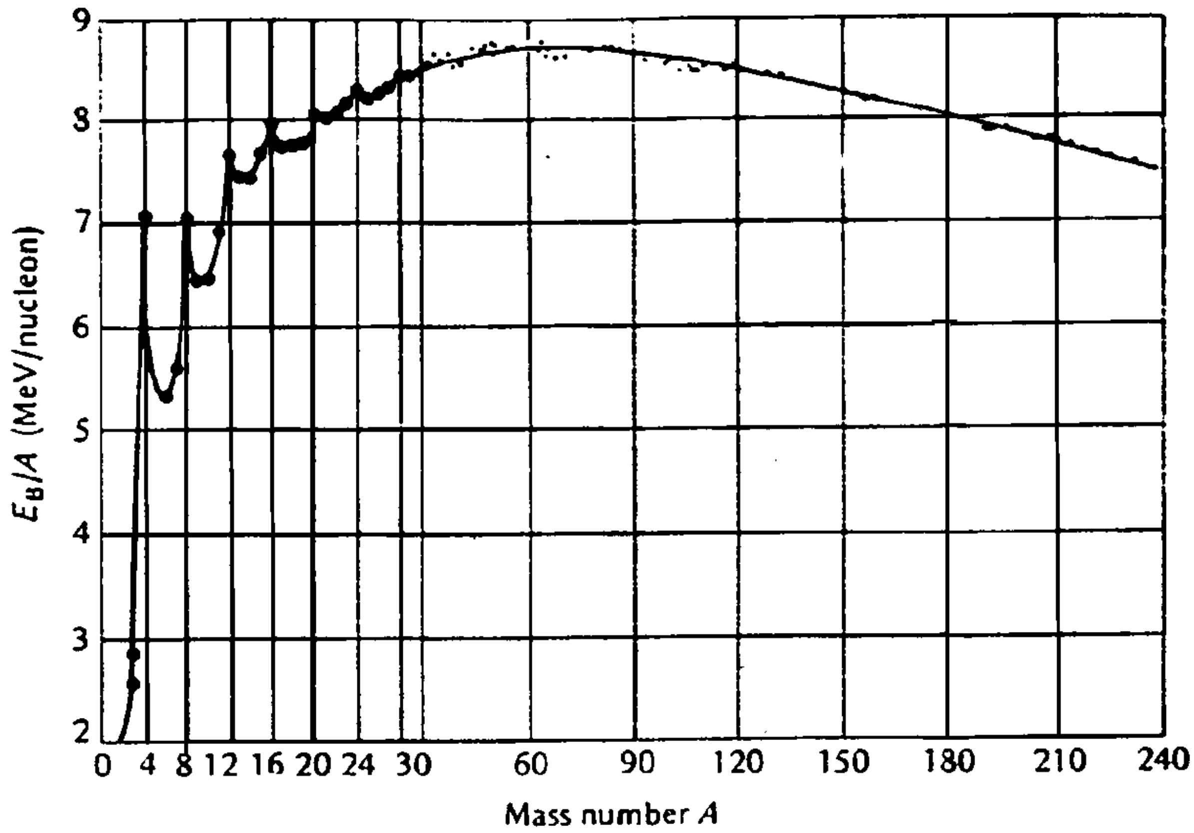
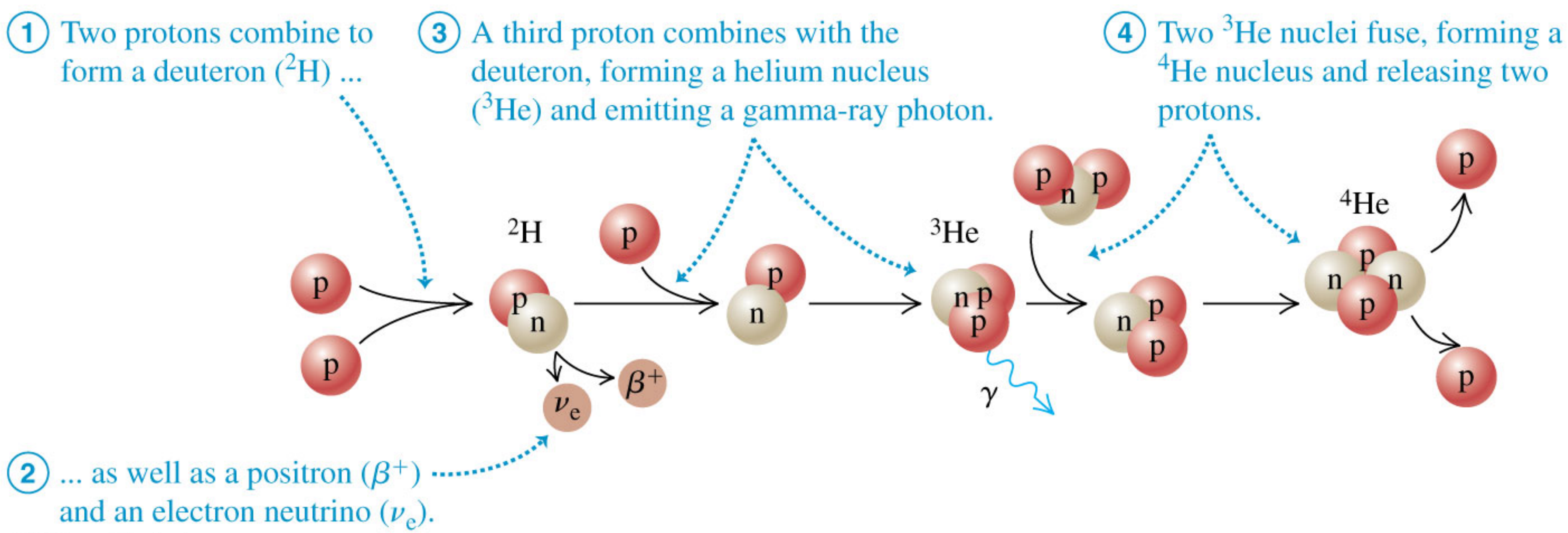


Figure 43.16

Fusion, pp cykeln i solen



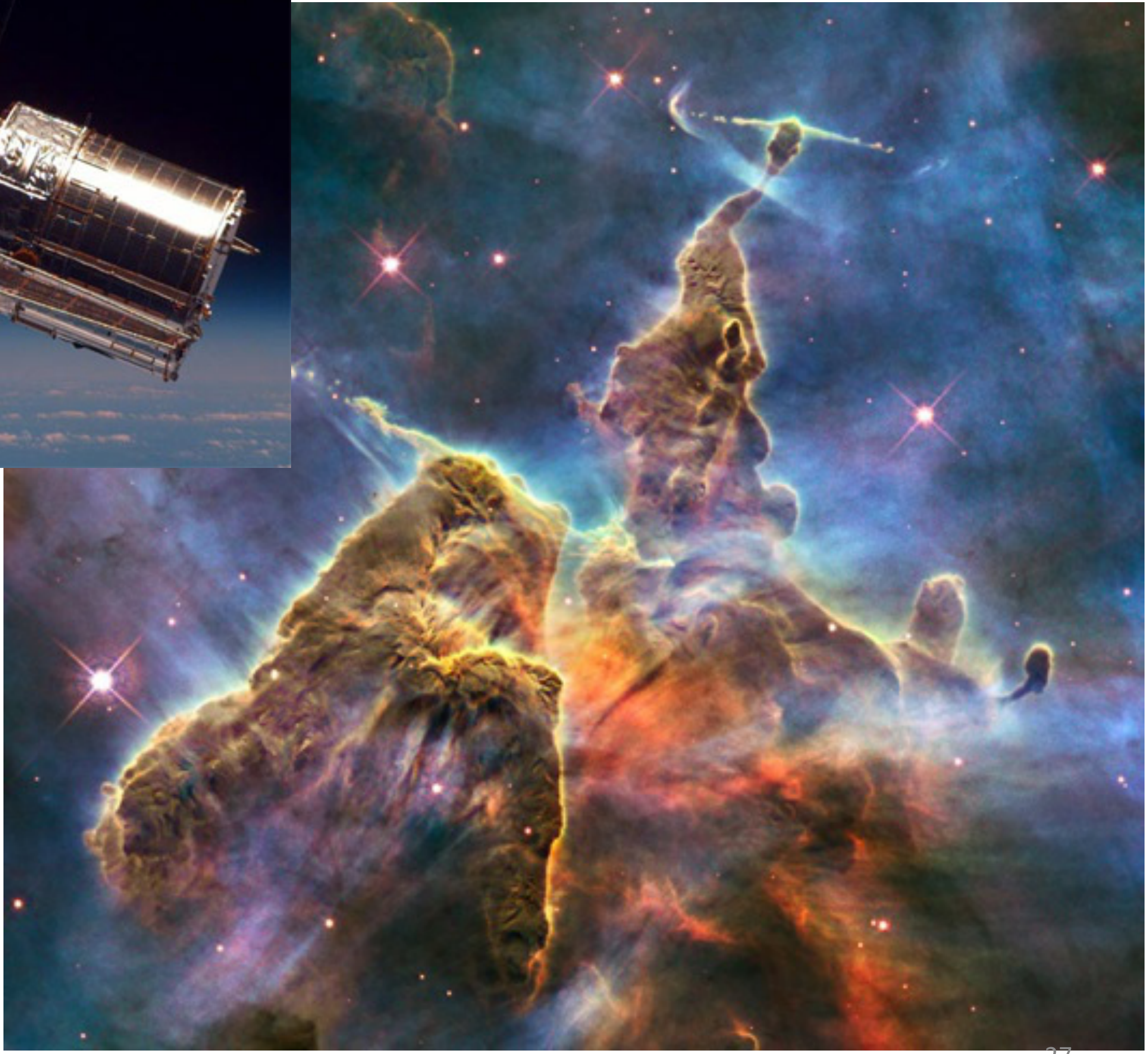
$^{1}H + ^{1}H \rightarrow ^{2}H + e^{+} + \nu_{e}$

$^{1}H + ^{2}H \rightarrow ^{3}He + \gamma$

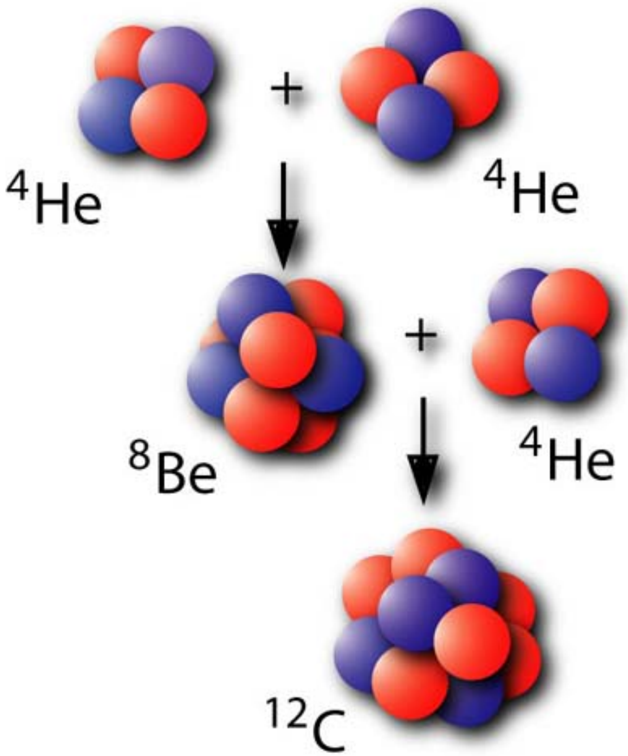
$^{3}He + ^{3}He \rightarrow ^{4}He + ^{1}H + ^{1}H$

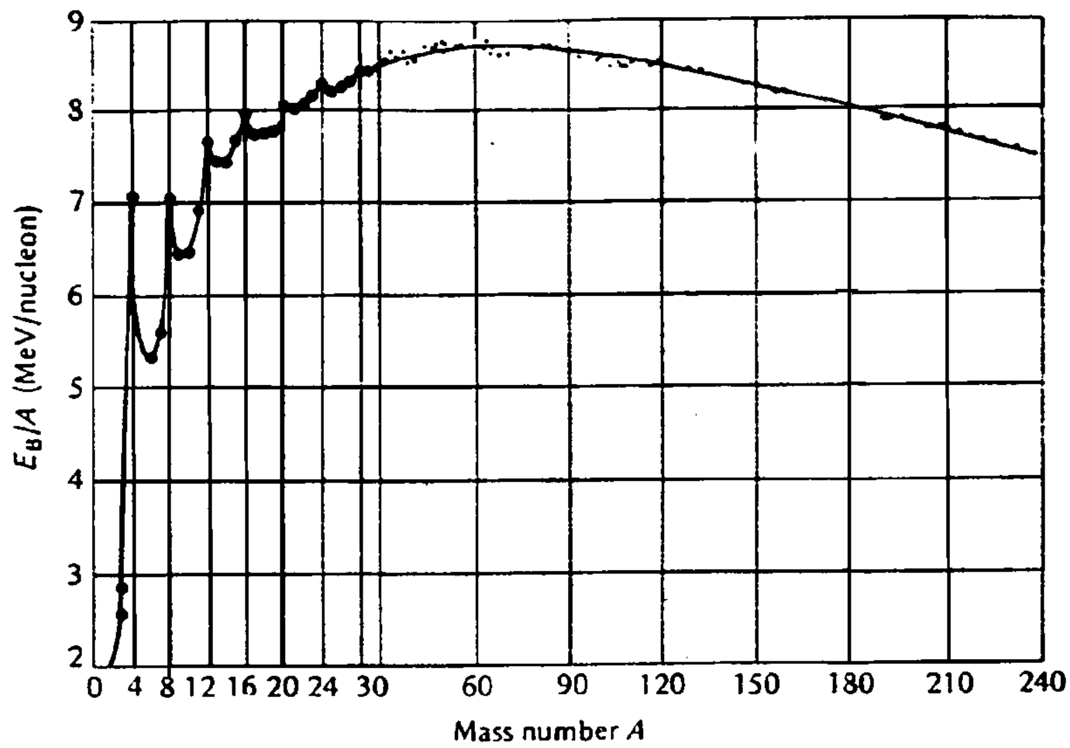
En stjärna föds…

Hubble teleskopet



Trippel alfa processen

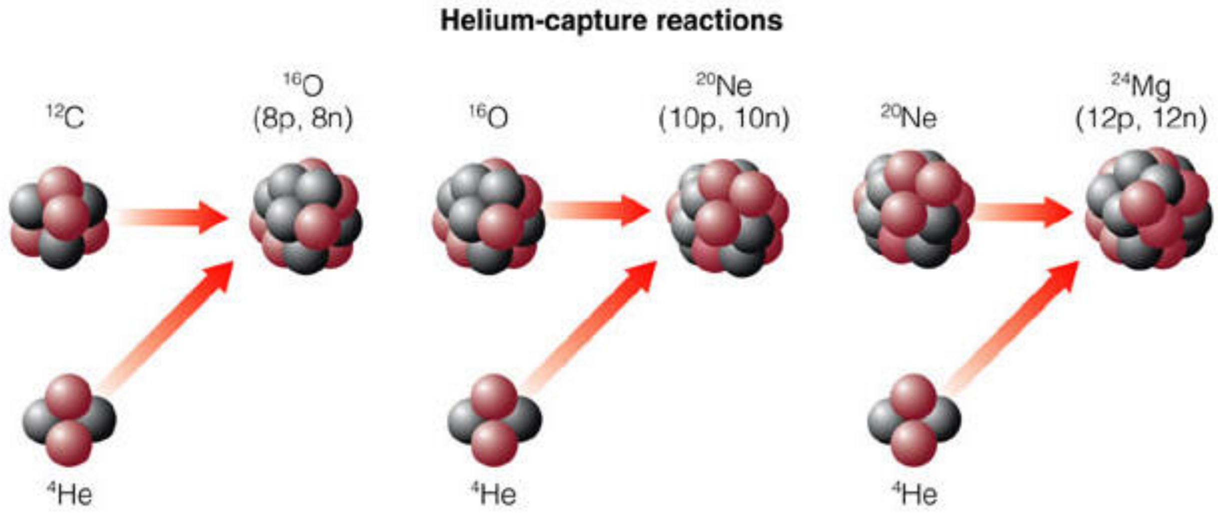




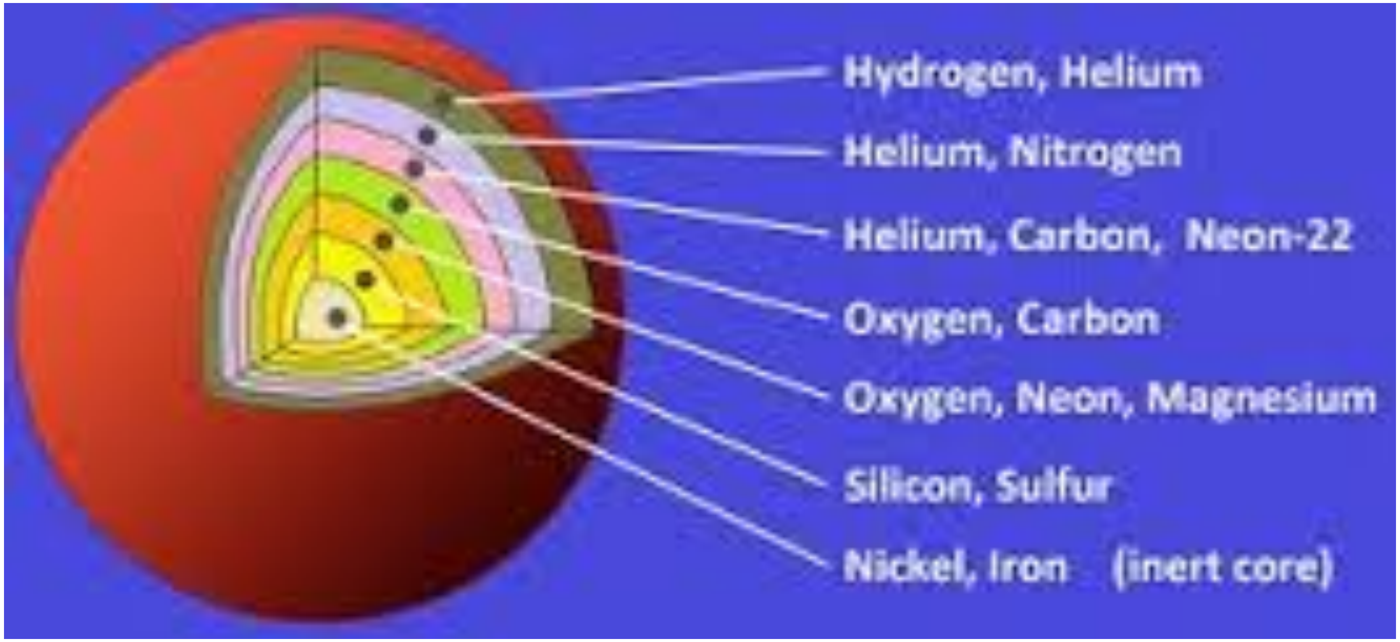
^{8}Be extremt kortlivad (~10^{-16}s)

$$
\begin{aligned}
{}^{12}C + {}^{12}C &\rightarrow {}^{16}O + 2\,{}^{4}He \\
&\rightarrow {}^{20}Ne + {}^{4}He \\
&\rightarrow {}^{23}Na + p^{+} \\
&\rightarrow {}^{23}Mg + n \\
&\rightarrow {}^{24}Mg + \gamma
\end{aligned}
$$

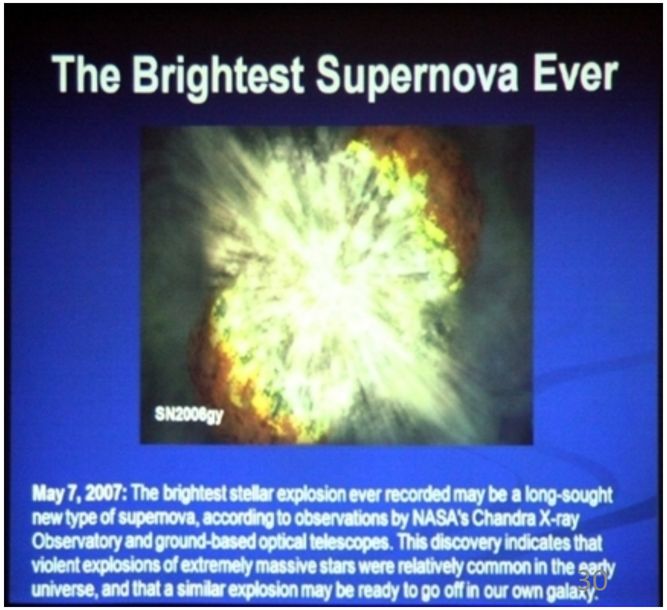
Kolförbränning,
Syreförbränning,...



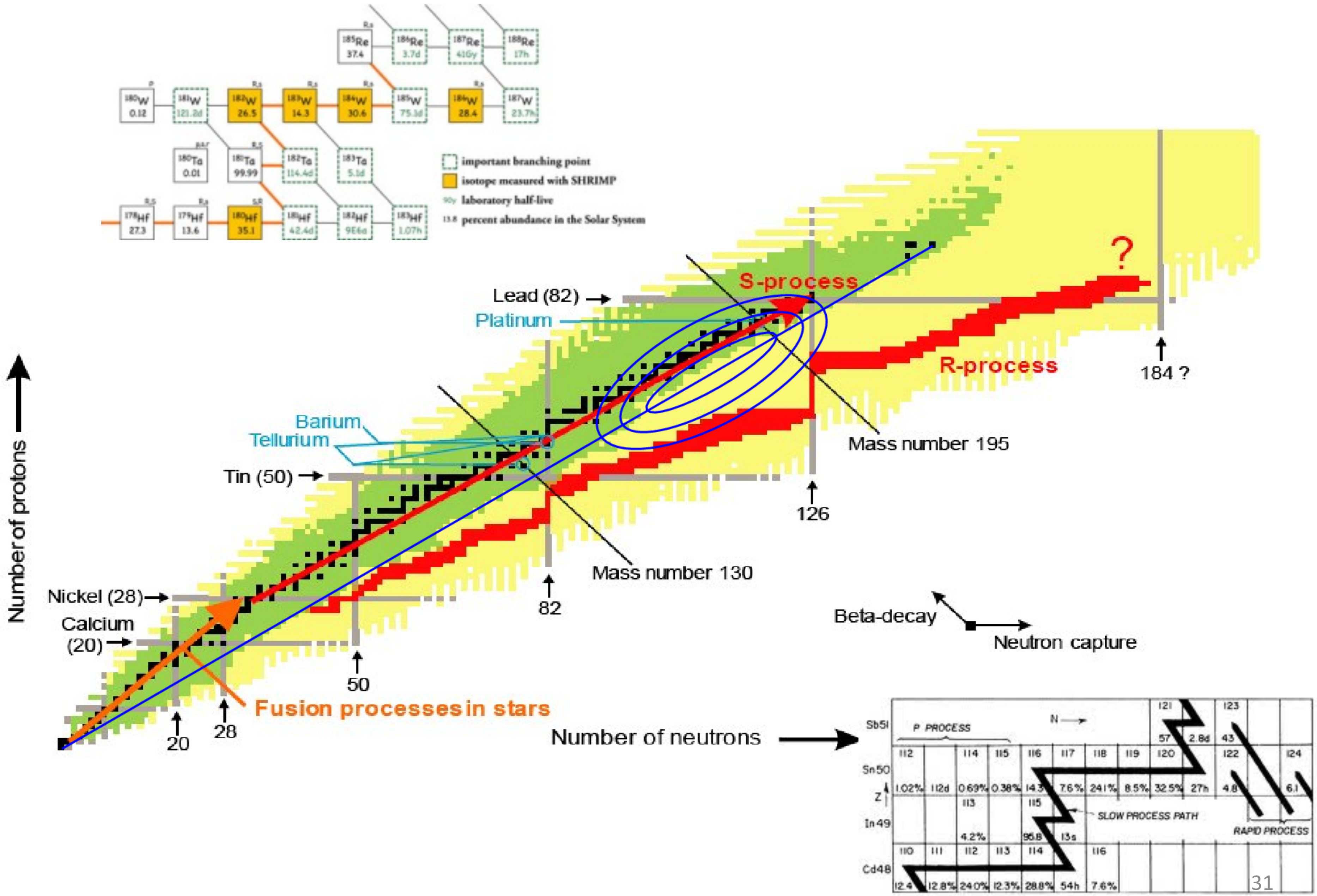
Fe i centrum



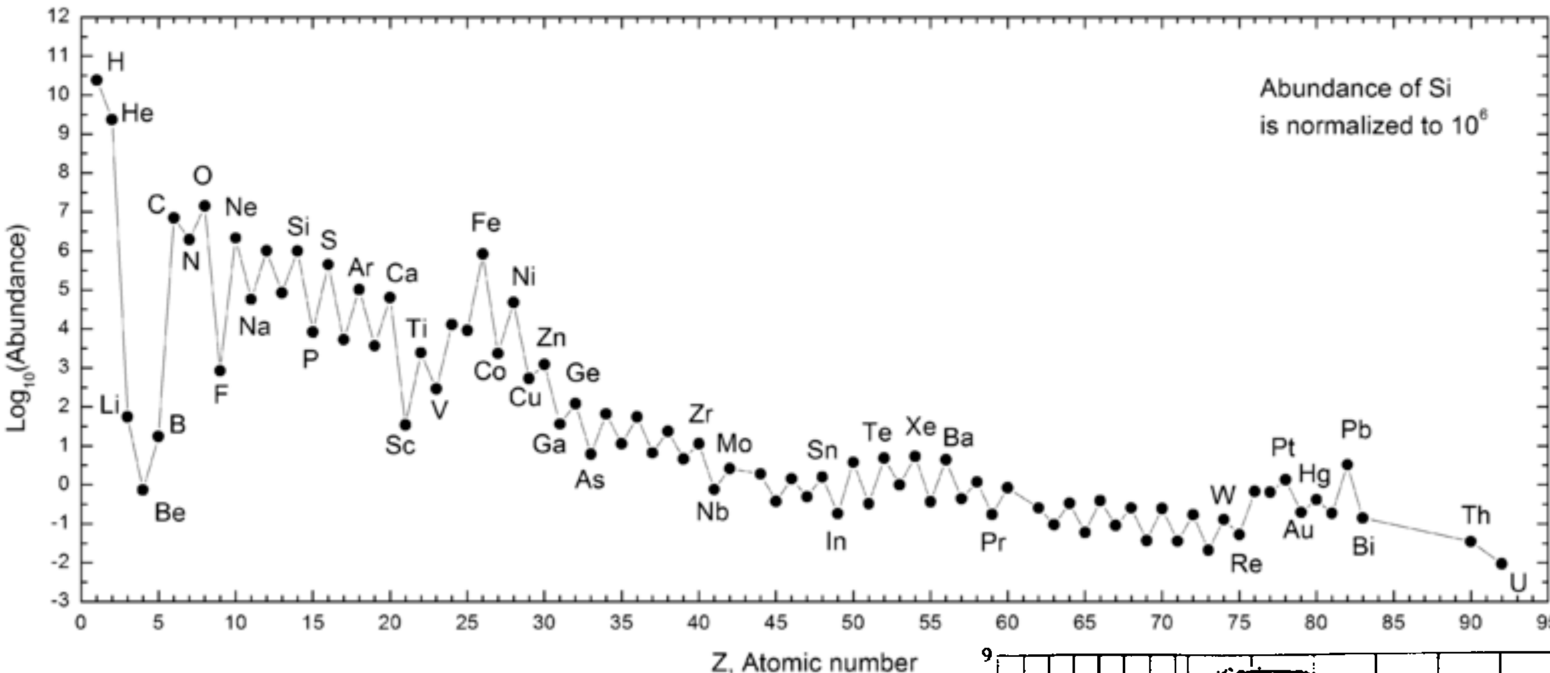
Hydrogen, Helium
Helium, Nitrogen
Helium, Carbon, Neon-22
Oxygen, Carbon
Oxygen, Neon, Magnesium
Silicon, Sulfur
Nickel, Iron (inert core)



The Brightest Supernova Ever
SN2006gy
May 7, 2007: The brightest stellar explosion ever recorded may be a long-sought new type of supernova, according to observations by NASA's Chandra X-ray Observatory and ground-based optical telescopes. This discovery indicates that violent explosions of extremely massive stars were relatively common in the early universe, and that a similar explosion may be ready to go off in our own galaxy.


important branching point
isotope measured with SHRIMP
laboratory half-live
percent abundance in the Solar System
S-process
R-process
?
Lead (82)
Platinum
Barium
Tellurium
Tin (50)
Nickel (28)
Calcium (20)
Fusion processes in stars
Mass number 195
Mass number 130
184 ?
126
82
50
28
20
Number of protons
Number of neutrons
Beta-decay
Neutron capture
P PROCESS
SLOW PROCESS PATH
RAPID PROCESS

Grundämnenas förekomst i solsystemet



N.B:
Li/Be/B brist
Udda-jämn effect
Även ämnen tyngre än Fe

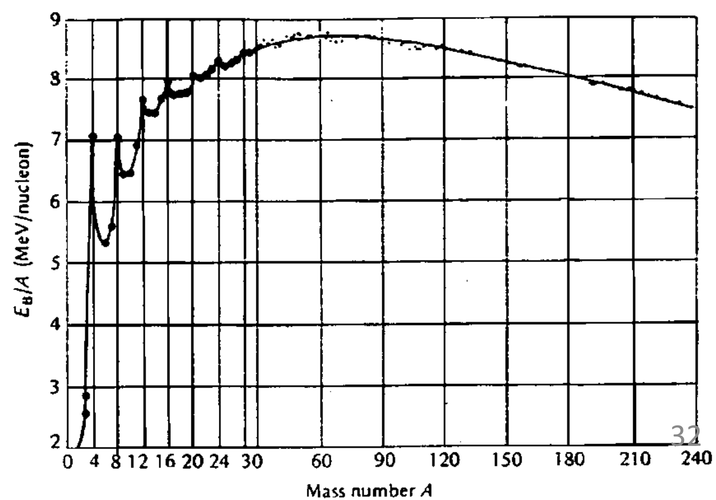
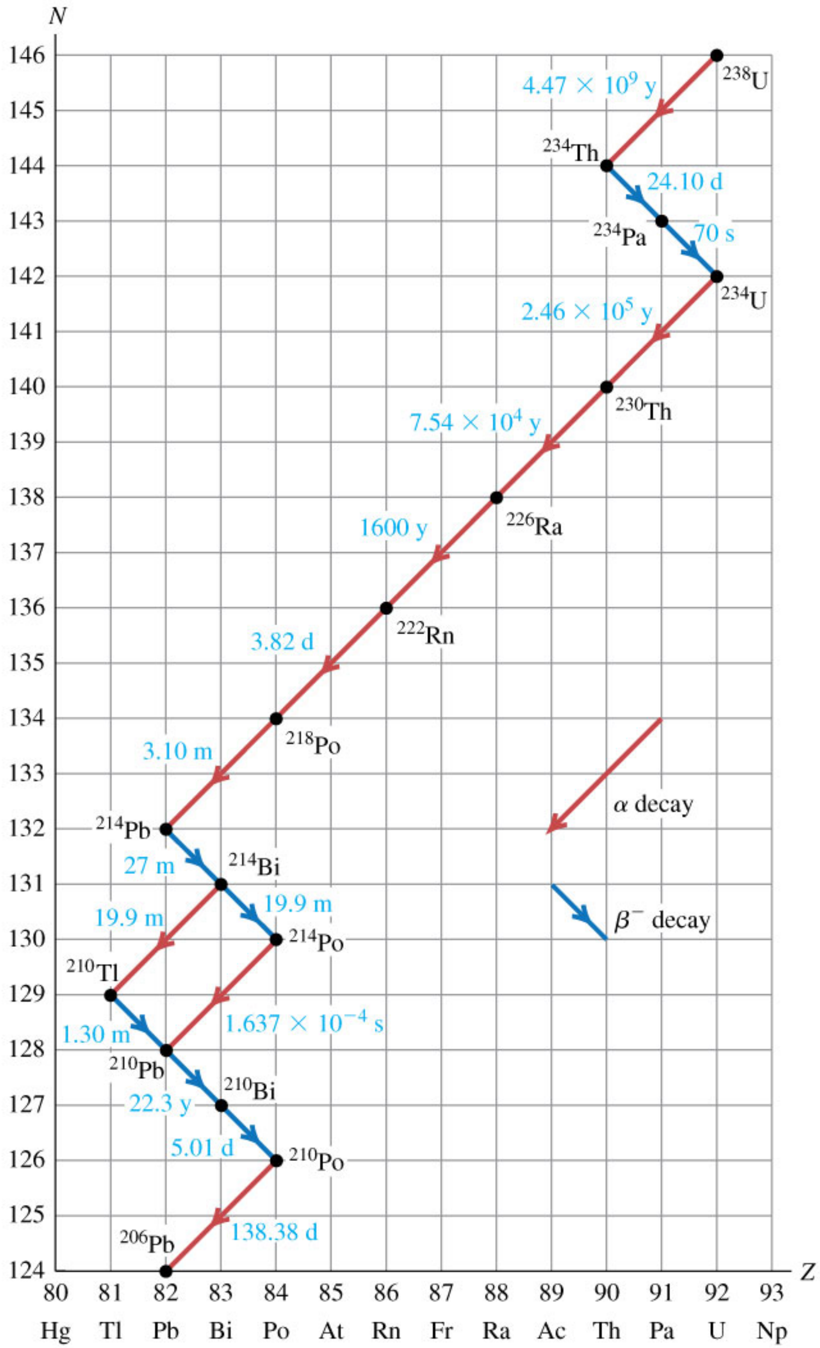


Figure 43.7

Uranium series



4 series in nature

Uranium
Actinium
Thorium
Neptunium

All end in Pb isotope