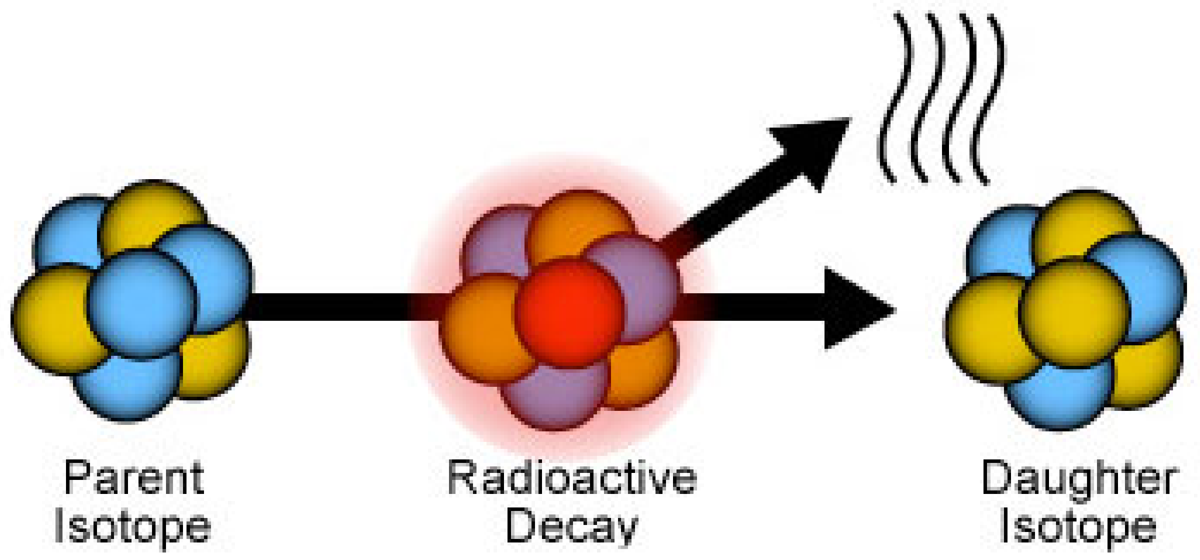
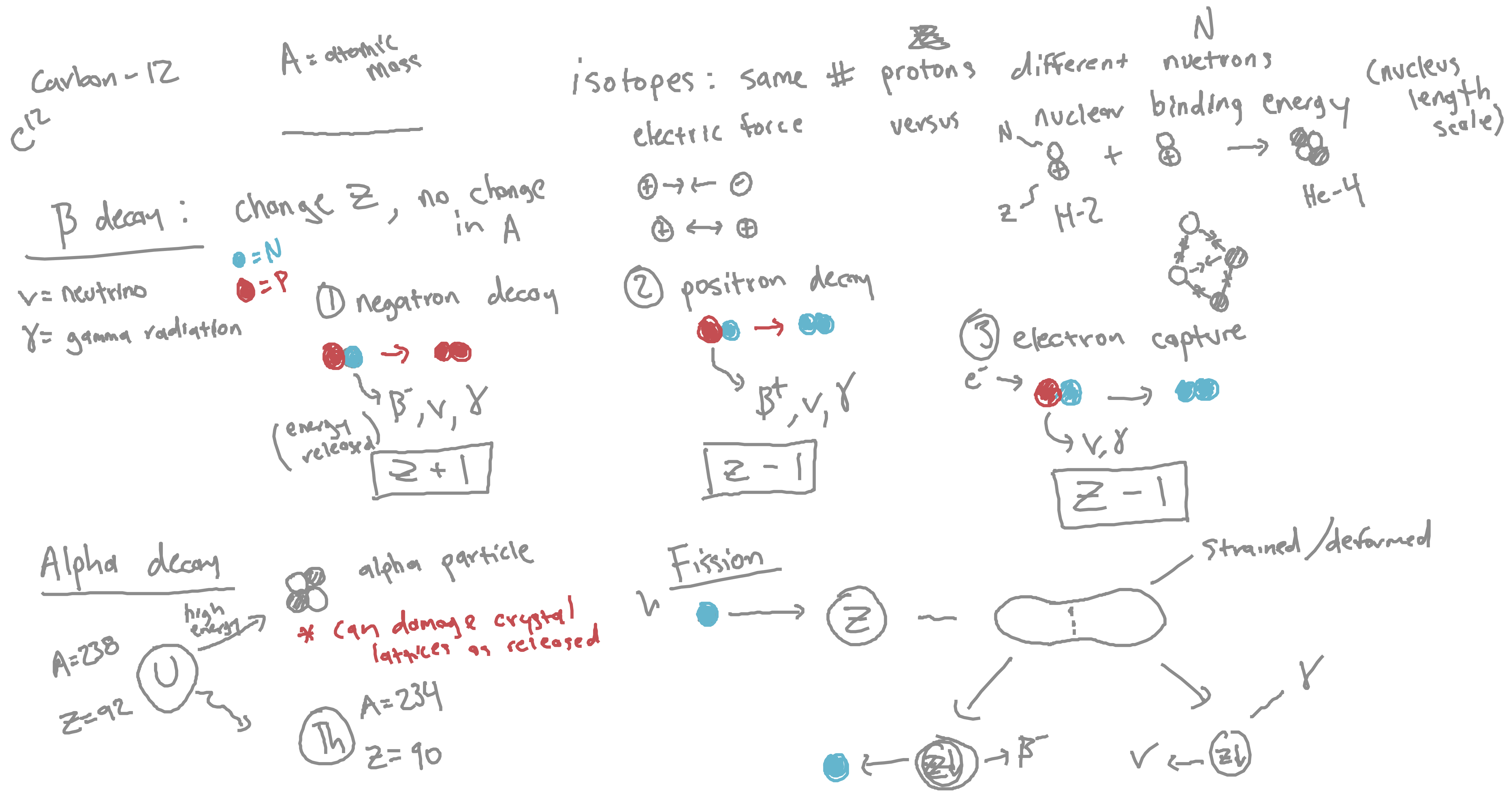


Lecture 11: Radioactive Decay

1. Mechanisms
2. The decay equation

We acknowledge and respect the lək̓ʷəŋən peoples on whose traditional territory the university stands and the Songhees, Esquimalt and W̱SÁNEĆ peoples whose historical relationships with the land continue to this day.

Mechanisms of radioactive decay.



The decay equation.

Rutherford + Soddy 1902

N = number of moles of an isotope

$$\frac{dN}{dt} \propto N \qquad \frac{dN}{dt} = -\lambda N$$

λ ← proportionality constant
decay constant

$$\int \frac{dN}{N} = \int -\lambda\, dt \qquad \ln x \Big|_{N_0}^{N}$$

$$\ln N - \ln C = -\lambda t$$

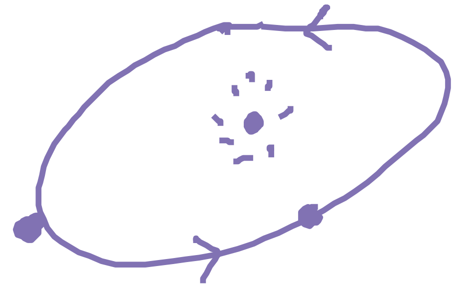
N_0 = initial concentration of N

$$\ln \frac{N}{C} = -\lambda t$$

$$e^{-\lambda t} = \frac{N}{C} \qquad C e^{-\lambda t} = N \qquad N_0 e^{-\lambda t} = N$$

Experiments to test "constant"

- ↳ high vs low T
- ↳ high or low P
- ↳ high vs low Magnetic field



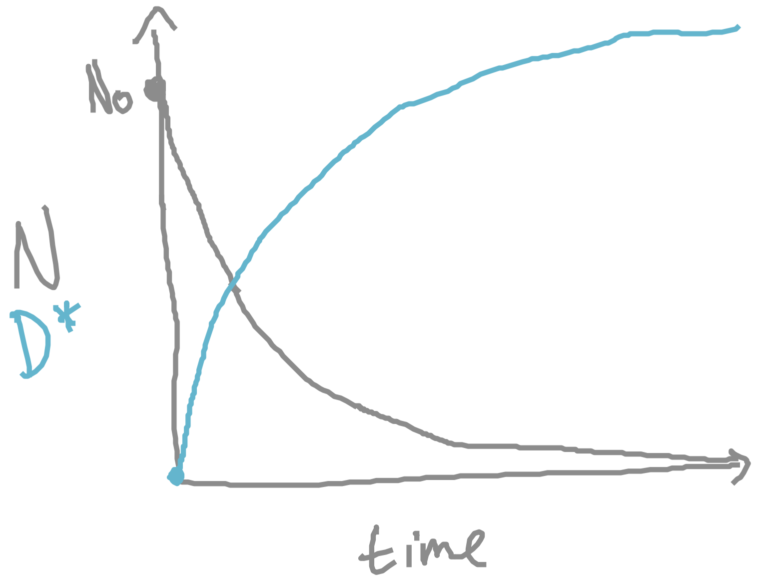
no change from gravity

The decay equation.

measurable

$N_0 e^{-\lambda t} = N$

not measurable — measurable



N = parent isotope

D = descendant isotope

$N_0 e^{-\lambda t} = N$

$N e^{\lambda t} = N_0$

reversible

$D^* = N_0 - N$ Descendant created by the decay of N

$D^* = N e^{\lambda t} - N_0 e^{-\lambda t}$ * hard to measure absolute values, so ratio w/ stable isotope common

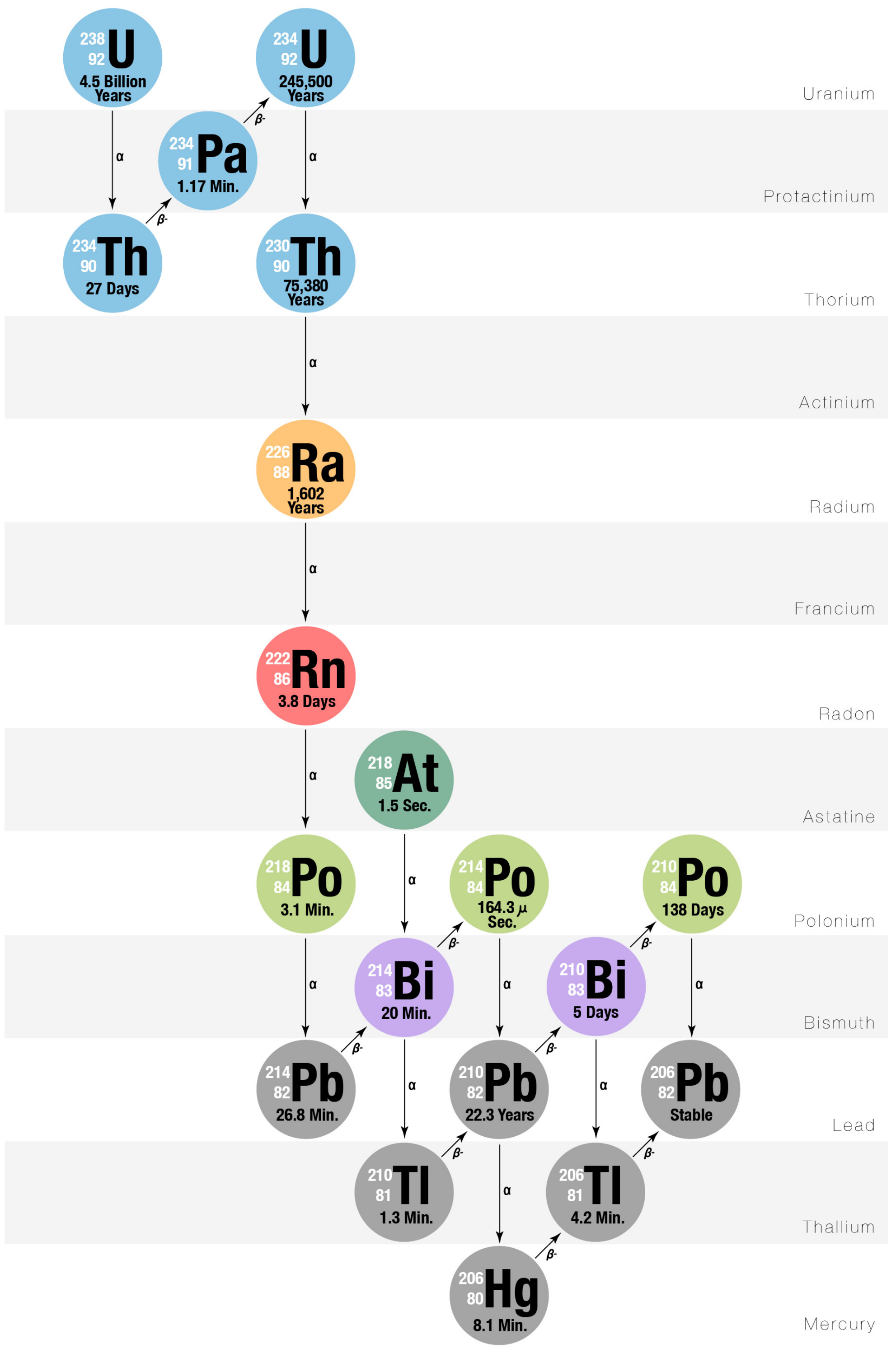
$D^* = N(e^{\lambda t} - 1)$

↑ measured

$\frac{D}{X} = \frac{D_0}{X} + \frac{N}{X}(e^{\lambda t} - 1)$

$D = D_0 + D^*$

initial D — generated D



238 92 U 4.5 Billion Years
234 92 U 245,500 Years
234 91 Pa 1.17 Min.
234 90 Th 27 Days
230 90 Th 75,380 Years
226 88 Ra 1,602 Years
222 86 Rn 3.8 Days
218 85 At 1.5 Sec.
218 84 Po 3.1 Min.
214 84 Po 164.3 μ Sec.
210 84 Po 138 Days
214 83 Bi 20 Min.
210 83 Bi 5 Days
214 82 Pb 26.8 Min.
210 82 Pb 22.3 Years
206 82 Pb Stable
210 81 Tl 1.3 Min.
206 81 Tl 4.2 Min.
206 80 Hg 8.1 Min.
α
β-
Uranium
Protactinium
Thorium
Actinium
Radium
Francium
Radon
Astatine
Polonium
Bismuth
Lead
Thallium
Mercury