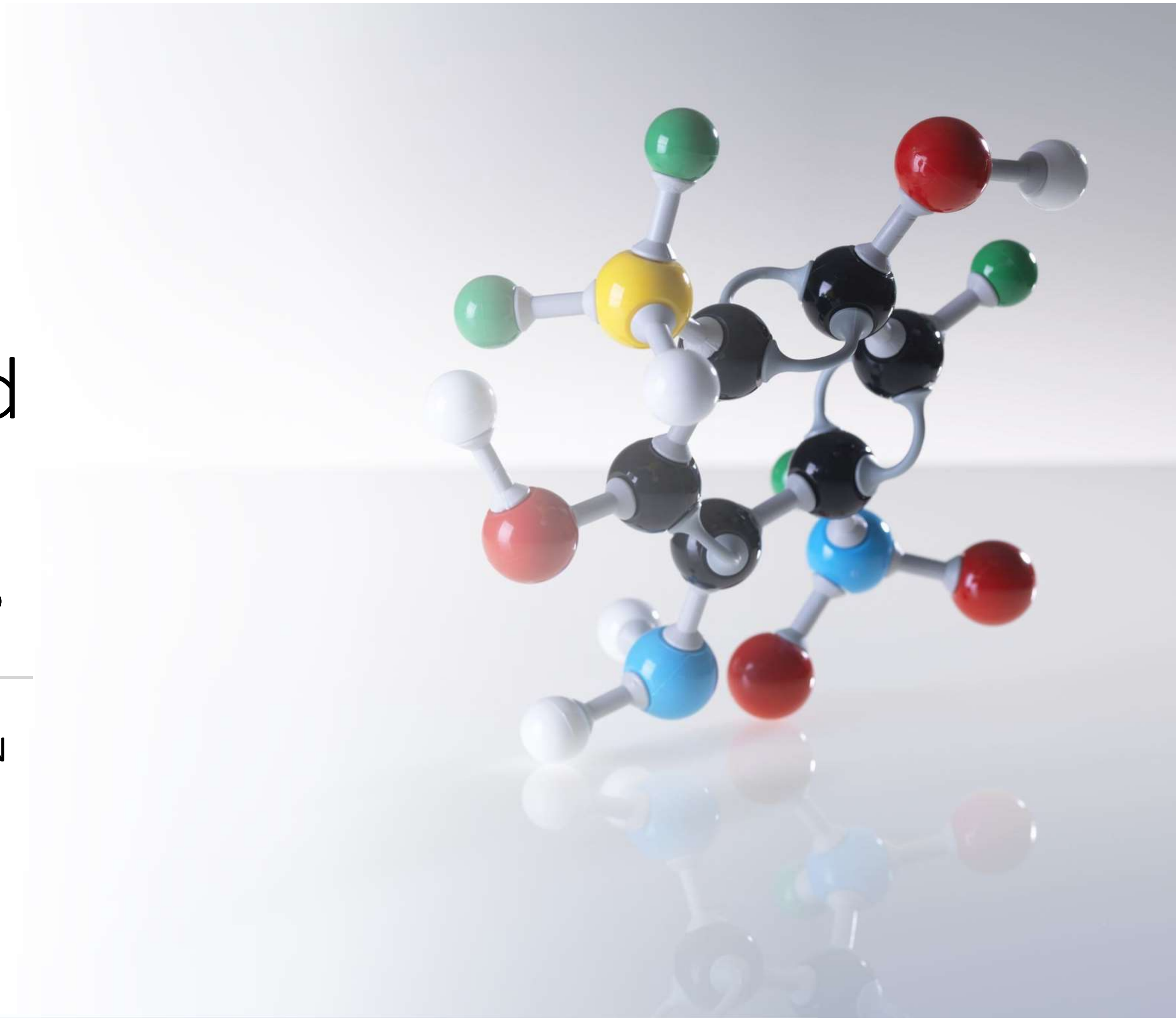
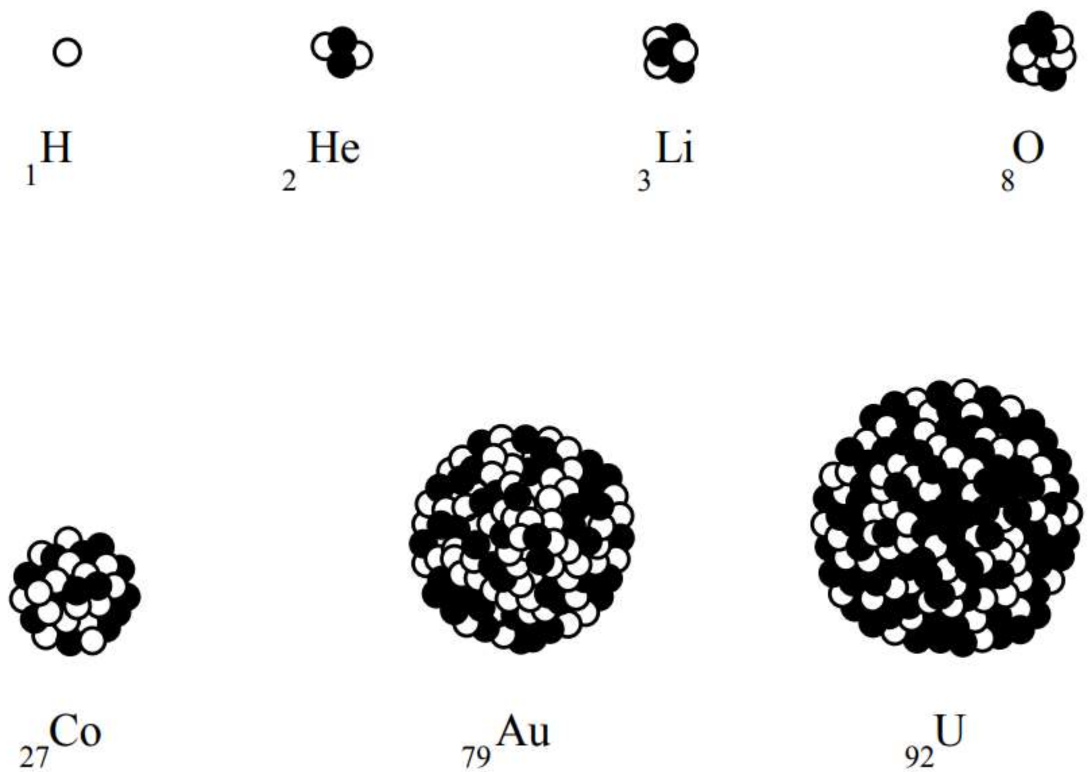
Introduction to Fission-Induced Nuclear Particle Physics

(Explained and Simplified by a USN Reactor Operator)





Atomic Number = Protons

Naturally Occurring Uranium

$^{234}_{92}U$	$^{235}_{92}U$	$^{238}_{92}U$
92 Protons 142 Neutrons	92 Protons 143 Neutrons	92 Protons 146 Neutrons

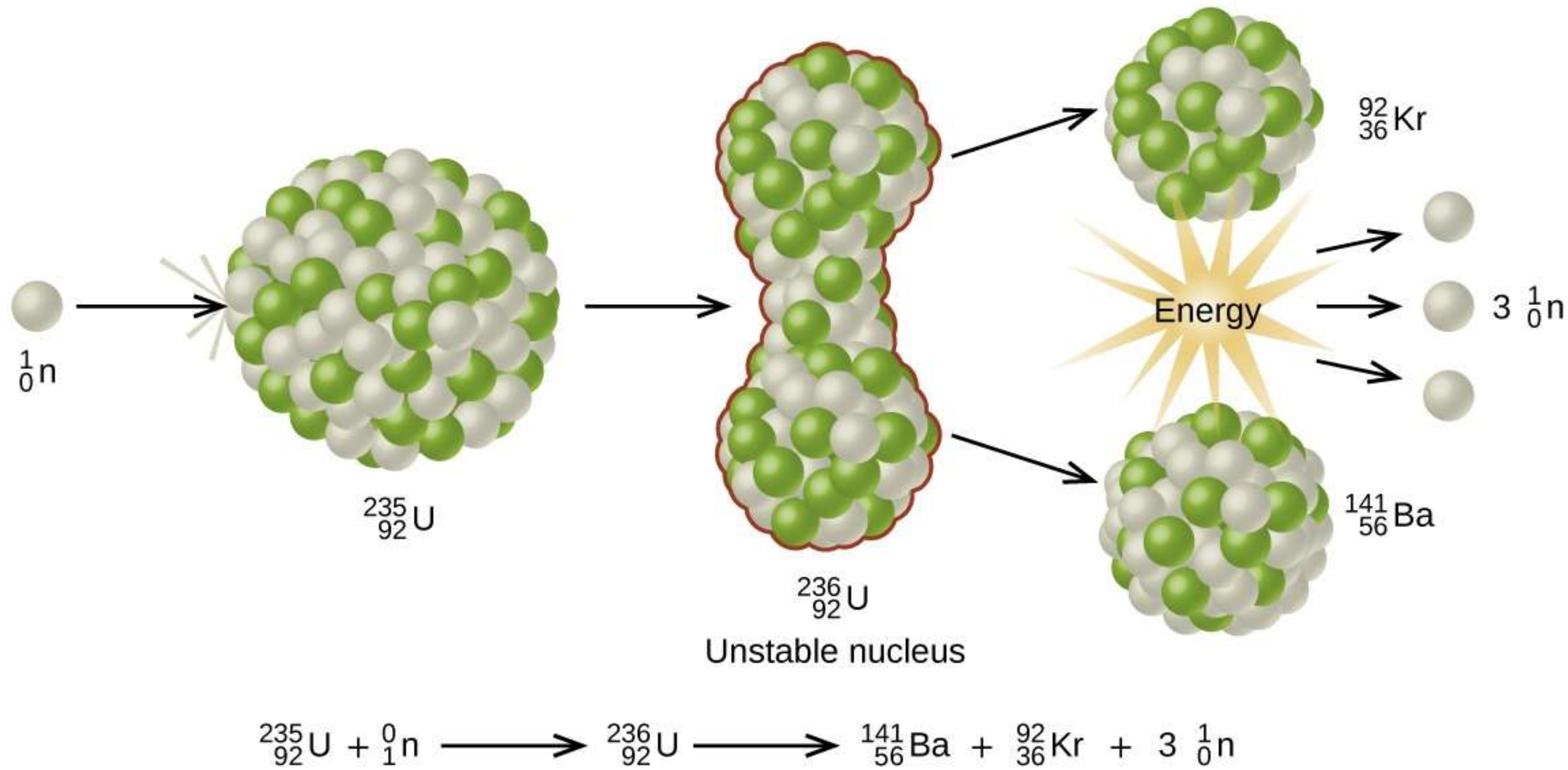
Isotope = Protons + Neutrons

ENRICHMENT
(% U-235)

Uranium Ore (0.7%)

Fuel Pellet (3.5%)

Not just any rock will do…
We need more isotopes that
produce controllable fission.



Fission (Liquid Drop Model)

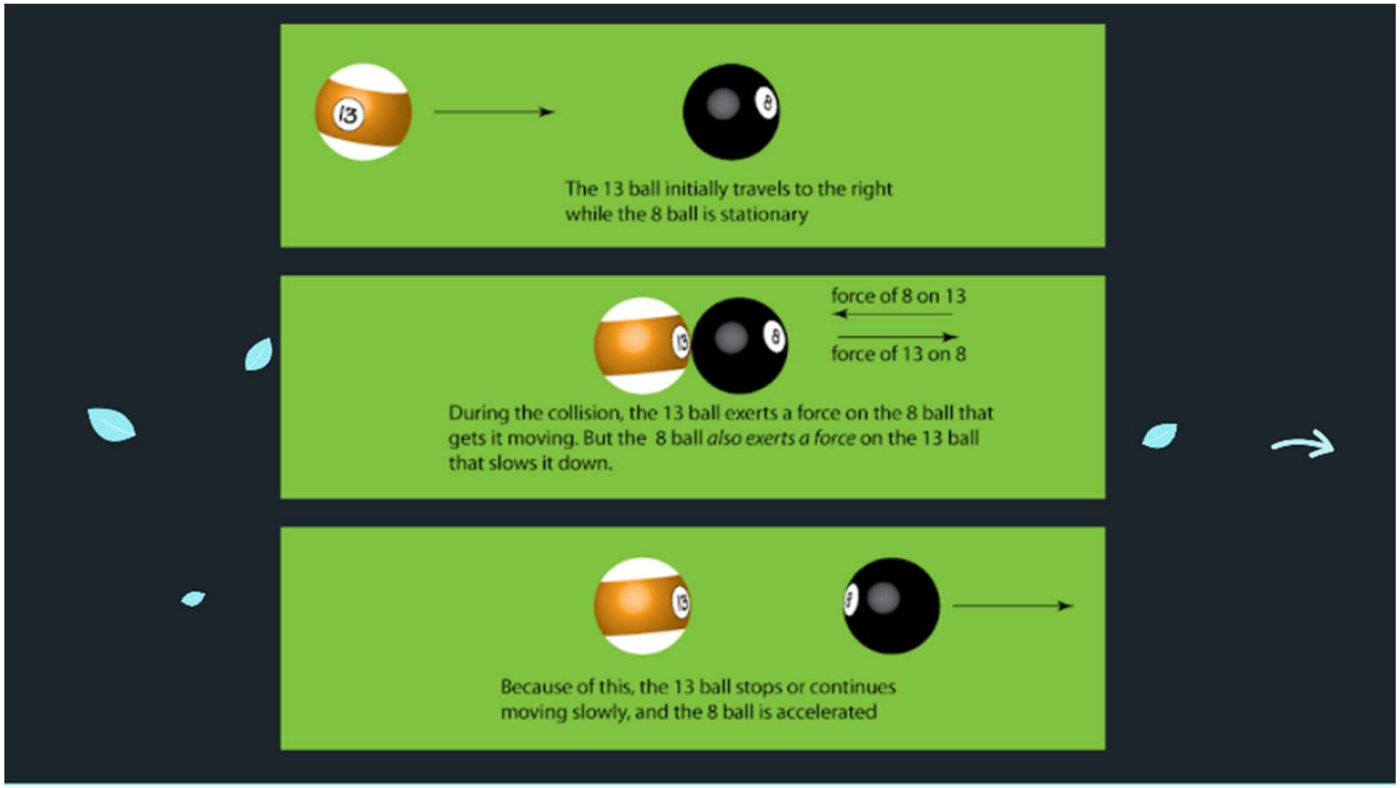
1st Law of Motion: A object at rest will stay at rest and an object in motion will stay in motion unless acted upon by an outside force

Examples of 1st Law: unless another ball hits the ball, it will not move

2nd Law of Motion: force = mass x acceleration

Examples of 2nd Law: the acceleration of the ball is determined by how heavy it is and how much force you hit it with

3rd Law of Motion: for every action, there is an equal and opposite reaction
Examples of 3rd Law: if you hit cue ball, it shoots toward the ball you were aiming towards



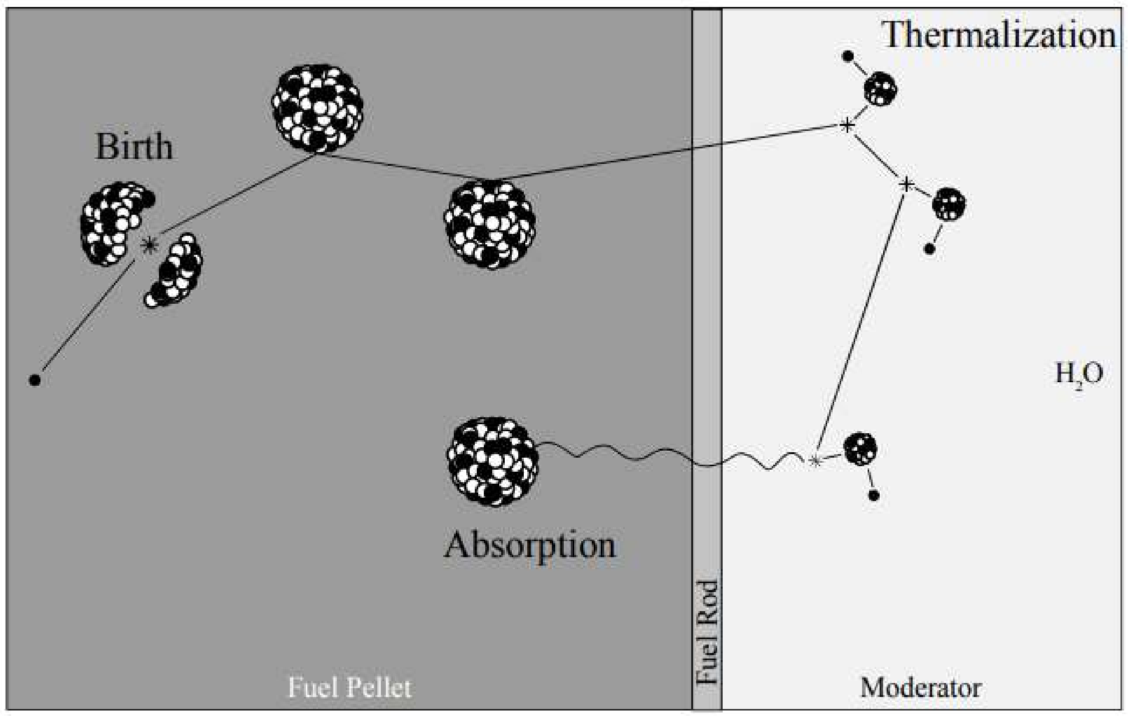
Newton’s Laws At Work

Fission creates “fast” neutrons.
Fast neutrons are not readily absorbed by the U235.

Fast neutrons transfer their energy through similar sized particles (Hydrogen)

Neutron = 1.008665 amu

H Atom = 1 amu



A “slow” (thermal) neutron creates fission by becoming absorbed by U235

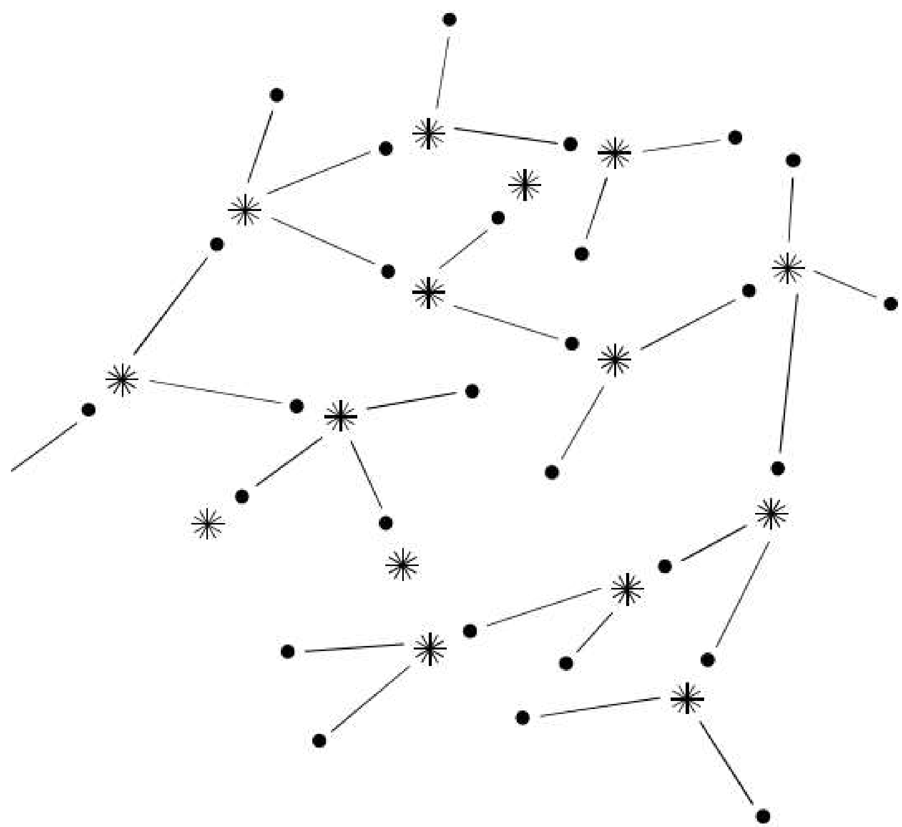
After enough collisions, the neutron becomes “slow” (thermal).

The neutron is at a resting energy level and cannot realistically slow any further.

A “slow” (thermal) neutron creates fission by becoming absorbed by U235

Neutron Life Cycle

A Self-Sustaining Chain Reaction



Fission Chain Reaction

Definitions and Key Concepts

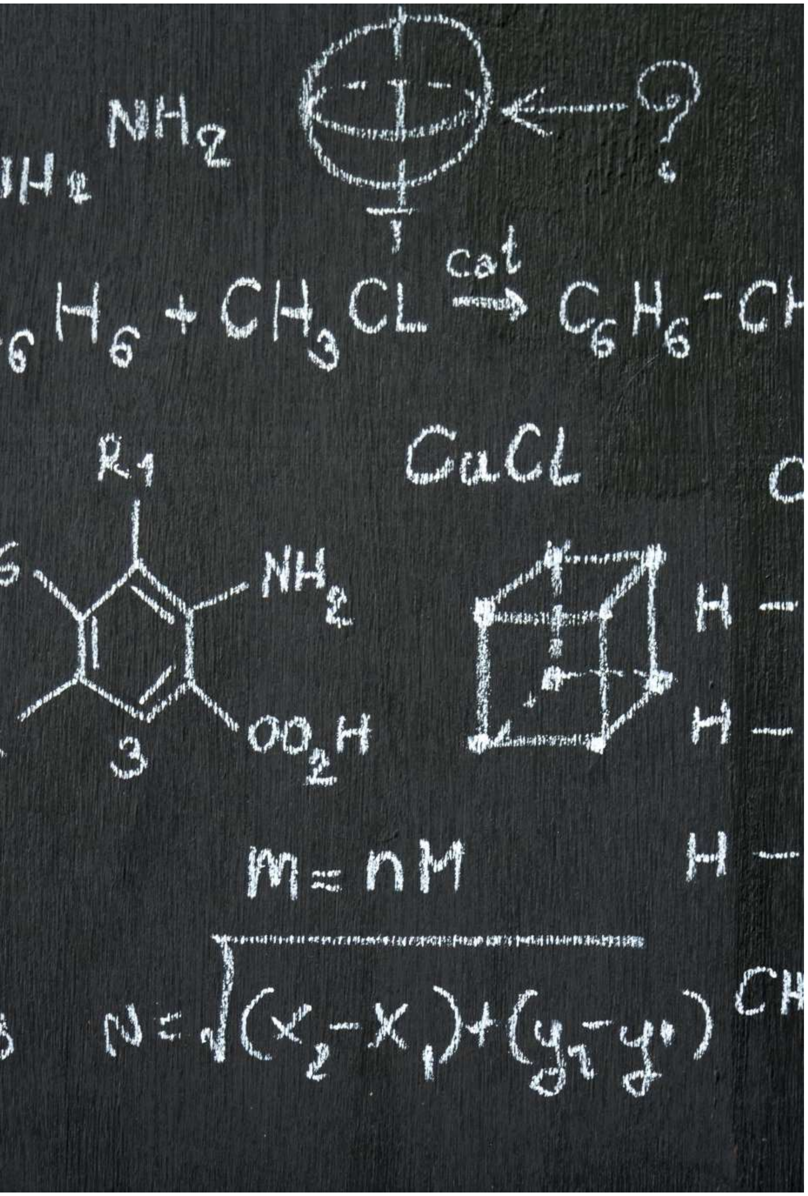
Joule - the SI unit of work or energy, equal to the work done by a force of one newton when its point of application moves one meter in the direction of action of the force, equivalent to one 3600th of a watt-hour.

Calorie - the energy needed to raise the temperature of 1 kilogram of water through 1 °C, equal to one thousand small calories and often used to measure the energy value of foods.

Water has to absorb **4,184 Joules** of heat, or 1 calorie, to increase in temperature of 1 kilogram of water by 1 degree Celsius.

Electron Volt - a unit of energy equal to the work done on an electron in accelerating it through a potential difference of one volt.

The total binding energy released in fission of an atomic nucleus varies with the precise break up, but averages about **200 MeV* for U-235 or 3.2 x 10^{-11} joule**.



Particle Physics in a Nutshell

If fission of an atomic nucleus makes 200 MeV of energy, producing 3.2x10^-11 joules, and 1 joule is 6.242x10^+18 electron volts, how many fissions does it take to raise the temperature of 1kg of water 1C?

4184 (Joules) x 6.242x10^+18 (ev/Joule) = 2.612x10^+22 (ev)

2.612x10^+22 (ev) / 2.0x10^6 (eV/fission) = 1.306x10^16 fissions

1,306,000,000,000,000 Fissions

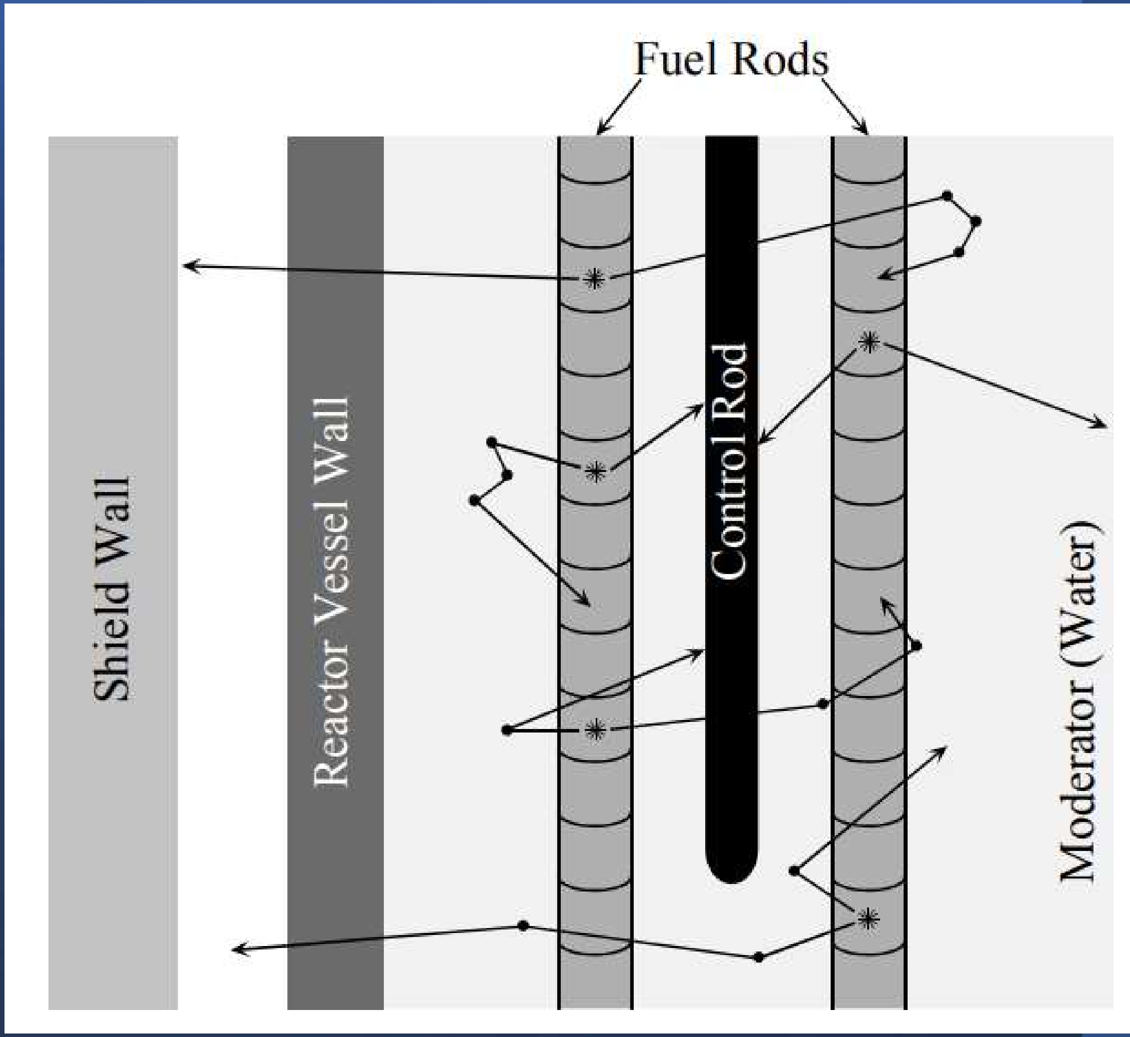
Trillions of fissions per second are required to raise temperature!

There are approximately 1.2x10^18 atoms in a grain of salt

120,000,000,000,000,000

What does a Reactor Operator control?

Here is a quick example!



What rods do I move?

How much fuel should I expose?

How much water do I use?

What temperature am I trying to maintain?