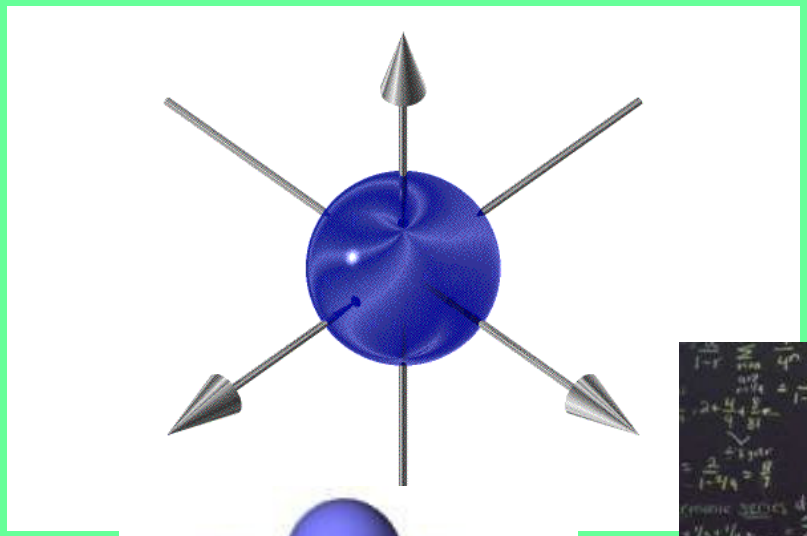
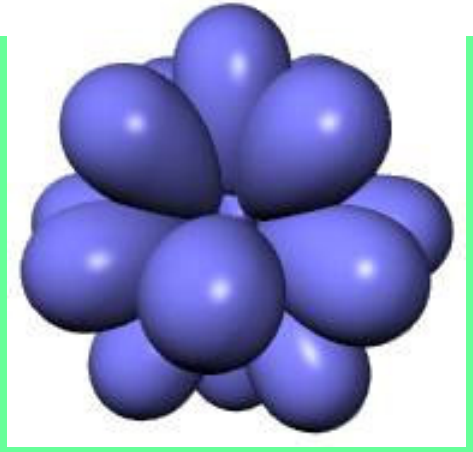
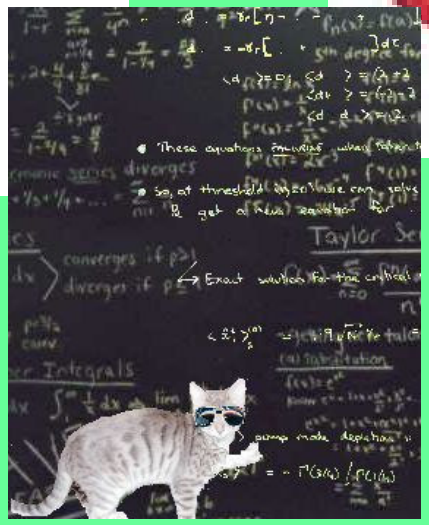
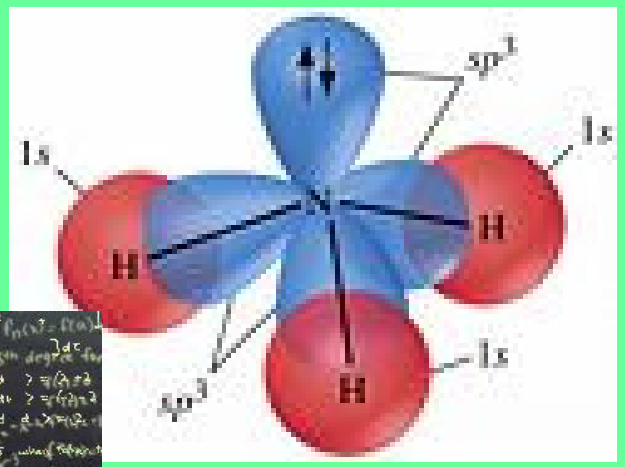
Modern Models of the Atom





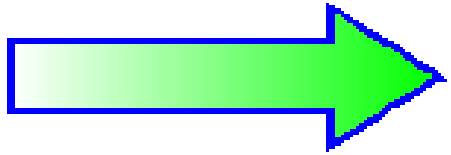




Light: Waves or Particles?

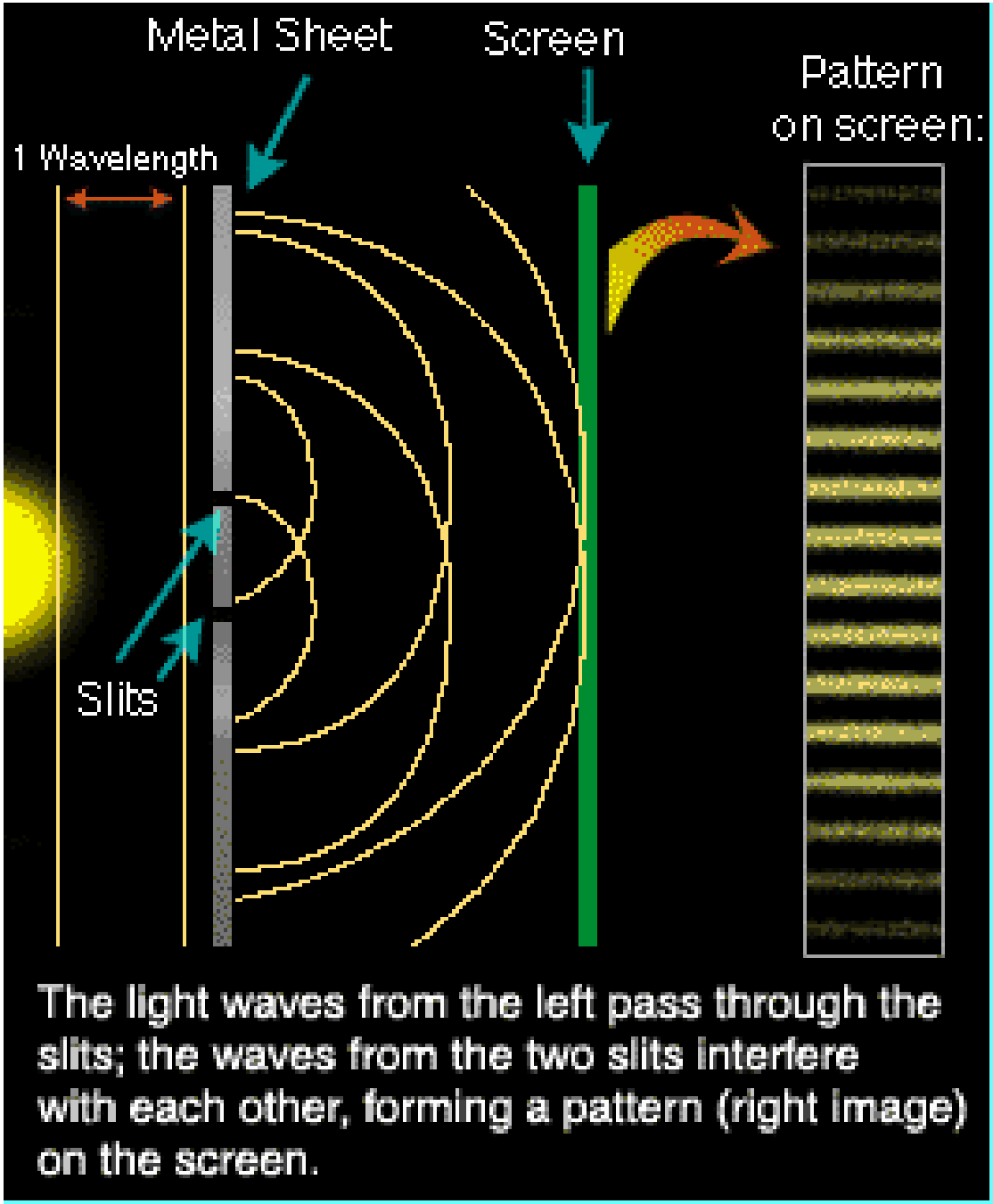
--interference and diffraction can only be explained by thinking of light as made up of waves.

--Around 1900, experiments gave results that could only be understood by thinking of light as made up of particles

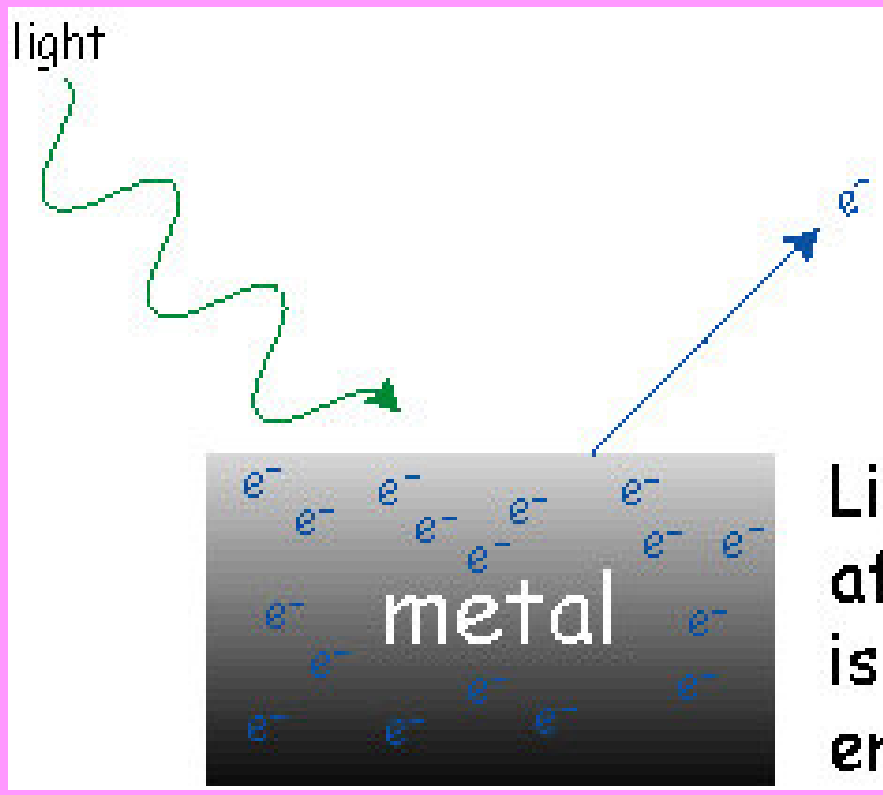
 Craziness!!!??

Hints that the Micro World is Crazy:

- Blackbody Radiation and the Ultraviolet catastrophe
- The Photoelectric Effect
- Compton Scattering



Experiments show that light must be waves!



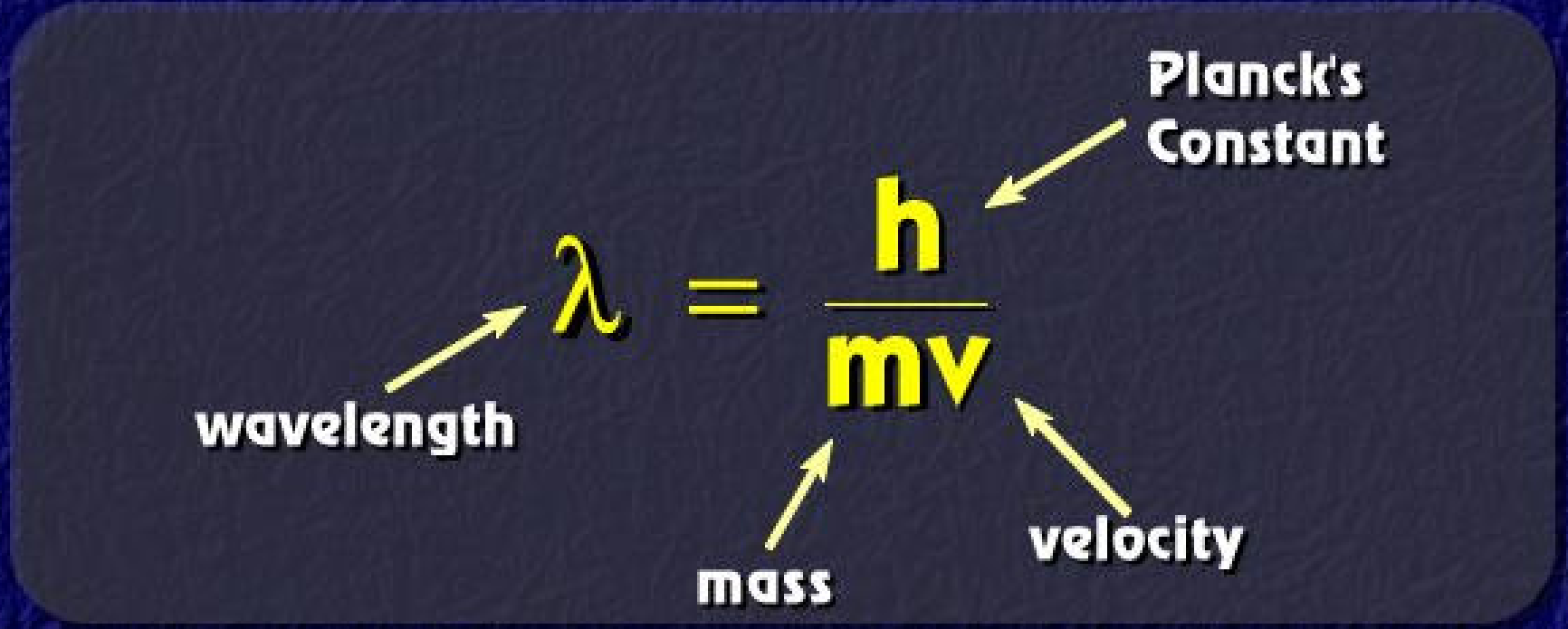
Light is shown on a metal and after a certain binding energy is overcome, an electron is emitted from the metal.

Other experiments show that light consists of particles!

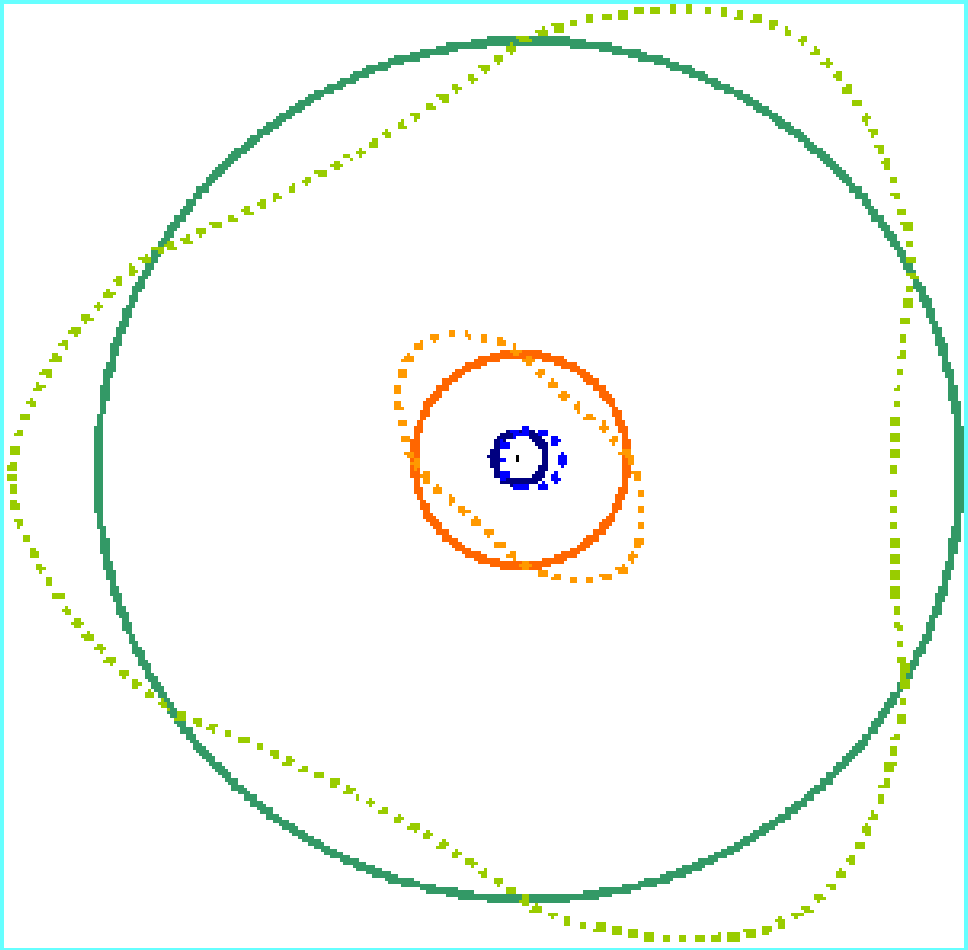
Louis de Broglie

Suggested that all particles have a "wave nature" and that things like light and electrons could be particles *or* waves!

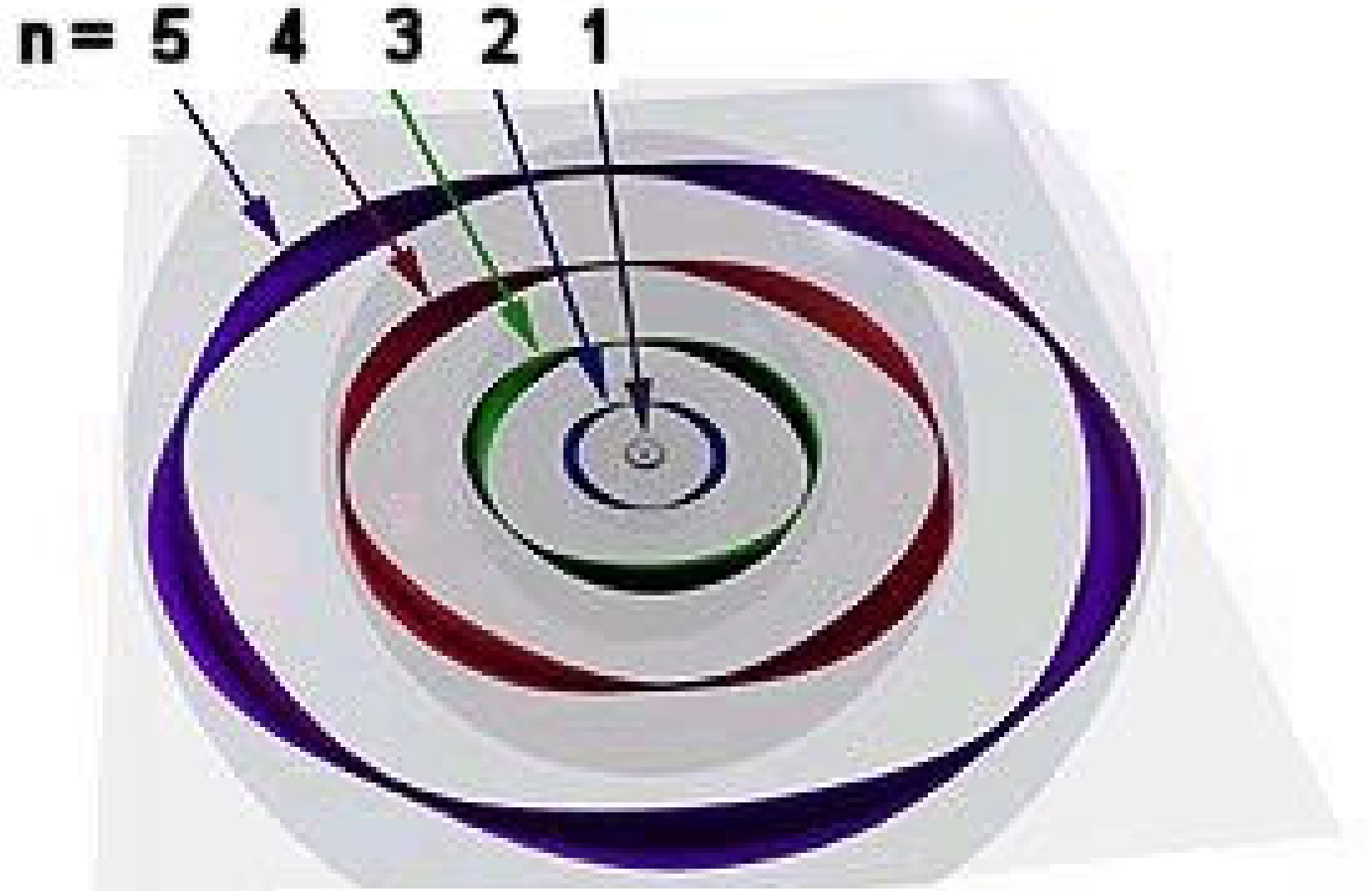
The de Broglie relation:



Every particle has wave nature as well, but it is only truly evident when a particle is very light, such as an electron ($m = 9.11 \times 10^{-28}$ g)



De Broglie's model of the atom. Electrons are like "waves" as they go around the atom.



Louis De Broglie Atom, 1924

Erwin Schrodinger

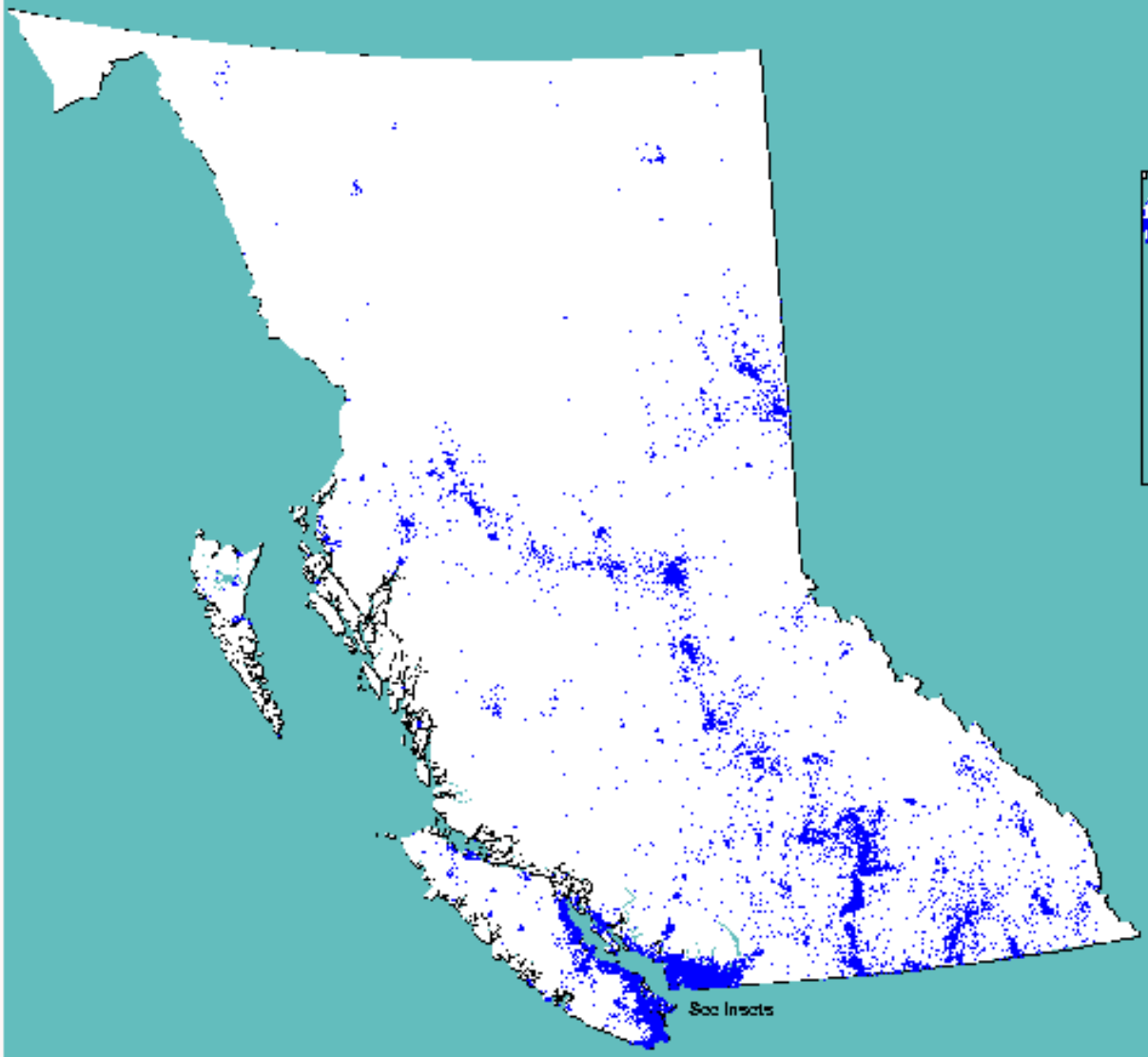
$$\frac{-\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2}+U(x)\Psi(x,t)=i\hbar\frac{\partial\Psi(x,t)}{\partial t}$$

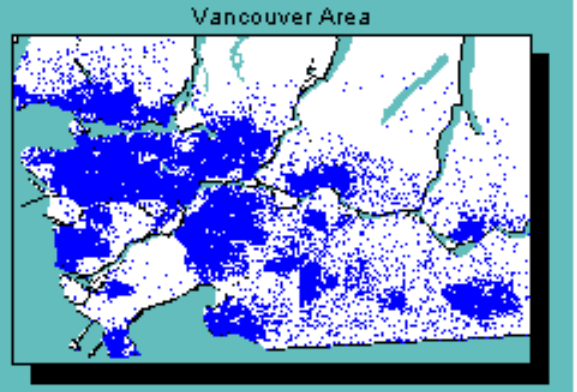
$$\frac{-\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2}+U(x)\Psi(x,t)=i\hbar\frac{\partial\Psi(x,t)}{\partial t}$$

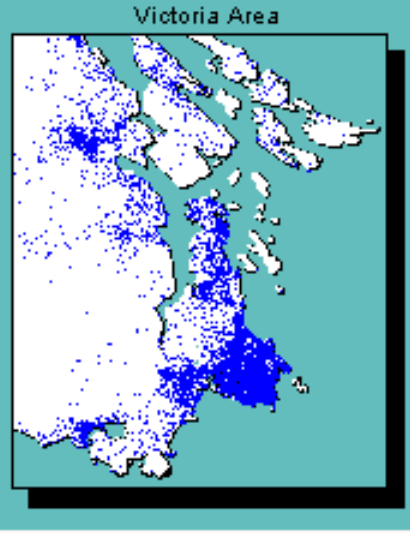
The Schrodinger Equation

Schrodinger used mathematics to predict how electrons behave in an atom!

1996 Census Population
Population Distributed Randomly Within Enumeration Areas
1 Dot = 50 Persons



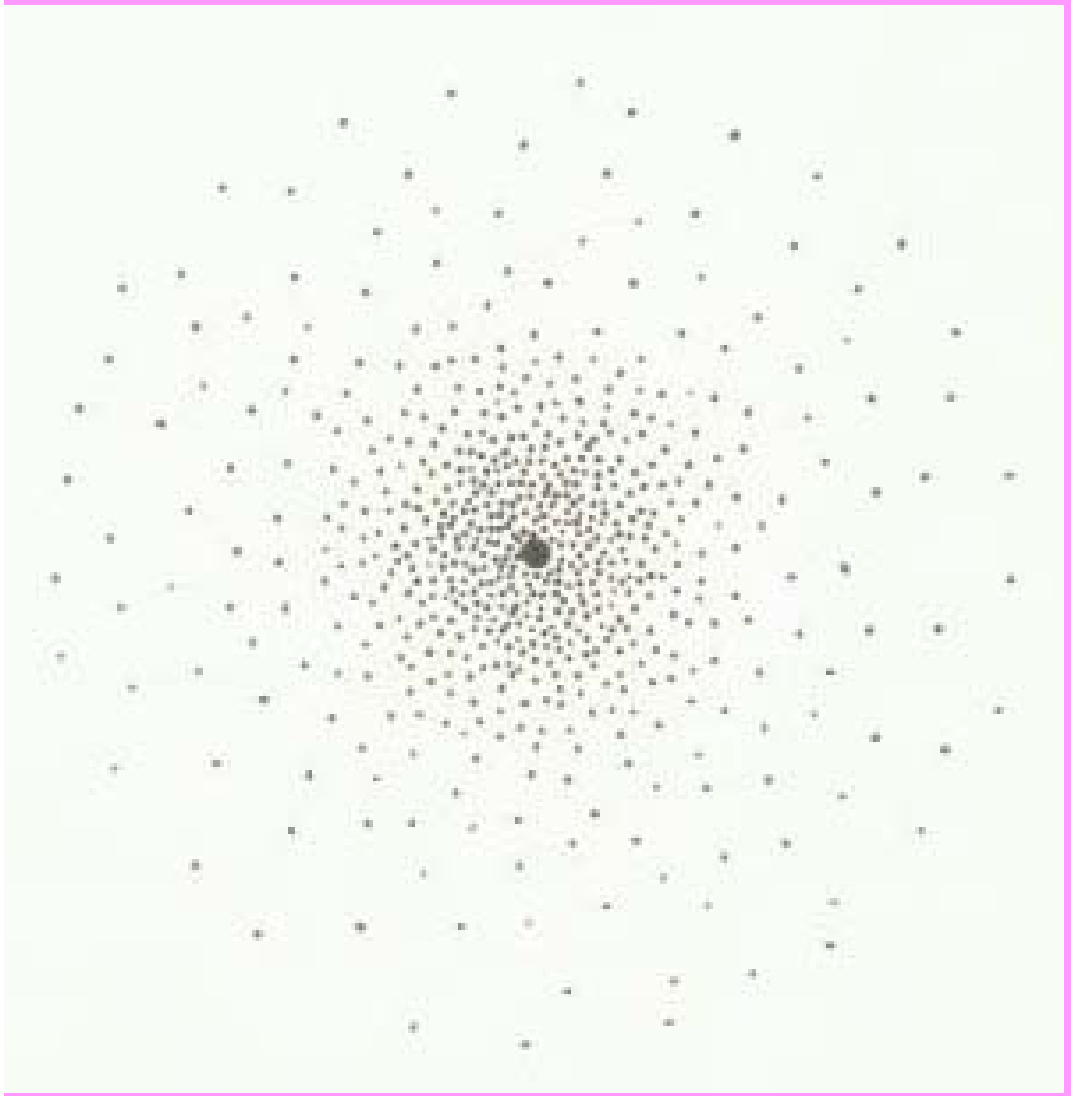




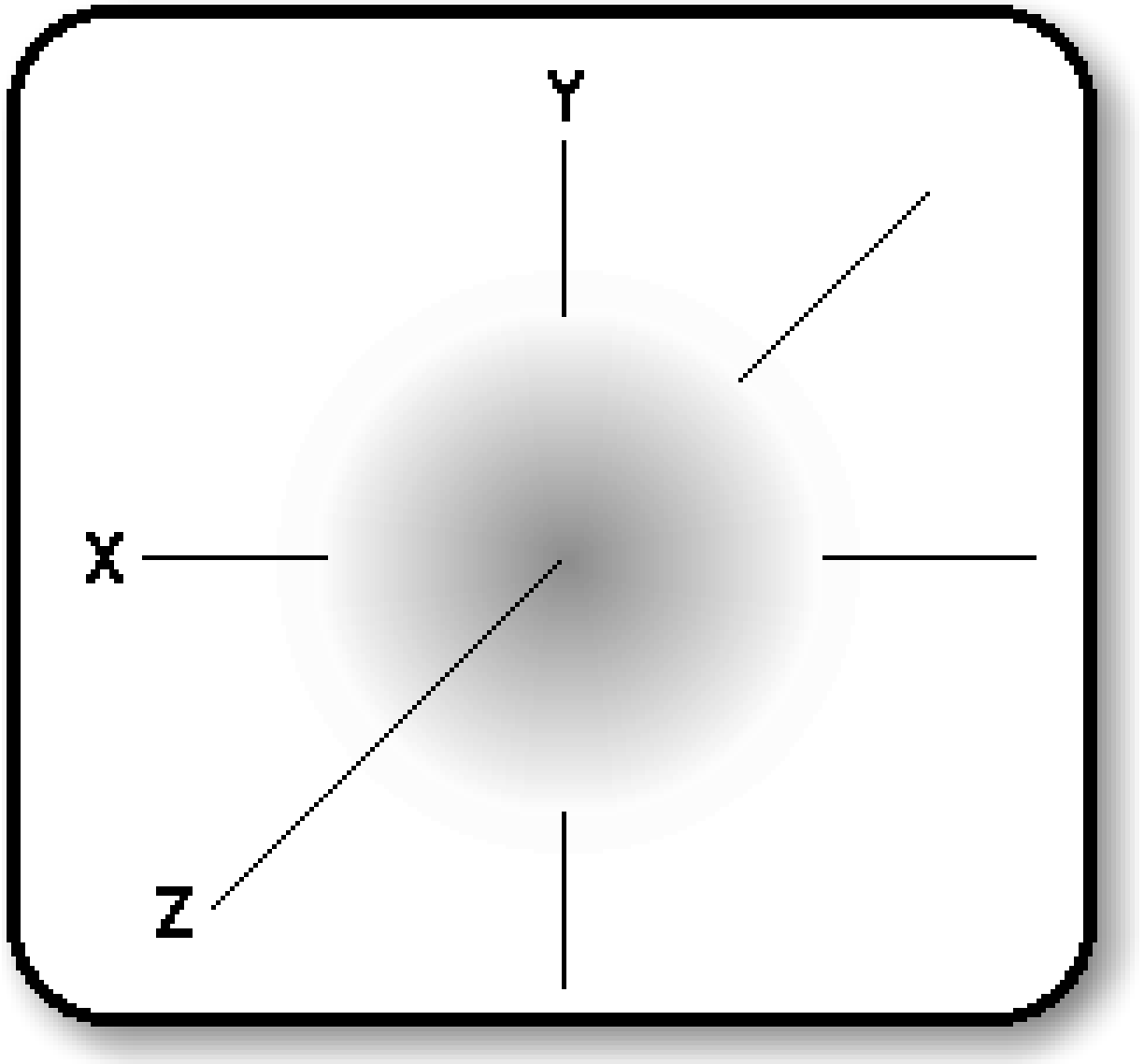
Data Source: 1996 Census, Statistics Canada

Prepared by: BC Stats, Victoria

Orbital movies

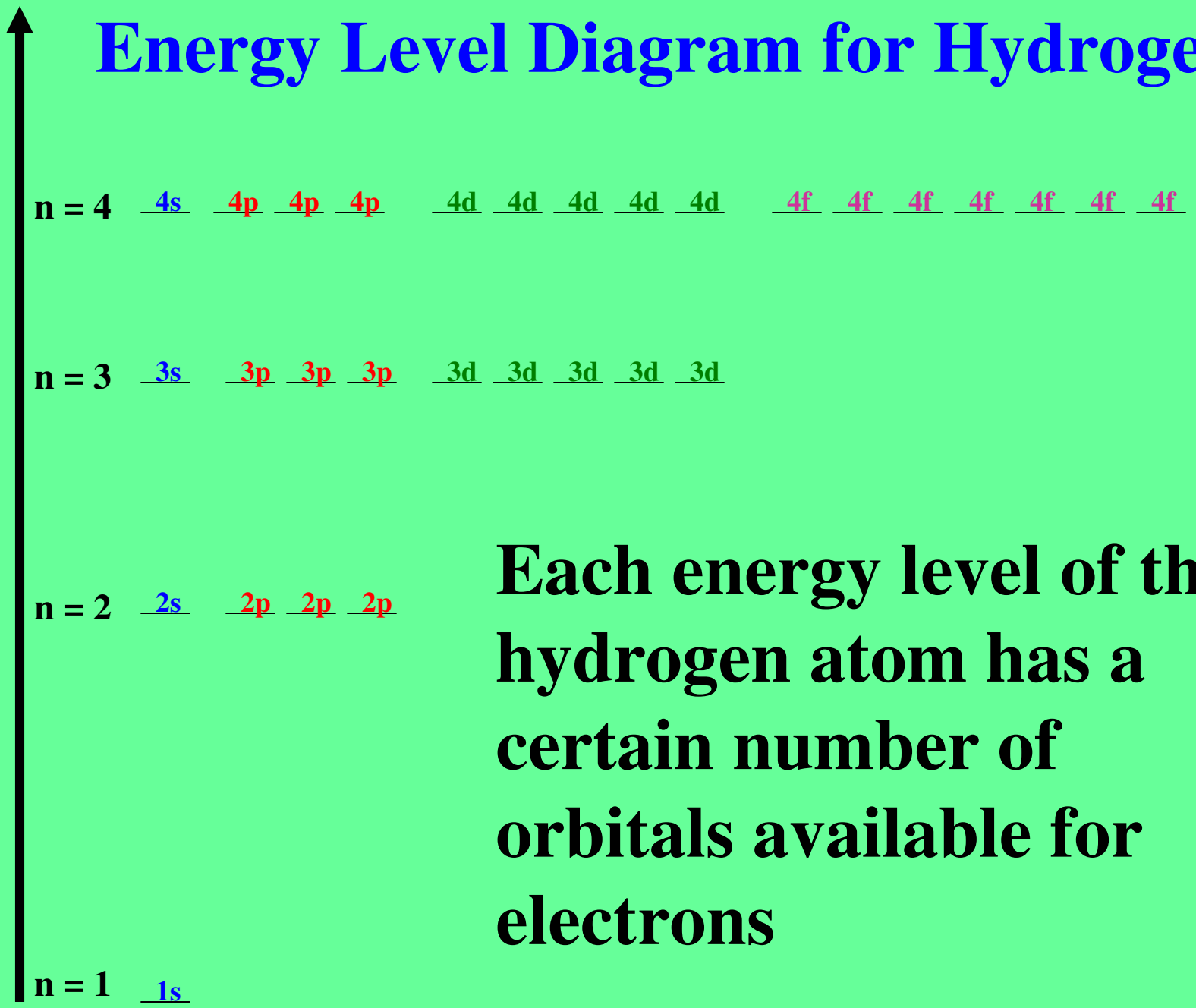


An orbital is a region in space where the probability of finding an electron is high. The denser the orbital, the higher the probability.



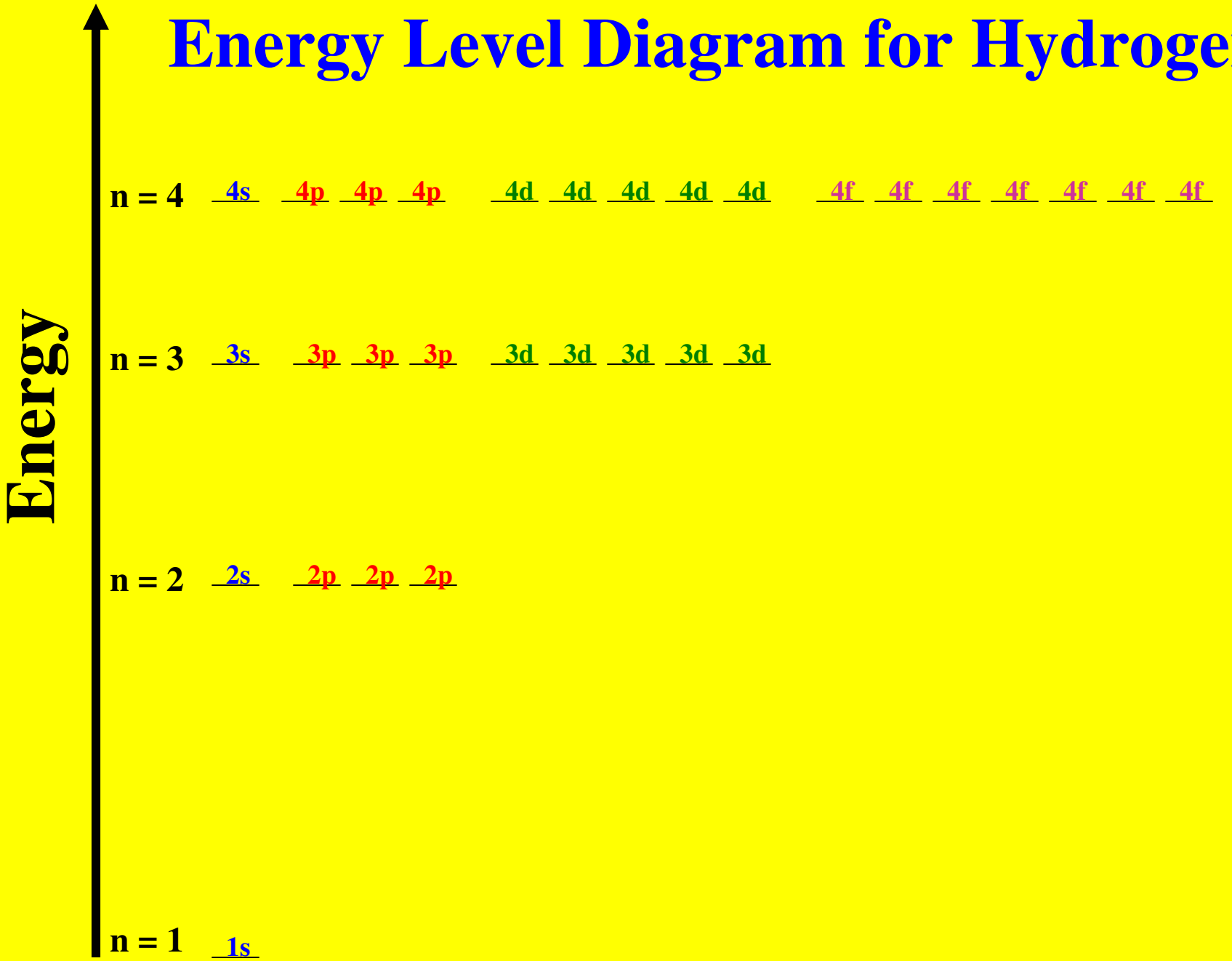
A 1s orbital

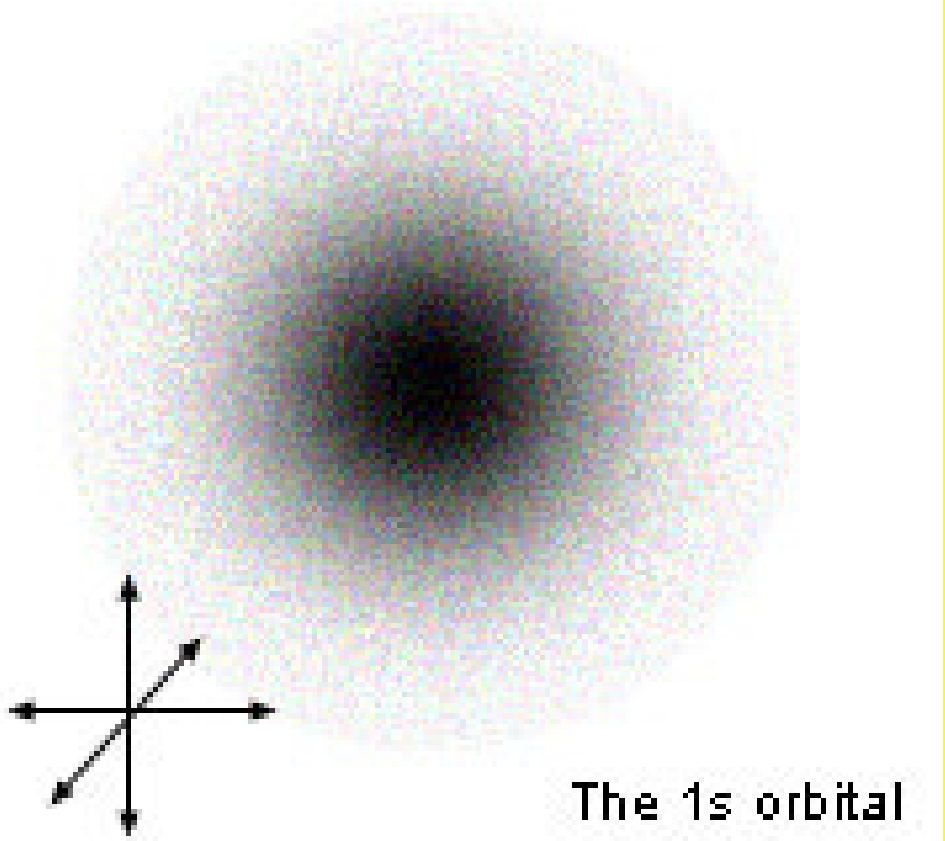
Energy Level Diagram for Hydrogen



Each energy level of the hydrogen atom has a certain number of orbitals available for electrons

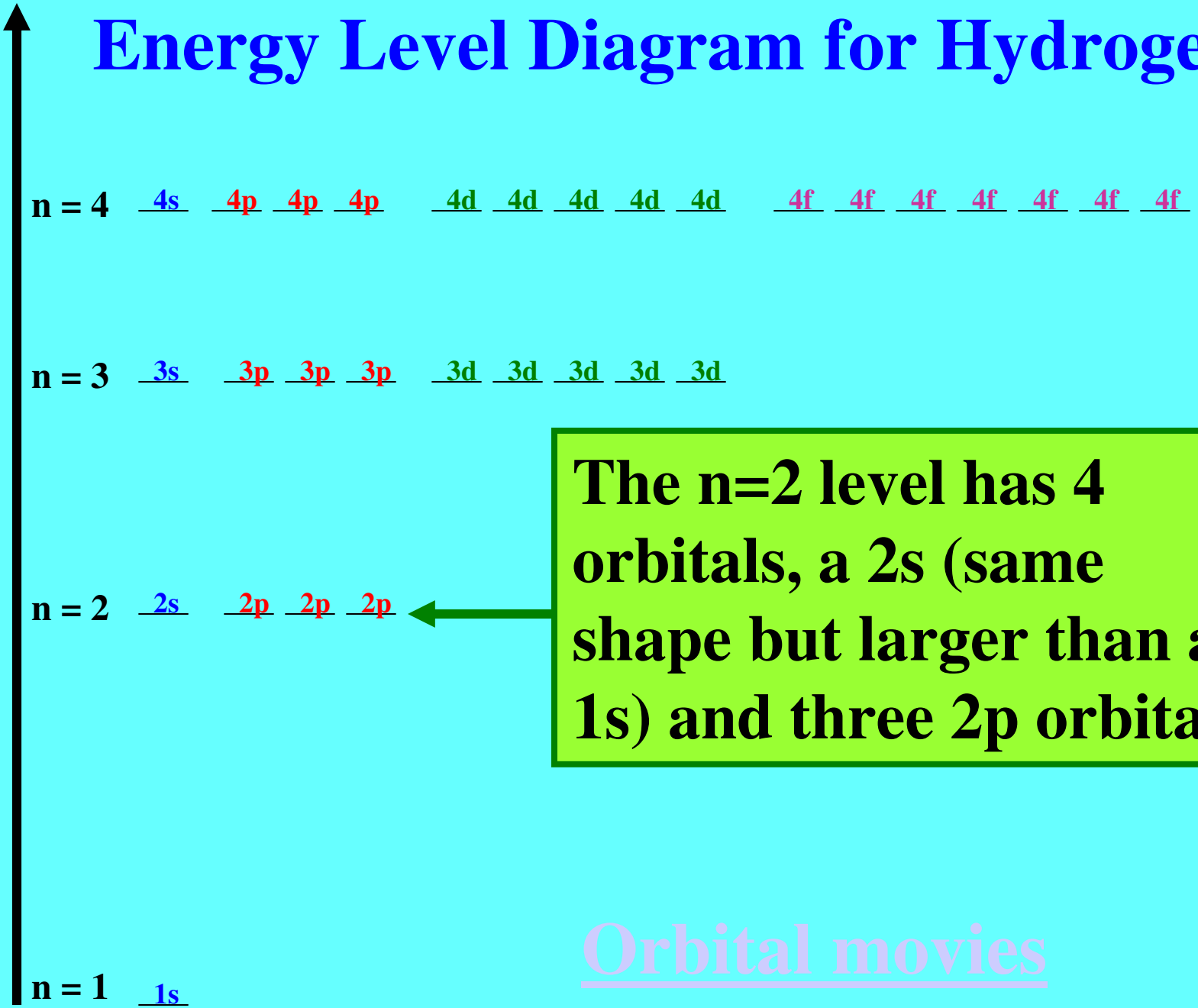
Energy Level Diagram for Hydrogen





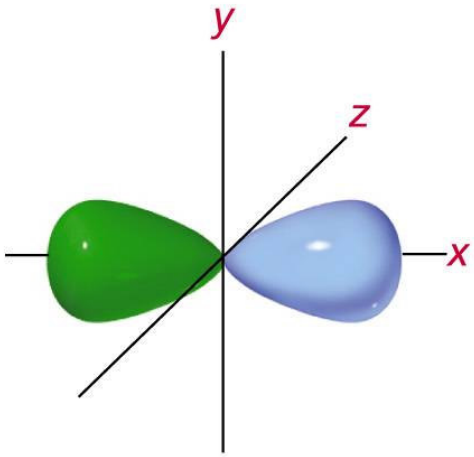
Energy levels are designated by a quantum number called “n – the principal quantum number” Level n=1 has just the 1s orbital

Energy Level Diagram for Hydrogen

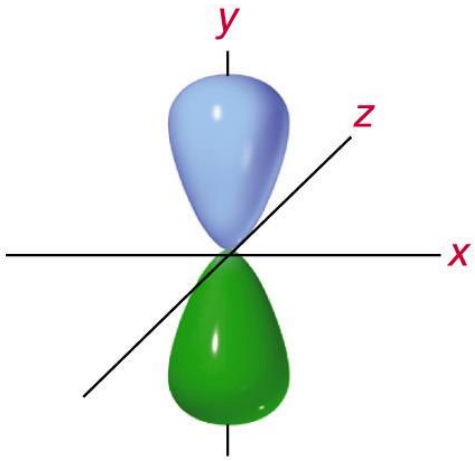


The n=2 level has 4 orbitals, a 2s (same shape but larger than a 1s) and three 2p orbitals

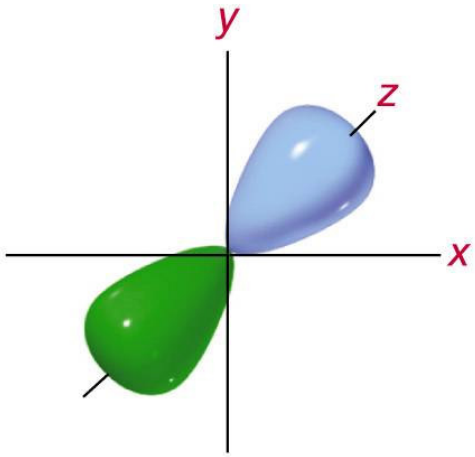
Orbital movies



$2p_x$ orbital

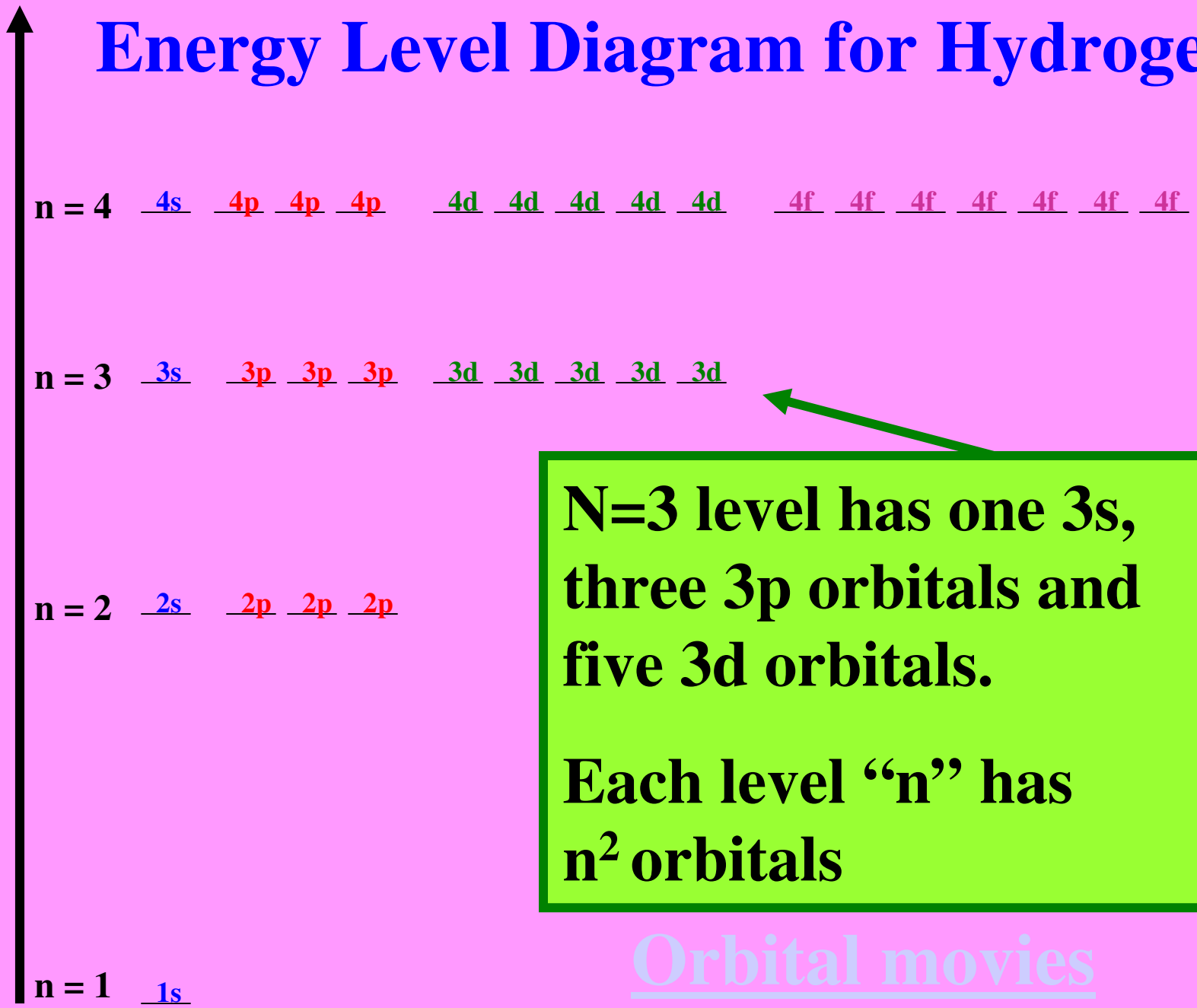


$2p_y$ orbital



$2p_z$ orbital

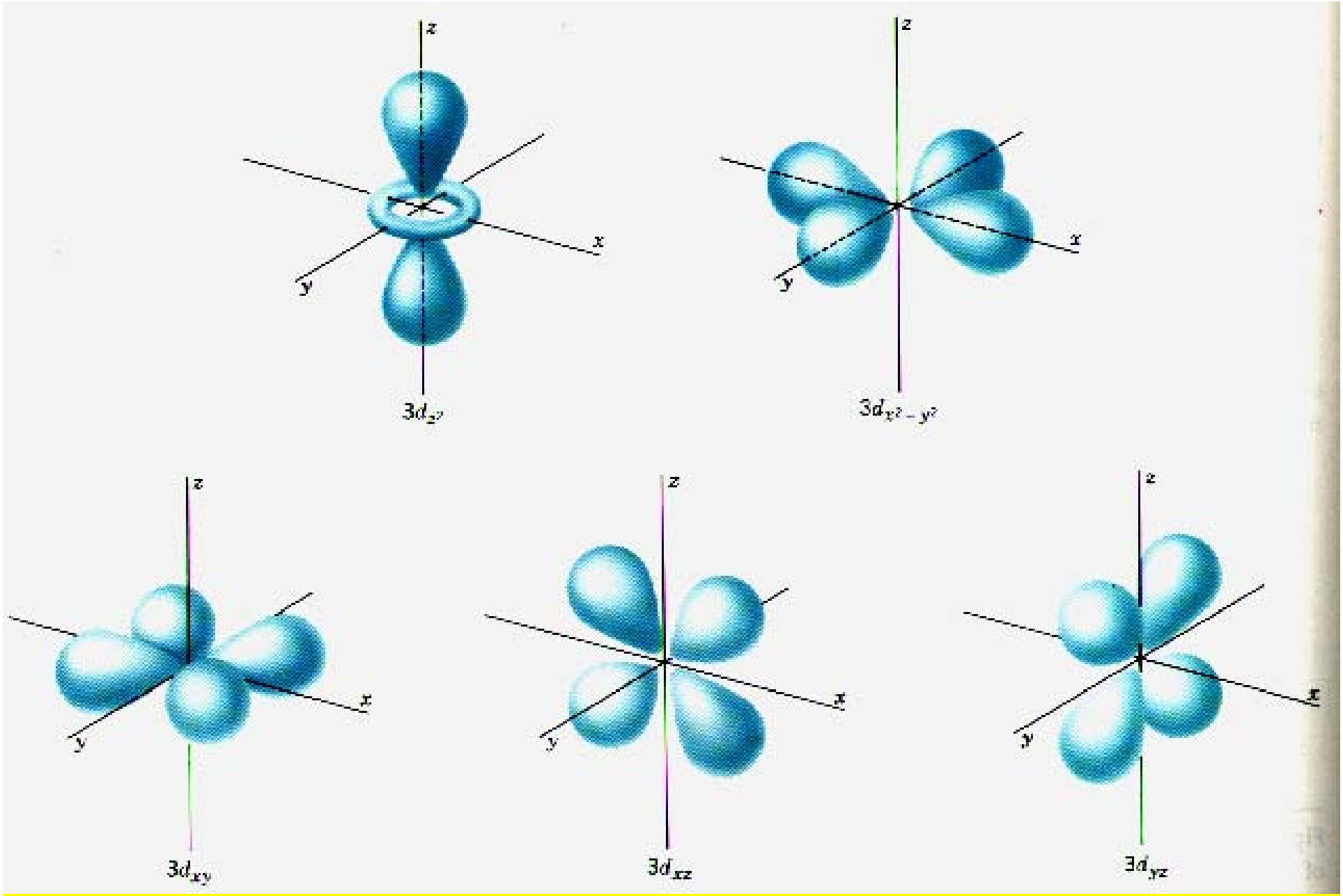
Energy Level Diagram for Hydrogen



N=3 level has one 3s, three 3p orbitals and five 3d orbitals.

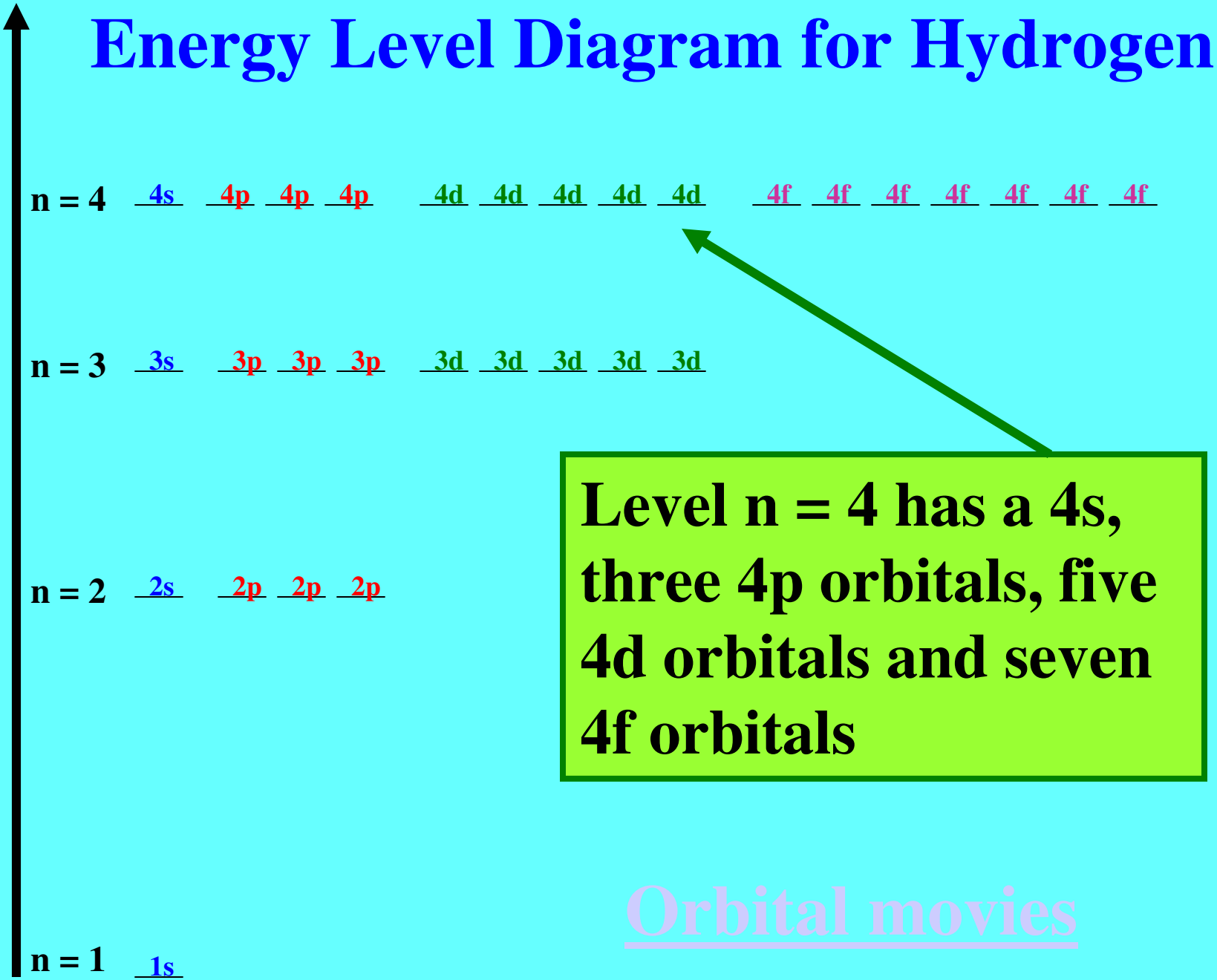
Each level "n" has n^2 orbitals

Orbital movies



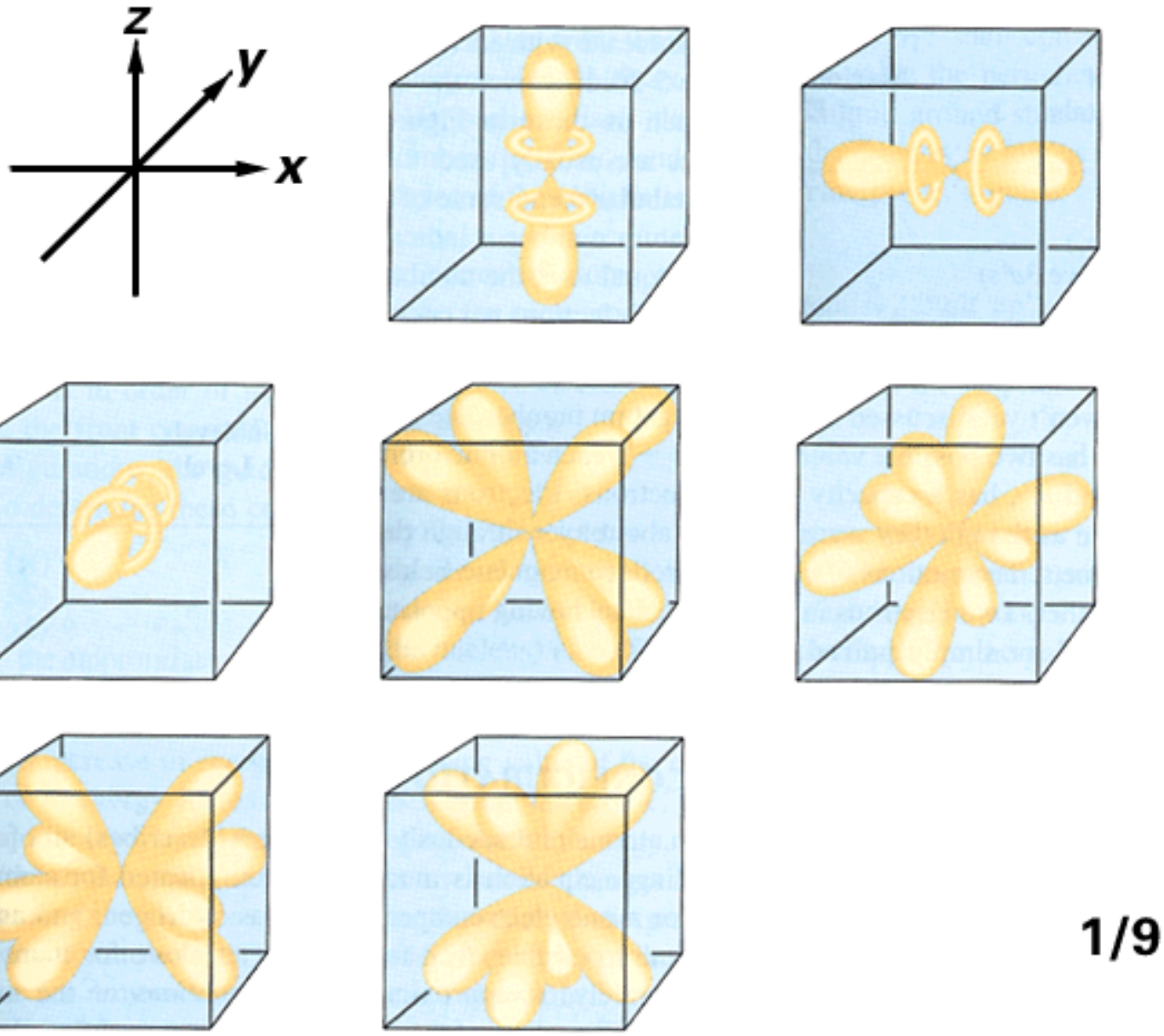
The five 3d orbitals [chime d-orbitals more]

Energy Level Diagram for Hydrogen



Level n = 4 has a 4s, three 4p orbitals, five 4d orbitals and seven 4f orbitals

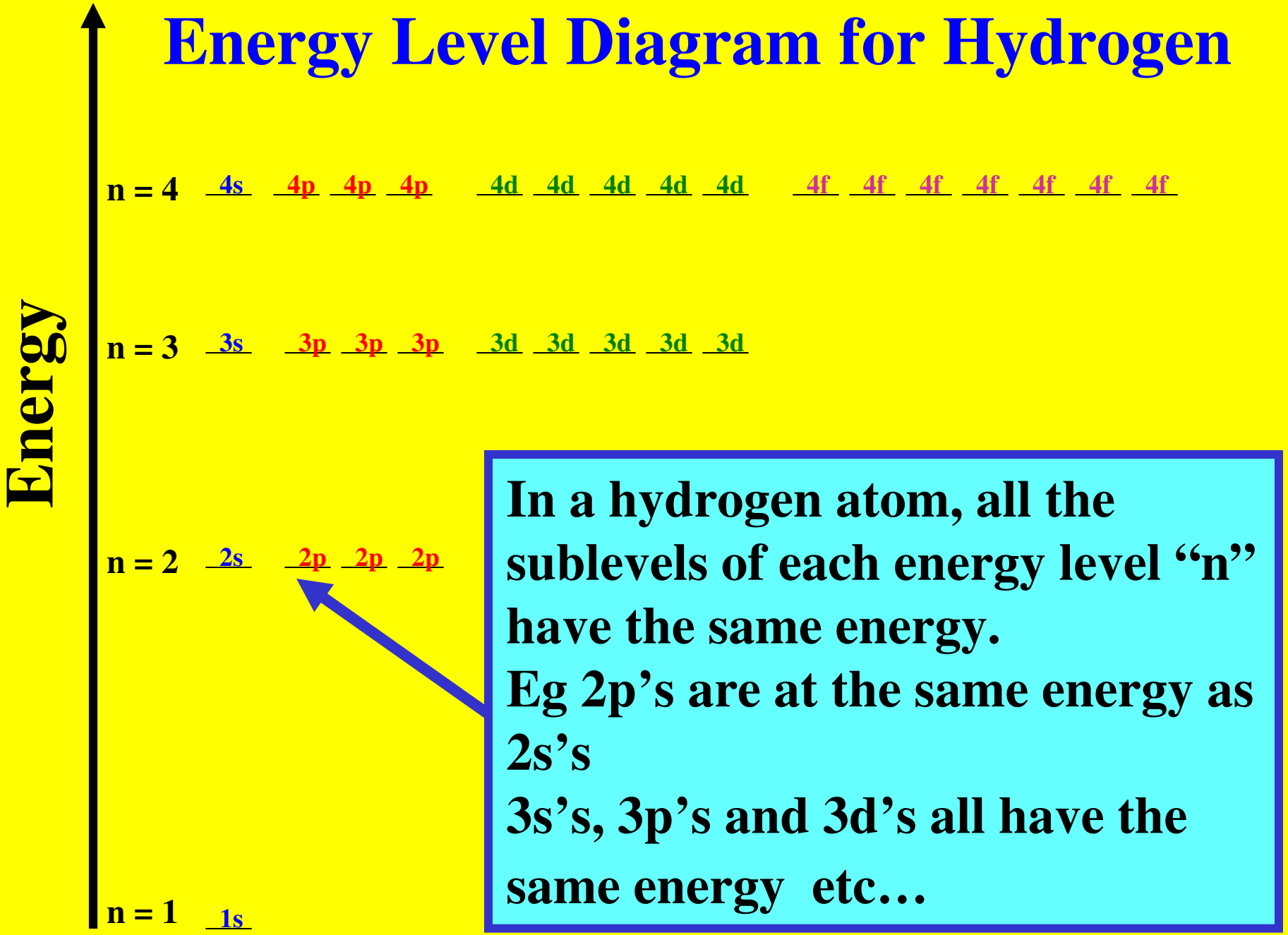
Orbital movies



1/9

The 4f orbitals

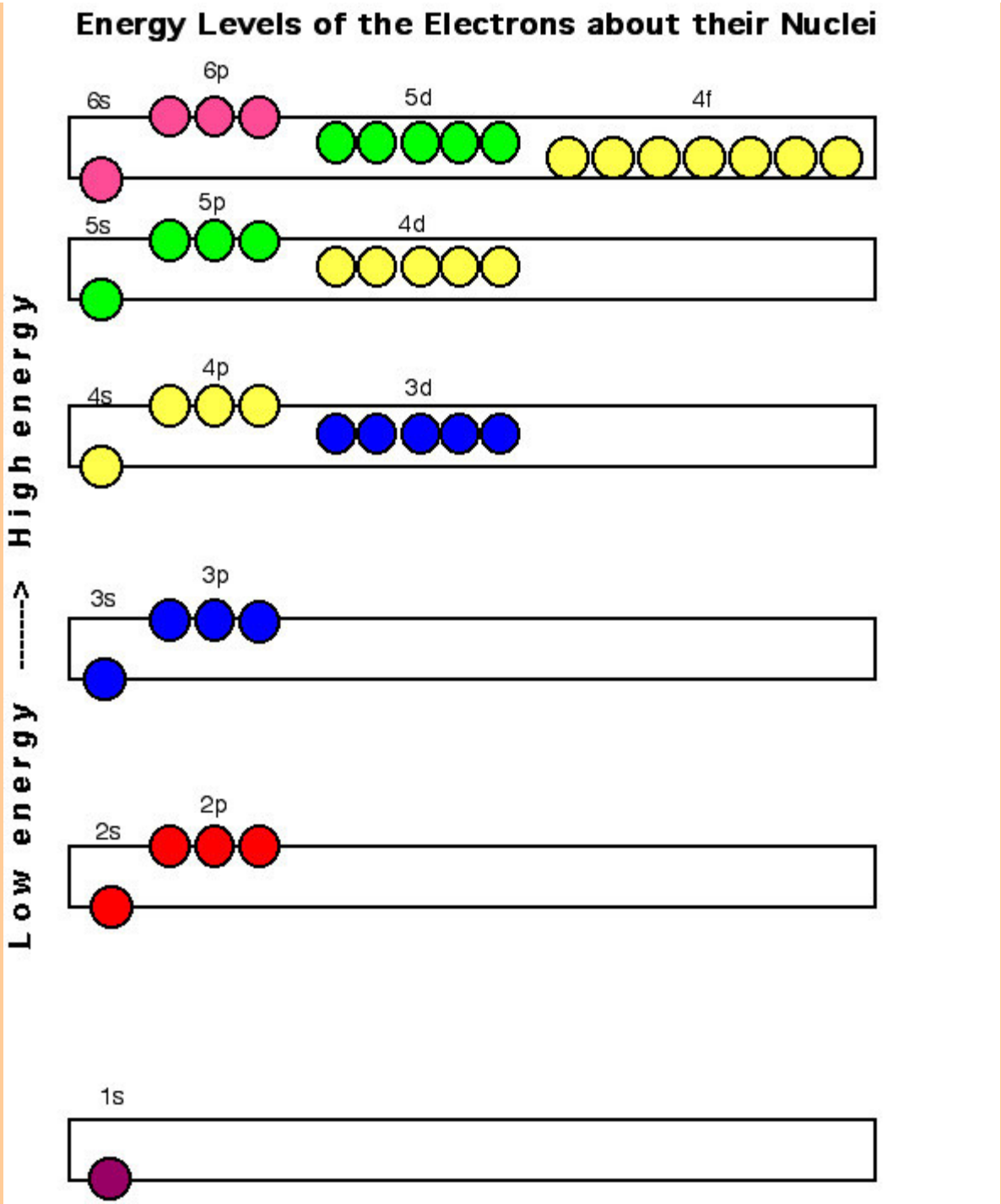
Energy Level Diagram for Hydrogen



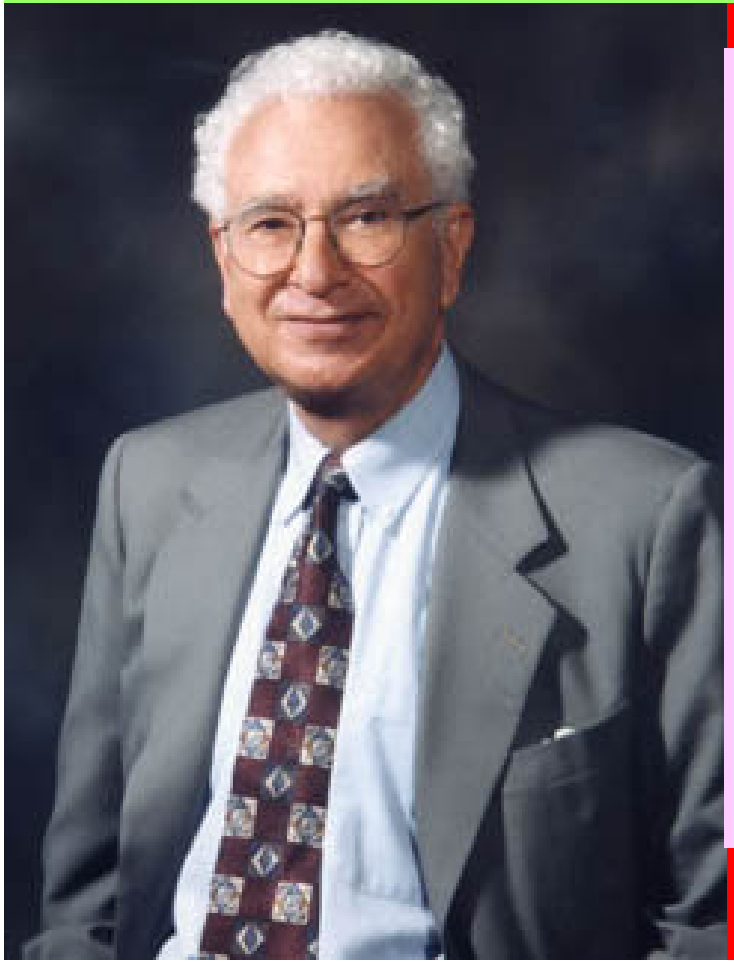
In a hydrogen atom, all the sublevels of each energy level "n" have the same energy.
Eg 2p's are at the same energy as 2s's
3s's, 3p's and 3d's all have the same energy etc…

java orbitals

In "many electron" atoms (atoms other than hydrogen), the "sublevels" have different energies. Eg the 2p orbitals have slightly higher energy than the 2s. The 3p's are higher than the 3s and the 3d's are higher still.


Energy Levels of the Electrons about their Nuclei
Low energy ------> High energy
1s
2s
2p
3s
3p
4s
4p
3d
5s
5p
4d
6s
6p
5d
4f

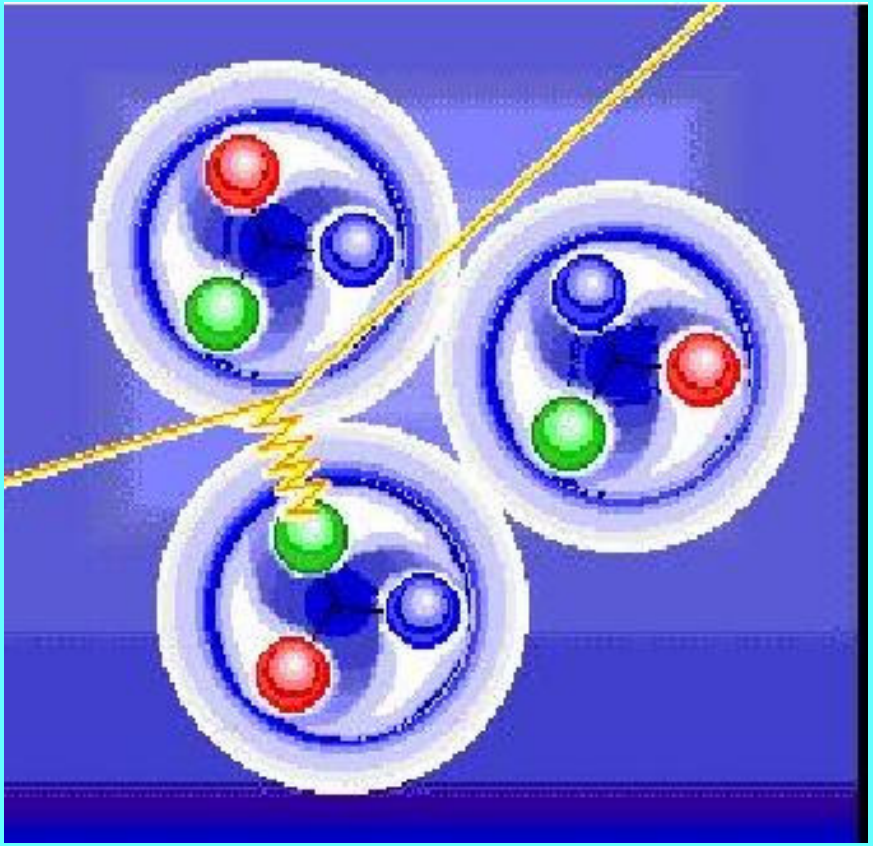
In 1969, Professor Murray Gell-Mann received the Nobel Prize in physics for his work on the theory of elementary particles …he found that all of those particles, including the neutron and proton, are composed of fundamental building blocks that he named "*quarks*."



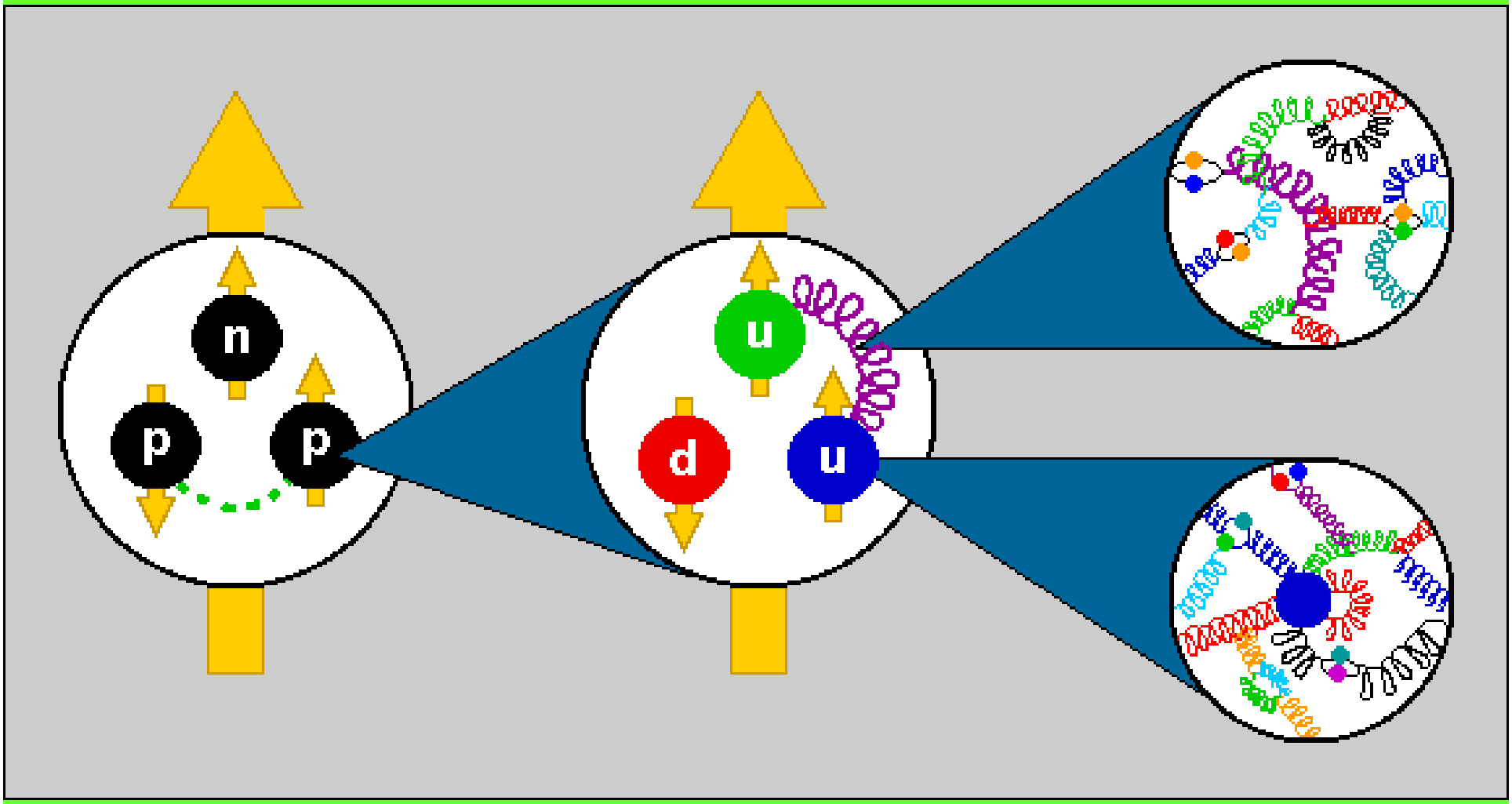
The quarks are permanently confined by forces coming from the exchange of "*gluons*." He and others later constructed …*quantum chromodynamics*," which seems to account for all the nuclear particles and their strong interactions." ...

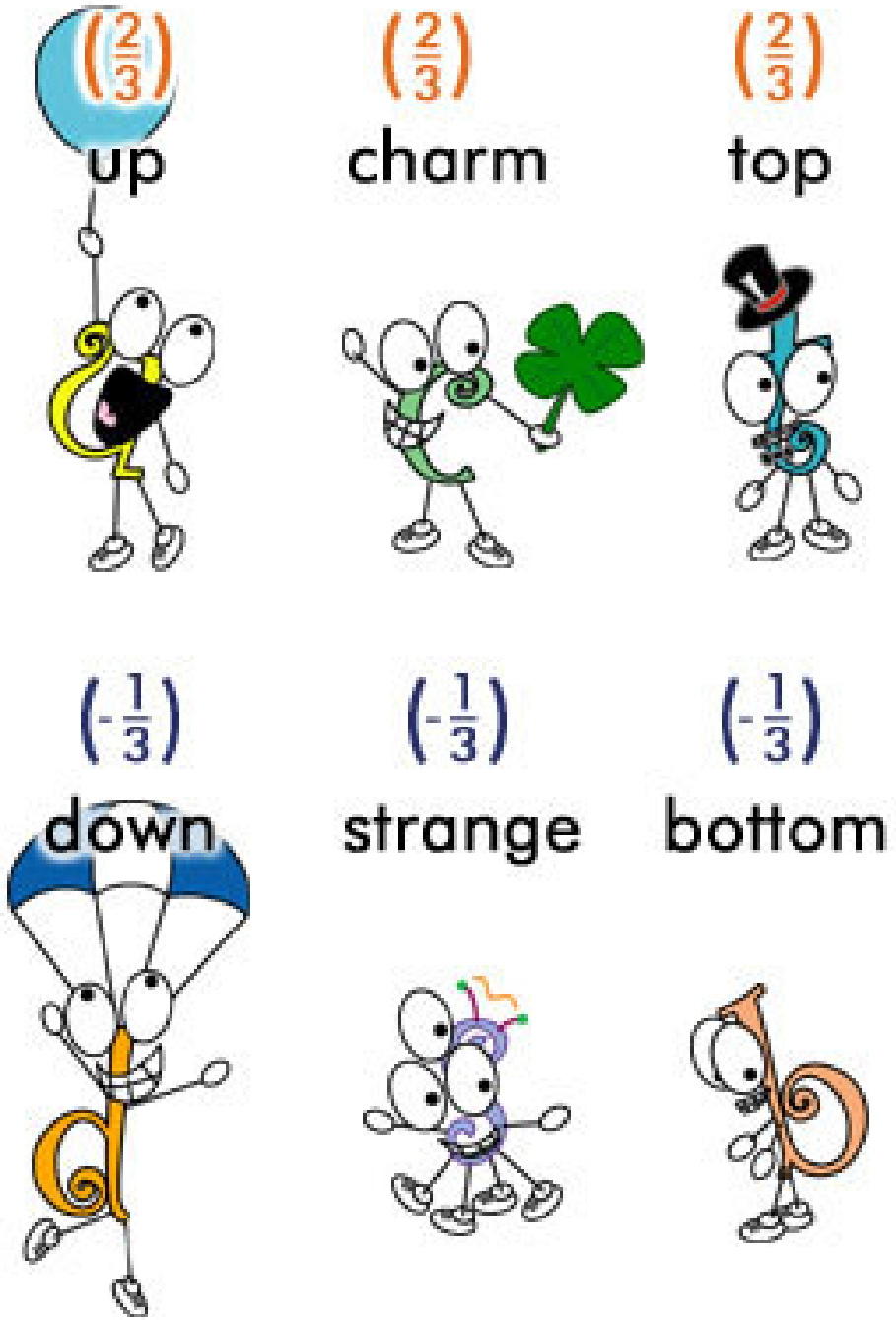
Quantum Chromodynamics

Protons and Neutrons are composed of smaller particles called quarks



A proton consists of two “up” and one “down” quark.





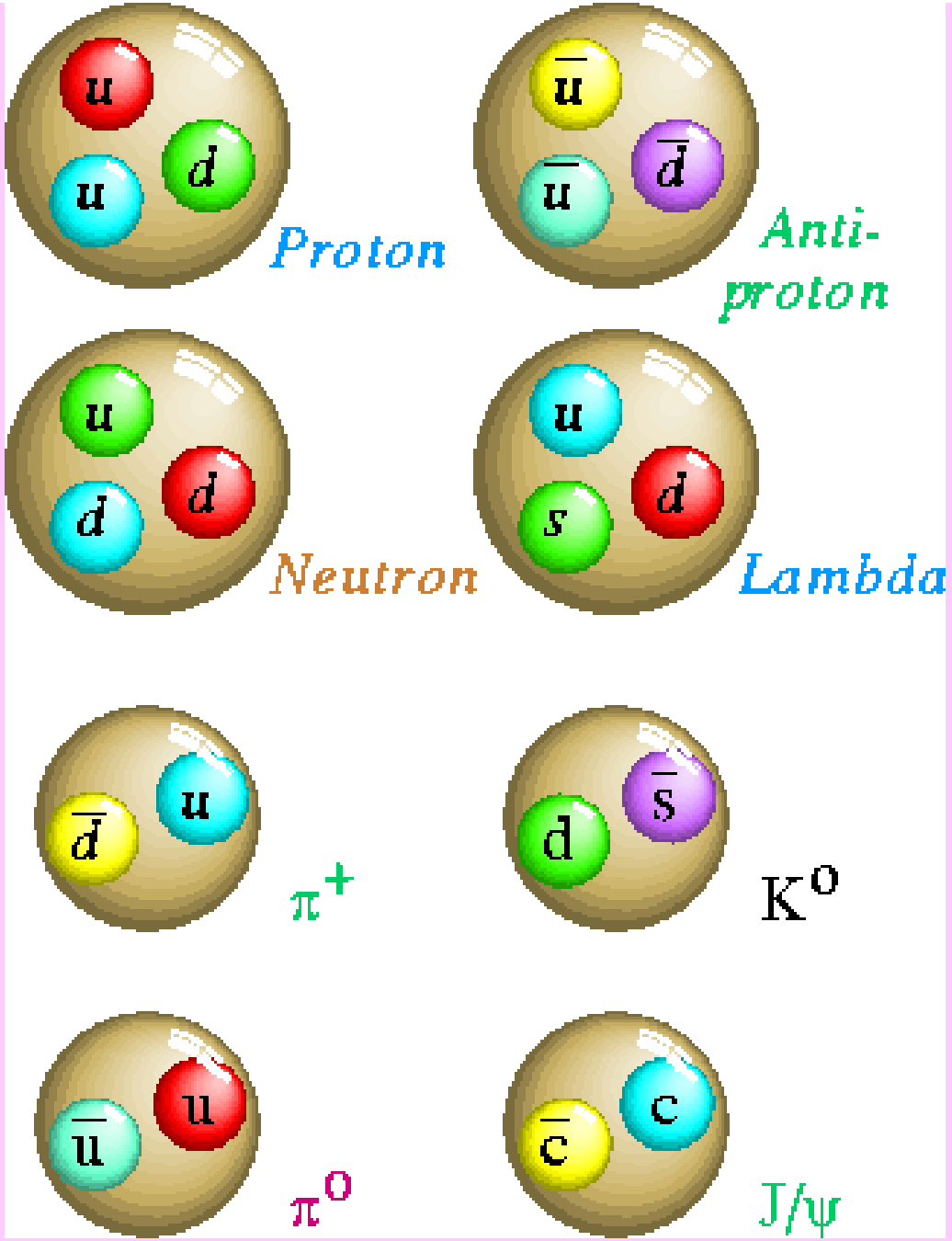
"Flavors" of quarks

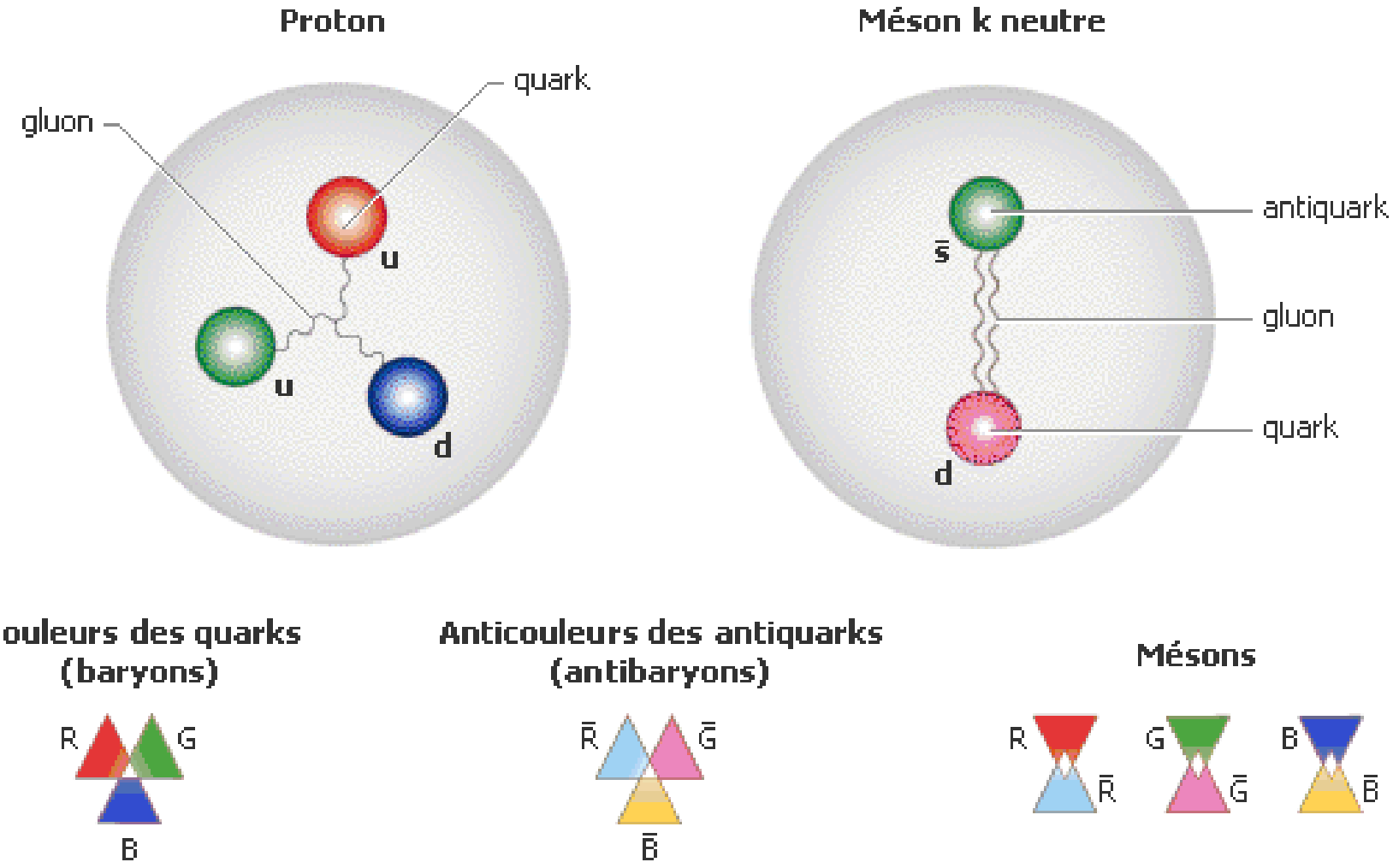
ANTIQUARKS

$\bar{u}$ $\bar{c}$ $\bar{t}$

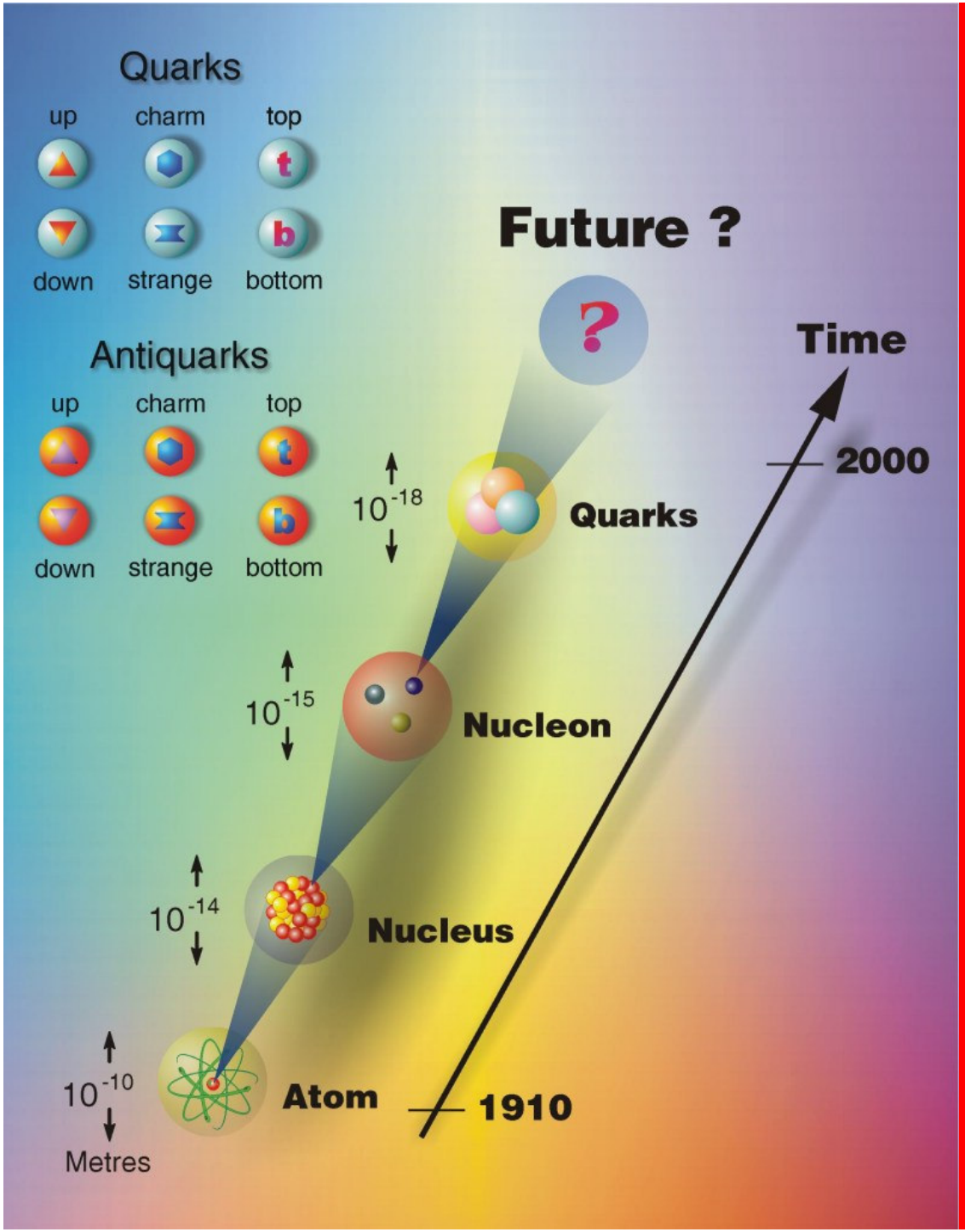
$\bar{d}$ $\bar{s}$ $\bar{b}$

Different combinations of quarks produce different particles





Quarks are held together by "gluons"



Will it ever end?