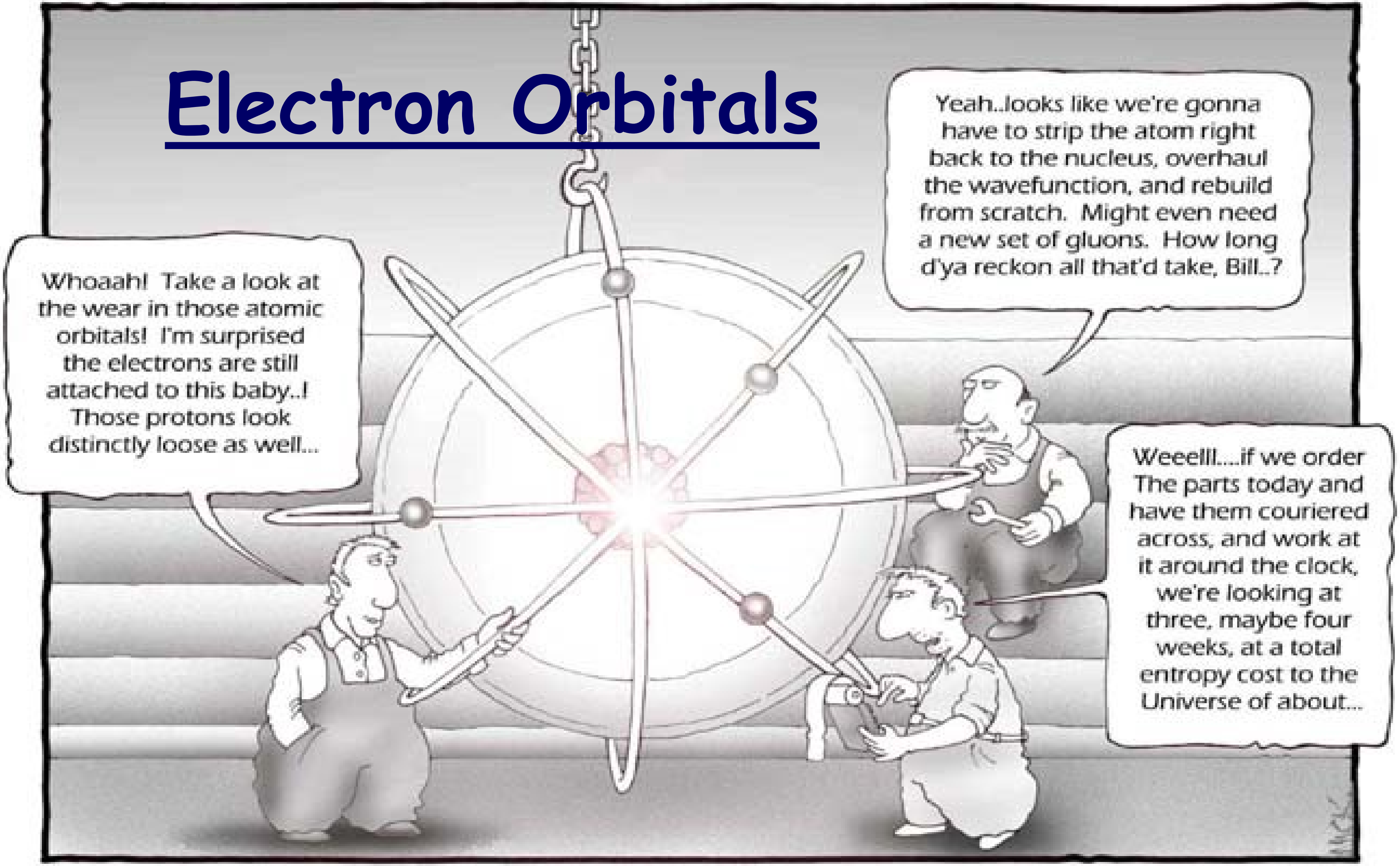
Electron Orbitals



Quantum mechanics.

Cartoon courtesy of lab-initio.com

The Bohr Model of the Atom

Neils Bohr

I pictured electrons orbiting the nucleus much like planets orbiting the sun.

But I was wrong! They're more like bees around a hive.

Quantum Mechanical Model of the Atom

Mathematical laws can identify the regions outside of the nucleus where electrons are most likely to be found.

These laws are beyond the scope of this class…

Heisenberg Uncertainty Principle

Werner Heisenberg

"One cannot simultaneously determine both the position and momentum of an electron."

You can find out where the electron is, but not where it is going.

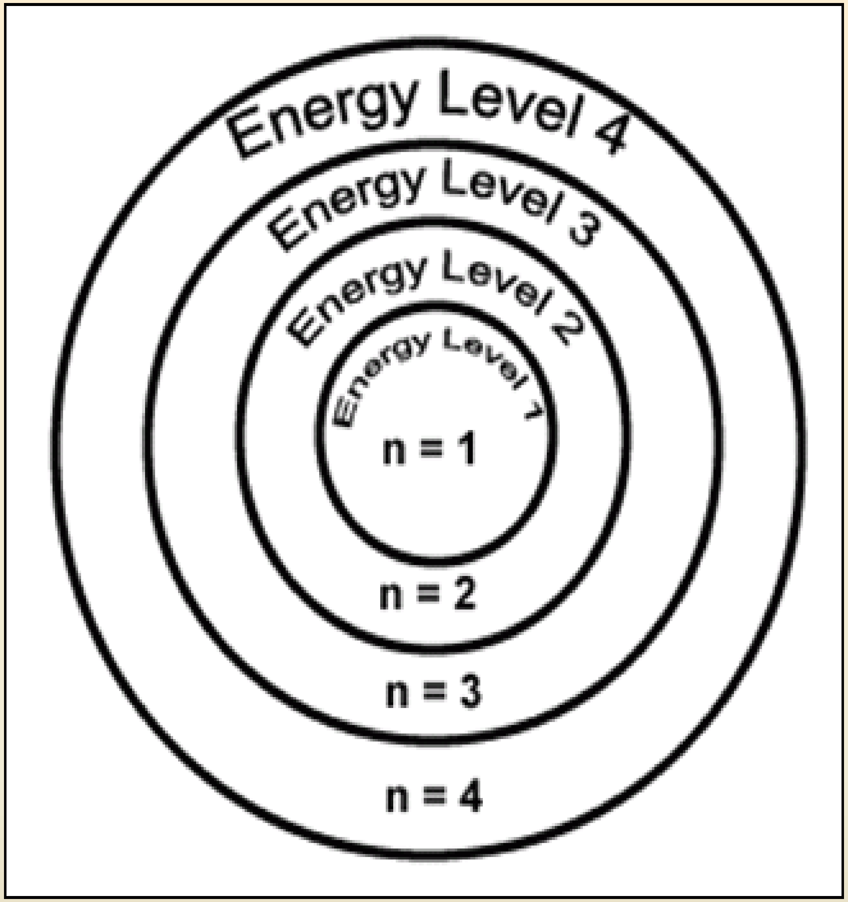
OR…

You can find out where the electron is going, but not where it is!

Electron Energy Level (Shell)

Generally symbolized by n, it denotes the probable distance of the electron from the nucleus. “n” is also known as the **Principle Quantum number**

Number of electrons that can fit in a shell: $2n^2$



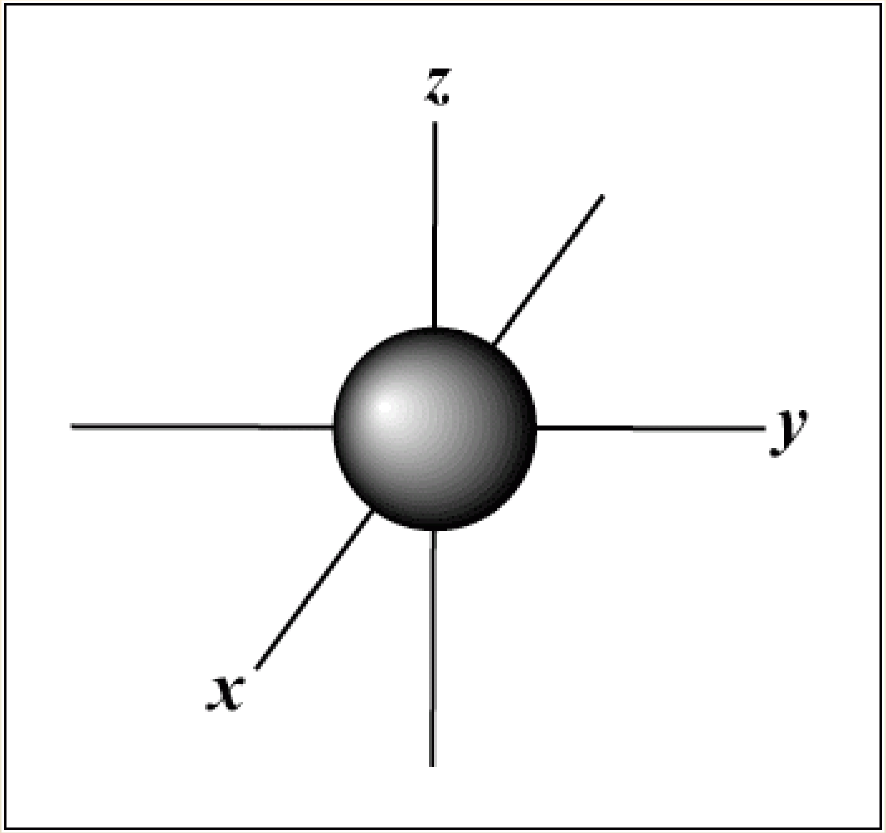
Electron Orbitals

An orbital is a region within an energy level where there is a probability of finding an electron.

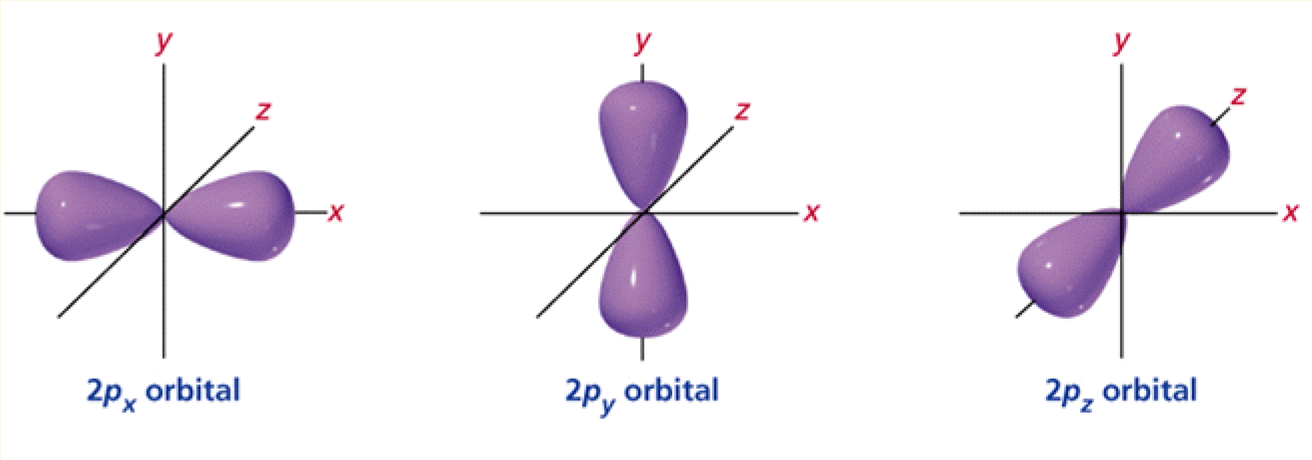
Orbital shapes are defined as the surface that contains 90% of the total electron probability.

s Orbital shape

The *s* orbital has a spherical shape centered around the origin of the three axes in space.

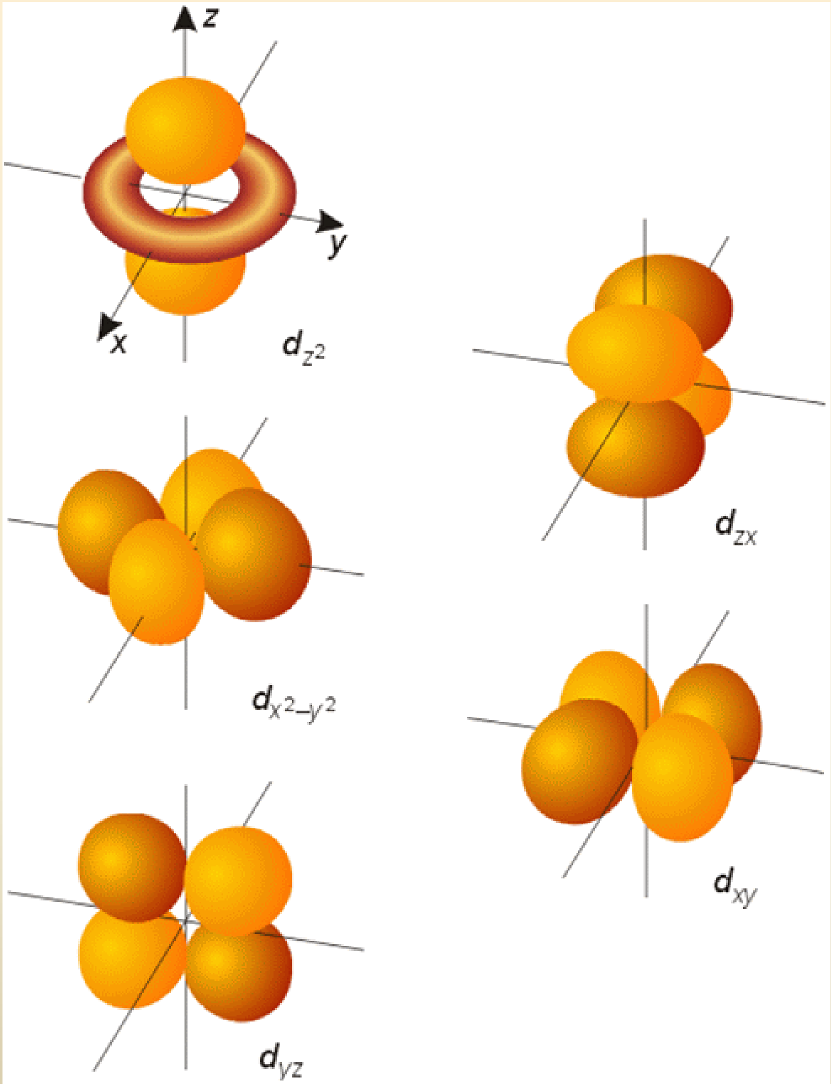


p orbital shape



There are three dumbbell-shaped *p* orbitals in each energy level above n = 1, each assigned to its own axis (x, y and z) in space.

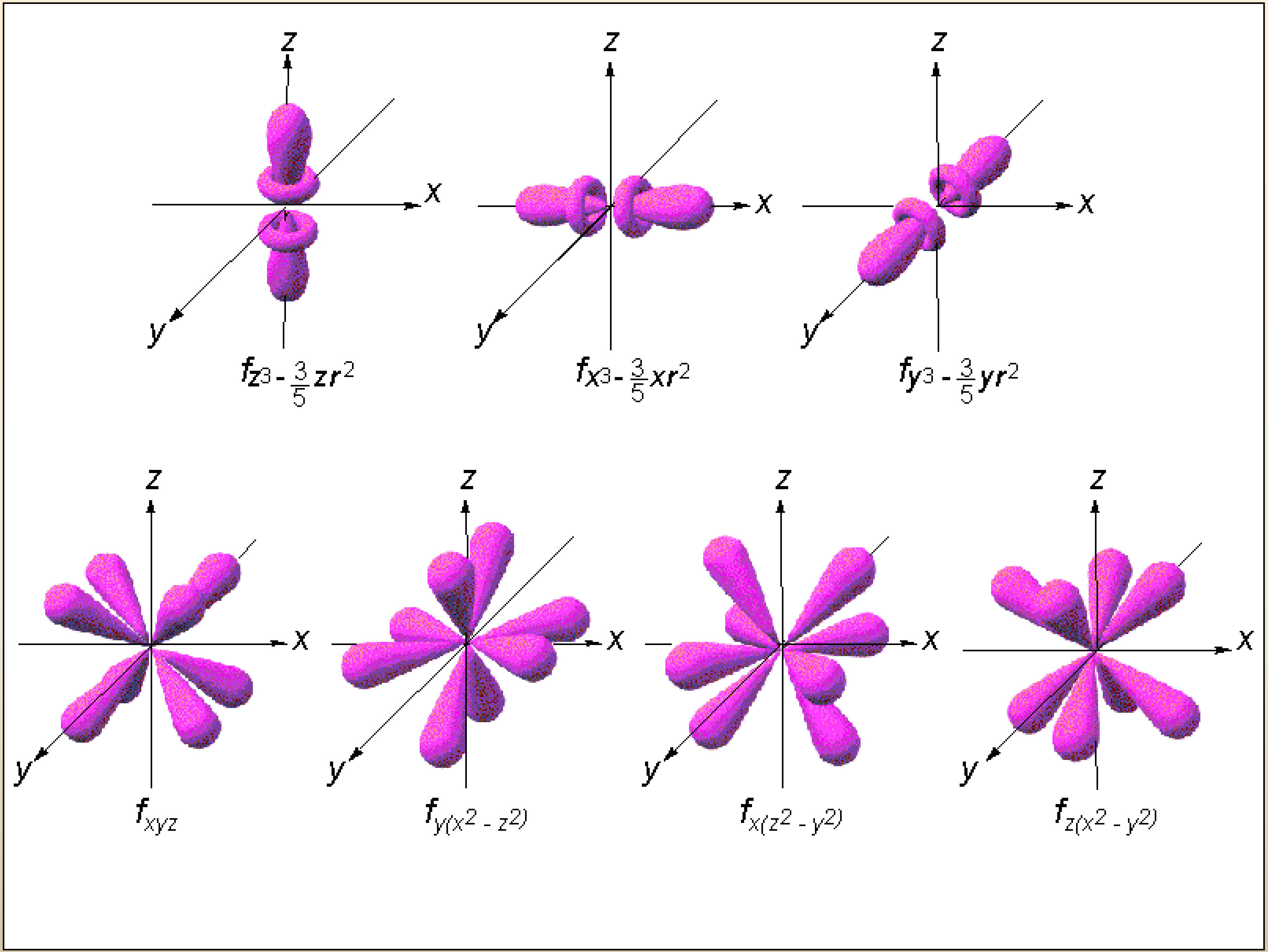
d orbital shapes



Things get a bit more complicated with the five *d* orbitals that are found in the *d* sublevels beginning with n = 3. To remember the shapes, think of "<u>d</u>ouble <u>d</u>umbells"

…and a "<u>d</u>umbell with a <u>d</u>onut"!

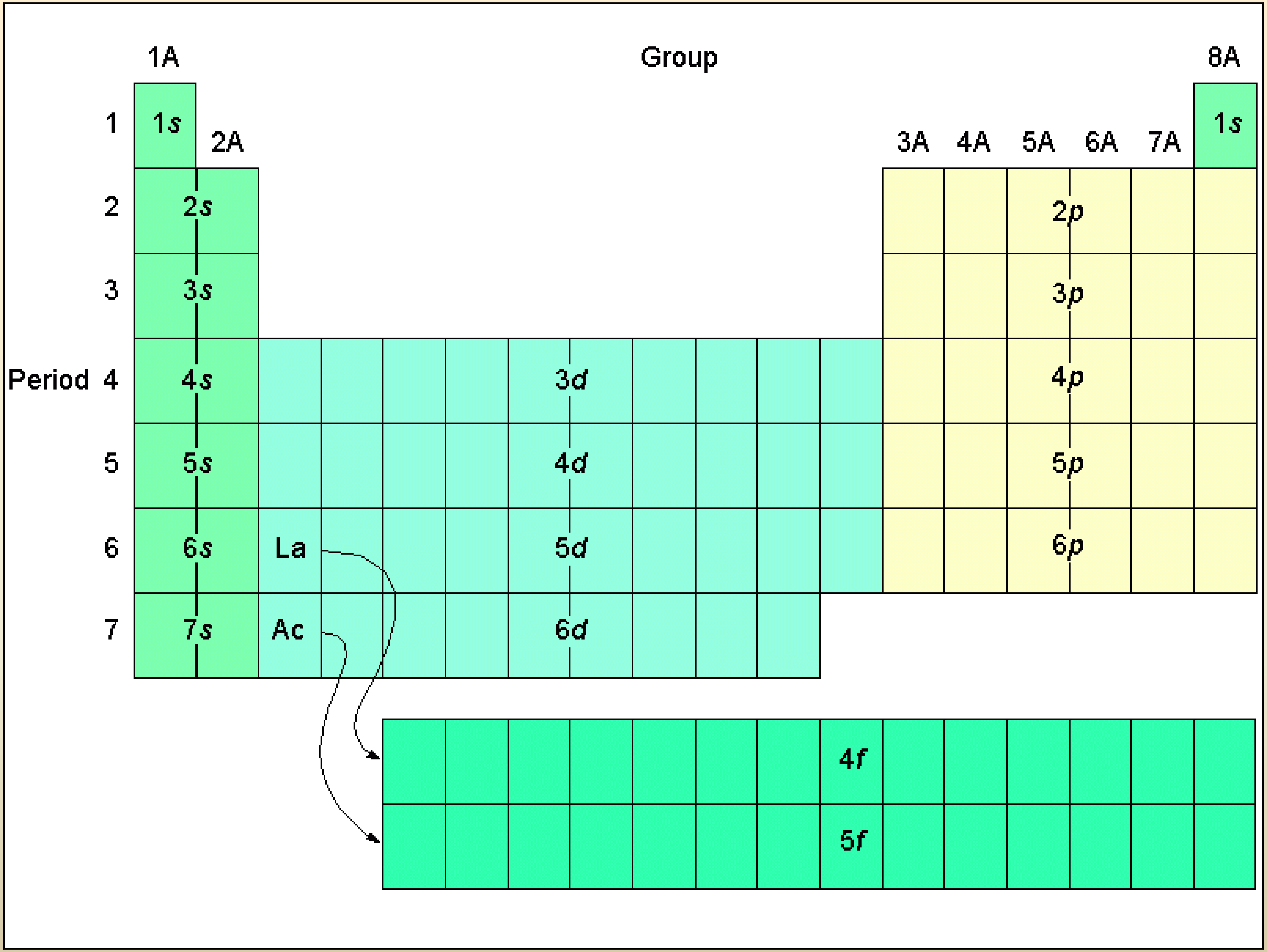
Shape of f orbitals



Energy Levels, Orbitals, Electrons

Energy Level (n)	Orbital type in the energy level (types = n)	Number of orbitals	Number of Electrons	Number of electrons per Energy level ($2n^2$)
1				
2				
3				
4				

Orbital filling table



Electron Spin

Electron spin describes the behavior (direction of spin) of an electron within a magnetic field.

Possibilities for electron spin:

$$+\frac{1}{2} \qquad -\frac{1}{2}$$

Pauli Exclusion Principle

Wolfgang
Pauli

Two electrons occupying the same orbital must have *opposite* spins

Electron configuration of the elements of the first three series

H $1s^1$							He $1s^2$
Li $2s^1$	Be $2s^2$	B $2p^1$	C $2p^2$	N $2p^3$	O $2p^4$	F $2p^5$	Ne $2p^6$
Na $3s^1$	Mg $3s^2$	Al $3p^1$	Si $3p^2$	P $3p^3$	S $3p^4$	Cl $3p^5$	Ar $3p^6$

Element	Configuration notation	Orbital notation	Noble gas notation
Lithium	$1s^2 2s^1$	1s: ↑↓ 2s: ↑ 2p: _ _ _	[He]$2s^1$
Beryllium	$1s^2 2s^2$	1s: ↑↓ 2s: ↑↓ 2p: _ _ _	[He]$2s^2$
Boron	$1s^2 2s^2 2p^1$	1s: ↑↓ 2s: ↑↓ 2p: ↑ _ _	[He]$2s^2 p^1$
Carbon	$1s^2 2s^2 2p^2$	1s: ↑↓ 2s: ↑↓ 2p: ↑ ↑ _	[He]$2s^2 p^2$
Nitrogen	$1s^2 2s^2 2p^3$	1s: ↑↓ 2s: ↑↓ 2p: ↑ ↑ ↑	[He]$2s^2 p^3$
Oxygen	$1s^2 2s^2 2p^4$	1s: ↑↓ 2s: ↑↓ 2p: ↑↓ ↑ ↑	[He]$2s^2 p^4$
Fluorine	$1s^2 2s^2 2p^5$	1s: ↑↓ 2s: ↑↓ 2p: ↑↓ ↑↓ ↑	[He]$2s^2 p^5$
Neon	$1s^2 2s^2 2p^6$	1s: ↑↓ 2s: ↑↓ 2p: ↑↓ ↑↓ ↑↓	[He]$2s^2 p^6$