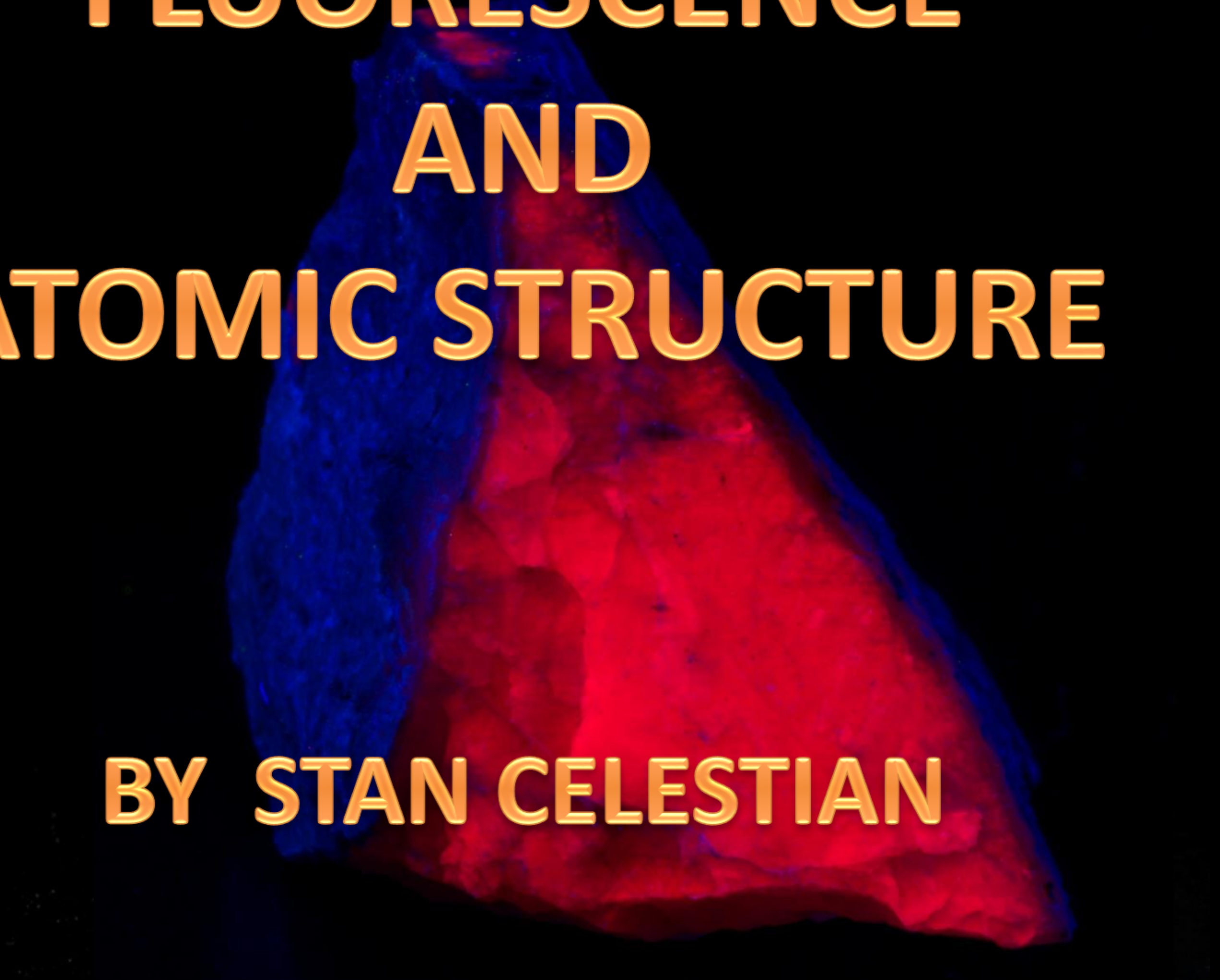
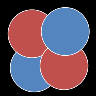
FLUORESCENCE AND ATOMIC STRUCTURE



BY STAN CELESTIAN

Eucrpytite from the Midnight Owl Mine, Arizona

Basic Atomic Structure

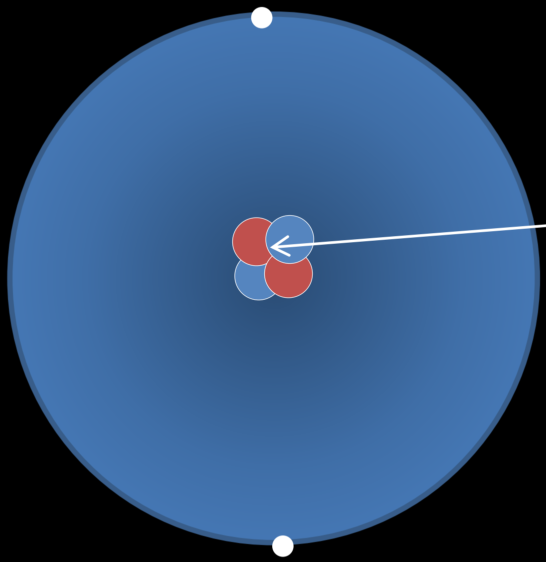


Atomic Nucleus

In this example the nucleus is simply a proton. This is essentially an atom of Hydrogen.

More complex atoms have more protons (red) and neutrons (blue) that make up the nucleus. This is now an example of a Helium atom. It contains 2 protons and 2 neutrons.

Basic Atomic Structure



Two protons require two electrons to produce a neutral atom.

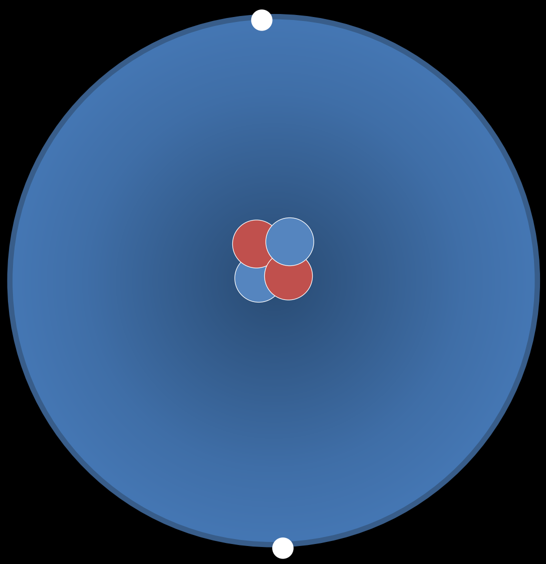
Surrounding the nucleus are electrons.

Atomic Nucleus

Electrons are found in specific orbitals at specific distances away from the nucleus.

The number of electrons and their spacing from the nucleus is unique for each element.

Basic Atomic Structure

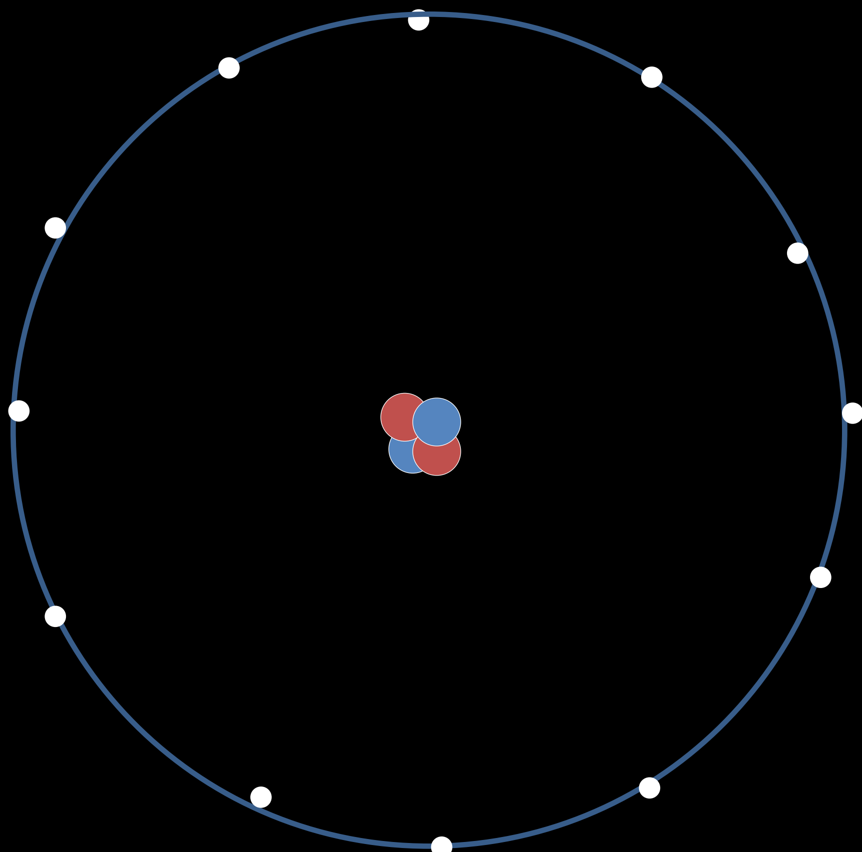


As the number of protons (and neutrons) within the atomic nucleus grows, the number of electrons surrounding the nucleus also grows.

This growth is not random.   There is a definite, measurable distance between electron orbitals for each element.

It is the number and orbital spacing of the electrons that controls **fluorescence** as well as many other properties of matter, including minerals.

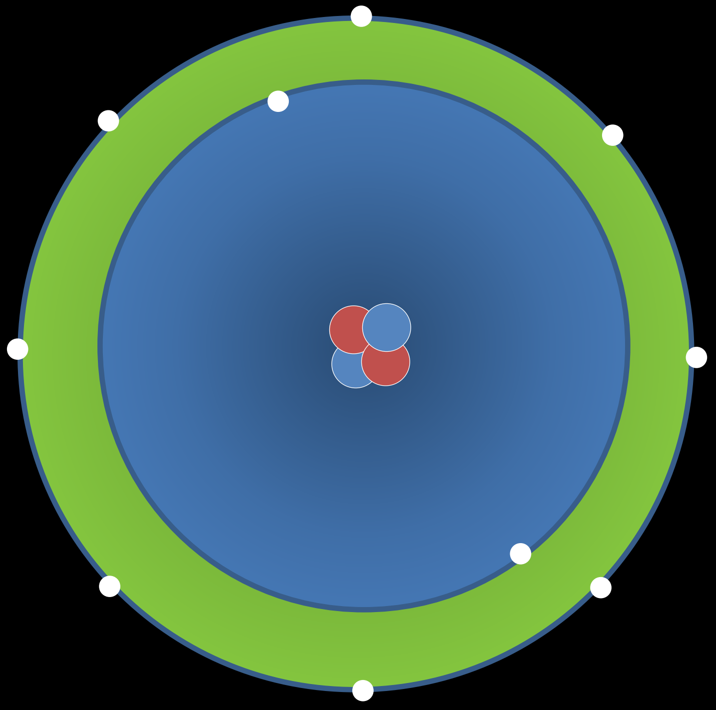
Basic Atomic Structure



This cloud of electrons produces an orbital shell around the inner electron orbitals and the nucleus.

For purposes of illustrating the orbitals, a static model is used.

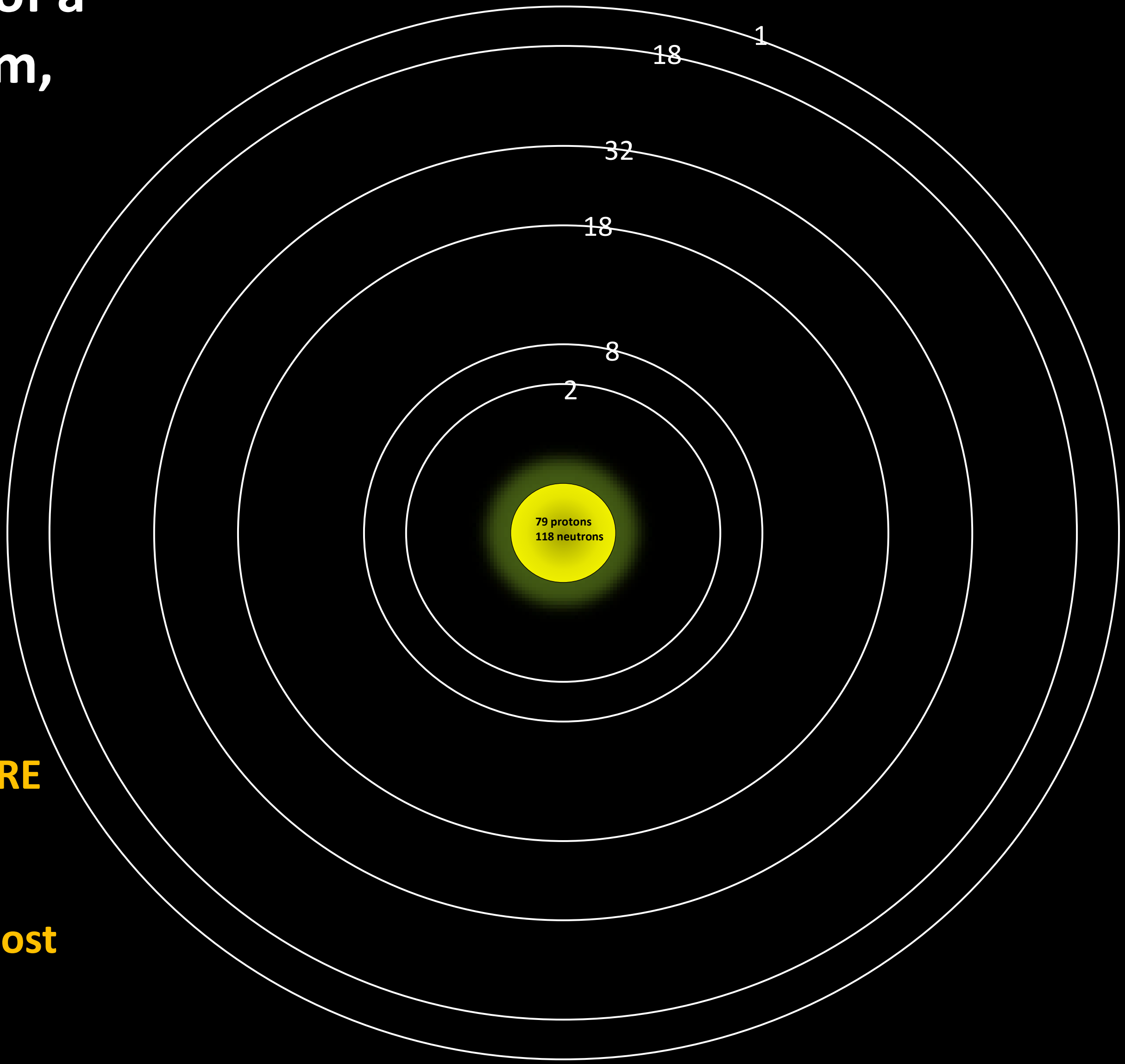
Basic Atomic Structure



That frenzy of electrons in the shell is actually understood fairly well and can be represented as a circular orbit around the nucleus.

This model now shows two shells of electrons. The first shell has two electrons and the second shell has 8 electrons.

Here is an example of a more complex atom, **GOLD**.

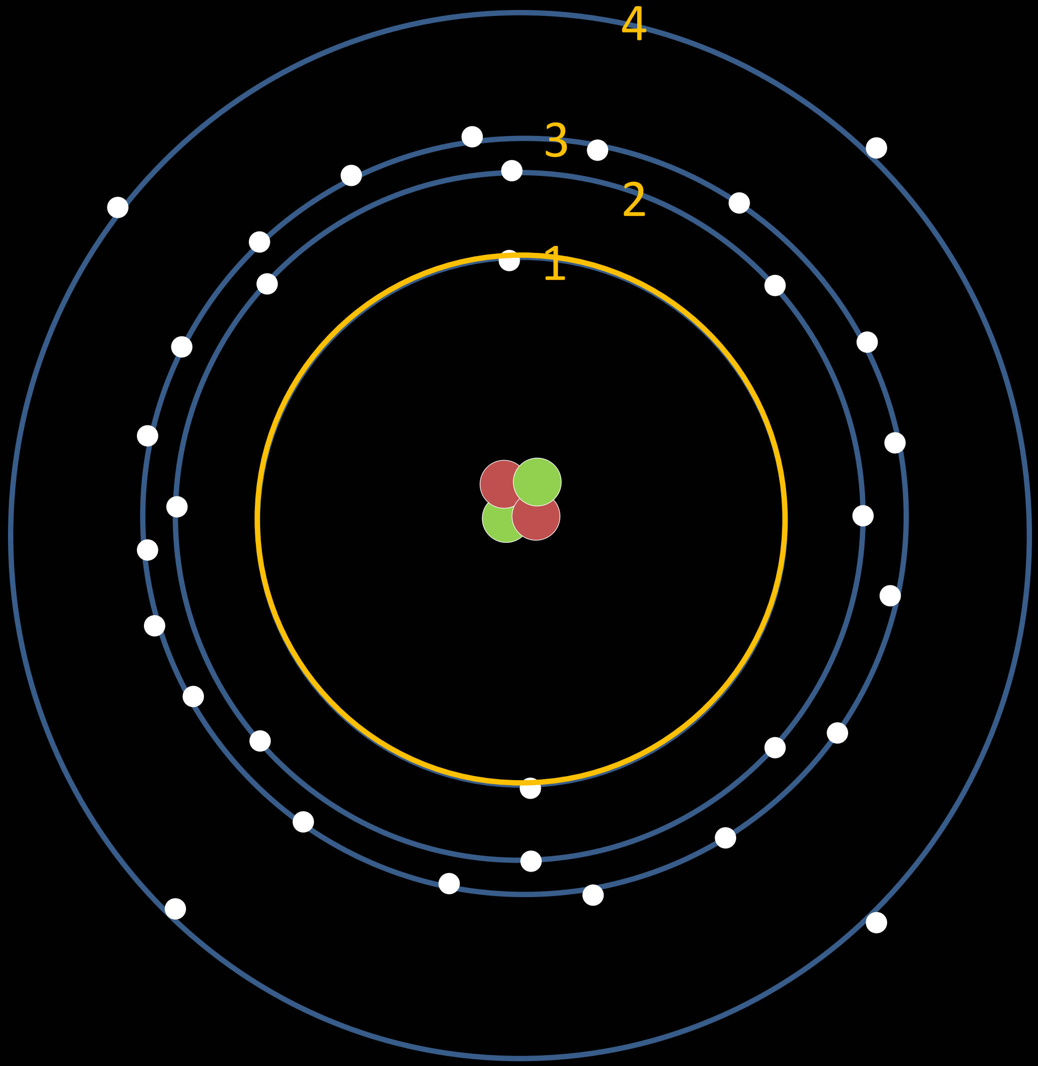


GOLD ATOMIC STRUCTURE

Gold always contains 79 protons in its nucleus and most commonly 118 neutrons.

First Energy Level: 2 electrons
Second Energy Level: 8 electrons
Third Energy Level: 18 electrons
Fourth Energy Level: 32 electrons
Fifth Energy Level: 18 electrons
Sixth Energy Level: 1 electrons

Basic Atomic Structure



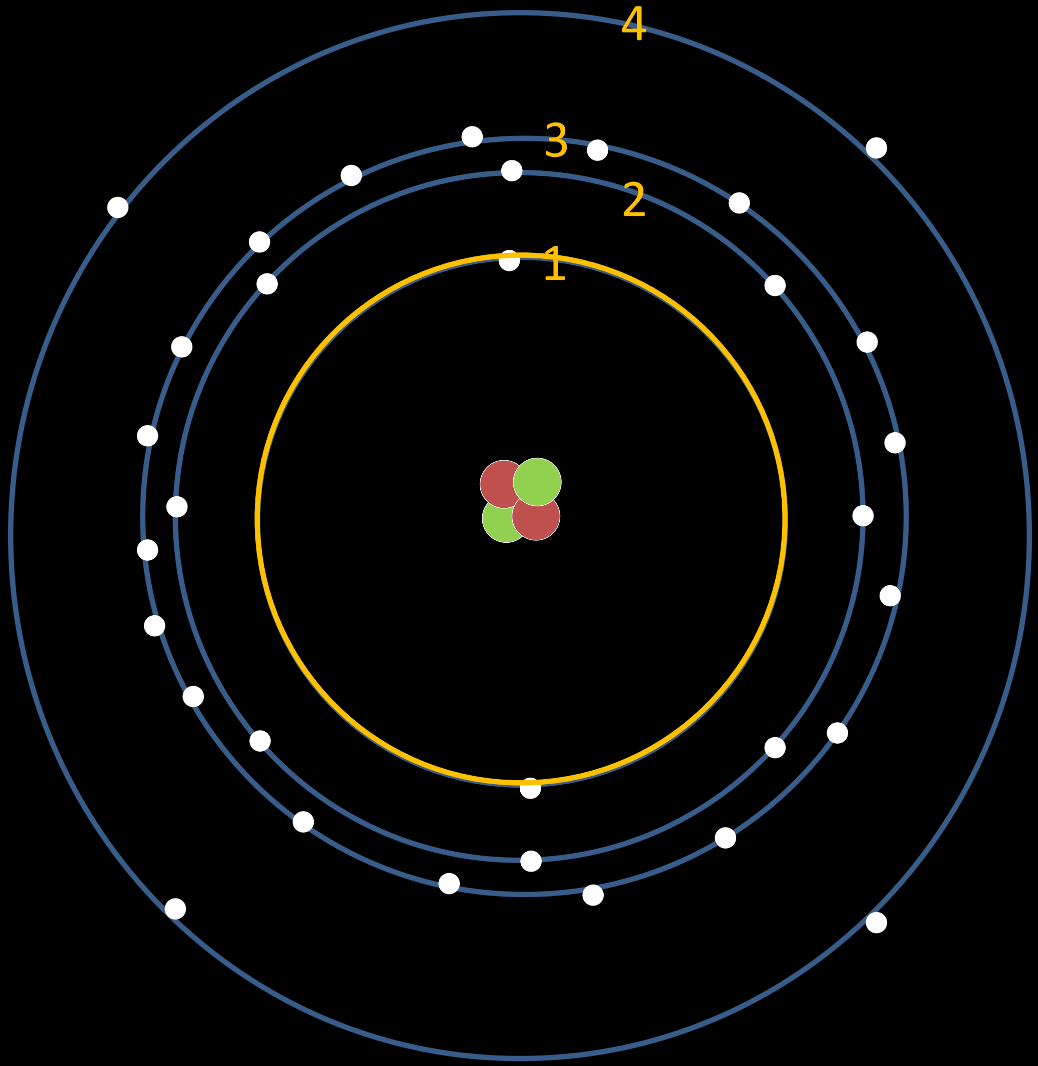
More shells and electrons have been added to create this <u>hypothetical</u> atom for the example of fluorescence.

Note the different spacing between the shells of electrons. Some shells are closer than others. In particular notice the close spacing of shells 2 and 3. The gap between 3 and 4 is greater than that of the gap between 2 and 3.

Shell 1 is called the ground state. Shell 2, 3 and 4 are at increasingly higher energy levels. It takes energy to lift an electron to a higher energy level.

<u>This model is not to scale</u>. If the nucleus of the atom was the size of a golf ball, the first electron shell would be 1.5 miles away.

Basic Atomic Structure



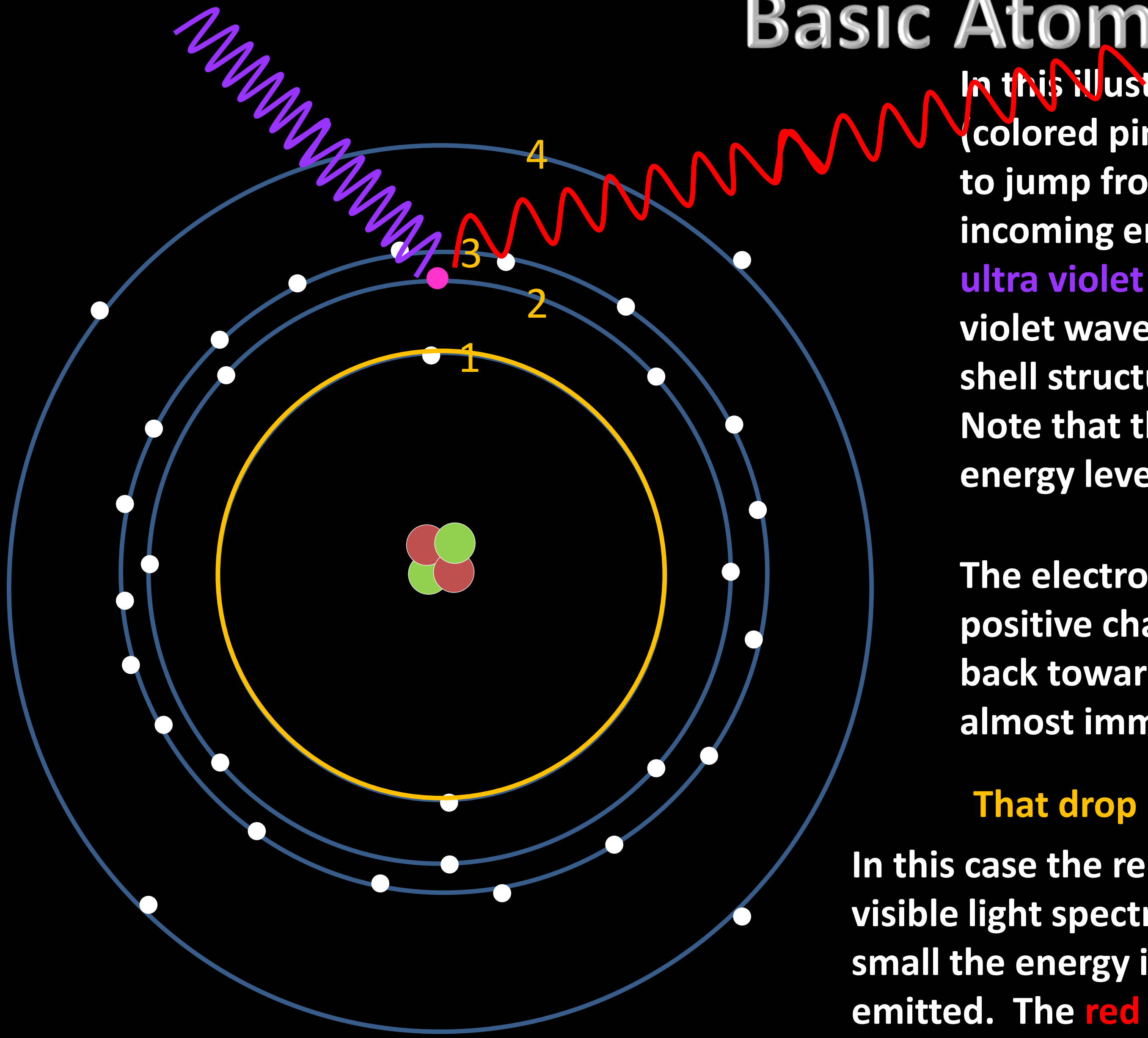
An electron must absorb a specific discrete amount of energy to move from one orbital to another. That energy quantity depends on the spacing of the energy levels (how big the jump is) and the strength of the positve charge in the nucleus.

The jump from level 2 to 3 requires less energy than the jump from 2 to 4 or from 3 to 4.

Electrons returning towards the ground state release energy. That energy is dependent on the distance the electron drops. An electron dropping the greater distance 4 to 3 will release more energy than a drop from 3 to 2.

The drop from 4 to 2 will release even more energy. <u>The bigger the drop, the greater the energy released.</u>

Basic Atomic Structure



In this illustration an electron (colored pink) is given enough energy to jump from level 2 to level 3. The incoming energy is in the form of ultra violet light and is shown as the violet wave coming into the electron shell structure from the top left. Note that the electron moved up one energy level.

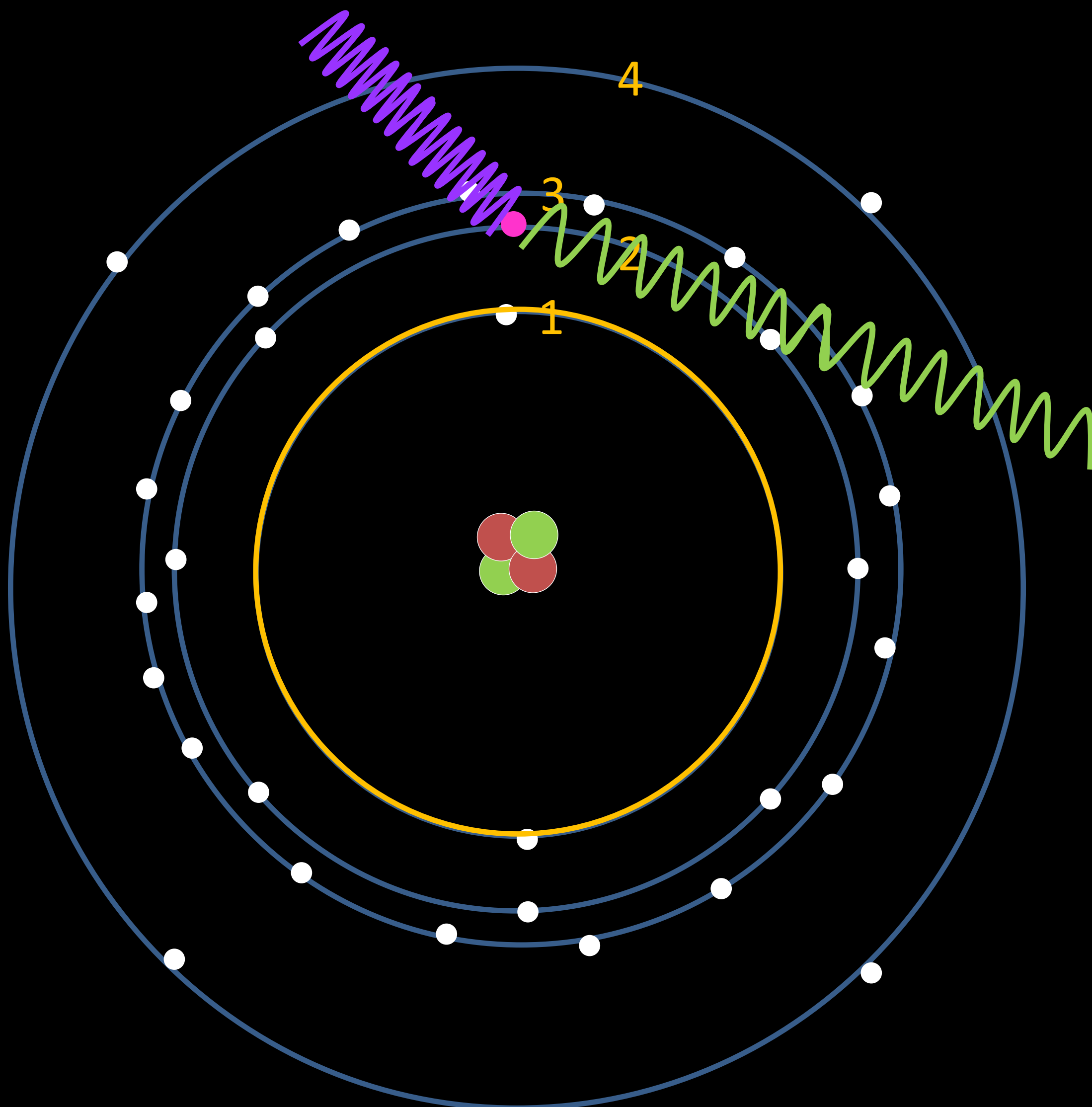
The electron is unstable and the positive charge of the nucleus pulls it back towards the ground state almost immediately.

That drop releases energy.

In this case the release of energy is in the visible light spectrum. Because the drop is small the energy is low and red light is emitted. The red wave was shown as a longer wavelength wave.

This release of visible light is called **FLUORESCENCE**.

Basic Atomic Structure

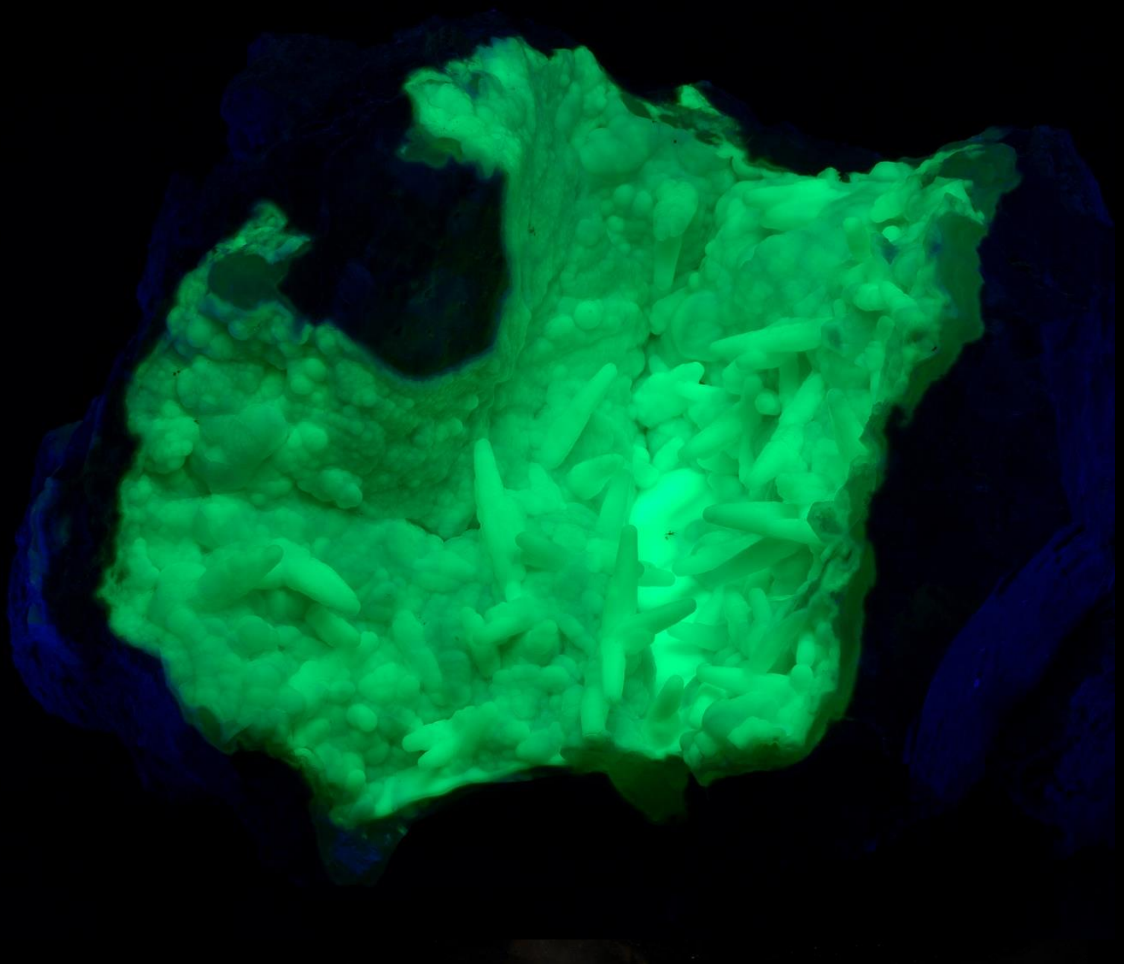


If that pink electron (representing any electron in that orbital) absorbs just the right quantity of energy, it can jump to an even higher energy level. In this example it jumps from level 2 to level 4.

That jump required more energy and the electron will thus drop a greater distance to return to orbit 2. That greater drop will release a higher energy wave. In this case it is green.

Each element has a unique spacing of electron shells. Electrons require energy to jump to the higher levels and release energy when they fall back towards the ground state. When some minerals are exposed to ultra violet radiation these transitions of electrons can take place. When the spacing of the electrons is just right, visible light is released, the mineral fluoresces.

EXAMPLES OF FLOURESCENE IN MINERALS

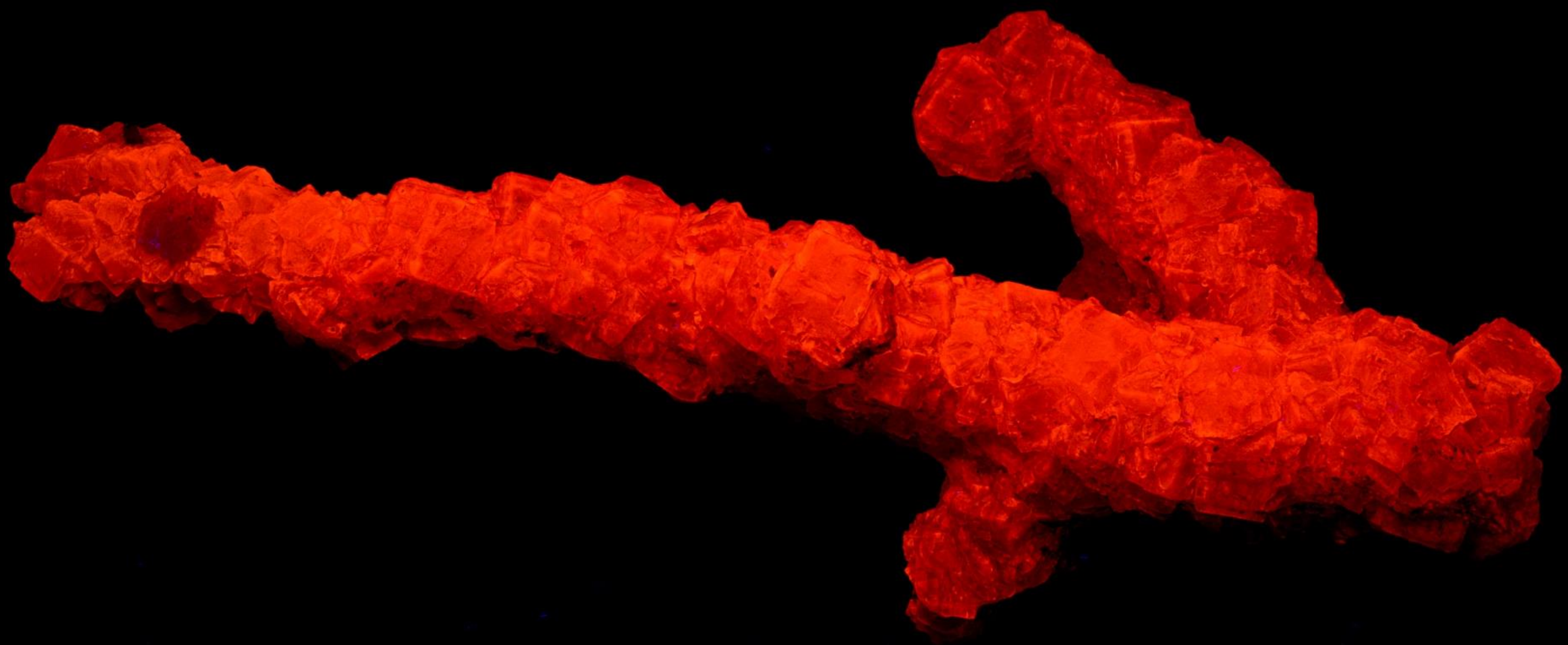


This is a portion of a geode from Potts Canyon in central Arizona. This white light image shows crystals of calcite that have been coated with a cryptocrystalline (*crypto* is Greek for *hidden*) coating of quartz. This substance is called chalcedony.

It is this chalcedony coating that fluoresces when exposed to ultra violet radiation.

It is important to note that the chalcedony is not simply reflecting light, it is emitting light as the excited electrons (those that have gained energy and jumped to a higher energy state) are now falling back towards the ground state.

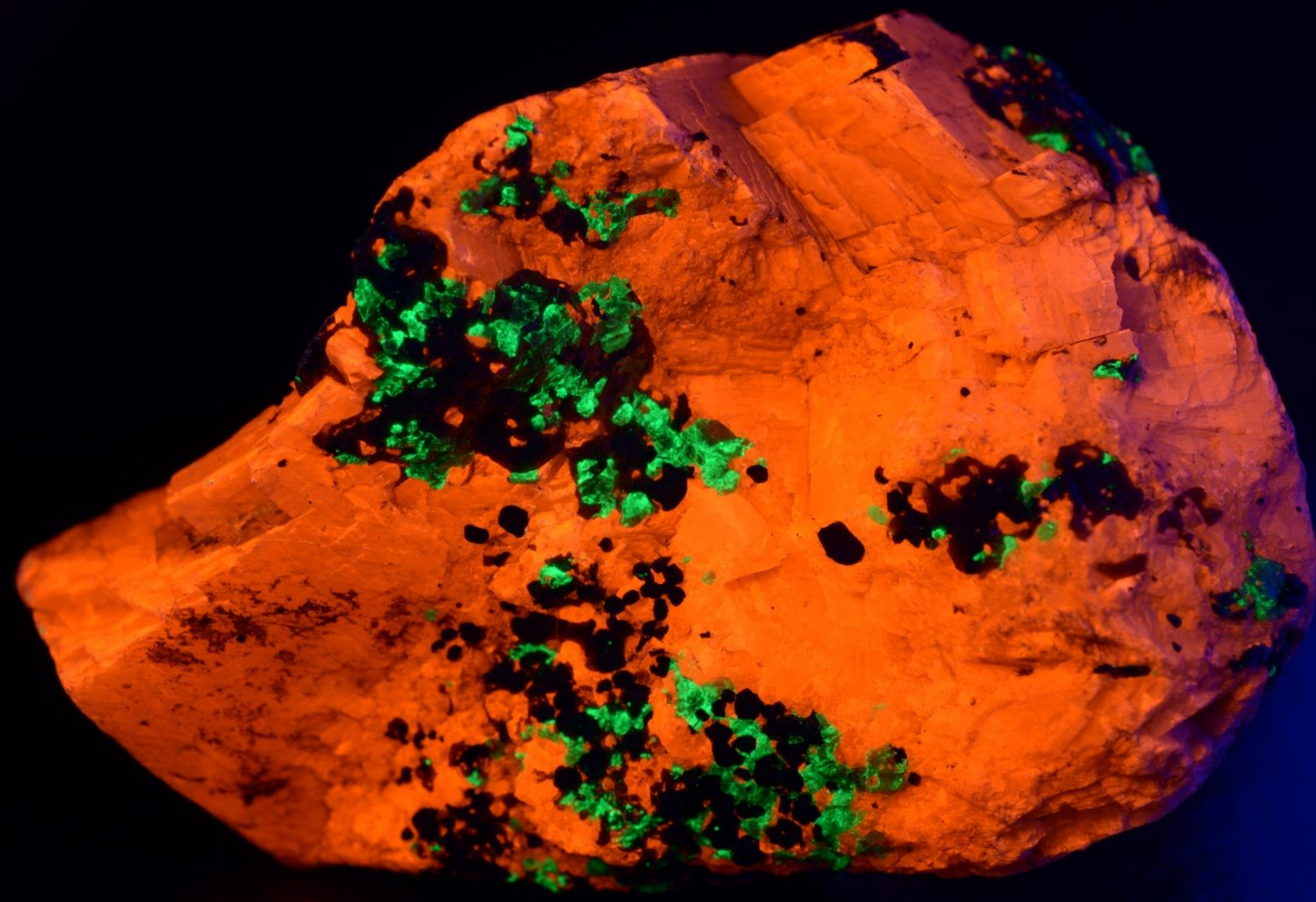
This is a specimen of the mineral Halite (ordinary salt) coating a twig. It was collected from the shores of the Salton Sea in California.



Under the influence of the ultra violet light, the electrons in the salt become excited and jump to higher energy levels. However, unlike the chalcedony in the previous example, the electrons in the halite fall a shorter distance and emit light of a lower energy – a reddish orange light.

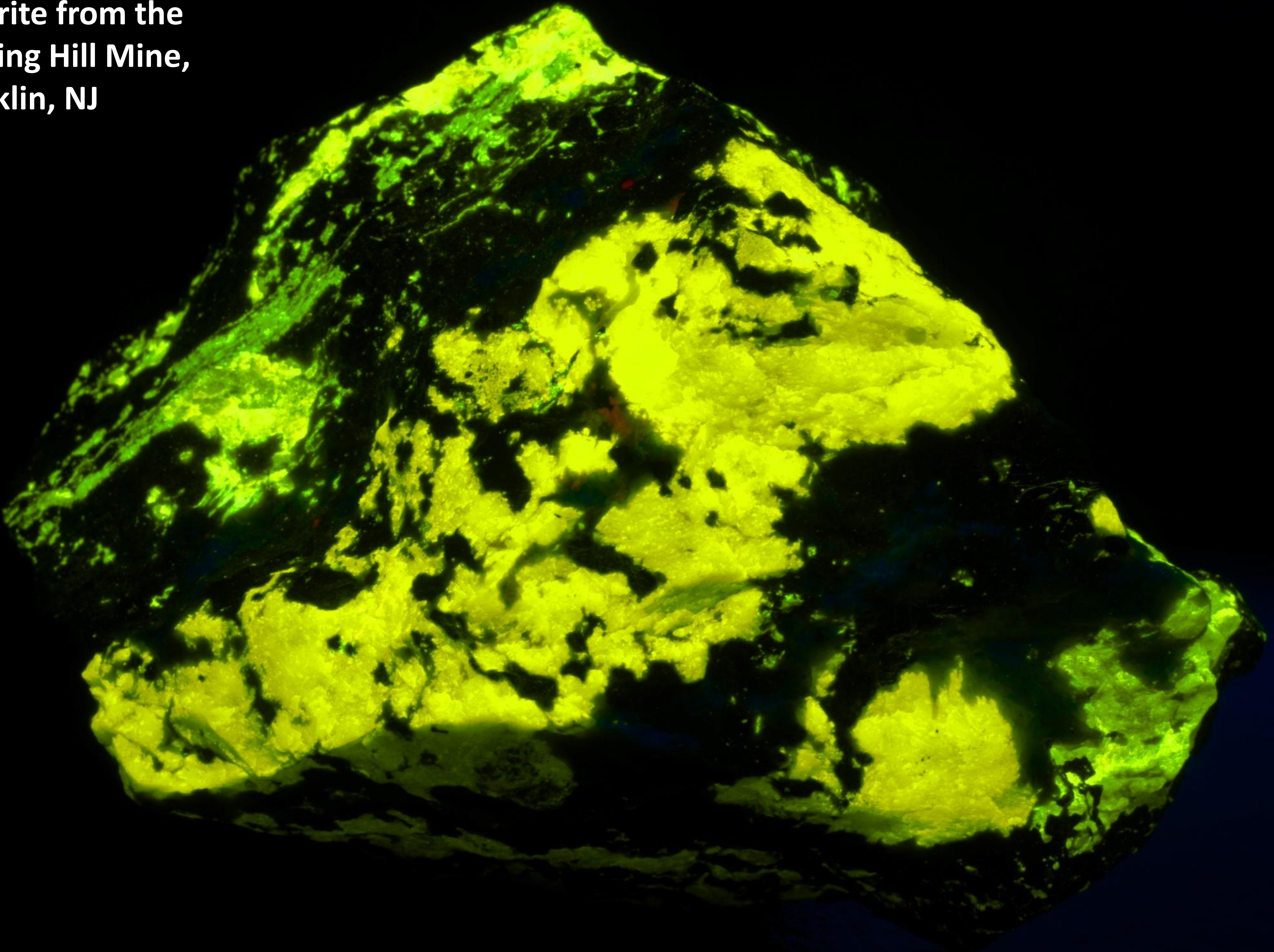
Willemite (brownish orange), Calcite (milky white) and Franklinite (black)

This view shows a rather dull and boring rock. It is from a world famous fluorescent mineral collecting area in Sterling Hill, New Jersey.



When exposed tho UV light, the common becomes a treasure: Willemite (green), Calcite (orange) and Franklinite (still black)

Esperite from the
Sterling Hill Mine,
Franklin, NJ



http://sterlinghillminingmuseum.org/

Below the picture from the web page of the Sterling Hill mine is a link to the page. If you are ever in the area it is an interesting place to visit. You can even collect some fluorescent minerals near the museum. The specimen of the Willemite, Calcite and Franklinite (slide 14) was collected there just a few years ago.

Not all minerals fluoresce and, in many cases, not all of the same minerals will fluoresce. For example, the Halite from the Salton Sea fluoresces a brilliant reddish orange. Halite from other localities do not fluoresce at all. Most minerals do not fluorescence because the spacing of their electron shells does not permit the release of visible photons when the excited atoms drop towards the ground state.

These minerals are not "self activators". Even the mineral Fluorite, after which fluorescence was named does not by itself fluoresce. It contains an *activator,* the element Europium, as an impurity in its crystal structure. Most minerals that fluoresce have these activators either as part of their structure or as impurities.

For example the greenish fluorescence of chalcedony is due to small amounts (a few parts per million) of uranium. Without the uranium as an activator, chalcedony will not fluoresce.

The mineral Autinite is a self activator. The electron shells that create the bright green fluorescence are part of the mineral's basic composition.

Autininte - $Ca(UO_2)_2(PO_4)_2 \bullet 12(H_2O)$

Here is a partial list of activators:

Antimony
Bismuth
Chromium
Copper
Dysprosium
Europium
Lead
Manganese
Silver
Terbium
Thallium
Tin
Titanium
Tungsten
Uranium
Vanadium
Yttrium

When present in the right amount, these elements can cause fluorescence.

These wavelength ranges are used for fluorescent mineral studies and targeted by scientific lamps.

Ultraviolet Wavelength Range				
	Wavelength	Abbreviations		
Short-wave	100-280nm	SW	UVC	Highest UV Energy
Mid-wave	280-315nm	MW	UVB	
Long-wave	315-400nm	LW	UVA	Lowest UV Energy

THE END