

# **MODULE**

- **Crystallography**
- **Crystal Growth**

# Crystallography

It is beyond the scope of this introductory course to delve deeply into the complex and rigorous field of scientific crystallography, however; it will be necessary for us to have a passing acquaintance with a few basics. This is because the majority of gems are crystalline, and the specific nature of their *crystalline structure has bearing on both their outward form, and their physical and optical properties.*

# Crystallography

**Minerals usually form distinct crystals.** The shape of the crystals has been found to play an important role in the identification of minerals. The study of crystals is called *crystallography*

# The Crystal Systems

There are seven\* basic plans upon which all mineral crystals are built. They are known as the "*crystal systems*".

Each of the systems has a unique architecture, based on the lengths, and angles of intersection of planes through the crystal called "axes", about which there are degrees of symmetry.

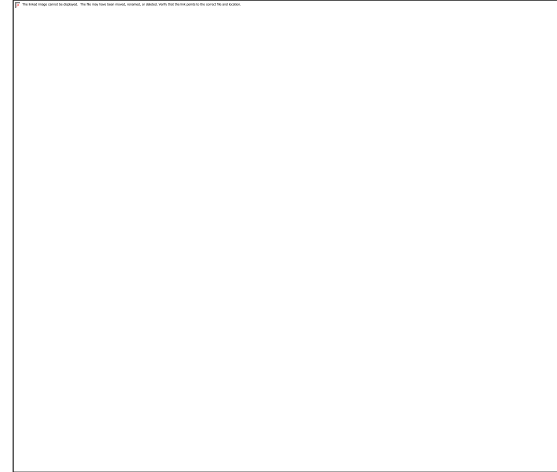


# Unit Cells

The innermost structure of each crystal is based upon atomic-scale building blocks that exhibit the symmetries shown in the "axes" column in the diagram above. These tiny building blocks are called "unit cells". The shape of a unit cell is different in each of the crystal systems: a cube in the cubic system, a "brick" for the tetragonal system, etc. *These tiny structures assemble themselves as the crystal grows, and build the crystal up to its finished size and shape*

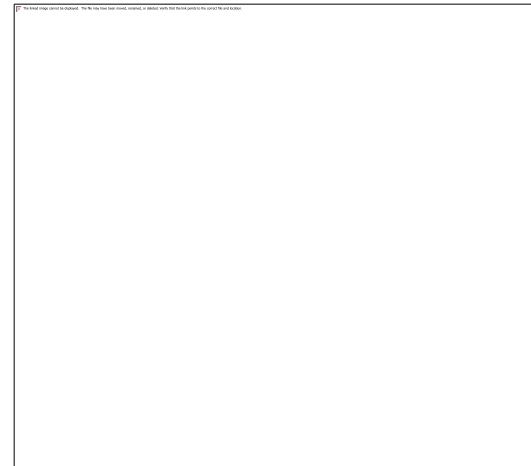
# Crystal "Habits"

**A few of the crystal habits, due to their similarity to common objects, are especially recognizable and have acquired special names, as demonstrated by the specimens below:**



**Acicular (needle-like): golden rutile crystals in quartz**

**Acicular (needle-like)**



***“Puffball-like” mesolite specimen of radiating acicular needles***

**Prismatic (pencil-like)**

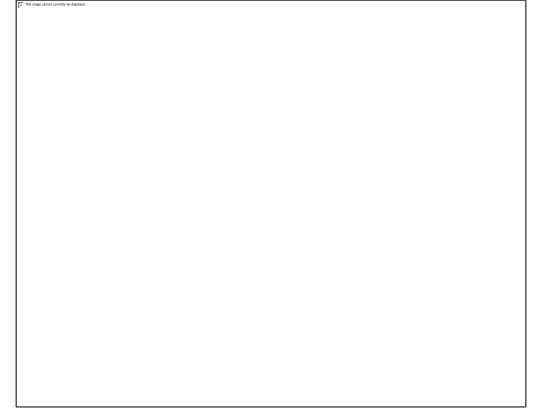


***Tourmaline crystals***

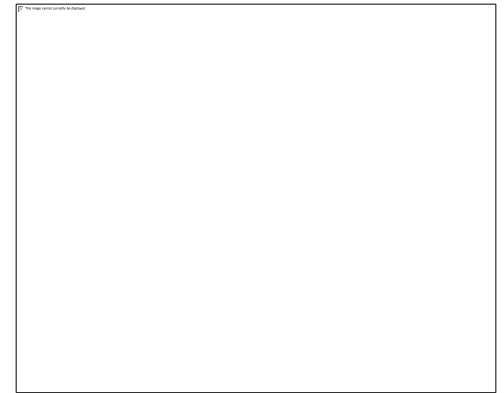


***Red beryl crystal in matrix***

***Quartz with black manganese dioxide crystal inclusions***



***Sandstone matrix with iron oxide dendritic crystals on surface,***

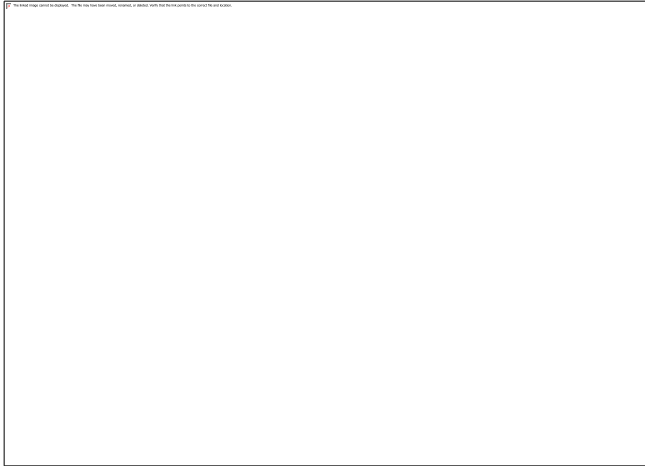


***Dendritic* (like tree branches)**

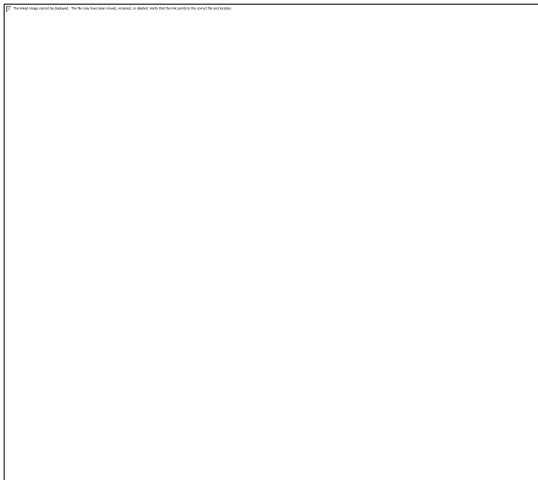
***Dendritic native copper crystals***



**[Drusy (like sugar or powdery snow on a surface)**



***Pyrite crystals on matrix***



***Botryoidal (seen in aggregate gems only, like a bunch of grapes or bubbles): blue chalcedony***

# Crystal Growth

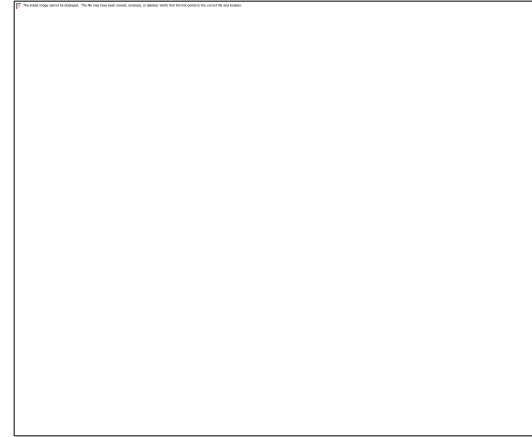
## Factors affecting crystal appearance:

Temperature/Pressure: the effect of rapid versus slow cooling of a melted material has different outcomes. The same molten mass of atoms, or the same solution, or vapor of materials can crystallize differently, depending on the temperature and pressure at the time, and in the place, where crystallization occurs. *This is because there can be more than one stable crystal lattice composed of the same atoms.* The various stable configurations that a particular gem species can crystallize in, are referred to as its "polymorphs".

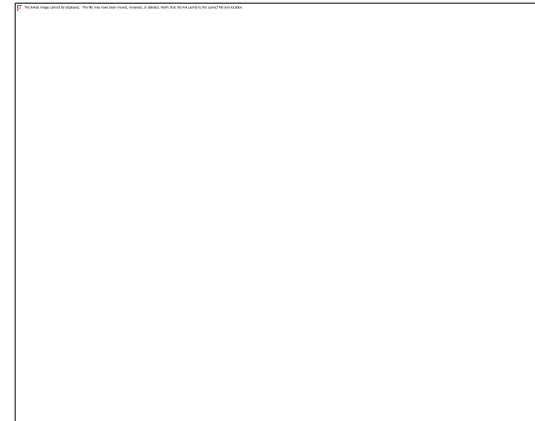
# Polymorphs

**When two materials have the same chemical formula but have crystallized differently (due to each being subjected to different temperature/pressure conditions at formation), they are called polymorphs. The most famous examples are diamond and graphite. Both have the same chemical formula (just C, pure carbon), but the "lead" in your pencil and the diamond on your finger, obviously exhibit quite different properties. Graphite crystals are formed of sheets of tightly bonded carbons atoms in layers which are very loosely bound to each other, allowing lots of slipping and sliding. Diamond crystals have each carbon atom bonded tightly to four others surrounding it in all directions, so the whole structure is very strong and durable.**

# ***Polymorphs of carbon***



***Diamond (uncut dodecahedral  
(12 sided) crystal)***



***Graphite***

# Space available

**Crystals often form in cavities, cracks, bubbles, and other cramped places, the size and shape of which will limit growth possibilities. Some directions of potential growth might be unavailable or limited, while others afford plenty of "growing room". It can also occur that two or more crystals which start growing in a space independently, can contact and/or interpenetrate each other resulting in *"twinning"*.**

# Chemical elements present

Each species requires a particular set and proportion of chemical elements for its basic makeup, and cannot grow without them. Non-required elements, though, which incorporate into the growing crystal in trace amounts can have dramatic effects on the appearance (usually color) of the gem. For example, a very small amount of the element chromium, when present along with the necessary aluminum and oxygen, turns, what would otherwise have been colorless corundum, into red ruby. In addition, fluctuations in the amount or type of growth materials present can lead to color zoning.

# **Presence of other minerals**

**Minerals do not usually form crystals in complete isolation. As a particular crystal is forming, other minerals, also in the process of crystallization, can be captured by it (to show up as inclusions) or capture it. Exactly how this plays out will depend on the relative crystallization temperatures and pressures required by the materials in the group.**

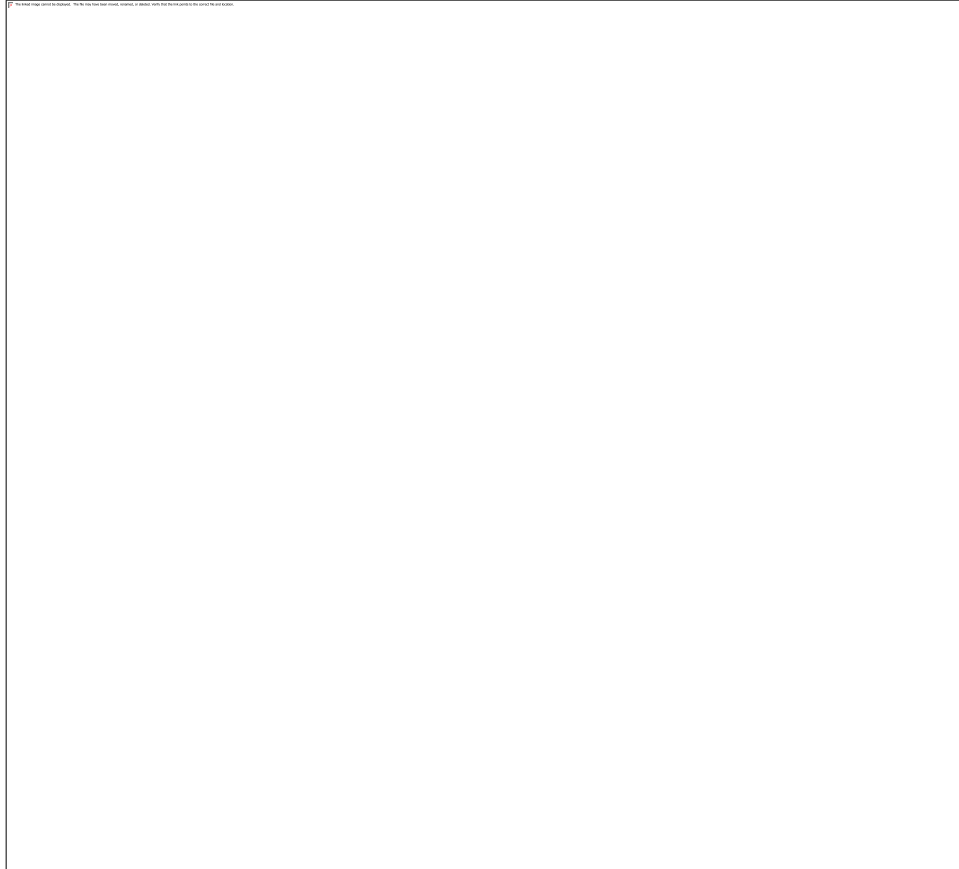


***Quartz from Madagascar with fluorite  
crystal inclusions, inset picture at 10x]***

# Special Growth Phenomena

## Twinning

When growing crystals of the same mineral share one or more faces, the result is a crystal "twin". Depending on the nature of the twinning, which can be on either a visible, or a microscopic scale, the shape of the crystal might be dramatically affected, or the material's properties could be noticeably altered. Sometimes, evidence of twinning can be seen in a crystal or cut gem due to unusual color or inclusion patterns.



***Twinned quartz crystals in "rabbit ear" form***

# Phantoms Crystals

**Due to changes in environmental conditions, starts and stops of crystal growth occur. When other minerals, which are favored in the new conditions, start to grow, they sometimes crystallize on the "old" faces of the temporarily inert material. When conditions change, and the host once again starts its growth, evidence of the pauses may now be visibly captured as outlines**

# Negative Crystals

**Likewise, certain conditions may completely block the growth of an interior portion of a crystal leaving a void which is bounded by the sides of the crystal around it at first glance this "negative" crystal looks like a solid crystal inclusion, but it is indeed empty.**

# Pseudomorphs

The term "pseudomorph" literally means false form. A pseudomorph is, in a way, the opposite of a polymorph. Whereas polymorphs are different crystal forms of the *same* chemical compound, a pseudomorph shows a crystal form which is not one recognized for its species. To put it another way, it's the case of one mineral taking on the outward form of another while keeping its chemistry unchanged. Let's take the example of Goethite which is an iron oxide mineral that crystallizes in the orthorhombic system. A glance back at the diagram for the crystal systems shows us that orthorhombic gems *do not* form in perfect cubes. Pyrite, however is an iron sulfide mineral (in the cubic system) that frequently forms crystals shaped like perfect cubes.

# Pseudomorphs

**Pseudomorphs occur when environmental conditions occur that cause the replacement of one chemical compound with another without altering the pre-existing three dimensional structure. Mineralogically, the item is named as an "X" pseudomorph (ps.) after "Y".**