

**UNIVERSITY OF ZAMBIA
DEPARTMENT OF MINING ENGINEERING**

**COURSE OUTLINE FOR INTRODUCTION TO
GEMOLOGY (MIN 3019)**

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Malachite

Malachite and
azurite

COURSE OBJECTIVES

Equip students with knowledge in the following aspects:

- To appreciate what constitutes gemstone materials
- Understand the geology and occurrence of gemstones
- Investigate their physical and optical properties (gemstone identification)
- Mining of gemstones
- Gemstone processing
- Gemstone valuation and marketing

COURSE OUTLINE

- What is Gemology?
- Definition of gemstones
- Natural gems
- Synthetics
- Artificial products
- Classification of gems
- Geology of gemstone materials and their occurrences.
- Mining of gemstones

COURSE OUTLINE – cont/d

- Physical and optical properties of gemstones:
 - Physical properties
 - Optical properties
- Gemstone fashioning
 - Faceting
 - Tumbling
 - Caving, etc

COURSE OUTLINE – cont/d

- Synthetic and Artificial Products
- Gemstone enhancement
- Gemstone valuation and marketing

COURSE EVALUATION

Final examination:	60%
2 term tests:	15%
Laboratory	15%
Assignments	10%

References:

Books	
Gemstones of the world	W. Schuman
Gemstones of the world	Webster and Schuster
Hand book of gemstones I.D (R.T.L)	
Gems (sources, Descriptions, I.D)	R Webster
Photo Atlas	E.J Guberin
Gemstone Identification made easy	A.L. Matline
Diamond grading ABC	V Pagel
Gemologists Compendium	R. Webster
Gemology	R.G Read
The Smithsonian Handbook of Gemstones	Cally Hall & John Taylor, Dorling Kindersley, 2002
Simon and Schuster's Guide to Gems and Precious Stones,	Kennie Lyman, Editor, Simon and Schuster, 1986

What is Gemology?

Gemology (or **gemmology**) is the [science](#), [art](#) and [profession](#) of identifying and evaluating [gemstones](#). It is considered a [geoscience](#) and a branch of [mineralogy](#). Some [jewelers](#) are academically trained gemologists and are qualified to identify and evaluate gems. Recently, the demand for gemological services has grown, as increasing quantities of synthetic gems such as [cubic zirconia](#) and synthetic [moissanite](#) are manufactured. Gemologists perform such work as the identification of synthetic and natural gemstones, fracture-filled gemstones, and color-enhanced or treated natural gemstone

INTRODUCTION

Basics

What is a Gem?

A **gemstone** or **gem** (also called a **precious** or **semi-precious stone**, a **fine gem**, or **jewel**) is a piece of [mineral](#), which, in cut and polished form, is used to make [jewelry](#) or other adornments.

INTRODUCTION

Basics – cont/d

However certain rocks (such as lapis lazuli), or organic materials that are not minerals (such as amber or jet), are also used for jewelry, and *are therefore often considered to be gemstones as well.* Most gemstones are **hard**, but some soft minerals are used in jewelry because of their luster or other physical properties that have aesthetic value. **Rarity** is another characteristic that lends value to a gemstone.

SAMPLE OF JET



JET VASES

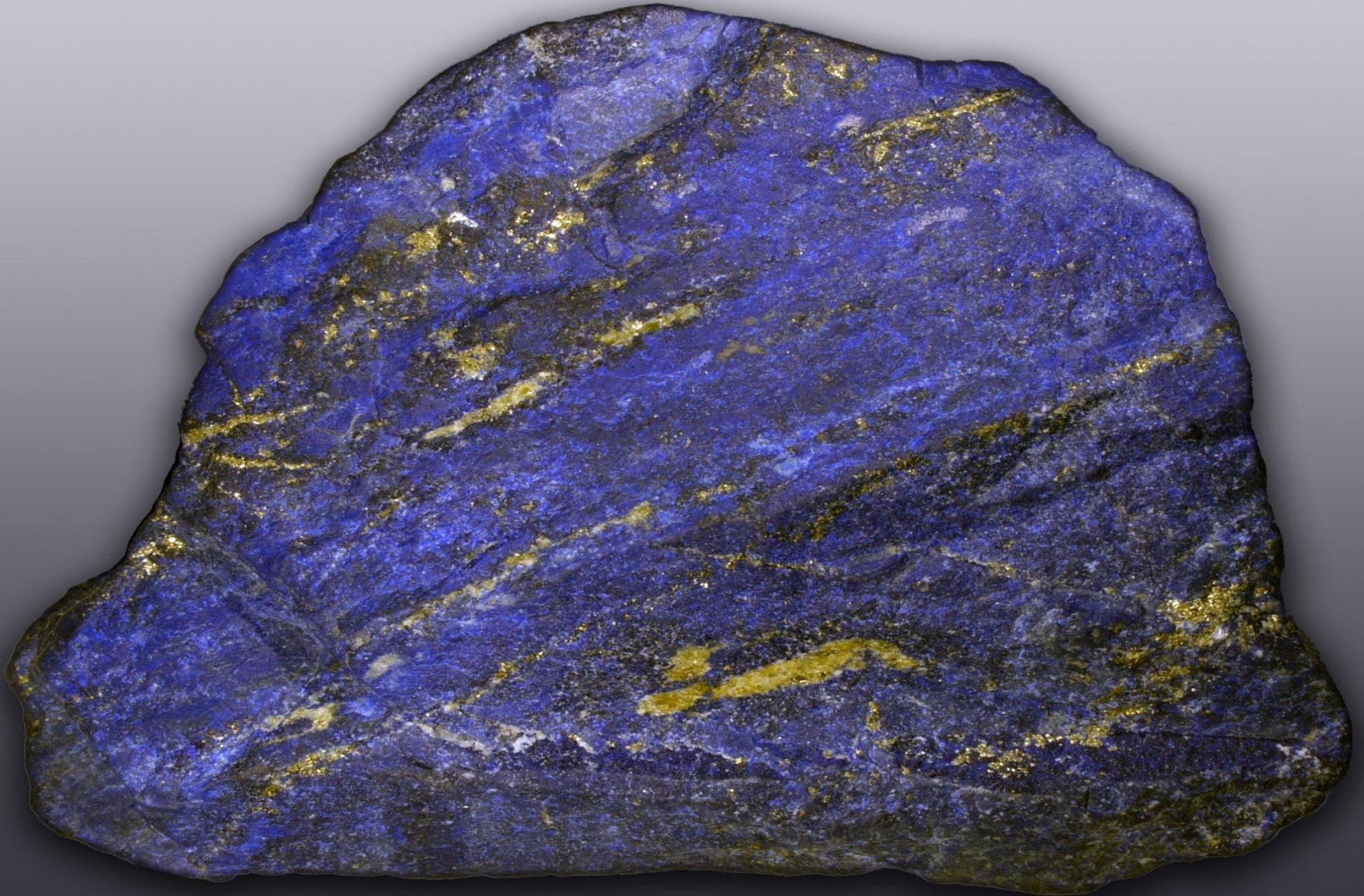


INTRODUCTION

Basics – cont/d

Apart from jewelry, from earliest antiquity until the 19th century [engraved gems](#) and [hardstone carvings](#) such as cups were major luxury art forms; the carvings of [Carl Fabergé](#) were the last significant works in this tradition.

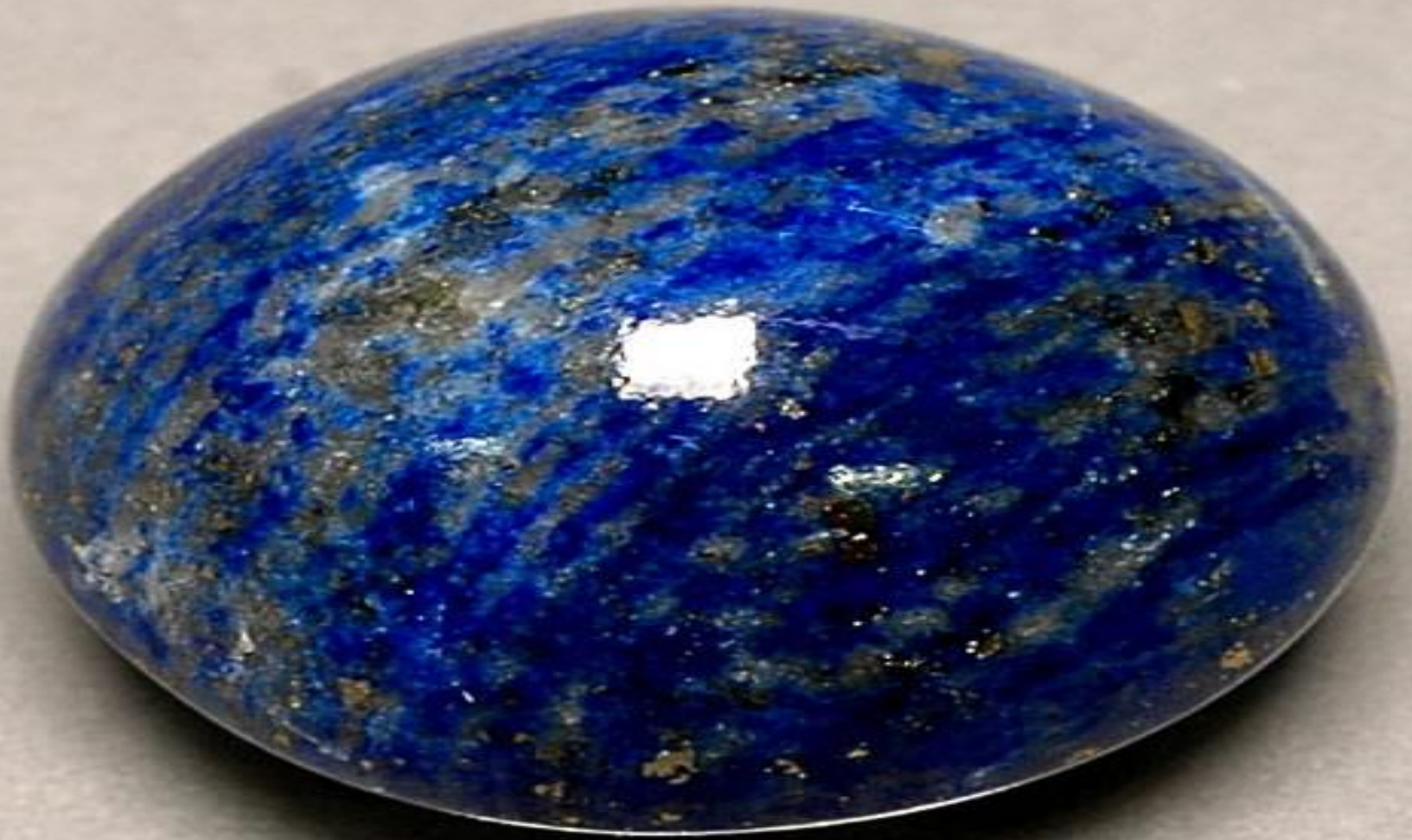
LAPIS LAZURI



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What is a gem?

A gem is a natural, mineral or organic substance, that has substantial beauty, rarity, and durability.

What is a gem? - Cont/d

Natural means that the material was not made, or assisted in its making, by human effort. When such *is* the case, modifiers such as "laboratory grown", "synthetic", "cultured", or "man-made", must, by Federal Trade Commission (FTC) regulations, be used in the descriptions of any such pieces being advertised or marketed. Man-made "gems" have all the chemical, optical and physical characteristics of the natural materials they imitate, but they do not have their rarity or value. You can be certain whenever you see any of the above modifiers that the material in question is *not* of natural origin.

What is a gem? - Cont/d

A mineral can be defined as a crystalline solid with a specific chemical formula, and a regular three dimensional arrangement of atoms. (this definition will be broadened to include "amorphous" materials which have a specific chemical formula but do not have a specific crystalline structure, for example, opal and natural types of glass).

What is a gem? - Cont/d

Mineral Gems

Iolite, which has a specific chemical formula of: $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$ and a regular arrangement of atoms which places it into a crystal system, with other minerals of similar structure, known as the *orthorhombic* crystal system is a mineral gem. Another example is emerald, $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$, a member of the *hexagonal* crystal system. (*The attributes of the various crystal systems will be presented in an upcoming lesson.*)

What is a gem? - Cont/d

Organic Gems

An organic gem is one that was made by living things, present or past. Examples include pearls, coral, jet, ivory, shell and amber. Such gems consist of the molecules formed by the organism, although these molecules may have been altered somewhat due to compression or other geological or chemical forces.

BLUE AMBER FROM DOMINICAN





AMBER

MOSQUITO IN AMBER



TYPICAL AMBER WITH INCLUSIONS



UNPOLISHED AMBER STONES



Organic Gems

Gems such as "petrified dinosaur bone" and many other "stony" fossil gems, are classified as mineral, rather than organic. Although its true that bone is an organic material: the reasoning involved is that the *original* organic molecules and structures of long ago have been totally replaced with mineral solutions such as silica. (This common geological process is called *petrifaction*).**

What is a gem? - Cont/d

BEAUTY

A gem is beautiful. Beauty, of course, is a subjective concept that has many aspects, and differs from viewer to viewer, but in general, the attributes of gems which excite our sense of beauty include, color, transparency, luster, brilliance, pattern, optical phenomena and, in some cases, distinctive inclusions.

What is a gem? - Cont/d

RARITY

A gem is rare. There are two types of rarity involved: relative and inherent.

- ***Relative***: Many gem minerals occur in various locales and, often, in large deposits, but the vast majority of the material does not approach "gem quality".
- ***Inherent***: Other minerals occur in only a few locations or in very small deposits. Inherently rare gems are *doubly rare* as the fraction of an already small amount of ore which is gem quality is very, very, small indeed.

Rarity

The mineral corundum (of which ruby is a gem example) is widespread and abundant. So much so, that an enormous amount of low grade corundum is used in industry for abrasives, due to its hardness (9 on a scale of 10). [Interestingly, very tiny, non-gem grade, corundum crystals have found use in today's beauty industry as the active ingredient in both medical "dermabrasion" agents, and over the counter "exfoliating" products.]

Rarity

Benitoite, on the other hand, is found in gem quality in only one location on Earth: the San Benito River Valley in California. Only a few ounces of cut gems result from each year's mining efforts, almost all of which are quite small in size. Ironically, this ultra-rare, nearly unobtainable stone has been officially designated as the State Gemstone of California.

Rarity

Usually in a deposit of gem mineral bearing ore, the majority is not the mineral being sought. From the small portion of the ore which bears the gem mineral, the majority is too low grade to have any gem uses. For example, 80% of the diamond recovered from diamond bearing ore, is industrial grade.

Rarity

Within the small amount of gem grade material, the bulk of it is of lowest quality and useable only for inexpensive beads or trinkets. The even smaller amount of better material which can be extracted, is mostly middle grade, or that which is used for cabochons and better beads and carvings. A tiny fraction is high grade and can be used for faceting. Most of the facet grade material has some defects in color or clarity that limit it to "commercial" quality gems. Only the most miniscule part of the original deposit is top grade: AAA color and flawless clarity.

GEM PRICES

How valuable are gemstones? If you ask people at random to name a valuable commodity, many might say gold. And true, we do think of gold as valuable. Consider this:

- Good quality amethyst gems sell for about \$40/ct
- Fine quality aquamarine sells for around \$200/ct
- Highest gem quality blue sapphire sells for as much as \$2500/ct.

Pure gold, however, is worth *well under \$10 per carat!*

Down through the centuries, gemstones have represented the *ultimate* in portable wealth

DURABILITY

A gem is durable. It must be strong enough to withstand the stresses and forces involved in fashioning it, and its subsequent use as an ornamental object, or in jewelry. Most everyone has heard of "hardness" and knows that harder is better, in terms of using gems for jewelry but in reality, hardness is only the beginning of the story. There are two other aspects of gem durability that are at least as important as hardness.

Three Aspects of Durability

- **1) *Hardness* is the ability to resist scratching. Commonly measured on the "Mohs" Scale of 1 - 10. Talc lowest (1), diamond highest (10). Soft gems, especially those below 7 will tend to become dull through abrasion with harder materials in the environment, and lose their surface polish and their crisp edges over time.**
- **2) *Toughness* is the ability to resist breaking or chipping. This property is measured in relative terms rather than on a numeric scale: sphalerite is fragile, diamond is moderately tough and jade is exceptionally tough. The lower the toughness of a gem the more susceptible it is to damage by the kinds of blows and knocks that are inevitable with frequent wear and use.**

Three Aspects of Durability

- **3) *Stability* is resistance to changes caused by environmental factors such as temperature, chemicals and light. Apatite is temperature sensitive, pearls are chemically sensitive, and Kunzite's color is unstable in strong light. Unstable gems exposed to common factors of the natural or man-made environment are likely to break, change color, or lose their luster.**

Classifying Gems

There are any number of ways by which gems can be classified. Most common ways:

- **PRECIOUS OR SEMIPRECIOUS: (HISTORICAL VIEW OF VALUE)**
- **FACETED OR CABOCHON: (CUTTING STYLE)**
- **NATURAL OR SYNTHETIC: (ORIGIN)**
- **ENHANCED OR UNENHANCED: (TREATMENT STATUS)**
- **SIMULANT OR FAKE: (HOW REPRESENTED)**
- **COLORED STONE OR DIAMOND: (GEM INDUSTRY VIEW)**
- **JEWELRY OR COLLECTOR GEM: (WHO WILL BE THE END USER)**



Turquoise

Hematite

Chrysocolla

Tigers-eye

Quartz

Tourmaline

Pyrite

Sugilite

Carnelian

Snowflake

Moss

Obsidian

Agate

Malachite

Rose

Ruby

Quartz

Jasper

Amethyst

Lace

Lapis

Lazuli

Agate

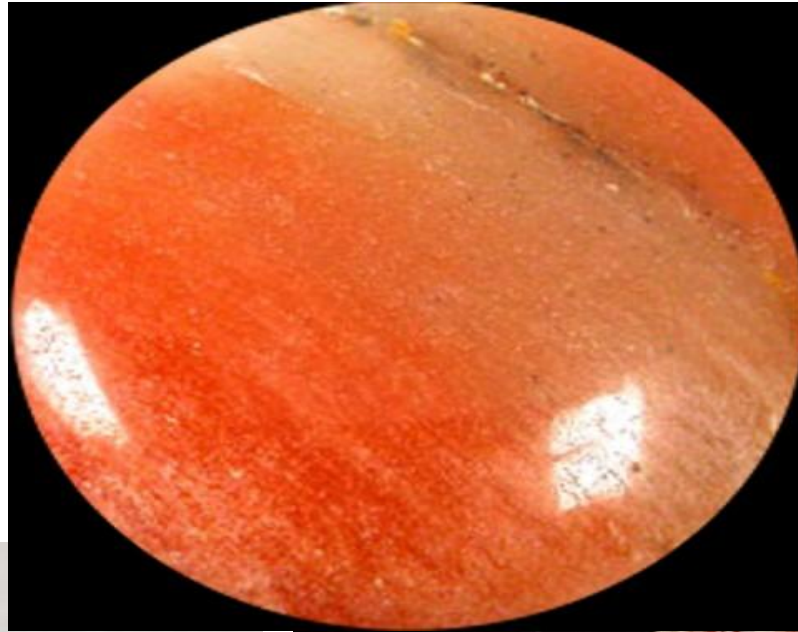
PRECIOUS OR SEMIPRECIOUS: (HISTORICAL VIEW OF VALUE)

"Precious or Semiprecious". These terms were routinely used (until about the 1980's) to separate diamond, ruby, sapphire, emerald and sometimes pearl, from all other gem species such as tourmaline, jasper and amber. Most gemologists no longer use these words and consider them out-moded. *Why?*

Jasper



JASPER



HOPE DIAMOND (45.52 ct.)



PRECIOUS OR SEMIPRECIOUS: (HISTORICAL VIEW OF VALUE)

The term, "precious", implies rarity and high value, but, in reality, the individual specimens of each gem species and variety exist within in a full spectrum of rarity, and of value, from very low to very high. Some pieces of "semiprecious" gems are rarer, and more valuable than some individual specimens of "precious" gems.

PRECIOUS OR SEMIPRECIOUS: (HISTORICAL VIEW OF VALUE)

So what should we call them then? Simple
CALL THEM: *gemstones or gems*. These
terms will cover them all, regardless of where
a given piece lies within the continuum of
rarity, beauty, and value for its species.

CLASSIFIED BY CUTTING STYLE

Faceted or cabochon cut: are the two most common ways in which gems are fashioned.

- **Faceted stones are usually cut from transparent rough of relatively high clarity. They are fashioned with a top (crown) and a bottom (pavilion) that have intersecting flat planes called facets, on their surfaces. These facets have shapes that are generally triangular, kite shaped or rectangular.**
- **Cabochon cutting is most often used for translucent and opaque gems and such pieces generally have a flat bottom and a smoothly curved top called a dome.**

Classified By Origin: Natural or Synthetic

- **Natural**: A natural gem is one produced entirely by geologic and/or biological processes without any human input or assistance.
- **Synthetic**: laboratory grown, manufactured, or "cultured" by human intervention.
- A synthetic can be a copy of a natural mineral such as corundum, amethyst, or pearl, or it can be a unique material not found in nature like YAG (yttrium aluminum garnet) or cubic zirconia. In addition to the use of synthetics as gem substitutes, they are also made for industrial, electronic, and research purposes. Examples include synthetic diamonds used as abrasives, and synthetic rubies and garnets used in lasers.

CLASSIFIED BY TREATMENT

Unenhanced or Enhanced:

- **Unenhanced**: means (except for cleaning and/or fashioning into a useable gem) that the material is *as it was yielded from Nature*. The color, transparency, hardness, or optical phenomena have not been changed by man.

CLASSIFIED BY TREATMENT

Enhanced: an enhanced gem has received some type of treatment to change its characteristics: Ex. irradiation, heating, dyeing, oiling, laser drilling, etc. There are numerous treatments, some of which are routine, have little effect on value, and are considered acceptable as long as they are disclosed to the buyer, and others which are considered extreme and which *dramatically* alter the value of the gem. A treatment may increase, decrease or have no effect on the durability of a gem. (gem enhancement will be covered in detail.)

Classified By Intended Use

Simulant or Fake

- **Simulant**: a material, either natural or synthetic, which is being used to imitate another material. Simulants look like what they imitate, but they may or may not share its chemical, physical and optical properties. Not all simulants are synthetics! These mimics are correctly termed either "simulant", "imitation", or "faux".
- Ex. synthetic ruby can be used to simulate a natural ruby, but it is also possible for natural red spinel to be used to simulate a natural ruby.
- **Fake**: any material which is represented as something it is not. The fake can be of man-made, or natural origin. *****Whether something is a fake or not, is simply a matter of "truth in advertising***

Not Fakes

- ***A synthetic ruby offered as a synthetic ruby.**
- ***Man-made red glass offered as a "faux" ruby.**
- *** A cubic zirconia offered as a "diamond simulant".**

Fakes

- *** A natural red garnet offered as a ruby.**
- ***A man made Moissanite offered as a diamond.**
- ***An enhanced colored diamond offered as an unenhanced colored diamond.**
- **Simple test: if the material is represented accurately, it is *not* a fake, if it is represented inaccurately it *is* a fake, regardless of whether it is natural or man-made!**

Classified By Industry Terms: Colored Stones or Diamonds

- **Gemologists put all colored stones together into one category and all diamonds into a separate one--> regardless of their color! The reasons for this is that there are great differences which exist in the systems for fashioning, grading and marketing these two categories of gems. This distinction doesn't divide cleanly, however, between all stones that show color, and all that are diamonds.**
- **Some gems which are classified as "colored stones" are, in fact, colorless. Examples would be white sapphire, white beryl, phenakite and rock crystal quartz. Some diamonds have color, in fact, they are referred to as "fancy" diamonds, amongst which we find the green, pink, blue, yellow, orange, brown, red and black diamonds.**

CLASSIFIED BY WHO WILL BE THE "END USER"

"jewelry" gems or "collector" gems:

- This distinction is not as clear cut as some of the others. Although there are over 3000 species of minerals, of which only 100 - 150 have the characteristics that we associate with gems, and of these, only about 50 species make up a regular part of the jewelry marketplace. In reality, though, the properties of jewelry and collector stones overlap and grade into one another.
- In general, a jewelry gem is one that is both *durable* enough to be used for most jewelry applications, and *common* enough to be found in the marketplace in at least moderate amounts. Aquamarine is a good example of a jewelry gem. It is both durable enough and common enough to be readily used, and is widely found in the jewelry marketplace.
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- A collector gem is one that is either *not durable* enough to be used in jewelry, or so *rare* that it is not found within the common market channels for jewelry.
- Transparent rhodocrochite is an example of a collector gem which, is not durable enough to be set and worn in jewelry, although it is abundant enough to have a place in the jewelry market if it were useable.
- Clinohumite is an example of a collector gem which is quite durable enough for most jewelry uses, but so rare that only a few collectors are able to obtain specimens, so it is not found within the normal gem and jewelry channels.