Light, Life &

The color we see is a sensation caused by the stimulation of eye sensors by light. Photo: Cynthia R. Marcusson

"In the beginning, God created the heaven and the Earth. And the Earth was without form and void and darkness was on the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, 'Let there be light,' and there was light. And God saw the light, that it was good, and God divided the light from darkness."

— Book of Genesis, King James Version of the Holy Bible.

"Let there be Light!" The words of Genesis proclaim the separation of light from darkness as the cardinal act of creation. We are beings of light. If not for the sun's light, we would be unable to call this wonderful planet home. One of the prevailing theories of the dinosaurs' extinction has the loss of light central to its premise. A gigantic meteorite striking the Earth led to the presence of an ash cloud large enough to disrupt the food chain through the blockage of light.

Light is the difference between life and death. We use light every moment of our waking lives; it affects us in many ways we have probably not considered. As Jewelers and gemologists, we use light in its most marvelous form of all: gemstones.

When you show a customer a tanzanite, you are not just saying, "Oh, isn't this gem beautiful." What we marvel at is, "Look at what this gem does with light!" The excitement we feel from the light being captured in a gemstone is contagious. Besides bringing much joy to your life, excitement and enthusiasm are powerful selling tools. Generating this awe in your customers can start them on a serious gemstone habit.

With this article, I hope to help you to "see the light" — to gain a higher understanding of light and directly or indirectly pass this excitement on to your customer. Light is a very broad and complex subject, and this is not a defini-

Luster

By Cynthia R. Marcusson, Cynthia Renee & Co.

As jewelers and gemologists, we use light in its most marvelous form of all, gemstones. Gems courtesy of Cynthia Renee & Co.

tive treatise. Rather, I hope to "shed enough light" on light so you are "delighted" and intrigued enough to more appreciate the wonders that strike your eyes every day.

The Language Of Light

The metaphors used above can sound a bit contrived — even corny. But they demonstrate an important point: The strength and beauty of light are so fundamental to our lives that metaphors of insight and light flourish within our language.

"A Thousand Points of Light!" The comics won't let us forget that one in the near future. More sublime are "Seeing is believing" and a "sunny disposition." Some of us are blessed with a "light of our life" and "light up" when they walk into the room.

A "bright" person goes farther in the world than one with a lackluster personality. Before we understand something, we are "in the dark." We even symbolize our first understanding of something by a cartoon light bulb over the head.

Spiritually, we move "toward the light." Gospels sing "This little light of mine, I'm gonna let it shine" and cry, "I found the light!" Vampires fear the light.

Light never means dark, weighty or brooding — how often do you see poets or "intellectuals" dressed in white? The Lone Ranger wears white; the bad guys are bedecked in black.

Light affects our moods. There is mood light and mood music to accompany banquets planned with purely romantic intentions. Mood rings from the 70's used colors to depict the degree of our mental turbulence. We have stark confessional lights; bright, blinking, confusing lights; psychedelic lights; and anxiety-producing strobe lights.

In some northern latitudes, depression is combatted by sitting under panels of concentrated light. More people die during a period of dark gloomy weather, most of them elderly, who lose the "light to live" during dark days. Rates of suicide and alcoholism increase in countries with a high percentage of cloudy days. Recently, I met an Alaskan who is a psychological counselor during Sitka's dark fall and winter months and a commercial fisherman during the brighter summertime. Where did I meet him? On the beach in Southern Mexico soaking up the sunlight for revitalization!

While still a clerk at the Swiss Patent Office, young Albert Einstein mused, "What would it be like to ride on a beam of light?" His eventual answer is a leading force shaping the world today. Among many things, Einstein showed that no physical body, from subatomic particle to spaceship, can move faster than the speed of light. Light travels very fast — 186,000 miles per second. Like geologic time, the speed of light is impossible to fathom. While in school, a physicist friend wore a coveted T-shirt imprinted, "186,000 miles per second: It's not just a good idea — it's the Law."

Light-Years And Light Waves

So, light moves pretty fast. Can you imagine? The light that strikes your eye while you're gazing at the moon left the lunar surface 1.3 seconds before. The sun is eight light-minutes away; to cross the 93 million miles to the Earth, sunlight takes eight minutes! The stars are light-years away. A light-year measures distance, not time, and equates to approximately six trillion miles.

Try this. In your mind's eye, draw a map in which the huge distance between the Earth and sun (93 million miles) is reduced to one inch. Now, using our scale of one inch equals 93 million miles as a measure, how far away must we place our nearest star, Alpha Centauri? The answer: 4.3 miles. This is the closest star to our solar system. Our galaxy, the Milky Way, is 100,000 light-years in diameter. Imagine the vastness of our universe as we contemplate galaxies beyond our galaxy.

Fine opal and the seven spectral colors of visible light. Sir Isaac Newton assigned seven colors to correspond with the seven notes, A through G, of the musical scale.

Light is a form of electromagnetic energy. This energy is transported by traveling electromagnetic waves. Waves have certain properties, whether they are waves of light, water, sound or something else. In grade school, we all drew the ocean as a series of squiggly waves. The high points are the crests, and the low points are the troughs. The *wavelength* is the distance between successive troughs or crests. Waves also have a *frequency* defined as the number of waves that pass a given point within a particular time period — like the train from New York to Philadelphia that passes every hour. The wave's *amplitude* is half the distance between its crest and trough.

The waves of light and other electromagnetic radiation run the gamut from very long, low frequency radio waves to extremely short, high frequency subatomic waves. Since all electromagnetic waves move through space at the speed of light, the difference between the energy they transport is in their wavelength and frequency. Pick a spot ten feet from where you are sitting. If you were a low energy wave (long wavelength and low frequency), your natural pace would get you to that spot in two long, loping steps. As a high energy wave (short wavelength and high frequency), your natural pace would be to cross that distance in 10 short, high hops. Low energy waves can go for longer distances than higher energy ones. There are no gaps in the wavelengths of the electromagnetic spectrum; one wave grades into another.

Remember the brain wave monitor to which television's Dr. Welby's patients were connected? Imagine that screen before your eyes. Picture one end where the wavelengths are long. The waves ever so gradually shorten in length and increase in frequency as they move across to the screen's opposite end. Let's climb aboard this wave train.

We start with very long waves; waves that are so long and of such low frequency that they can travel great distances — power transmission waves. As the waves become more energetic, they begin to vibrate faster. They become waves one of our senses has the

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ability to experience when passed through a quartz crystal — radio waves.

A bit more energy, and they provide the means to a very low energy activity — television waves. As the waves increase in energy, we lose our ability to sense them audibly, but they can heat our coffee — microwaves. As the waves vibrate faster, another one of our senses kicks in, and we detect them as heat — infrared waves.

As the energy increases, we lose the sensation of heat but gain use of what most consider our most valuable sense: sight. We see reds and as the waves shorten and vibrate faster and faster, we move through oranges, yellows, greens, blues, indigos and violets. Visible light is just the name we give to the wavelengths we sense as color.

At a point, the waves begin to vibrate so quickly that we lose our ability to see them — these are the ultra-violet waves that tan our bodies and cause kunzite to lessen its color.

As the waves get even shorter and increase their vibrations, we get x-rays which penetrate most solid matter as easily as visible light penetrates glass...then gamma rays, which play such a part in gemstone irradiation.

The end of our screen marks the shortest length and highest frequency waves — cosmic rays.

Envision An Orchestra Of Colors

The seven spectral colors of visible light (which are easy to remember as the acronym ROY G. BIV) were arbitrarily assigned by Sir Isaac Newton who wanted the colors analogous with the seven notes, A through G, on the musical scale. There are many colors in the light spectrum in addition to the seven Newton chose. This musical analogy presents an interesting paradigm through which to understand white light and its spectral color components.

With music, we have the treble and the bass. Think of an orchestra of colors based on wavelength: the lower energy red wavelengths are the deep bass; violet wavelengths represent the higher pitched treble. The spectral colors between red and violet are the tubas, clarinets, oboes, flutes and piccolos — each contributing their uniquely identifiable range of pitches (i.e., wavelengths). If all the instruments are playing simultaneously, we have a symphony of white light. White light contains the complete orchestra of spectral colors.

But an orchestra rarely has all instruments playing equally. To do so would eliminate the sensual nuances we find so enjoyable. Different instruments are highlighted and combined

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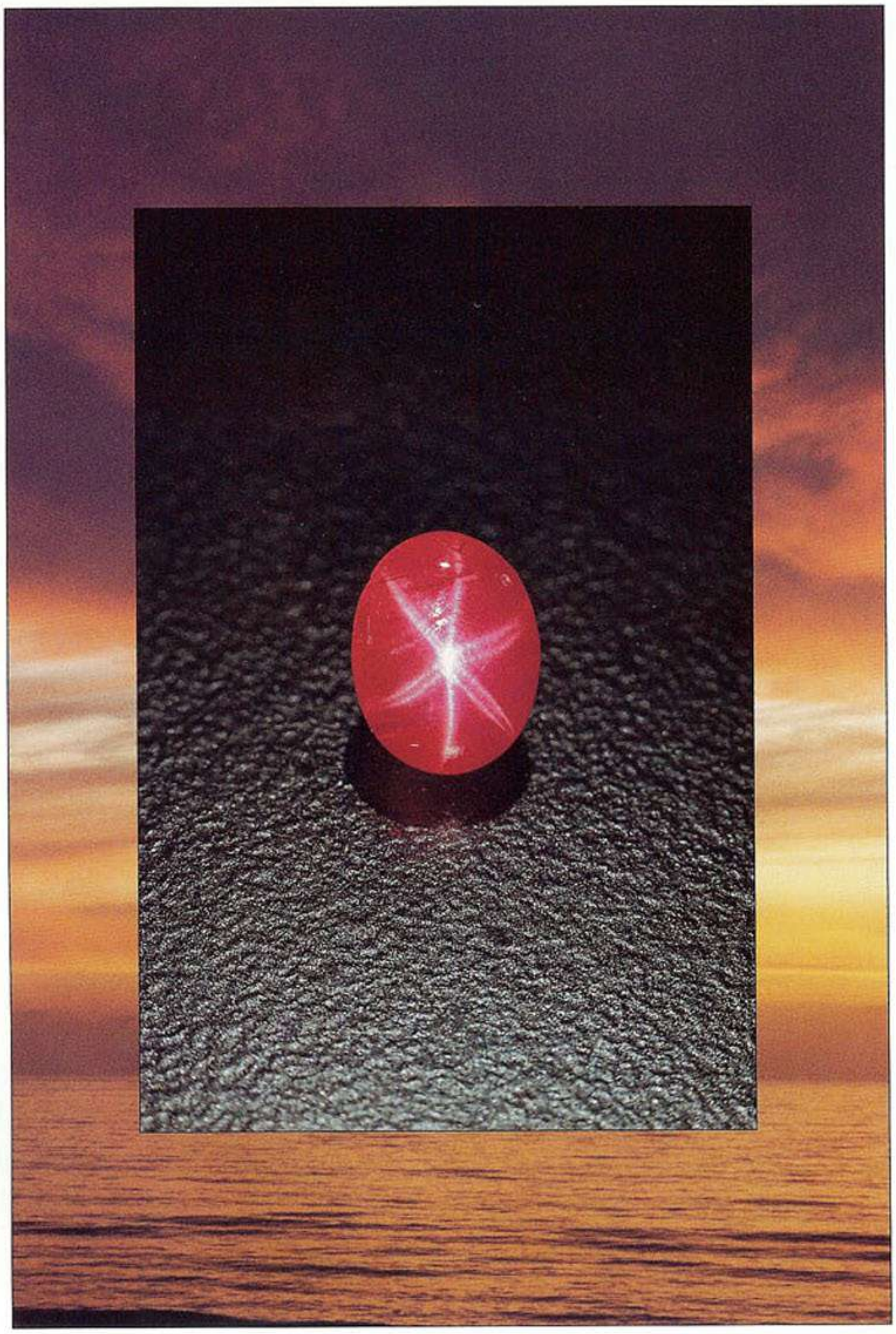

Dust particles combine with the setting sun to give us glorious sunsets. Photo: Cynthia R. Marcusson. Light reflecting from internal inclusions occasionally brings us a perfect star ruby.

Blue skies and moonstones share the ability to scatter the shorter wavelengths of sunlight at Mono Lake, California. Photo: Cynthia R. Marcusson

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over the course of the concert. The wavelengths of light are also combined in varying proportions.

Why Is The Sky Blue?

When white light strikes an object, some light waves are reflected while others are absorbed. An object does not absorb all wavelengths equally. The color we see is a sensation caused by the stimulation of eye sensors by light energy. The color we perceive is a result of a combination of wavelengths being reflected from an object. Some people have a wider range of color perception than others.

Our atmosphere scatters and absorbs some wavelengths more than others. The sky is blue because shorter blue wavelengths are scattered by gas molecules in the atmosphere. Mars' sky

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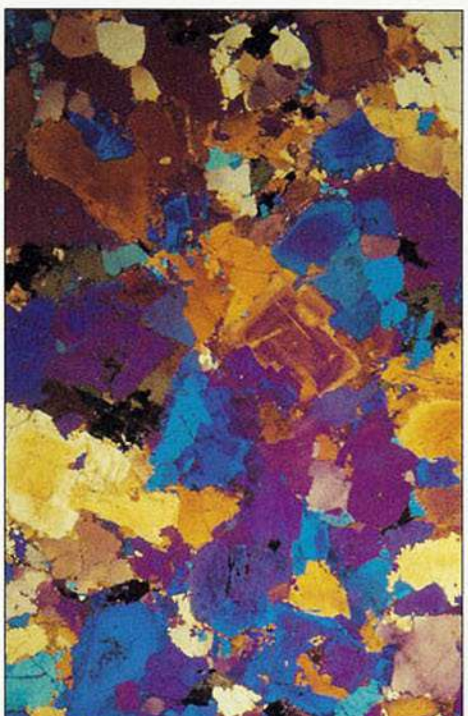

Polarized light with a gypsum plate causing light waves to interfere with each other. Photo: John Koivula

Polarized light, which limits the directions in which light can travel. Photo: John Koivula

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appears pink because the reddish iron-ore dust in its thin atmosphere is more effective at scattering red wavelengths.

At dusk, the light of the setting sun struggles through a longer path than when directly overhead. The dust and pollutants in the air scatter reddish wavelengths producing brilliant sunsets. Some of last summer's glorious sunsets were courtesy of ash from the Philippine volcano.

With gemstones, most of the results of scattering produce luster rather than color. Light scattered from inclusions or other internal structures within a crystal can produce a great variety of optical effects. *Aventurescence* and *schiller* are terms for reflections from small inclusions as seen in sunstone and aventurine. The shimmery adularescence of moonstone is also due to scattering; this time caused by light diffracted internally from closely spaced planes.

How tranquil it is watching moonlight reflected over the ocean. Gem *chatoyancy* is a very similar scene; needles or hollow tubes oriented parallel to each other reflect and scatter the light. We get cat's-eyes. *Asterism* results from light reflecting from needles that aren't parallel. In corundum, rutile needles can grow in three orientations and display a six-rayed star when properly cut.

Artificial lighting does not have the wide spectrum of sunlight or its brightness. This light is not white, and its color components are unbalanced.

Incandescent lamps give off the broadest light spectrum, reflecting mostly yellow-red light. They create light by heating a filament until it glows. Fluorescent lights emit narrower wavelengths. Giving off a bluish light that can make the skin look ghastly, they glow from light given off by specific atomic elements. Alexandrite readily transmits both red and green wavelengths and turns either color when their wavelengths are dominant.

The Light Infantry And Other Configurations

When a light ray passes from one medium, such as air, to a denser one, such as water, part of the light is reflected from the surface back into the air and part enters the water. The light moves more slowly through the more dense water and no longer follows its original path. Instead, it is bent, or *refracted*. You have probably noticed refraction in the way a spoon held in a glass of water appears bent.

A basic method of identifying gems is by measuring their *refractive indexes*. An RI is a ratio. It shows proportional relationships between two figures — betting odds or "three great years out of five" are ratios we hear almost every day. An RI compares the velocity of light in air and its velocity in a denser material.

Think of several rows of soldiers, seven abreast. They are marching across flat hard land at the same speed. All of them hit a muddy area at the same time: they simultaneously slow in crossing, keeping their orderly configuration, and speed up once crossing is completed. They continue marching. Another muddy area arises, but this time it is positioned so the soldiers march into it at an angle. The outer row enters the mud first and is the first to slow. In turn, each successive row hits the mud and slows. Since the rows slow at different times, this causes the formerly straight columns to bend. It is a similar case with light entering a prism: the columns of spectral colors in a ray of white light move through the prism at different speeds, causing a bending and separation of the light into its spectral colors.

Light with longer wavelengths travels at greater velocities than light of shorter wavelengths. Because of this, red light has a lower RI than violet light. The difference between the RI's for these two wavelengths is called dispersion, and if this difference is great, the gem is said to be very dispersive.

The *dispersion* seen in rainbows is due to light refracting off atmospheric water droplets. Halos around the moon form when light refracts off ice crystals. Little dispersive color is perceived because of the moon's low light intensity.

A diamond's dispersive power is highlighted by skilled faceting. The green demantoid garnet actually has a higher dispersion than diamond; a fact that is visually masked by its darker body color. Baroque pearls have a higher incidence of orient over more spherical pearls. The light hitting the pearls hits overlapping nacre layers and separates. The more irregular the surface, the more opportunities for dispersion.

Polarization limits the directions in which light can travel. Historically, polarization studies were made to investigate the nature of light. Today, we reverse the procedure and deduce something about the nature of the object being studied in polarized light. Polariscopes are fixtures in gemological laboratories. The scale of polarization studies ranges from galactic to subatomic. Besides helping to separate tsavorite from chrome tourmaline, polarization studies

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suggest Saturn's rings are made of ice crystals and determine the size and shape of viruses.

Opals And Butterfly Wings

As a child, I loved to go walking after the rain had stopped. The stark city streets were transformed by the ribbons of spectral swirls in the oily puddles of water. Part of the appeal of blowing soap bubbles is a similar iridescent light display. Sometimes we can look into a crystal and see the same thing.

Two or more light waves traveling the same path can interact so as to reinforce or cancel each other, adding or subtracting from the color spectrum. This is known as interference. The interference of light reflected from the surface or interior of a crystal can produce beautifully iridescent patterns. A choncoidal fracture in quartz or internal inclusion in a pink tourmaline can hold a dizzying array of interference colors.

The interference and scattering of light act in combination for coloring opals and butterfly wings! Opal is composed of tiny spheres of silica arranged in a closely packed, orderly three-dimensional pattern with the voids between the silica molecules occupied by air and water. As light passes through this network of silica, it is scattered in all directions. As the light waves pass through from adjacent openings, the waves interfere and flash out of the gem in nearly pure spectral colors. As the opal is turned in the light, different wavelengths are diffracted as flashes of brilliant colors. In common opal the pattern of silica spheres is so small, they merely scatter the light giving an opalescent effect and there is no interference of light waves to give us the play of color.

Laser Intensity

Light gives us life and the ability to make a living through the enjoyment of gemstones. Beyond that, it is essential in our modern technology.

A laser (which stands for Light Amplification by Stimulated Emission of Radiation) is a device that produces extremely brilliant intense light. The sun emits approximately 7,000 watts per square centimeter; lasers can produce over a billion watts in beams a centimeter square.

In fact, the intensity of laser beams are such that with a few watts of power, a laser can be sent to the moon and bounce back giving a distance measurement of extreme accuracy. Lasers produce measurements and record movements with great precision. Huge tunneling machines keep their drills on straight lines through the guidance of lasers. Lasers are proposed to shoot down ballistic missiles in the "Star Wars" strategic defense system.

Lasers are life giving when used by physicians to remove cataracts, constrict blood vessels and protect blood banks from deadly viruses including the HIV virus that causes AIDS.

Laser disk recordings have revolutionized the entertainment industry — Nat "King" Cole is warbling from my CD player now. Lasers protect our credit cards from fraudulent duplication through holograms and help us to move quickly through grocery checkout lines. Some gems are even cut and sculpted with lasers.

Lasers carry not only light, but information. Modern communication systems are based on two inventions: the laser and fiber optics, which are strands of hair-thin, ultra-pure glass that carry laser light for miles.

It is fascinating to ponder the extent in which we are bathed in electromagnetic waves. The sun is the primary source of these waves. While in a room reading this article, you are crisscrossed by radio and TV waves; microwaves from radar systems and telephone relay systems may also reach you. Electromagnetic waves from light bulbs, heated engines, and computer screens vibrate all around you. Waves from x-ray machines dance through the room as do those from radioactive materials buried in the earth.

Beyond this, waves reach us from stars and other objects in our galaxy and even from other galaxies. Go to a dark room and turn on your television to a non-channel, one of those that only has snow on the tube. Now, turn the brightness down as dark as possible. There will be little pops of light showing on the screen, a portion of which are waves just striking the Earth from the "Big Bang."

The Big Bang that started it all with the words..."Let there be Light!" **JQ**

Special thanks to Owen Bordelon for his dips into the well of support and off-hour musings on the Nature of Things... including Light.

***Cynthia R. Marcusson** is a frequent contributor to JQ Magazine on the subject of gems and gem promotion. She owns Cynthia Renee & Co., and has developed her own line of fine colored gemstones. Cynthia is a popular speaker/educator, featured by groups such as the Gemological Institute of America, The Mineralogical Society of Southern California, and the American Gem Society. In addition, she conducts in-store marketing/training seminars, and is a community speaker on behalf of local jewelry stores. For further information please contact: Cynthia Renee & Co., P.O. Box 1763, Fallbrook, CA 92088, Tel: 619-728-5150, FAX: 619-728-1982.*