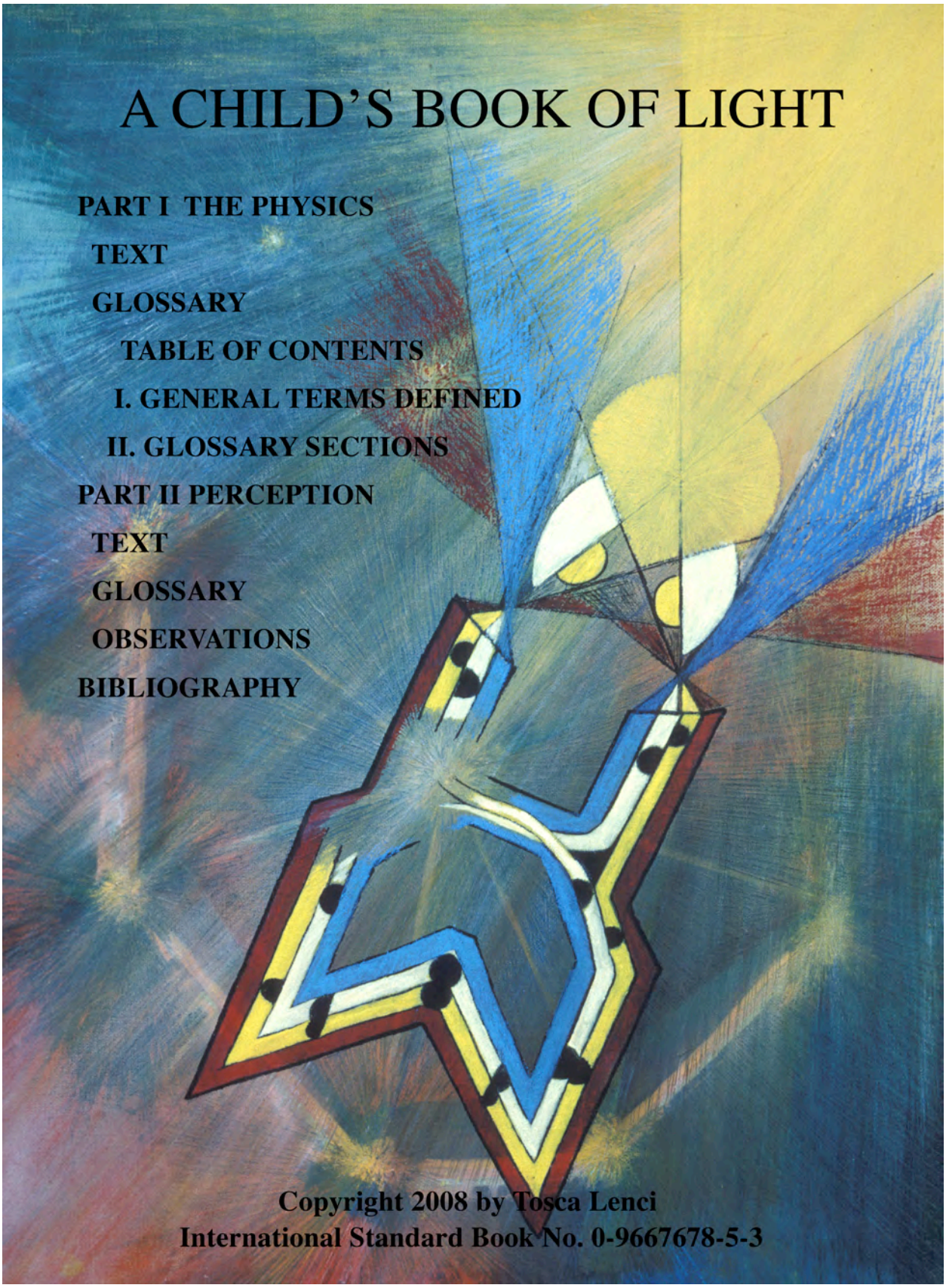
A CHILD'S BOOK OF LIGHT



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A CHILD'S BOOK OF LIGHT

Part One

The Physics[1]

Quantum or *wave mechanics*--"quantum field theory"/QFT--postulates the four identified *force fields* as quanticized at all points. In theory calculations, *wave equations* represent excitation of points (vibrations/oscillations) correspondent with *quantum* particles. *Vacuum fluctuations* reflect particle interaction processes, including *pair production a*ppearances/ disappearances of particles. Most modernly, a vacuum is conceived as possessing an energetic structure in itself.

Quantum electrodynamics (QED) mathematically represents interactions of electrically charged particles through exchanges of theoretical *photons*, considered also as giving rise to light. QED's calculations embrace complex values of probabilities of particle paths and amplitudes. Mathematical "fine tunings" are employed to balance derived equations for coupling the nuclear and electrodynamic force fields.

One school of physics suggests that results of experiments point to the need for a "beyond-the-standard-model" (BSM) physics if gravity is to be incorporated clearly in general relativity, and if comprehension is to be made of factors such as *entanglement* (the apparent bond between quantum systems, in which measurement of one affects the other) and *confinement* (the inability to free *quarks* or obtain charge fractions as required under the theory).

Relativity theory encounters particular limit in the extremely short-distanced quantum domain, where faster-than-light particle connections would need to occur. Since general relativity dictates that energy and mass are equivalable, and because quantum theory requires all fields to be represented by particles, searching continues for a gravity-transmitting particle.

String theory is one attempted approach to explain the apparent behavior of matter in gravity over microcosmic distances (a precondition being *supersymmetry/*SUSY--that every

[1] The accompanying Glossary section is an integral part of this brief text.

particle has a ‘superpartner’ with a different *spin*). Another theorization is the “Higgs field,” conceived as a permeator of ‘space’ that gives mass to sub-atomic particles. However, again, in that quantum theory requires all fields be represented by particles, there a search is on for a *Higgs boson,*” presumed as more than 100 times the mass of a proton.

Einstein originally considered the Universe as static and initially proposed a *cosmological constant (CC)* to represent the energy inherent in ‘space’ devoid of matter, and to account for cosmic acceleration. According to relativity theory, motion of one object is perceivable only in comparison to another’s. With motion detectable only *relatively,* the *CC* in perceivable effect would be motionless--an absoluteness would exist, but its apprehension would be prohibited by observation’s integration in the system. Einstein later accepted obviation of the *CC,* following conclusions from the research of Vesto Slipher and Edwin Hubble, that the Universe was expanding steadily. An expanding Universe still forms the basis of accounts of its origin and development (from a “Big Bang”).

Potential existence of the *CC* gained new life, however, in the wake of subsequent astronomical observations, and discovery (in laboratory vacuums in which no mass is detectable), that a ‘hidden’ energy expresses itself across distances, as if via a medium within which the fundamental forces act and upon which their sub-fields rely. This has brought into question the consistency of the super-‘cold, empty’ vacuums of ‘space’ and purveyance of detectionless dark energy. The theory of general relativity itself renders ‘space’ an active constituent. Distances between points are influenced by the contiguities of matter, energy, and gravitational force--contrary to the dimensionality of Newtonian ‘space’ and that of initial quantum physics.

The basic postulate of the General Theory is taken to establish the role mass plays in gravitational relation distinct from ratios between force and acceleration. Gravity is unique in the uniformity of its energetic force on all bodies (conversely, for example, particles in an electrical field move varyingly according to energy-to-mass ratios).

A *Theory of Everything* uniting the fundamental forces would need both to explain the *CC vis-a-vis* vacuum energy and to distinguish Planck’s universal constant. Presently the *CC* is

considered a 'property' of 'space' but not a force in itself. Its unimaginable smallness, however, would be beyond physical scales to isolate and measure. Giant nuclear reactors can track ferrosecond atomic reactions, but their speeds defy clear determinations of their patterns.

As Einstein noted of his formula, $E = mc^2$:

> "We can reverse the relation, and say that an increase of E in the amount of energy must be accompanied by an increase of
>
> $$\frac{E}{c^2}$$
>
> in the mass. I can easily supply energy to the mass—for instance, if I heat it by ten degrees. So why not measure the mass increase, or weight increase, connected with this change? The trouble here is that in the mass increase the enormous factor c^2 occurs in the denominator of the fraction. In such a case the [relative] increase is too small to be measured directly, even with the most sensitive balance." *Einstein,* page 340.

Thus far, mathematical computations balancing measurements of pulse patterns must incorporate statistical probabilities and include a constant (*e.g. Planck's)* of unknown nature.

Einstein's phraseology differed from, but paralleled much of Michael Faraday's conclusions regarding 'space' as a continuum. Acceptance persisted in Faraday that, after extensive experimentation with magnetism, all substances range in varying degrees in two classes, *paramagnetic* and *diamagnetic,* and that lines of a certain amount of force consistently passes between and through matter:[2]

> Since, "...in...a metal, the atoms must, according to the usual view, be very far apart from each other, how can we for a moment imagine that its conducting power belongs to it, any otherwise than as a consequence of the properties of space, or as I have called it, the *m*? So also its other properties in regard to light or magnetism, or solidity, or hardness, or specific gravity must belong to it, in consequence of the properties or forces of *m*, not those of the *a* [its particle(s)], which, without the forces, is conceived of as having no power[s]. But then surely the *m* is the *matter*.., for where is there the least ground...for imagining a difference in kind between the nature of that space midway between the centres of two contiguous atoms and any other spot between those centres? ...the difference between a supposed little, hard particle and the powers around it I cannot imagine." *Lavoisier, et al.,* page 853.

That magnetism and moving electricity exhibit inseparable association is best observed with metallic *ferromagnetic* substances. *Electromagnetism* causes "lining up" of substances' "randomly-directed axes of domains." A fundamental value for *alpha,* the "fine structure constant" which controls electromagnetic strength (and thus how subatomic particles interact with each other) is an as-yet-unachieved quest. Possibility remains that the known forces all manifest

[2] While Faraday strove for zero magnetism, 'one hundred percent magnetism' has yet to be explored.

within a pervasive energetic 'grid' of omni-active, point-through-point exchanges, their instantaneity admitting perception of experimental collections and separations, but not isolation--that *alpha,* captured in a specific arrangement experimentally, is reorderable only to a point certain within and allowed by its environmental state.

With respect to the first postulate of relativity's *Special Theory,* and that confirmation of a 'static' medium could not be detected, Einstein remarked:

> "According to general relativity, the concept of space detached from any physical content does not exist. ... Since the theory implies the representation of physical reality by a continuous field, the concept of particles or material points cannot play a fundamental part.... The particle can appear only as a limited region of space in which the field strength or the energy density are particularly high." *Einstein,* page 348.

The original *Bohr* atomic model postulated circular orbiting shells of *electrons* as containers of elemental cores, and that energetic emission or absorption resulted from shifts in their electron positions. After Ernest Rutherford's contributions, the circular model's inability to account for positioning of detectable fine spectroscopical lines of radiant energy led to the concept that atoms or groups of atoms might be distributed about a center in accordance with fixed geometric principles (the "secondary valence" or "coordination theory"). Subsequently it was concluded, and the Standard Model (SM) amended to reflect, that electrons do not move about a nucleus and instead form a 'standing wave' about it. Each particle had associated with it a specific periodic 'wave,' *i.e.* displacements/ vibrations.[3]

Of all the theorized atomic constituents, the *neutrino* has yet to be assigned a mass value. Existence of neutrino mass (posited to be an almost infinitely small fraction of an electron's) would force a revision of the present theoretical framework of subatomic physics. Results of one international study may have determined that neutrinos universally carry at least as much mass as all stars and galaxies.

Recently the neutrino has come largely to be considered the best candidate for part of the 'missing' *dark* [meaning *undetected*] *matter,* surmised as totaling some 30 percent of the

[3] *Transverse* 'waves' being displacements/vibrations at right angle to the direction of propagation (*e.g.* light and x-rays), and *longitudinal* 'waves,' in the direction of propagation (*e.g.* sound).

Universe, and oscillating from one to another state as trillions stream from cosmic rays, the sun, supernovae, and nuclear decay. All 'known' mass is taken as constituting only some five percent of the Universe, where *dark energy* is considered as occupying the remaining approximately 65 percent, and of the same density wherever located from Earth surface to galactic 'space.'

Dark energy is postulated as a 'repulsive'/'anti-gravity' force which, under current theory, would obviate gravitational collapse--such as of the posed *black holes.* One proposal is that black holes are, instead, agglomerations of 'wavelike' substance ("gravastars"), and that their deduced behavior would satisfy Einsteinian equations without yielding a *singularity.* Another concept negating singularity (arrived at by computer simulation, and reportedly reduced to a mathematical proof) is eventual vanishment of a black hole by virtue of 'oppositely-acting' centrifugal force counteracting gravity.

Meanwhile: The center of Earth's galactic disk shows an outward bulge, some 70,000 to 100,000 light years in diameter, harboring at the Milky Way center (some 26,000 light years away) what data appears to evidence is a black hole of a very small relative size, but with a mass concentration equal to 2.6 million suns. Satellite findings also report (1) what appears to be a plume of (theorized) *antimatter electrons* erupting from the Milky Way core, to some 3500 light years above the galactic disk; (2) that both the Milky Way and Large Magellanic Cloud (the galaxy nearest the Milky Way) are inside a huge halo of dark matter; (3) puzzling intrinsic energy of narrowly focused beams of gamma ray bursts found evenly distributed in 'space; and (4) orbiting x-ray observations suggesting that dark energy is Einstein's *CC.*

It is in keeping with the history of science, that Planck's introduction of *discontinuity* of radiation in all its forms--emission not a continuous stream but in discrete packets/*quanta*--laid the foundation for quantum mechanics. Then its experiments led to establishing that the position and momentum of 'particles' could be ascertained, but not both at once (*Uncertainty Principle).* In turn, tracked characteristics of forced atomic 'particle' interactions progressively have shown that, while subatomic interactions appear to manifest either as 'particles' or as 'waves,' ultimately, a "smearing out" occurs within the field.

Another aspect of potentially ambiguous connotations in SM constructs is the *relative* nature of *positive* and *negative*. The human body's sensitivities are drawn from subjective experience according to its constitution in its atmosphere. "Heat" and "cold" may have different meanings in the workings of the Universe, where the presently ascribed temperature scale ranges from *absolute zero* to an estimated hundreds of millions of degrees. Controlled plasma fusion containment experiments pose what one researcher has termed "an ultimate absurdity:" imagining "a *[cryogenic]* bottle, –269 degrees C cold, to contain a process involving millions of degrees of heat."

Another curious phenomenon is the behavior of water, which--rather than growing denser as would be expected under continuing freezing--by 4 degrees centigrade begins sharp expansion. The H_2O molecules, instead of closing together and 'reducing' movement, string out along elemental bond lines, and form an open crystalline matrix lighter than water's original substance. The atoms of cryogenically created *superfluid helium 4* lose individual identity entirely, fusing "into a single mathematical 'wave' form," their 'spin' unconfused by either centrifrugal or centripedal forces. Its rotation, measured as *angular momentum,* seemingly is innately oriented to a fixed, unturning Universe. *Superfluid helium 2* defies gravity altogether, its components insisting on spreading and climbing upwards; it is so minimally refractive that its surface in a clear container is invisible.

Causal dynamical triangulation (CDT), a recent new theory, envisions 'space' composed of simple triangular structures constituted geometrically similar to "buckyballs." Since quantum theory stipulates constant changes at very small scales for such a fundamental structure, calculations by CDT researchers sum probabilities of all possible configurations of simplex building blocks.

Einstein continued to sense a less convoluted explanation of universal forces, aware of Humankind's limitations to observation. Undoubtedly he would be amused to know that It is conjectured quietly in some circles that there is no empty 'space' and the *CC* is conjectured forming a static indivisible fundament, a nuclear fracture in which (*c* against *c*) breaks a conjoined

force of 34,151,040,000 mi./sec., while *conservation of angular momentum* could hold for quarkian behavior, along with *superconductivity, superfluidity* and *viscosity.*

However, atomic *cohesion*--how *E* value would be *held,* in varying aggregations to compose and maintain all masses—staggers conception of infinite planes of *E* force amid an exponential number of varyingly valued envelopes ('shells') of containment, where 'direction' has meaning only to the observer—and all within a multi-directionally distributed grid of *CC* in which galaxies and their interior regions are held by the energy between their entities. Still, Newton's law that gravitational force between two bodies depends upon, being proportional to the product of their masses and the distance between them, would not be abrogated in that balance of energy and relative distances within a closed mother field of momentum.

The purpose of the foregoing, however, was not to answer whether all masses are imperceptibly sub^{n}-microscopically geometrically-cogged 'spheres,' but to devise a structure upon which to stretch perception. One sees great detail, looking across a room full of objects or across fields to hills; yet the scene that enters the human eye's pupil has been reduced in transit to a mere two-fifths-inch. The reality in which operate mechanistic laws presents as many visual percepts as there are visual modalities to capture them. Be one bee or being, visual registration cannot exceed the parameters Nature has dictated.

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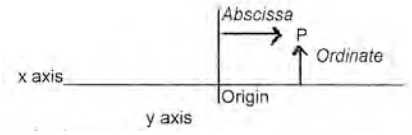
Physics Glossary

I. GENERAL TERMS DEFINED (Parenthetical references are to Glossary Sections.

Allotropic: State of an element, the physical properties of which vary from the regular form, but nonetheless can take part in the element's usual compounds (e.g. the ozone form of oxygen).
Amplitude: The maximum departure of an oscillation from the equilibrium value; in 'wave' motions such as electromagnetic or sound, the amount of energy carried by a wave is determined by its amplitude.
Angular Momentum: A quantity calculated for an object (e.g. Earth's moon) in motion around a point (e.g. center of the sun), by the formula *L* = mvr, wherein m the object's mass, v the magnitude of its velocity, and rthe separation between the two yield *L,* angular momentum. As the formula allows, v and rare inversely correlated; thus, *conservation of* angular momentum (evidenced by experiments as a rigorous factor in the Universe) demands that a decrease in separation be accompanied by an increase in velocity, and vice versa. (See also Cryogenics Superfluid Helium 4.)
C.G.S. System/" centimetre-g ram-second" system: System of physical units derived from the centimeter, gram mass and the second. Velocities in CGS units may be measured in centimeters per second.
Chain reaction: Emission of neutrons via uranium-35 fission causes sequential neutron bombardments in a multiplication of emissions.
Convection: Transference of heat through the motions of a liquid or gas/air; portions in contact with heat lose density, expand, and are forced (in atmosphere) upwards, replaced with colder, more dense portions, setting up currents. **Coordinates:** Planes A line joining points, straight and on the same surface.

Axis: (a) An imaginary line about which a body or system moves/rotates, or (b) axes lines along which measurement is taken in the system of coordinates of analytical geometry.

Coordinates Measured plane distances of a point/P from the right-angled intersection (0 point/origin) of a horizontal (x) axis and a vertical/perpendicular (y) axis, the respective portions between 0 and P along the axes termed abscissa and ordinate.



Density: In physics, measured as mass per unit volume and expressed in grams per cubic centimeter, in which CGS units it is numerically equal to its specific gravity, the ratio of a substance's density (at the temperature under consideration) to the density of water at 4 degrees C (the temperature of its maximum density-defined as 1.000 grams per milliliter. (The density of water reduces as its temperature decreases and it begins to expand--as ice at 0 degrees C, density is 0.9168 degrees; see also Freezing Point, below. *See* also Atmospheres Atmospheric Compressibility of Water.
Electromagnetic wave: See Electromagnetic _Force, etc
Energy, Atomic: Energy released from nucleus at the expense of an atom's mass (the atomic energy made available by one gram of 'converted' matter being extremely large).
Energy, Dark: Refer to Universe
Energy, Electrical: See Electricity
Energy, Generally: Capacity for doing work in varying forms inter-convertible by suitable means; included are Atomic, Radiant, Kinetic, Electrical, Heat/Thermal, Chemical, and Potential.
Energy, Heat/Thermal: See Thermodynamics and Heat
Energy, Kinetic: Energy a body possesses by virtue of its motion; the energy of motion.

Energy, Potential: Energy which a body possesses by virtue of its position (*e.g.* a coiled spring), measured by the mount of work performed in passing from that state to that in which its potential energy is considered to be zero; the energy of position. (For electric potential, *see* Electricity.)
Energy, Radiant: *See* Radiation/Radiant Energy.
Equilibrium: State of balance between opposing forces or effect.
F.P.S. System/"foot-pound-second" system: The British system of physical units derived from the three fundamental units of length, mass, and time, *i.e.,* the foot, pound mass, and the second.
Femtosecond: Pulse (such as of light) = 1^{-16} second.
Fission: Breaking/splitting of nuclei.
Force field: A 'space' within which force(s) can be activated.
Forces: (*See also* Sub-Atomic Quanta and Quark Particles
SNF/Strong nuclear force: That force which binds the constituents of atomic nuclei and postulated quarks that compose other particles. It is considered the greatest known force. It is conceived as acting only on *hadrons.*

EF/Electromagnetic force: That force of an apparent boundless range, which acts between entities according to their magnetism or charge; acts upon both hadrons and leptons but with dissimilarities. Estimated at 137 times weaker than the SNF it nonetheless is considered the second greatest force, causing nuclear interactions ten billion times faster than interactions of the weak nuclear force (*see* next). EF interaction never admits "parity." *Refer to* Electromagnetism and Quarks/Parity.)

WNF/Weak nuclear force: The force related to radioactive decay of nuclei. It is estimated at 100,000 billion times weaker than the SNF. (*Parity* can be violated in WNF interactions.*)* Acts upon both hadrons and leptons, but with dissimilarities.

G/Gravitational force: That force of apparent infinite range which acts between objects and is related to their mass. Surprisingly, it appears to be so extraordinarily weaker than the other forces as to seem almost insignificant. *See* Gravitation.

See also Universe, Mass/Matter, Universe Content.

When two or more forces act in the same direction against an object the sum of the forces = *net force.* When forces act in opposite directions against an object (*i.e.* force 5---object---10, subtract: *net force* = 5. When force is the same from each direction = 0 *net force.*
Freezing point: The temperature of equilibrium in the change of state from liquid to solid at a pressure of 1 normal atmosphere.

Whereas "most" liquids shrink as they cool and are most dense when frozen, water, upon reaching 4^{o} C, begins expanding and continues until 0 degrees, at which point it undergoes another sharp expansion: instead of molecules closing together as movement is reduced by cold, they 'string themselves out' along the lines of the hydrogen bonds between them, and by 0^{o} C have formed a crystalline structure that is airy, open and '*lighter'* than liquid water itself.

Atmospheric compressibility of water: From unity at 1 normal atmosphere, compression is diminished only .0233 to 500 A (7500 lbs/sq.inch) and continues to diminish in similarly small hundredths, *e.g.* reaches only .8606 of unity at 5000A. (*See also* Magnetism, Diamagnetic.)

Depression of freezing point: Refers to the lowering of a liquid's freezing point when a solid is dissolved in it. With certain exceptions, the depression is proportional to the number of molecules or ions present. (*Refer to* Cryogenics.)
Fusion: Roughly, a 'melting' together—high-temperature, nuclear combination of light atomic elements that frees large amounts of energy. Fusion research is prohibitive due to the unearthly high temperatures it requires, estimated at some 100 million degrees. (4/28//2005: Report of successful fusion experiments, but realized release of energy miniscule compared to that required for production.) (*See also* Solar System, Sun.)
Hierarchy Problem: A mathematical 'fine-tuning' performed in calculations, necessary to account for the fact that gravity appears as being so much weaker than the other forces.
Ion: Atoms or groups of atoms with charge related to increase or reduction of electrons—positively charged ions lack electrons to maintain neutrality; negative ions have an excess.

A positively charged ion is termed a *cation.* A negatively charged ion is termed an *anion.* The 'softening' of wter and other industrial uses separating substances is effected by *Ion*

exchange. The work to remove an electron from an atom is measured in electron-volts. Some compounds are believed to consist wholly or partly of ions held together by electrical attraction. *(Refer to* Atoms.)

Isotope: An element with a different than standard number of neutrons in its muclei, identical in its standard chemical and physical properties excepting its weight/mass. (Nearly all elements found in nature are mixtures of several isotopes.)

Light: *See* Light.

Light Year: The distance traveled by light in one year, approximately 6 x 10^{12} miles (six million million miles).

Macroscopic: Large enough to be observed by the naked eye, or considered in terms of large units or elements.

"Mandelbrot Set:" A method to describe and calculate fundamental organizing structure by way of "fractals," shapes with fractional dimensions, in a geometry of Nature.

Mass/Matter: (*See also* Mass, Generally) Classical physics recognized three possible states of matter—solid, liquid and gas, different in how their individual atoms interacted. Other states have been recognized in recent decades, *e.g.* plasma (an essentially electrical gaseous medium) and superconductive states (of certain matter at extreme low temperatures—*see* Cryogenics). Although "matter" and "mass" have come to be used interchangeably, "matter," strictly speaking, initially referred to observable substances of which physical objects were composed.

Matter, Dark: *Refer to* Universe.

Measurement Equivalents: Kilometer/km = 0.62 miles; meter/m = 39.37 inches; centimeter/cm = 0.39 inches; millimeter/mm = 0.04 inches; kilogram/kg = 2.2046 pounds; gram/g or gm = 0.035 ounces; centigram/cg = 0.154 grains; milligram = 0.015 grains; grain = minute portion of a particle, a small hard particle or crystal.

Microscopic: Of, relating to or conducted with a microscope or microscopy.

Nanometry: Uses a scale in which a *nanometer* is equal to one billionth of a meter (some 50-80,000 times finer than the width of a human hair.

Octahedron: A solid bound by eight equal and equilateral faces.

Oscillate: To vibrate; to move back and forth between two points; to vary above and below a mean value.

Polygon: A closed plane figure bounded by straight lines.

Polyhedron: A solid formed by plane faces.

Quadrilateral: A plane figure bounded by four straight lines.

Quarks: Postulated fundamental sub-atomic particles constituting protons and neutrons--*refer to* Quantum Theory and Quarks.

Quark Theory: A theory of the structure of matter, which theorizes that all *hadron*-type particles consist of quarks. (*Refer to* Quantum Theory and Quarks.)

Reciprocal of a quantity: 1 divided by the quantity (*e.g.* reciprocal of 5 is 1/5); conversely, one of a pair of numbers whose product is 1 (2/3, 3/2).

Resonance: A system subject to oscillation is said to be in resonance when an exciting force applied to it raises its amplitude to its natural capacity of frequency.

Solid State: State of matter in which the molecules of the substance are considered to be vibrating/oscillating with small amplitude about equilibrium positions. A solid is said to possess *cohesion*—keeping the same shape unless changed by external force—due to the large force[s] of existing between neighboring molecule[s].

Specific Gravity: The ratio of the density of a substance, to its temperature under consideration, to the density of water at 4 0^{o} C, the temperature of water's maximum density.

Square: Quadrilateral having all its sides equal and all its angles right angles.

Squaring: Multiplying a quantity by itself; *i.e.* raising it to the *second power.*

Temperature measurements: Advanced scientific work uses the C and K scales.

Centigrade/C scale: The melting point of ice ("ice point") is taken as 0^{o} C and the boiling point of water ("steam point), 100^{o} C. A centigrade degree is equal to one-hundredth of the difference between the temperatures of the melting point of ice and boiling point of water under 1 normal A.

Kelvin/K or A (absolute thermodynamic): K temperature range is drawn from the cycling of heat exchanges (presaged by the work of one Nicolas Leonard Sadi

Carnot, initiator of the science of heat movement, or thermodynamics). The K scale interval between ice and steam points also is 100^{o} C, so that the magnitude of a degree is the same as with the C scale; however the K/A scale leads into minus degrees and the fixing of Absolute Zero.

Farenheit/F scale: The melting point of ice is taken as 32^{o} F and the boiling point of water under one normal A as 212^{o} F. Farenheit degree = 1/180 of the difference between the melting point of ice and boiling point of water under 1 normal A.

Absolute Zero: 0^{o} K/A, accepted as the coldest temperature possible in the Universe; the point at which atoms apear to come to virtual standstill—a 'macroscopic quantum state' where atoms no longer move and/or fuse (equal to -273.1^{o} C and -459.65^{o} F.)

Tensor: Quantity expressing the ratio in which the length of a vector is increased.

Tetrahedron: A polyhedron of four faces.

"Theory of Everything:" First proposed by Einstein and reiterated by Stephen Hawking, would be represented by a single set of equations explaining all the fundamental forces. (*Refer to* Special Theory/Cosmological Constant).

Triangle: Plane figure bounded by three straight lines, its three angles totaling 180 degrees.

Triangle of Forces: Three forces will be in equilibrium if they meet at the same point represented, in magnitude and direction, by the sides of a triangle taken in order.

Triangle of Velocities: If a body has three component velocities that can be represented in magnitude and direction by the sides of a triangle taken in order, the body will remain at rest.

Trigonometry: Branch of mathematics via which numerous problems may be solved by calculation of unknown parts of a triangle when three parts are known; assisted by the use of trigonometrical ratios.

Vacuum: Strictly, a volume in which there would be no molecules or atoms--a perfect vacuum (on earth) being unobtainable. (Evangelista Torricelli's 1643 discovery that 'air' had weight furthered Otto von Guericki's dramatic 1654 demonstration of an evacuated vessel in which neither would a candle burn nor sound be carried.) *See also* Magnetism and Cryogenics..

Vector: Any physical quantity requiring a direction to be stated to define it completely, *e.g.* velocity as measured in Physics is equal to a rate of motion in a given direction, measured as length per unit time, commonly represented by a directed line segment whose length represents the magnitude and whose orientation in space represents the direction.

Vertex: The point opposite to and farthest from a base line.

Vortex: A mass of whirling or circular motion that tends to form a cavity or vacuum in its center. (Eddy: a current running contrary to the main current.)

Work: That activity done by a force (*f*) when it moves its point of application through a distance (*s*)--equal to *force* times *distance* times the *angle of displacement. Work* is calculated in Centimeter-Gram-Second/CGS system units (or Foot-Pound-System/FPS).

II. GLOSSARY SECTIONS

RADIATION/RADIANT ENERGY/RADIOACTIVITY (*See also* Atoms.)

Radiation occurs naturally in varying, usually small amounts on Earth (*background radiation)*. It is greater in mountainous areas where less atmosphere blocks cosmic radiation. Near north and south poles it is intense.

Cosmic rays: Composed of positive, enormously charged particles (shown capable of penetrating a yard or more into solid lead). Streams flow out from the sun constantly in all directions and past Earth's orbit. Rays lose energy rapidly as they enter, pass through and collide with the substance of Earth's atmosphere.

In the 1930's (contrary to a theory that cosmic rays were electromagnetic, thus unaffected by Earth's magnetic field and would strike all portions of its atmosphere equally), it was theorized that the rays were constituted of charged particles and, if so, they would react to Earth's field, with more detected as one approached the magnetic poles and less in tropic regions. Ensuing research demonstrated that such a "latitude effect" did exist.

Gamma rays: Have energy equal to 511,000 electron volts--highest energy than all other forms of radiation. When positrons and ordinary negatively-charged electrons collide, they 'destroy each other' and spawn gamma rays.

Under ordinary conditions, an atom 'recoils' as it emits a gamma ray. The recoil is large, varies from atom to atom; the wavelength depends on the amount of recoil and is subject to considerable spread. Recoil of crystals, however, is vanishingly slight and emit gamma rays with an exceedingly narrow spread of wavelengths--the "Mossbauer effect."

Planck's Constant: The formula ("a universal constant") that connects a frequency of radiation with a quantum's energy. The value of the quantum in ergs is equal to the product *hv,* where *v* = the frequency of radiation in cycles per second and $h = 6.624 \times 10^{-27}$ erg.sec. (Planck unit of length, 1.61×10^{-33} centimeter, 21 powers of 10 smaller than the diameter of an atomic nucleus; Planck unit of time, 5.36×10^{-44} second; according to one physicist, to probe these scales would take a particle accelerator the size of a galaxy.) (*See* Electricity for *erg.)*

Observation: 1/16/1994: Compton Gamma Ray Observatory mapping of some 600 satellite-detected gamma ray bursts, which appear as narrowly-focused beams evenly distributed in the sky and not confined to the Milky Way or halo around it, are still a puzzle as to what is the intrinsic energy-- the most powerful gamma ray burst detected 1/31/1993 was not of a thermal type. (*Refer to* Milky Way Galaxy.

Atomic energy: Energy released from a nucleus at the expense of its mass, according to Einstein's mass-energy equation.

Radioactivity: Spontaneous disintegration of atomic nuclei. Radiant energy emitted by a radioactive substance spreads out in all directions at the speed of light, passing through all general barriers. The most common manifestations are (a) a neutron present in an unstable nucleus is converted into a proton with emission of an electron and a neutrino, yielding an isotope of an element of atomic number exceeding that of the original element; (b) a proton present in an unstable nucleus is converted into a neutron with emission of a positron and a neutrino, yielding an isotope of an atomic number one less than the original nucleus.

High-energy particles emit radiation when subjected to deflection by an electromagnetic field.

Radioactive elements, as opposed to standard elements, seek stability by decay/release of neutrons in the form of photon particles. (Examples, the "half-life" of a sample of artificial isotope copper 64 is 12 hours, over which it decays into stable isotope nickel 64. Millions of years are required for a sample of Uranium 238 to decay into stable lead 206; and it is estimated that half of what remains of the original radioactive uranium on Earth will take some 4.5 billion years for 50 percent of it to diminish: Uranium 238 = 92 protons, 54 neutrons, 92 electrons; Uranium 237 = 92, 53, 92; Uranium 235 = 92, 51, 92.)

Alpha and Beta rays: Following the decision begun by the work of the Curies, that rays given off by radioactive substances were of differing kinds, *alpha* and *beta* were the initial designations,

respectively, for positively charged and negatively charged rays found to be oriented in one or another direction in a magnetic field (Rutherford). The terms still are used; but--in that both now are considered to consist of speeding particles--the terms alpha particles and beta particles are used.

Radiation, Particle theory of:

Three types of particle radiation initially were posited:

Alpha: Formed of two protons and two neutrons leaving nucleus (Although, because that equals composition of the Helium atom, alpha particles might be termed helium nuclei, helium nuclei, never termed alpha particles.) Alphas have more energy than the helium nucleus and move at high speed but are least penetrating of nuclear radiation (*e.g.* radium-originating alpha particles from a luminous watch face don't pass through the watch's face)

Beta: A neutron that has undergone transformation into three particles—proton, electron and neutrino. The new proton stays in the nucleus resulting in an elemental change. "Beta particle" refers to the released electron only. It escapes; but recalculation of the energy it should carry not being met, the neutrino was conceived to account for extra energy carried away. This contributed to conception of the "weak nuclear force," as opposed to the "strong (nuclear-binding] nuclear force."

Gamma: Photon of extremely high energy. Gamma radiation does not change the number of protons nor thus the identity of the atom, nor does it change one isotope to another, because there is no change in the number of neutrons. It is posited as a release of extra energy from the nucleus that remains after some previous nuclear reaction.

"Black Body" Radiation: Theory proceeded from premise that a 'perfect' black body—absorber of radiation falling on it, of whatever wavelengths—would emit all wavelengths, if heated to incandescence. Subsequently it was discovered that emitted radiant wavelengths reached a peak at some intermediate level, leading to "Wien's displacement law:" the shift of peak wavelength varying inversely with temperature (radiation per temperature risings ranges as follows: moderately-hot-infrared-dull red-bright red-yellow-white-blue white-ultravioloet [super hot]-x-ray region [sun's corona]).

Attempts at correspondent equations served either short/high-frequencies or long/low-frequencies but not both, until Planck's equation, based not on non-infinitively-subdivisible energy but quantum energy/particles, where *h* represents the constant of the ratio of the size of a quantum and its frequency of radiation. (Although what *h* represents remains unclear, with suitable value[s] Planck's formula permitted exact reproduction of the observed spectrum.)

(*Refer also to* Atoms, Valency, Electronic Theory of.)

MASS, GENERALLY: (*See also* Universe, Mass Content of)

Classically, the property of a body that is a measure of its inertia, which commonly is taken as a measure of the amount of material it contains that causes the body to have weight in a gravitational field.

In modern physics, mass is the ratio between force applied to a body and the resulting acceleration--a force applied to a body produces an acceleration proportional to the force; the constant of proportionality is the *mass* of the body. (In chemistry, the "Mass Action Law" states that the velocity of a chemical change is proportional to the active masses [molecular concentrations] of the reacting substance.")

Rest mass: The mass of a body exclusive of additional mass acquired by it when in motion, according to the theory of relativity—the mass of a body at *rest, relative to the observer*. The factor that mass varies with velocity is critical to nuclear physics when considering velocities approaching the speed of light.

Inertia: (not to be confused with *inertness)*-- the property of remaining 'at rest' or in uniform motion in an unchanging line and not acted upon by applied force.

Anti-(-Matter)Mass: Postulated undetectable form of matter in which the electrical charge or other property of each constituent 'particle' is the reverse of standard mass, and that when the two come into contact each instantly is annihilated, producing *gamma rays.*

Refer to Relativity, Einstein's Theories of, Special Theory; Higgs Field, etc.

UNIVERSE

It is estimated that the Universe consists mainly of hydrogen and helium in a 9:1 ratio; stars/suns also are mainly hydrogen.

Temperature, Outer Space: Taken as 3 degrees above Absolute Zero.

Relationship of galaxies: A mapping of the Universe by sectors with three-dimensional buildups of sector slices revealed that galaxies tend to be in the same relative spacing as to area between them.

"Hubble Law:" The speed of a galaxy is in a simple proportion to its distance: double the distance and the galaxy is receding twice as fast.

"Hubble Constant: Mathematical value used in calculation of the scale of the Universe, based on the "Hubble radius"--taken as delimiting that portion of the Universe that can come to be apprehended from Earth—under the recession theory, once a galaxy attained the speed of light further data would be unobtainable. The Hubble radius was estimated at 13 billion light-years.

Ongoing calculations via studies of nuclear reactions in stars yielded an estimate of the age of the Universe different from Hubble's two billion years--the different range being attributed in large part to the persistent mystery of the amount of matter in the Universe. Correction of perceived flaws in his scale resulted in a revised start of the Big Bang at 15-20 billion years.

Abbe Georges Lemaitre was first to suggest that the Universe began with a single explosion of an exponentially dense collection of all its constituents. The concept stemmed from extrapolating backward in time the theory of an expanding universe emanating with Edwin Powell Hubbell's extensive studies of the distance, velocities and recession of galaxies.

Fred Hoyle in the '40's was a leading challenger to the proposition that the Universe began with a "Big Bang" (the term he coined, that gained general use). Hoyle was a pioneer of a "Steady State" hypothesis--that new matter eternally was created to replace galaxies and that the Universe always had existed and always would exist. Science altogether turned against that hypothesis when observations in the mid-'60's revealed cosmic radiation presumably left over from the Big Bang, which theory has prevailed as the simplest explanation for the origin of the Universe.

Michael Faraday found implication through his extensive research that magnetic lines of a certain amount of force were universally passing through matter, keeping it in a constant state of tension, leading to conception of 'space' as a continuous *part*, permeating all masses in every direction (*see also* Magnetism, Diamagnetic). Faraday's related work focused on the transference of force from particle to particle at a distance or across a vacuum; as he questioned—in the ordinary atomic theory, if 'space' be a conductor, how can it be that certain substances (*e.g.* shellac) appear to 'insulate'/not conduct while others (metals) do not 'insulate' and do conduct (metals)?

As Faraday stated referring to experiments with potassium, "in which as a metal the atoms must, according to the usual view, be very far apart from each other, how can we for a moment imagine that its conducting power belongs to it, any otherwise than as a consequence of the properties of space, or as I have called it, the *m?* so also its other properties in regard to light or magnetism, or solidity, or hardness, or specific gravity must belong to it, in consequence of the properties or forces of *m,* not those of the *a* [its particle], which, without the forces, is conceived of as having no powers. But then surely the *m* is the *matter* of the potassium, for where is there the least ground...for imagining a difference in kind between the nature of that space midway between the centres of two contiguous atoms and any other spot between these centres? A difference in degree, or even in the nature of the power consistent with the law of continuity, I can admit, but the difference between a supposed little, hard particle and the powers around it I cannot imagine.

"To my mind, therefore, the *a* or nucleus vanishes, and the substance consists of the powers or *m;* and indeed what notion can we form of the nucleus independent of its powers? All our perception and knowledge of the atom, and even our fancy, is limited to ideas of its powers: what thought remains on which to hang the imagination of an *a* independent of the acknowledged forces? A mind just entering on the subject may consider it difficult to think of the powers of matter independent of a separate something to be called *the matter,* but it is certainly far more difficult, and indeed impossible, to think of or imagine that *matter* independent of the powers." (Page 851).

Einstein phraseology differed but paralleled much of Faraday. As Einstein noted, "According to general relativity [*see* that section], the concept of space detached from any physical content does not exist. ... Since the theory implies the representation of physical reality by a *continuous* field, the concept of particles or material points cannot play a fundamental part.... The particle can appear only as a limited region in space in which the field strength or the energy density are particularly high." "...[I]n the field theory of general relativity, we meet the same problem of a field-theoretical representation of matter as was met originally in connection with the pure Maxwell [electromagnetic] theory." "Since the gravitational field is determined by configuration of masses and changes with it, the geometric structure of space is also dependent on physical factors. ... ..[B]esides the gravitational field there is also the electromagnetic field [which] had to begin with be introduced into the theory as an entity independent of gravitation. ... But the idea that there exist two structures of space independent of each other, the metric-gravitational and the electromagnetic, was intolerable to [my] theoretical spirit." (Pages 348, 312, and 84-285; *refer also to* Relativity, Einstein's Theory of).

Continuing research has led to the general consensus that something still is missing as to the overall structure of the Universe, giving rise to theories such as "string" and "additional dimensions" (included below). New definitions appear to require a "neutralization" of gravity by some force external to the seeming effect of it on light, and a separation of gravitational effects from inertial ones.

"String Theory:" Proposes that acceleration of matter is caused by an energy field that suffuses space like a thin fog, constituted of tiny 'strings' vibrated by theorized "graviton" particles which, when they move, force 'space' to curl around them.

"Causal dynamical triangulation/CDT:" A new theory (*ca.* 2007) that constructs spacetime geometry from simple triangular structures similar to the 'buckyball' geodesic dome surfaces, using a basic building block of a 4-simplex, the equivalent of a tetrahedron but in four dimensions. Researchers calculate the overall geometry by summing probabilities of all possible configurations of simplexes, in that quantum theory stipulates the fundamental structure constantly changes at very small scales. CDT is proffered as a promising approach to unifying the laws of gravity with quantum mechanics (*see* Quantum Theory and Quarks). Next step would be incorporating matter into the model.

"**Space-Time Fabric:"** A view that space and time are welded together in a four-dimensional continuum.

Frame dragging: It is theorized that the Earth's spin should drag/twist space-time fabric, based on Einstein's proposal that the space-time fabric can be curved by the presence of celestial bodies.

Stars, nuclear mechanism: The qualitative theory of the mechanism of power/temperature of stellar interiors began with union of a hydrogen nucleus (*i.e.* a proton) and a carbon nucleus, initiating a series of reactions culminating in regeneration of the carbon nucleus and conversion of four hydrogen nuclei into a helium nucleus/alpha particle (Bethe), leading to the conclusion that hydrogen was the "fuel" of a star and helium the "ash," with carbon the catalyst. A later evolved second model involved the direct union of hydrogen nuclei to form helium, in a number of steps, as a mechanism that could proceed at lower temperatures (Bethe). The answer to, where dun and stars obtained energy, thus was summed: when hydrogen is converted into helium (whether directly or via catalytic influence of carbon), nearly one percent of the mss of the hydrogen is converted to energy. (The total mass of the sun's hydrogen is considered so great that the loss of mass to radiation, estimated at some 4,200,000 tons every second, consequently would remain imperceptible over millions of years.)

Supernova: A star that apparently exploded all at one moment, as opposed to a *nova,* which blasts away a relatively small amount of mass but returns to its apparent standard state.

Mass/Matter, Universe Content:

Galaxies, stars, and planets are believed to account for only approximately five percent of the universe if current cosmological theories are correct. Another 30 percent is held to be ***dark matter,*** and the balance, ***dark energy*** (the terms, "dark," referring not to color but to its non-detection).

In the "standard model" of the Universe, all particles except neutrinos have assigned mass; that model will need to be revised, however, if recent discoveries of neutrino mass are

validated (*see* Neutrino). For whatever the mass of the neutrino may be, and while it has been considered as the best candidate for dark matter, it also has been posited as composing only a part of missing mass termed "hot dark matter," leaving a larger, unknown remainder called "cold dark matter."

Hunt for dark matter began decades ago with technology developed to resolve fuzzy patches in the universe and discover new galaxies. Observations revealed that movement of massive galaxies was affected by something other than the mass illuminated in their velocity and motion. An apparent consistent speed of rotation did not match what existing laws decreed the rate should be, as if an unknown gravitational cause was holding masses together. Now posited at an estimated 73 percent of universe content, dark energy is being considered as the dominant force--a 'repulsive' effect that overtakes gravity.

Black Holes: "Supermassive" black holes appear to be situated at centers of galaxies, their existence betrayed only by their apparent gravity and radiation--a gigantic region that would 'suck' everything, including light, into them. Their size and constitution appear to have a direct correlation to their surrounding galaxy and a constant relation to the central part (bulge), supporting the notion that the evolution and structure of a galaxy is closely tied to the scale of its black hole. (Supermassive black holes are distinguished from the relatively 'small' black holes created by explosion and death of a star.)

Thousands of galaxies have been studied over the past decade. Hubble Space Telescope signals indicated a cluster of galaxies some 4.5 billion light-years away both permeated and surrounded by a cloud and a halo of 'dark matter.' In the most massive galaxies their black holes appear to be rapidly growing while at the same time more new stars are being created within them. Should there be a large collection of mass at a galaxy core, stars near it would orbit faster.

One technique used to map galaxies is *gravitational lensing.*

Gravitational lensing: The appearance of more than one image of the same object, such as a quasar, in telescopic view of a galaxy in front of the quasar. The phenomenon is attributed to the bending of the quasar's light by the gravitational field around the intervening galaxy.

Miscellaneous News Reports:

10/21/1994: Report that the Hubble Constant is equal to 80 kilometers per second per megaparsec (=3.62 million light years)--*i.e.* for every megaparsec between galaxies they will recede from one another at 80 kilometers per second, based on data of the Hubble Telescope's "Extragalactic Distance Scale Key Project."

July 1995: Report of University of Gotenborg physicist's computer simulation of the rotation of the theoretical swirling of gas and dust that forms a black hole; that it demonstrated increased internal pressure as opposed to the decrease that would be expected, due to centrifugal force counteracting gravity. The suggested conclusion--that matter's mysterious behavior around a black hole could be explained simply if centrifugal force was pointed oppositely/'inward' and at some point in the black hole vanishes—*i.e.* theorizing that centrifugal force can have certain properties in one place and contradictory ones in another, which reportedly successfully was reduced to a mathematical proof. It suggests a gravitational field strong enough to close in a light beam on itself.

1/1/1998: Colleagues at the Planck Institute spelled out data reported as conclusive evidence of a black hole at the center of the Milky Way—some 26,000 light years away, tiny in size but of a mass equal to 2.6 million suns—detected via a combination of radio telescope observations. Only a very small, dense object could hold the movements of 200 stars close to "Sgr A," tracked via advanced computer enhancement of infrared light, and in such closed orbits at more than a million miles per hour.

1/10/1998: Report that 1989 and 1990 COBE satellite measurements of all thermonuclear activity yielded twice as much accumulated starlight as can be attributed to all known stars and galaxies--more than expected, it implied there were more stars in the past then anticipated.

3/25/2002: Report of an as-yet unpublished paper in which its researchers propose a *gravastar* in place of a black hole. A gravastar is conceived as a star-size agglomeration of 'wavelike' substance that would be the underlying space-time fabric of the Universe—a starsized analogy to a Bose-Einstein condensate (the difference being that a laboratory B-E condensate

forms from atoms; *see* Quarks). Collapse of an imploding star would cease at a certain point, with a thin shell of pure gravitational energy forming around it. According to the researchers' calculations, the 'condensate' inside the shell would exert an outward force, which pressure would prevent the shell from further collapse—hence no black hole would form; and "Einstein's equations would be satisfied without any singularity forming."

7/18/2003: First report from DEEP2 spectrograph analyses of wavelengths from 130 galaxies revealed regions where starry masses are "spongelike and foamy; the project will observe and map at least 50,000 galaxies over the ensuing three years...to yield direct clues to...nature of dark matter and dark energy." Another study revealed dark matter is most dense at the center of the galactic cluster but falls away sharply with distance. Yet another specialized telescopic study reported the continuing survey of 120,000 galaxies within a billion light-years of Earth has revealed at least 20,000 massive black holes steadily growing both in size and mass. And the most massive galaxies—those with the most rapidly growing black holes at center—also are growing larger, more and more stars being born within them.

5/19/2004: Observations via NASA's orbiting Chandra X-Ray Observatory, focused on distant galaxy clusters, supports earlier findings suggesting that dark energy is Einstein's cosmological constant.

February 2007: Dark energy reported to have the same density of about 10^{-26} kilogram per cubic meter (equivalent to a handful of hydrogen atoms), wherever it is located from Earth's surface to galactic space. The unidentified substance, that as a whole exerts a kind of 'antigravity force,' is the best concept for cosmic acceleration.

5/16/2007: Report of data from the Hubble Telescope presented convincing new evidence for the existence of dark matter in a huge ring circling the remains of two clusters of distant galaxies. More and more evidence points toward dark matter being a real material, probably elementary particles. Fanciful names coined for the theorized unknown particle(s), among them, neutralinos, axions, MACHOS (Massive Compact Halo Objects), and WIMPS (Weakly Interacting Massive Particles).

12/18/2007: Report of telescopic images showing a black hole in a "death star galaxy" shooting a stream of radiant energy into the lower section of a neighboring galaxy. It is conjectured that an area of hot gas, 'compressed' over time by such energetic jets, could form a star.

MILKY WAY GALAXY

Termed "an ordinary galaxy" (and only one of billions of galaxies in the observable universe), the Milky Way's estimated diameter is 100,000 light years and its thickness, 1,000 light years--an 'island' disk of 200 to 400 billions of stars that houses the Sun and its planets. The core is approximately 25,000 light-years from Earth. (If the galaxy were reduced to an 80-mile diameter, the solar system would be .08 inches wide.) Active star formation takes place in the galaxy, especially in the high-density regions of its "spiral arms."

At the center of the galactic disk there is an outward bulge some 70,000 to 100,000 light years in diameter. The center harbors a very large concentration of mass (suggested to be a "black hole").

As early as 1930, data showed dense stores of hydrogen and other elements at the center. A particularly powerful source, from a narrow region (SgrA), was long speculated as the remains of a massive supernova.

Modern telescopic techniques permitted an averaging of cancellation of atmospheric distortions, to reveal that the closer stars are to the center of the galaxy the faster they orbit—the innermost ones moving as fast as .5 percent the speed of light (about 900 miles per second). A mass that keeps stars in so fast and tight orbits would need to be some 2.5 million tons packed into a tiny space, implying a density in the middle of the Milky Way of at least a trillion times that of its 'suburbs.'

As to the galaxy's velocity, Einstein's Special Theory of Relativity poses that there can be no preferred inertial frame of reference in space with which to compare its motion, in that motion must be specified with respect to another object. (Nonetheless, some astronomers placed the MW Galaxy velocity at 600 km per second, relative to observed locations of other galaxies, with later estimates ranging between 130 to 1000 kms per second.)

The “milky way” hazy band of light, which looks brightest in the direction of Sagittarius (toward the galactic center) results from objects lying within the galactic plane. Its division of the sky into two roughly equal hemispheres indicates Earth’s nearness to the galactic plane.

Miscellaneous News Reports:

6/8/1993: Report that calculations using the process of “astrometry” indicate the Milky Way galaxy is as much as 10 times heavier and bigger than previously was thought, suggesting a mass equivalent to 600 billion suns, at least six times more than the visible objects of the galaxy. The analysis is based on measurements of the movement of the Large Magellanic Cloud, the galaxy nearest to the Milky Way, it being asserted that the measurement is much more reliable than all previous determinations and that both the Milky Way and the LMC are inside a huge halo of dark matter, proving its existence beyond a doubt.

4/29/1997: Report of discovery via Compton Satellite of what appears to be a plume of “antimatter” erupting outward from the Milky Way core, rising some 3500 light years above the galactical disk. Only “antimatter electrons” (aka positrons or positive electrons) were found to be present, not antiprotons or entire antimatter atoms. The Compton Satellite was able to identify the specific energies of detected gamma rays, and the “fountain” was apprehended tuning instruments to the characteristic electron-positron annihilation energy.

6/29/2004: Report of researchers’ astonishment that measurements of Saturn’s magnetic field (via instruments on Cassini satellite) indicated that the field is aligned with Saturn’s axis of rotation--that Saturn’s poles lie on either side of its equator. The magnetic field of Saturn (not known to have an iron core center like Earth and Jupiter to generate their magnetic fields) appears to be generated “by processes that completely unknown.”

SOLAR SYSTEM

The solar system completes one orbit in the Milky Way Galaxy every 225-250 million years (a *galactic year;* it estimated there has been 1/1250th of a revolution since the origin of humankind).

Sun: The sun consists almost entirely of Hydrogen gas, the atoms of which fuse into the larger element Helium under tremendous heat and pressure. (It has been estimated that some 800 millions of tons of Hydrogen fuses into Helium every second.) Through the development of spectroscopy, it was discovered that a gas when cooled absorbs the wavelengths it emits when hot, which led to ascertaining elements that compose the sun. Oxygen, nitrogen and neon are minor sun constituents.

The sun’s approximate circumference is 2.7 million miles; approximate diameter, 866,000-875,000 miles; approximate radius, 433,000-435,000 miles; mean distance from Earth, 93,000,000 miles; mean surface temperature given between 5,700 and 6,000 degrees C/K; fusion temperature at center, 15,000,000 degrees

Circa 1938 the atomic interactions were defined that yield sun and star fuel power from fusion of four Hydrogen atoms into a Helium nucleus, with lost mass converted into energy.

Heliopause: The edge/boundary between the solar system and interstellar regions.

Solar wind: Term for a regular flow of electrically charged particles emitted by the sun, a stream of ionized gases, creating a *heliosphere* (magnetized bubble of hot plasma around the sun) that eventually crosses the system to encounter charged particles and magnetic field at the heliopause. When solar wind encounters Earth’s magnetic field it is deflected like water around the bow of a ship ***(bow shock)***.

Van Allen Radiation Belts: Concentric ‘nested’ rings/shells of ‘trapped’ radiation around Earth composed of solar particles held by Earth’s magnetic field (discovered via data registered by a Geiger counter placed on first Earth satellite, Explorer 1). The area proceeding from the bow shock, to surround Earth, is termed the *magnetosphere,* into which the full force of the solar wind is prevented from entering. Those high energy charged particles of solar wind that do enter the magnetosphere are trapped in the Van Allen belts.

Earth: Earth, of an estimated 12,700 km diameter, is believed to have a solid inner core of mostly iron and nickel, surrounded by a liquid ‘outer’ core also mostly iron and nickel, for a total core diameter of some 7000 km. Every change in distribution of Earth’s mass affects its rotation; a surprisingly large amount of variation in the spin is due to atmosphere and seas—the pertinent

quantity being not the rate of speed/spin but angular momentum, the product of mass and spin. Angular momentum constantly shifts from the solid planet, to air, and into the oceans.

The field lines defining the structure of the **Earth's magnetic field** are similar to those of a simple bar magnet. The Earth's rotation is 'tipped' relative to the axis of its magnetic field, so that the longitudinal line to the north magnetic pole does not coincide with the north rotational pole. Earth's magnetic field is not completely understood. *See also* Magnetism, Terrestrial.

It is estimated that a point at Earth's equator travels 1100 km (682 miles) per hour; but a point the poles is not moved by rotation, which effect produces a *Coriolis force:* 'air,' winds and water are deflected toward the west in the northern hemisphere and toward the east in the southern hemisphere.

Miscellaneous Reports:

5/27/1993: Report that analysis of intense low-frequency radio emissions detected by Voyagers 1 and 2 indicates they were produced by electrically charged gases/plasma from the sun, interacting at the heliopause with cold gases from interstellar space.

12/6/1994: Report of planned unmanned mission to Mercury to explore why it is so dense and has such a strong magnetic field.

ATMOSPHERES

Composition of Earth's:

Atmospheric pressure (or 'weight') fluctuates about the standard unit from day to day and position to position. ("We live submerged at the bottom of an ocean of air," said Italian scientist Evangelista Torricelli, 1608-1647, who invented the mercury barometer after Galileo's initial discovery that air had 'weight;' the theory was experimentally perfected by French mathematician Blaise Pascal.)

Earth's atmosphere "superrotates," *i.e.* moves faster than the planet.

Atmospheric pressure: The standard unit, 1 normal atmosphere, supports a column of mercury 760 millimeters high (29.92 inches) measured at sea level, latitude 45 degrees, at 0^{o} C temperature. 1 normal atmosphere averages 14.72 lbs. per square inch.

Regions: Beginning at earth's surface, named areas are of differing content and extent, as follows: (slightly varying distances are found)

Troposphere: Rising and falling pockets of 'air,' the troposphere is the active convection layer in which Earth's weather conditions collect. It extends from sea level some 7 to 10 miles (newer research indicates 14 km/8.68 miles) and constitutes half of Earth's total atmospheric weight. A buffer region 4 km/2.48 miles at top is termed the "tropopause." Troposphere temperature decreases with altitude. Its composition:

	% (at sea Level)
Nitrogen	78.03/78.08
Oxygen	20.95/20.99
Argon:*	.93
Carbon dioxide	.03
Hydrogen	.01
Neon*	.0018
Helium*	.0005
Krypton*	.0001
Xenon*	.00001

*Noble (inert) gases. The last of the five noble gas is Radon. *See* Atoms for atomic numbers and weights.

Stratosphere: 'Air' flow region extending $25^{\pm}$ miles above the troposphere, of the following composition:

	%
Nitrogen	79.2
Oxygen	7.0
Hydrogen	13.6

Mesosphere: Region extending from the top of the stratosphere to an altitude of $50^{\pm}$ miles above sea level.

The stratosphere and mesosphere contain a high content of **ozone,** a particularly reactive (allotropic) form of oxygen having three atoms per molecule, formed when oxygen is subjected to silent electric discharges—a bluish gas, it occurs in ordinary 'air' only in very small amounts.

Ionosphere ("Aurora") aka Thermosphere: Region extending beyond the former, to some $275^{\pm}$ miles above sea level (also referred to as the "Heaviside-Kennelly layer"). Heavily ionized, its density of free charged electrons/particles varies with solar activity, and it is strongly influenced by solar winds--layers can vary in height and ionization depending on solar cycle, season, and time of day. The Ionosphere reflects longer, wireless 'waves', permitting their transit and reception around earth.

Atmospheric compressibility of water: From unity at 1 normal atmosphere, compression is diminished only .0233 to 500 A (7500 lbs/sq.inch) and continues to diminish in similarly small hundredths, *e.g.* reaches only .8606 of unity at 5000A. (*See also* Magnetism, Diamagnetic.)

ATOMS

Atom Structure:

Atomic structure, which appears to be extremely 'open" in nature, has been postulated as follows:

Almost the entire atom mass resides in its central core, the *nucleus,* the span of which is estimated at some 10-trillionth of a centimeter. (The typed period at the end of this sentence—a thin layer of ink about one millimeter in diameter--contains roughly three or four billion atoms.) The nucleus consists of neutral *neutrons* and 'positively' charged *protons* (*i.e.* in effect, the core is 'positively charged'). In the initial "Bohr" atomic model, nuclei of the various elemental atoms were envisioned as enveloped/'orbited' by containing levels/"shells" of 'negatively' charged *electrons*--two electrons assigned to an inner shell (with the exception of hydrogen, which has only one electron) with additional shells and the number of electrons held in each different amongst all the remaining elements. The electron "shells" appeared subject to striking particular balances in shell contents (*e.g.* each of the inert noble gases—*see* below—holding a 'stable' 8-electron power in its outermost shell; *refer also to* Valency, Chemical).

The electron 'shell' portion of the Bohr model was modified, after the work of Erwin Schrodinger (and peers) to reflect quantum *wave mechanics* (*refer to* Electromagnetism).

Neutral atoms have the same number of electrons as they do, protons--their 'positive' and 'negative' charges are balanced. Removal or addition of outer electron(s) renders an atom an *ion.*

Ion: Atoms or groups of atoms charged relative to an increase or reduction of electrons. Positively charged ions lack electrons to maintain neutrality, negative ions have excess. The work to remove an electron from an atom is measured in electron-volts. Some compounds (salts, bases, acids) are thought to consist wholly or partly of ions held together by electrical attraction. (*Ion exchange* occurs in solutions of certain combinations of substances, such as in the 'softening' of water and industrial uses in separation of substances.)

Cation = positively charged ion; ***anion*** = negatively charged ion.

Radical: An atom that maintains its identity through changes that affect the rest of a molecule (joined atoms) of which it is a constituent--present in a series of compounds (joined groups of atoms).

Isotope: An elemental atom bearing its standard atomic number but differing in its weight. The nucleus of an isotope of an element contains the same number of protons as the element in its standard form, but a different number of neutrons (*e.g.* chloride-35 and 37, bearing the same number of electrons).

Angstrom Unit: Unit of length used with reference to atomic measurements. In general, one atom measures one or two Angstrom units--100 million Angstrom units = one centimeter (*e.g.* one inch = 254 million Angstrom units).

Valence: The combining activity/*valency* bonding power of an atom or radical, each having a fixed capacity for combining with others, determined by the 'outermost' "shell" of its electron system.

Valency, Chemical: Chemical combination takes place by the transfer or sharing of electrons between atoms, *e.g.* the valency of Oxygen is 2 in H_2O (water), the single electron of two

hydrogen atoms combining with the six electrons of Oxygen's outer 'shell' to stabilize at 8-electron power. Hence a molecular compound is dependent upon valency arrangements (order of joinings) of its atoms. It is possible for an atom to serve more than one bond depending on the valence of its joiner(s), while an "isomer" can result in instances of different valency arrangements (*e.g.* molecules of ethyl alcohol and dimethyl ether contain the same atoms--6 hydrogen, 2 carbon and one oxygen--but valence-wise are differently combined).

Electrolysis: Decomposition by electricity of a mass in solution. According to a Faraday law, the mass liberated by a given quantity of electricity is proportional to the atomic weight of the element and inversely proportional to the valence of the element liberated.

Electronics: The study of controlling the activity of electrons.

Valency, Electronic Theory of: Electron bondings have come to be explained in terms beyond chemical valencings, upon the theory that atoms or groups of atoms, regardless of valences, might be distributed about a center in accordance with fixed geometric principles ("the coordination theory" or "secondary valence")-- an electron-sharing concept of bonding applicable outside the realm of organic chemistry. Linkages include: (a) a transfer in an *electrovalent* bond--the atom supplying an electron becomes a positive ion and the receiving atom, a negative ion; (b) *covalent* bond, where each atom contributes one electron of the pair of shared electrons; (c) a *coordinated* bond in which only one atom provides the shared pair (there also being electronic bond configurations intermediate between the three primary ones).

The original *Bohr* model of an atom (derived from the Hydrogen atom) postulated only circular electron orbits/shells. That model has become insufficient, however, to account for the positioning of detected, fine spectroscopical lines of radiant energy; and ensuing research has dealt with implications of potential electron elliptical and angular 'orbiting.'

Points embraced by Bohr's fundamental theory were a) radiation was emitted when an electron changed 'orbit'/position to nearer the nucleus; (b) radiation was absorbed if an electron was driven farer from the nucleus; c) radiation was produced, then, by 'shifts' in energy levels of subatomic particles, not by oscillation or acceleration of the particles—*i.e.* the theory contradicted the standing belief that electromagnetic radiation occurred through electrons accelerating in 'orbit.' The issue was resolved when it was determined that an electron was not moving about a nucleus but instead formed a "standing wave" about it. *(Refer to* Electromagnetism.)

In 1933 a first sample was produced of water in which all the hydrogen atoms consisted of a heavy isotope ("heavy hydrogen" or *deuterium)* with an atomic weight of 2 instead of the usual 1. ("Heavy water" played an important role in the next decade in moderating neutrons, slowing them down to be more effective in setting up a chain reaction.)

Modern theory and experimentation has led to concepts of atomic sub-particles, the greater the energy of which the more rapid its motion (*Refer to* Subatomic Quanta and Quark Particles).

Atomic Number: Number of electrons associated with an atom.

Atomic Weight: The scale of atomic weights was originally determined by chemical means, in which the weight of oxygen (15.9994 relative to assignment of 1 to Hydrogen, as the lightest element) was fixed at 16 by averaging its three isotopic forms. Later electromagnetic methods of measurement have yielded finer determinations.

Electronic charge: Value, the negative charge of the electron, 1.602×10^{-19} coulombs, 4.803×10^{-10} electrostatic units. (For *coulomb, see* Electricity; for *electrostatic unit, see* Electromagnetism, etc.

Neutron: Electrically uncharged particle possessing a mass nearly equal to that of the hydrogen atom and slightly greater than the proton; a constituent of all atomic nuclei except the normal hydrogen nucleus, which is a single proton. *(Refer also to* Sub-Atomic Quanta and Quark Particles, Electrons and "Pair Production.")

Proton: Positively charged particle having mass approximately 1840 times greater than the electron and charge numerically equal to that of the electron; 1.00757 atomic mass units. *(Refer also to* Sub-Atomic Quanta and Quark Particles, Electrons and "Pair Production.")

Electron: Mass is 9.107×10^{-28} gm., approximately 1/1848 [seen also as 1/1840] that of the hydrogen atom, with a negative electric charge of 4.803×10^{-10} *electrostatic units*.

Electrons were determined to be highly energetic, miniscule subatomic particles (it being estimated that it would require 2,000 of them to equal the mass of the smallest known atom). Experiments established that, when a neutron of a particular atom was absorbed by the neucleus of another via nuclear reactor bombardment, one or more electron particles was or were emitted, and the new nucleus became an atom of the next higher element.

Refer to Sub-Atomic Quanta and Quark Particles, Electrons and "Pair Production."

Positron: Of the same mass and quantity as, but of 'positive' opposite charge of an electron (aka "positive electron;" "anti-electron," "antimatter electron"), which appears to make an a backward electron curve in a magnetic field—a 'reverse electron;' a "moving place" missing an electron, sometimes called an "electron hole." Positrons, emitted by many artificial radioactive elements, are produced in the process of 'pair production' (*e.g.* in 'collision radiation'--a photon giving rise to a positron and electron and those, two more photons that continue the process; from gamma-rays with energy equal to twice the mass of the electron.) When positrons and ordinary electrons collide they destroy each other and spawn gamma rays. *(Refer also to* Sub-Atomic Quanta and Quark Particles, Electrons and "Pair Production.")

In the following atomic descriptions, shells and their respective numbers of electrons are shown from the core outward. (Atomic weights can vary minutely between periodic tables, as indicated)

Hydrogen/H: Atomic element No. 1 (one 'shell,' 1 electron); atomic weight, 1.0079. Colorless, odorless, tasteless, inflammable gas, lightest substance known; molecule is diatomic (contains two atoms); is found in all living things. Cryogenized hydrogen In liquid form occupies 790 times less volume than in gaseous form.

Inert/Noble gases: That family of six ordinarily chemically inactive gases--helium, neon, argon, krypton, xenon, and radon, detailed below—of which minute or trace amounts of the first five occur in 'air' (*see* Atmospheres).

Helium/He: Inert gas; atomic element No. 2 (one 'shell,' 2 electrons); atomic weight 4.0026; occurs in certain natural gases; some is occluded in rare earth mineral compounds. Helium liquifies reluctantly unless heavily pressurized, turning only into slush at –452 degrees. (10/10/1996 a Nobel prize was awarded for creation at extremely low temperatures of a Helium 3, a form that within two-thousandths of a degree of absolute zero attains "superfluidity," flowing without loss of energy friction. (*Refer to* Cryogenics.)

Neon/Ne: Inert gas; atomic element No. 10 (two shells; 2 and 8); atomic weight, 20.179/.183.

Argon/Ar: Inert gas; atomic element No. 18 (three shells; 2, 8, 8); atomic weight, 39.948/.944

Krypton/Kr: Inert gas; atomic element No. 36 (four shells; 2, 8, 18, 8); atomic weight, 83.80.

Xenon/Xe: Inert gas; atomic element No. 54 (five shells; 2, 8, 18, 18, 8); atomic weight, 83.79/.80.

Radon/Rn: Inert but unstable radioactive gas; atomic element No. 86 (six shells; 2, 8, 18, 32, 18, 8); atomic weight, 222;

Nitrogen/N: Atomic element No. 7 (two shells; 2, 5); atomic weight, 14.008/.0067/.007; odorless, invisible, chemically inactive gas, forms approximately 4/5 of Earth's atmosphere; forms essential part of proteins (fixation/nitrogen cycle).

Natural nitrogen compounds are scarce. Until the early 1900's the only large-scale source was nitrate deposits in deserts of northern Chile. Then the Haber-Bosch process was perfected to fix atmospheric nitrogen in a gas pressure method, combined with hydrogen with iron as the catalyst, yielding ammonia for conversion into fertilizer and explosives.

Oxygen/O: Atomic element No. 8 (two shells; 2, 6); atomic weight 15.9994; odorless, invisible gas; chemically very active; essential to most forms of life; very widely distributed in compounds (oxides). Cryogenized oxygen is magnetic.

Gases, Generally: The compressibility of a gas varies in an inverse relationship with pressure ("Boyle's Law)—double pressure halves a gas, triple pressure yields one-third, etc. Subsequent

to that finding concerning pressure and volume, the relationship between temperature and volume was determined with considerable accuracy: for each degree Centigrade rise in temperature, the volume of a gas expanded 1/273rd of its volume at 0 degree; conversely, the volume contracted 1/273rd with each degree of fall in temperature—*i.e.* the volume would reach zero at –273 degrees C (--Jacques Charles' premise, effected by Kelvin/absolute zero. The law that the volume of a given quantity of gas is proportional to the absolute temperature where pressure is held constant is sometimes called not the Charles but the Gay-Lussac law, they later publishing a duplication of Charles' work.)

Van Der Waals initially provided an equation:

$\frac{PV}{T} = R$

(P = pressure; V= volume; T = absolute temperature; R representing a constant for each gas, variables adjusting with changes in one or another to keep the R value); however, it was nearly true with hydrogen, nitrogen and oxygen only if the temperature was raised and the pressure lowered. Eventually a final equation was had, involving the use of temperature, pressure and volume of a gas at its critical point (where the gas and liquid forms of the element become equal in density and cannot be distinguished from each other).

As a result of Van Der Waals' work, the Joule-Thomson effect (gas expansion with drop in temperature) was found to hold only to a certain characteristic temperature for each gas—which, for hydrogen and helium, is very low (their liquefaction impossible until methods were devised to approach absolute zero; *see* Cryogenics, etc.)

Carbon/C: Atomic element No. 6 (two shells; 2, 4); atomic weight 12.011; occurs in several allotropic forms (*e.g.* diamond and crystalline graphite; and combining with oxygen in the atmosphere serves plants in photosynthesis).

Tin/Sn (Stannum): Atomic element No. 50 (five shells; 2, 8, 18, 18, 4); atomic weight 118.69/.70/.71; specific gravity 7.31; melting point 231.85 degrees C; silvery white metal of carbon family.

Niobium/Nb: Atomic element No. 41 (five shells; 2, 8, 18, 12, 1); atomic weight 92.9064; first transition metal.

Rare earth elements: Highly similar rare minerals; at atomic numbers 57-71 (the "lanthanides," very similar to aluminum in many properties), with a second set commencing at 89 (the "actinides") proceeding into the 100's. A mineral containing one rare earth element contains all. They are difficult to isolate, in that their electron differences are minute.

Atomic Mass Unit: Scale used to express masses of individual isotopes of elements; approximately equal to 1.66×10^{-24} gram.

Electronegative elements and groups: Radicals that behave as negative ions, acquiring the negative charge by taking up electrons when united with other radicals by electrovalent bonds.

ATOMIC PILE AND PARTICLE ACCELERATORS

Atomic pile: The "atomic pile" was the structure that tested and achieved the first fission chain reaction --uranium and uranium oxide piled in combination with blocks of graphite that slowed neutron velocities for easier absorption, which absorption was contained by interior cadmium rods which, when withdrawn, a chain reaction became self-sustaining.

Particle Accelerators: The apparatus housed in a particle accelerator complex raises the energies of subatomic particles to billions of ***electron volts*** (*ev,* the unit of energy given to a charged particle by an electric field). High-energy beams appear to produce new kinds of particles through impressions of nuclear characteristics yielded by proton collisions with target nuclei. Techniques vary with different types of "atom smashers," in which the beam of particles, increasingly racing by giant cumulative voltages, is directed and focused by a series of strong magnets. The final result is a record on film of tracks made by the shattered fragments/particles as they pass through a bubble chamber filled with liquid hydrogen. (Condensing of droplets about ions makes tracks visible in a cloud chamber.)

QUANTUM MECHANICS

A body of theories, rules and processes of calculation emanating from Max Planck's 1900 introduction of 'discontinuity' into atomic physics and the theory of radiation: that radiation

(radiant energy of any form in addition to light) emits not as a continuous 'stream' but in small discrete packets called "quanta" (from the Latin *quantus,* or *how much*).

Following the work of Erwin Schrodinger (and peers), the Bohr atomic model with respect to electrons was modified to reflect quantum *wave mechanics* (*refer to* Electromagnetism). A particle is represented by a *wave function* (probabilities of where and in what direction it is and is going), together with for each point in space a probability of amplitude of finding it there—yielding, mathematically, a probability amplitude for each possible value of momentum (*i.e.* all the facts about a particle are wrapped in its wave function/state).

Quantum: A definite amount of energy (energy 'bursts') associated with electromagnetic 'waves'--*e.g.* light, x-rays, gamma rays--dependent on the frequency of the radiation.

Planck's constant: A factor combined with the velocity of light and Newton's constant of gravitation that provides an absolute system of units that set the scale for quantum gravity: a radiation's quantum of energy equals *hv,* wherein *v* = the frequency of radiation in cycles per second, and *h* = "Planck's constant," 6.624×10^{-27} erg.sec. (the elementary quantum of action'; .00000000000000000000000001 [26 zeros preceding the 1]).

Quantum "leaps:" Particles vanishing from one place and seemingly reappearing instantaneously in another, *i.e.* exhibit "nonlocal" behavior, *i.e.* defying Einsteinian premise that no mechanism could work at faster than speed of light.

Uncertainty Principle (Heisenberg's): That the position and momentum of subatomic particles separately can be ascertained but not both at once. They manifest either as waves or as particles depending on how they are examined. The uncertainty principle is a consequence of the fact that Planck's constant is not 0.

Quantum "weirdness:" Term denoting the conundrum of "quantum observership" in quantum measurement.

"Fine structure constant"/alpha: Controls the strength of electromagnetism, thus how subatomic particles interact with each other and light. Determining the fundamental value of *alpha* is an as-yet unachieved quest.

Quantum "criticality:" Encodes strong fluctuating changes of matter undergoing a 'second-order' phase transition at zero temperature, and underlies the unusual properties of a host of quantum materials. 2/16/2007: Researchers reported existence of more than one energy scale at a quantum critical point, their data providing evidence for an energy scale in the 'equilibrium excitation spectrum' additional to the expected slow fluctuations of the order parameter. Findings contradicted the conventional order-parameter fluctuation theory in two respects: the only low-energy scale in that theory is associated with the magnetic slowing down and a sharp feature in thermodynamics and transport qualities arises at only one point. (*Refer to* Cryogenics.)

SUB-ATOMIC QUANTA AND QUARK PARTICLES

Modern Physics postulated "quark" entities in the late 1960's, subsequent to detection via high-energy beams of 'graininess' in protons and neutrons--which gave rise to a semblance of interior centers of atomic charge--and in order to satisfy observed reactions in nuclear experimentation and explain structuring apparently derivable from them.

Research has indicated that light-energy of sufficient strength yielded quark reactions.

Quantum theory incorporates a scheme of particle construction and configuration based on the conceptualized units denoted quarks. Particles are classified into groups and families, according to their apparent degree of interaction with the strong nuclear force.

Reaction trackings in sophisticated high-energy accelerators led as well to the postulation of 'antiparticles' and 'antiquarks'—that, when one 'particle' met an 'anti-particle,' they eliminated each other--an electron and 'anti-electron' (equal to twice the electron's mass) could manifest from a gamma-ray of energy.

Quark *mass,* however, is a theoretical construct, relying for evidence on the procedures that define it. Still open to experimental testing is the possibility that discovered elementary particles in fact are composite, themselves, of some other elementary constituent(s).

Quarks, like electrons, essentially are mathematical figments; they are not assigned spatial extent but are assigned a number of properties, all of which must be inferred from measurable properties of composite particles made up of them. Those properties bear identifying

symbols or letters for use in the related complex mathematical calculations. The following are the main postulates, in brief, embraced by quark particle theory:

(a) a *quark* is a generic type of physical particle; (b) a quark is the only entity that interacts through all four fundamental forces; (c) electrons and neutrinos are designated *leptons* (non-participants in the strong force)*;* (d) quarks and leptons are considered as forming the basic constituents of matter; (e) quarks also present characteristic *types* and *flavors,* as follows (each list is in order of increasing mass)*:* an *up-type-quark* can be flavored "up," "charm," and "top;" a *down-type quark* can be flavored "down," "strange," and "bottom" (labels, only--not to be taken as denoting behavior or direction); (f) three quarks in different combinations compose protons and neutrons (the *hadrons;* participants in the strong force), as follows: 2 up quarks and 1 down quark = proton with a net charge of +1; 1 up quark and 2 down quarks = neutron with a net charge of 0; ((g) the up and down varieties of quarks are most abundant and primarily distinguished by their electric charge, critical to proton and neutron formation; (h) the nuclear force that binds quarks appears to grow not weaker but stronger the farther they are separated, yielding theoretical models of "quark-gluon plasma" which would last less than 0.00000000000000000001 second, should it experimentally appear if high-speed collisions of heavy ions (such as gold or lead) be brought by particle accelerators to breed it; (i) the complete set of designations for subatomic particles includes *quantum numbers,* derived from *spin, color,* and *parity;* (j) all quark particles generally are unstable.

The lifespans of subatomic particles appear dependent on their *speed* (*cf.* CERN '70's experiment in the Muon Storage Ring, in which the life of a supermagnetically-constrained *muon* [a heavier flavor of lepton than the electron] traveling at 99.94% speed of light reportedly was extended nearly thirty-fold).

Absence of convincing evidence of either free quarks or fractional electric charges is attributed to the factor of *confinement,* impossible to measure but which under theory a quark must possess.

Confinement: Proof of confinement is expected under a modern theory called *quantum chromodynamics (QCD),* and the possibility it may be able to break confinement by creating dense or hot quark matter—theoretically predicted phases of matter. (Concern has been expressed in some quarters, however, that the high-speed collisions could generate strange quarks to emerge from the vacuum and form a new type of nucleon (a "strangelet"), followed by an "ice-9" reaction and runaway fusion with normal nuclei.)

Photon: Postulated Interactive carriers of the electromagnetic force, capable of conveying different amounts of energy, but conceived of having no mass or charge, appearing to originate in the process that yields them; the compositor of electromagnetic radiation such as light.

Einstein's interpretation of Planck's formula: a photon's energy is inversely proportional to its wavelength.

Electrons: *First, see* Atoms, Electron.

Since the Lorentz-FitzGerald contraction (*refer to* Relativity, etc., Special Theory) reduces the volume of an electron as it speeds along and reduces it the more, the more rapidly it is moved, the electron also must increase its mass with velocity. According to the L-FG formulation, at 161,000 mi./sec. the mass of an electron is twice its rest mass and, at 186,282 mi./sec. (velocity of light) the mass must be infinite since the volume becomes zero (taken as another indication that the velocity of light in a vacuum is the greatest velocity at which any material object can travel; *see* Relativity, etc., Special Theory).

Electrons and "Pair Production:" (Example description:) An electron passing through the field of an atomic nucleus causes emission of a photon. After traveling a short distance the photon is absorbed by interaction with a nuclear electromagnetic field, giving rise to a positron and an electron. This conversion of a photon into a positron and electron is called 'pair production.' The pair of newly-created particles produces two further photons by collision radiation. These photons are again absorbed, giving rise to more electrons and positrons. The process continues until the final electrons and positrons created possess insufficient energy to continue maintain collision radiation.

Results of electron diffraction experiments indicate that electrons behave as if they are both waves and particles. To free/pinpoint an electron particle--wavelength being inversely proportional to momentum—the required wave must be of the length of the particle size. With

long-wave photons, the electron cannot be pinpointed, while with shorter wavelengths that impart high momentum the electron is thrown off course, yielding uncontrolled diffraction. (In effect, 'electrons are shorter than their own wavelengths.) After thousands of arrivals of electrons on the screen, instead of expected clusters, the result is a complex regular structure characteristic of waves interfering with each other. The very act of measuring—the interaction of the quantum and macroscopic systems—hides the baffling mixing of quantum research's view of waves and particles. It progressively has become evident that electrons, due to the 'wave' characteristics of particles, have to be viewed as 'wave' forms, without fixed positions—that electron 'waves' are smeared out, so to speak, over a relatively extended region. (*Refer to* Electromagnetic Force, etc.)

"Entanglement:" In theory, "entanglement" represents a bond between interacting quantum systems, in that a measurement performed on one of the systems affects the other, irrespective the distance between them. It appears to act instantaneously with an influence faster than the speed of light, reasons why Einstein and colleagues argued it a physical impossibility.

Quantum Numbers: Four numbers that designate energy levels (there originally being three).

Spin: Permissible energy levels in quantum analysis, due to the changing of position of a particle about or relative to an axis of its own besides other form(s) of energy with which it is involved--motion which may yield an associated magnetic moment whether or not the particle is charged.

Evolving from postulation that the fourth quantum number could be interpreted as spin, the unit of electron spin (clockwise or counterclockwise) was made equal to half a common quantum unit, so that the electron could be said to have a spin of +1/2 or –1/2.

The initial parity law held that particles emitting from a disintegrating atomic nucleus would be as likely to 'spin' in one direction as another. In 1957 experimentation verified that each type of elementary particle radioactively emitted had a characteristic 'spin,' and that parity was not conserved in weak interactions in which strange and neutrino particles were involved. (The contradiction stemmed from the following: natural particle motion is straight; in the weak interactions of beta decay [electron loss], particles largely traveled in predictable orbits; however, the more energy they received, the stronger the magnetic fields needed to keep them in an orbit.)

Parity and conservation of: The initial law held that 'particles' emitted in disintegration of an atomic nucleus would be as likely to 'spin' in one direction as another. Subsequent to the (above) 1957 finding, anti-matter (via introduction of *anti-quarks)* mathematically was included to satisfy parity in descriptions of directions in which interacting particles are established as moving.

Color: The assigned quark property associated with quark binding of *gluons.*

Gluons: Postulated carriers particle of the strong nuclear force

Neutrino: Postulated fundamental uncharged particle, the existence of which preserves the laws of conservation of mass and energy and conservation of momentum in certain nuclear reactions. The *neutrino* has zero or very small *rest mass* (has been reported as 'weighing in' at a infinitesimal fraction of the mass of the electron*,* trillions of them passing through the human body every second). The mere fact of neutrino mass forces a rethinking of the standard model, the theoretical framework of all subatomic physics. The neutrino may be quantum mechanical but not immutable, *i.e.* at any instant a certain probability exists that its mass may oscillate from one state to another.

Neutralinos: Exceedingly hard to detect postulated entities that rarely or never interact with other forms; they belong to the family of "weakly interacting moving particles/WIMPS."

Boson: A family of force-carrier particles, among which considered are photons, gluons, "W" particle and the "Higgs," were it found to exist (*see* below).

Gravitons: Postulated particles that would carry gravitational force.

W particles: Postulated particles to carry the weak nuclear force.

Bose-Einstein Condensate: The concept that light transmits by 'quanta'/photons led to assumption of rules ("Bose" statistics) relating to photon definitions. Einstein considered how the rules might apply to gas atoms, and his equations yielded strange behavior of atomic quantum mechanical energy at very low temperatures--at normal temperatures it positioned them at many different levels; but at extreme low temperatures a large fraction would change to the lowest energy level, descend and spread out, identically, as if one coalesced mass (likened by some to a 'super atom')—a phenomenon termed "Bose-Einstein condensation."

It was not until some 70 years later, in 1995, that the predicted effect was apprehended, through a combination of lasers and evaporative cooling, atoms were taken to the necessary extreme cold near absolute zero. The process involved multidirectionally applied laser light, pressuring of the ordinarily lightweight photons into high intensity beams directed at susceptible atoms in a vacuum cell. A small electromagnetic field ("laser trap") was used to control the range of laser pressure beams upon the atoms (and provide the 'color' pressure relative to the particular absorption of the atoms used, *e.g.* rubidium), and a strong magnetic field ("magnetic trap") was used to keep atoms in the center of the cell.

Instead of natural thermal photon/electron reactions of absorption (*e.g.* sunlight through fabric) and repulsion (bright sunlight off of chrome), the respondent susceptible atoms' electron-containing 'envelopes' underwent forced photon changes that slowed down/cooled the atoms, then cooled farther by an evaporative cooling process to separate condensed atoms from still faster-moving ones.

The resulting miniscule amount of B-E condensate produced (only a few million atoms at a time) appears to be the most fragile mass state yet achieved.

(*See also* Cryogenics.)

Higgs Field: A theorized energy-carrying field that permeates all of space and gives mass to sub-atomic particles. Since quantum theory requires all fields to be represented by particles, a Higgs *boson* would complete the picture; since the Higgs field is posed as being exactly the same everywhere, what varies is how the different fundamental particles interact with it (If something is not added to the standard-model equations; if the "top quark" isn't there, the standard model is not structured correctly.) Discovery of "the Higgs boson" would corroborate that space is not a void but permeated by an invisible field.

Added to basic understandings of matter and energy, the Higgs theory would solve the problem of *mass,* explaining the diversity whereby solid matter is heavy because it is rich in quarks while sunlight and radio waves flit around with no mass at all. (The Higgs boson is presumed to be massive compared with sub-atomic particles—perhaps more than 100 times the mass of a proton. As with all artificially created oversize particles, it would be highly unstable and exist the smallest fraction of a fraction of a second before decay into its constituents.)

In early 2000 collisions in a daring boost of power levels at the Large Electron Positron/LEP created short-lived massive particles that produced in decay just the pattern of subatomic flotsam expected if a Higgs had briefly appeared, but other familiar particles might produce the same pattern. In October of the same year it was reported that the Higgs quest would move on to searches by the giant accelerator at Fermilab and then the Large Hadron Collider/LHC.

Supersymmetry/SUSY: Generally considered a precondition for string theory, SUSY theorizes that every particle has a 'superpartner' with a different "spin" (*e.g.* 'superpartners of quarks, *squarks;* of photon, *photino;* and if a Higgs is found, *higgsino.*

Miscellaneous News/Reports:

Twenty thousand photographs of more than 400,000 alpha particles tracks of cloud-chamber bombardments with *nitrogen* yielded eight collisions of alphas and nitrogen molecules, in confirmation of transmutation of elements, 'matter' into 'matter' (Blackett). It subsequently was demonstrated that gamma rays passing through lead sometime disappeared (Blackett), giving rise to a positron and an electron, being the conversion of energy into matter, confirming Einstein's famous equation.

6/5 and 15/1998: Report of two year detector studies by a collaboration of 120 international scientists physicists apparently may have determined that neutrinos carry at least as much mass as all the stars and galaxies created since the Universe's beginning, and may account for a significant portion of its mysterious "missing mass"--oscillating from one state to another as trillions of them stream from cosmic rays, from the sun, from supernovas, and from the decay of other particles that make up every nucleus of every atom that exists. Even a miniscule mass would give them enough combined gravity to slow the expansion of the Universe and possibly even reverse it.

The experiment did not actually measure the mass of detected neutrinos but enabled experimenters to calculate the tiny difference between the neutrinos in each state just as they oscillated to another. At most, the actual mass of each neutrino state was an almost infinitely

small fraction of the total mass of an entire electron. Existence of neutrino mass would force a rethinking of the "standard model" theoretical framework of subatomic physics.

Large Hadron Collector/LHC Project of the European Organization for Nuclear Research (CERN) on outskirts of Geneva, Switzerland, planned for full power in 2008, searching for more massive fundamental particles, specifically the "Higgs boson" missing from the standard model. The possibility has been suggested that the LHC may produce "strangelets," a theoretical form of matter some think might exist at the center of neutron stars. Collisions of particle beams will occur at four locations, with four main detectors involved in different studies. (CMS and ATLAS projects will explore fundamental forces and basic nature of matter; "ALICE" will analyze collisions of lead nuclei to study quark-gluon plasma; LHCb is hoped to add to knowledge of matter versus antimatter.)

7/16/1990: Report of Livermore Laboratory encounter with "superdeformed" atomic nuclei ("as if one kept stuffing bowling balls into a ('spinning') bag but its moment of inertia didn't change").

7/14/1995: Report of creation of a "superatom" (technically, might be called a Bose-Einstein condensate), by cooling atoms of rubidium gas to a temperature where they lost individual identity.

3/5/2002: Report (met with skepticism) from Oak Ridge National Lab of bursts (although miniscule) of energy seemingly released by fusing of deuterium atoms in the collapse of acetone bubbles when the liquid was blasted with ultrasound.

5/17/2005: Report of discovery of an unexpected new subatomic particle, termed Y(3940), with hints of it possibly being an example of a "hybrid meson," a particle assumed composed of a quark, antiquark and gluon; however, its mass—about equal to a single atom of helium—was below theoretical estimates, leaving the experiment's results as an enigma.

6/20/2005: Reports of experimental results that appear to confirm that strange quarks in a proton's quark-gluon sea contribute to the structure of a proton and contribute to the proton's electric and magnetic fields, *i.e.* its charge distribution and magnetization. (Researchers watched to see how many protons were scattered by beams of alternate electron polarization sent into a hydrogen target.)

7/28/2005: Report of fleeting appearance (about one a month) of *antineutrinos* (termed "geoneutrinos" by scientists involved with in deep underground detector), "a first clear identification of radioactive chemical elements in the Earth's deep interior." "Antineutrinos are created as end products of a cascade of particles in the radioactive decay of elements like uranium and thorium."

CONSERVATION OF MASS AND ENERGY

Mass-Energy Equation: "Mass and energy are mutually convertible under certain conditions. The equation connecting the two quantities in any such transformation is represented by Einstein's $E = mc^2$, where c is the velocity of light in cm./sec. E is the energy, in ergs, released when a mass of m grams is completely converted into energy.

The sum total of energy and mass x c^2 is constant for any system and cannot increase or decrease. When colliding particles result in a loss of energy, then particles of greater mass must come into being. When particles 'dissolve'/decay into less mass, more energy must appear.

Principle of conservation of energy: Energy cannot be created or destroyed. It only is releasable through conversion, *e.g.* an electron and a positron colliding can annihilate each other in an emission of energy in the form of gamma rays.

Conservation of charge: Positive and negative energies cannot be transformed one into the other. A positive particle and a negative particle combine into a neutral one. Also conserved are momentum, spin, and strangeness.

Energy levels: An individual nucleus or atom as a whole can exist only in a specifically definite state characterized by the energy of the state. A series of energy levels correspondent to these permissible states exists for each different nucleus or atom.

When the nucleus of a heavy element (*e.g.* plutonium, atomic weight 239) undergoes fission, binding energy is released (such as in an atomic bomb); the number of resultant mass(es)/'pieces' are less than the original Conversely, fusion releases energy when lighter

nuclei are combined ((such as in the fusing of hydrogen nuclei into heavier nuclei in the hydrogen bomb); the resultant mass(es)/'pieces' are greater than the original.

MAGNETISM

Michael Faraday perceived that "all matter appears subject to the magnetic force as universally as it is to gravitating, the electric and the chemical or cohesive forces; for that which is not affected by it in the manner of ordinary magnetic action, is affected in the manner [above] described." (Page 627). His extensive experiments determined that, magnetically, substances ranged in varying degrees in two subclasses, ***paramagnetic*** and ***diamagnetic,*** venturing the law that, in an absolute vacuum or free space, a paramagnetic body tends from weaker to stronger places of magnetic action, and a diamagnetic body under similar conditions from stronger to weaker places of action (*i.e.* where a substance from one class is attracted, one from the other will be repelled; and where a bar of one will assume a certain position, a bar of the other will acquire a position at right angles to it). (Page 686).

An important Faraday commentary concerned the effects of water's *diamagnetism.* A solution of protosulphate of iron was made which (a) when, magnetically balanced, was neither attracted nor repelled nor pointed when in air; (b) pointed axially (along the magnetic line) if surrounded by water; (c) if made weaker in respect of iron, pointed axially in water and equatorially in air; and (d) could be made to pass more and more into the magnetic class or diamagnetic class, respectively, by addition of more sulphate of iron or more water. Astonished by the power of water to counteract the magnetic force of the salt of iron, and considering the by far greater portion of diamagnetic substances composing Earth's crust, he suggested it as hasty to assume that the more striking magnetic substances overrule entirely the effect of the former.

As to the magnetic force of oxygen (the more dense it becomes, the more paramagnetic), Faraday ended related experiment descriptions with the statement, "It is hardly necessary for me to say here that this oxygen cannot exist in the atmosphere, exerting such a remarkable and high amount of magnetic force, without having a more important influence on the disposition of the magnetism of the earth as a planet...." As to nitrogen, it appeared neither magnetic nor diamagnetic—"like space itself" (page 685).

From his experiments, Faraday concluded that magnetism--generally considered a peculiar and isolated effect--"was the consequence of a general property" of all matter, finding no single solid or unmixed fluid that remained neutral. He saw "some great purpose of utility to the system," whereby magnetic lines of a certain amount of force were universally passing through matter, keeping it in a constant state of tension, and conceiving of 'space' as a continuous part, permeating all masses in every direction "like a net, except that in place of meshes it...form[s] cells, isolating each atom from its neighbors and itself only being continuous"—questioning whether it was across by the action of contiguously succeeding particles that the force was carried onwards. (Additional information at Universe.)

Magnetic field, mechanically produced: A field of force represented as existing at a point if a small coil of wire carrying an electric current experiences a *couple* when placed at that point. The field may exist at a point due to the presence in its neighborhood of either a permanent magnet or of an electrical circuit carrying a current.

Magnetic line of force: A line along which each point is that of the magnetic field at that point.

Magnetic pole: Opposing points of a magnet's concentrations of magnetic forces. 'Unlike' poles attract and 'like' poles repulse. The force of either result varies inversely as the square of the distance between them.

The strength of a magnetic pole is measured in *unit magnetic pole* (the force between two equal poles one centimeter apart in a vacuum = one dyne).

Magnetic poles differ from electric charges, where one sign can exist independently and substances exist in which electrical force charges can move freely. Hans Christian Oersted was first to demonstrate the connection between magnetism and electricity, in an experiment where, bringing a compass needle near a wire through which a current was passing, the needle insisted on pointing neither with nor against the current but at a right angle to it, regardless of in which direction the current was moving.

Couple: The *magnetic moment* of a couple is the product of equal opposite forces acting upon a body and the perpendicular distance between them in the magnetic line of force.

Magnet, permanent: A "ferromagnetic" substance with which is associated a permanent magnetic field and magnetic moment = the couple that holds the magnet at right angles to a field of unit *magnetic intensity* = strength at a point of the field, measured in *oersted* C.G.S. units.
Oersted: CGS electromagnetic unit of magnetic intensity, equal to the intensity of a magnetic field in a vacuum in which a unit magnetic pole experiences a mechanical force of one dyne in the direction of the field.
Magnetic susceptibility: Ratio of the intensity of magnetization produced in a substance to the intensity of the magnetic field to which it is subjected.
Magnetic flux: Magnetic flux is the product of its area and the component of the magnetic intensity at right angles to the area.
Magnetic induction: Modification of magnetic flux, in a material medium introduced into a magnetic field, owing to interaction between the medium and the field.
Magnetic permeability: Ratio of magnetic induction to the external magnetic field causing the induction. Magnetic induction tends to a limiting value (*saturation value)* in a few substances with high permeability--notably iron--which substances are termed *ferromagnetic.* Permeability varies with the strength of the applied field.
Ferromagnetic substances: Including the metals iron, cobalt, nickel and certain alloys, they are vastly greater in magnetism than any other substances. Ferromagnetism is ascribed to unbalanced 'spin' in the inner elementary 'orbits—ionic spacing such that very large *exchange forces* cause large groups of atoms to align individual magnetic moments into highly magnetized domains. Points of axes of domains in unmagnetized iron are randomly directed; application of an external field serves to line them up. Each ferromagnetic substance loses magnetism beyond a specific temperature (the *Curie point* of that substance).
Magnetic field of electrical current: A magnetic field is produced surrounding a wire or coil carrying an electric current. If the current is moving from right to left, the direction of the field produced is at a right angle to it.
Terrestrial magnetism: The magnetic field of earth, the intensity of which varies with time and place.

A freely suspended magnetized needle (= *dip circle,* magnetized needle mounted to rotate in a vertical plane with the angle measured on a circular scale marked in degrees), will set itself pointing to Earth's north and south (magnetic) poles at an angle to the *magnetic dip* = the angle between the direction of the Earth's magnetic field and the horizontal (that is, the *angle* through which a the magnetic needle 'dips' from the horizontal, when free to swing in the vertical plane through the axis of the needle--the vertical plane that contains the direction of the Earth's magnetic field being the *magnetic meridian)*. The angle between the geographic and magnetic planes is termed the *magnetic declination.* Declination, dip and horizontal intensity are the three elements that define Earth's magnetic field at any point. The total magnetic intensity of Earth may be resolved into two components, the horizontal and the vertical (horizontal intensity = total intensity *cosine* angle of dip).
Magnetic equator: Line of zero magnetic dip, lying near the geographical equator but passing north of it in Africa and the Indian Ocean, south of it in the Americas and Eastern Pacific.
Magnetostriction: An iron bar changes its length somewhat when magnetized (Joule); an effect modernly used in connection with ultra-sonic sound-wave formation.

ELECTROMAGNETISM (*Refer also to* Electricity.)
Electromagnetism: Branch of physics that deals with the physical relations between electricity and magnetism.
Electromagnetic Force: Wide range of vibrations or 'wave' motions seeming not to require any known material medium for their propagation, traveling with a velocity of 2.9978×10^{10} cm. per second—approximately 186,000 miles per second (the speed of light). In order of increasing wavelength, they are gamma rays, x-rays, ultra-violet rays, visible light rays, infrared (heat) rays, and wireless or Hertzian waves.

Electromagnetic force (EF) developed by electrical current has an infinite range compared to the WNF. A 'photon-field' has been conjectured as a neutral stream or current of *bosons* that transmit force from one charged particle to another.

A "brain teaser" of Einstein's was to imagine what he would see, if he could observe an electromagnetic field while traveling at the speed of light.

Electromagnet: A core of magnetizable material surrounded by a coil of wire through which an electric current is passed to magnetize the core.

Transverse 'Waves': 'Waves' in which displacement/vibration occurs in a plane at right angle to the direction of propagation, *e.g.* light 'waves,' x-ray 'waves' (the lengths of the latter can be determined by crystal diffraction, where regular atomic order substitutes for diffraction grating used with ordinary light 'waves,' which latter grating cannot be made fine enough to measure x-rays).

(A possible effect, involving bulk surface-area to volume, may be the amplification of sound traveling across water's 'cooling' effect.)

Longitudinal 'Waves': **'**Waves' along which the displacement/vibration takes place in the direction of propagation (*e.g.* sound 'waves').

EMP/electromagnetic pulse: Nuclearly generated, wherein electromagnetic force interactions proceed through a neutral current, *i.e.* uncharged bosons would carry the force.

A believed apparent link between the electromagnetic and weak nuclear forces had led to contemplation of a point at very high energy where the probability of a weak interaction is greater than the probability of an electromagnetic interaction, so that the two forces--instead of differing in strength--simply may operate differently, depending on the energy of the particles upon which they act, permitting a neutral weak current to carry a charge to account for the transformation, one to the other, of a neutrino and electron when they interact via the WNF.

Electromagnetic units system/EMU: System of electrical units within the C.G.S. System, based on the unit magnetic pole, which repels a similar pole one centimeter away with a force of one dyne.

Current balance: Instrument for the determination of a current in absolute electromagnetic units--two similar coils at ends of a balance arm with a fixed coil above and below each. The six coils are connected in series in such a way that, when the current is passed through them, the beam experiences maximum torque. The beam is restored to its horizontal equilibrium position by means of a known torque, supplied by a rider sliding along the arm. From the known torque and the geometry of the system the current can be calculated.

'WAVE' MECHANICS

'**Wave' and 'Wave'-Motion:** 'Wave' is the term employed in the concept of energy propagation that occurs about a mean position of the locus of displacement/vibration at each periodic point of the energy path.

Each particle has associated with it a specific periodic 'wave.' ("Waves' are not considered as having real existence; the concept serves mathematical relations employed in assigning wave frequency and amplitude using rules derived partly by analogy with the propagation of light waves, partly by *ad hoc* hypothesis from known quantum conditions, and partly from necessary conditions of continuity.).

Phase: *Points* in the path of a *wave motion.* (Points are identical when displacement/variance and magnitude are in *equal phase.*

Wave-Length: The 'crest-to-crest' distance between points of equal phase of a 'wave' motion--equal to the velocity of the 'wave' motion divided by its frequency.

Frequency: The number of vibrations/displacements per second—equal to the velocity divided by the 'wave'-length.

Schrodinger equation: As time progresses, the values of the wave function ripple through space, similar to wave ripples on a lake. This implies that quantum phenomena also are smooth, and in a sense follows, for example, the precession of a spinning charged particle in a magnetic field, *i.e.* smooth evolution of states.

NEWTON'S LAWS

1. Every body continues in its state of rest or uniform motion in a straight line except in so far as it is compelled by external force to change that state.

2. Rate of change of *momentum* is proportional to the applied force, and takes place in the direction in which the force acts. In the presence of a force, a body will be accelerated in the direction of that force, the product of its mass by its acceleration being equal to the force (*f = ma).*

Momentum: The product of the mass and velocity of a body. For speeds approaching that of light, the variation of mass with velocity must be taken into account, and the value of *m* appropriate to the velocity of the body must be used in the expression for the momentum. *See* Relativity, Einstein's Theories of.

3. To every force there corresponds an equal counterforce acting in a direction opposite to that of the force. To every action there is an equal and opposite reaction.

Derivative: Every particle attracts/['receives'] every other particle with a force directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them.

The system developed from Newton's laws of motion provided means to determine motions of bodies possessing ordinary velocities; his theory, however, provided no explanation of the fact that the weight and the inertia of a body are determined by the same quantity—its mass. The motions of particles of very high velocities must be treated by a system of mechanics based on the theory of relativity, which considers the change with velocity of a particle's mass.

RELATIVITY, EINSTEIN'S THEORIES OF

Relativity is limited in particular in the extreme short-distanced domain of quantum mechanics, leading to different approaches to quantum gravity. String theory, which provides additional directions for particles to move, might explain apparent behavior of matter in gravity operating over sub-microscopic distances. Meanwhile, physics seeks a particle that transmits gravitational force.

Einstein's theory of general relativity made 'space' an active constituent—distances between points are influenced by how much matter, energy and gravitational force are nearby—as opposed to the three-dimensional space of Newton and the original, traditional quantum physics, where all that happened was fixed and immutable.

The greater the energy of a subatomic particle, the more rapidly it travels. However, the fact that quantum theory appears to allow faster-than-light connections between particles is a major discrepancy with the theory of relativity, which explicitly forbids it.

6/19/1995: A paper was scheduled to be published of the report by a team which seemingly got light to travel faster than its accepted maximum speed—photons "tunneled" through a special multilayer mirror at a velocity 70 percent faster than, and arrived at the detectors before, those traveling through air.

The Special Theory of relativity (1905) treats of objects or systems which either are moving at constant velocity with respect to one another (*unaccelerated* systems) or which are not moving at all (with a constant velocity of zero).

The General Theory of relativity (1916) treats of objects or systems that are speeding up or slowing down with respect to one another (*accelerated* systems). It explained some discrepancies between Newton's theory, most importantly opening the door to inconsistencies between it and electromagnetic theory.

The special and general theories came to be used conjunctly in ensuing scientific practice.

Special Theory:

Postulate 1, simply stated: *The [an] ether cannot be detected.*

Postulate 2: *The velocity of light is always constant relative to the observer.*

The Special Theory served derivations to explain certain phenomena and deduction of mathematical formulations enabling comparison with actual measurements. (Various methods are described here but all resultant formulae, themselves, are not.)

The undetectable ether:

The *lumeniferous ether* was conceived by earlier scientists as filling the 'emptinesses' of the Universe, present in all substances in greater or lesser degree, and carrier of light 'waves.' Its existence was taken to have been disproved finally by the famous Michelson-Morley experiment (on the premise of necessary effects on light of a drift or "wind" in an existing "ether," following Fizeau's finding of 1859 re the 'dragging' of the velocity of light in moving water). Although

correspondent differences of positions of receipt and intensity were not registered in the M-M projection and reprojection of light rays at right angles to each other, the experiment largely was taken as proof that an ether wind--thus an ether--did not exist. Other possible explanations continued to be introduced, however, in favor of the entrenched ether theory,

The most appealing counter-explanation was the Fitzgerald *contraction.* It postulated that objects contracted in the direction of their motion through the ether, and thus the path of the light ray against the "wind" would be shortened due to contraction of its measuring interferometer's arm. That hypothesis gained weight with the 1895 electron theory of Lorentz: that matter consisted of electric charges; that they generated electric and magnetic fields residing in the ether; that the electric charges of the object moving through the ether would be moved by the fields; and that the object also would contract as predicted by Fitzgerald's formula.

That work of Lorentz and Fitzgerald was deducible from Einstein's 1905 Special Theory, by which it could be shown that the Lorentz mass-increase with velocity held not only for charged particles, but for all objects, charged and uncharged.

Einstein concluded that *motion is relative:* an object only is perceived as in motion compared to something else, and its velocity only is relative to the other. Einstein did not conclude that an ether was non-existent, only that it could not be detected. A 'stationary' ether of *absolute* motion would be undetectable in that only *relative* motion can be detected; the ether in effect would be 'motionless.'

Einstein considered naming the General Theory the "Invariance Theory"—an absoluteness existing, but its apprehension only can be relative to the perceiver, due to the perceiver's participation in/being embraced by, its system. He posed that there were "hidden variables" in quantum physics. Although particles appear subject to a guiding wave that approximates Einstein's hidden agent, its detectability is unknown.

Contraction effect equation:

Predicts that each of two objects moving with respect to each other shrinks in its system relative to observation by the other, whose system remains constant. (The contraction effect is appreciable only when relative velocities are comparable to that of light.)

The Lorentz hypothesis, which was based on the necessary existence of an ether and applicable only to electric and magnetic fields, was verified as a logical consequence of the relativity theory.

From the point of view of an observer stationary to an object approaching the speed of light, the object would appear to be gaining mass and, the more energy moving it, the greater its apparent mass.

The contraction effect equation represents further that the mass of the 'shrinking' object increases (does not become *large;* becomes 'heavier' relative to size), leading to:

Mass increase with velocity equation: Representing that the relative amount of increase depends on the relative velocity of object, leading to:

Maximum possible velocity: The formula in consequence of the preceding two equations--that, as an object approaches the velocity of light, its length would approach zero, leading further to the conclusion that the maximum possible velocity is the velocity of light.

Equivalence of mass and energy:

Since a heavier object has more energy than a lighter one at the same velocity, and, if mass increases with velocity it follows that an object also gains energy, from which it follows that as mass decreases the object loses energy, it can be concluded that all mass has an associated/equivalent energy with velocity, and, further, since the amount of energy acquired or lost by the mass is dependent upon velocity and the maximum possible velocity is equal to the speed of light, it can be theorized that maximum energy is attained with an acceleration *meeting* the speed of light, *c,* Einstein drew the concluding equation, $E = mc^2$.

Sub-atomic processes of mass/energy conversion are far beyond purely chemical processes like ordinary burning, such as of coal, where a relatively small amount of energy (heat) is released but almost all mass is retained in different forms, *i.e.* soot, ashes, gases and ash.

Einstein noted, relative to measurement of the tremendous energy containable by a gram of material, and referring to his formula: "[W]e can reverse the relation and say that an increase of E in the amount of energy must be accompanied by an increase of $\frac{E}{c^2}$ in the mass.

I can easily supply energy to the mass—for instance, if I heat it by ten degrees. So why not measure the mass increase, or weight increase, connected with this change? The trouble here is that in the mass increase the enormous factor c^2 occurs in the denominator of the fraction. In such a case the increase is too small to be measured directly, even with the most sensitive balance." (Page 340).

Time-dilation effect:

The Special Theory predicted that each of two observers moving relative to each other would perceive a slowing of Time on the other's system. This postulation was difficult to test, in that the relative velocity of each observer would need to be comparable to that of light. An experiment devised in 1938 appeared to prove the effect. Hydrogen atoms were accelerated inside a glass tube to a velocity of *ca.* 1,100 miles a second—about 0.006 the velocity of light. The rate at which electrons vibrate in hydrogen atoms was used as a time process, which rate of vibration can be measured both when at rest and moving relative to the observer.

If time dilation were correct, the time per moving vibration would be longer. (Comparing a vibrating atom to a vibrating musical string, a decreased frequency corresponds to an increased or longer time per vibration; and every atom vibrates at its own specific frequency.) It was reasoned that, change in frequency accompanying change in vibration, and a decrease in the former representing an increase in time between vibrations, translated to a slowing of time in the atom. The results of the experiment, an increase in time per vibration, matched exactly the amount predicted by an equation derived from the Special Theory.

In 1971 an experiment was conducted using portable caesium atomic clocks, by which traveling east an average 59 nanoseconds (billionths of a second) were lost and traveling west, 273 nanoseconds were gained, relative to the point of departure—approximating closely the prediction of relativity theory. It follows that, confirmation that atomic clocks run faster at higher altitudes (and slower at lower), 'quark'/E velocity is increased (or decreased). Atoms in the clocks also would be subject to effects by added or decreased velocities relative to their direction and that of the earth's rotation.

Principle of Equivalence:

The basic postulate of the General Theory, cornerstone to establishing the particular role mass plays as a *source* of [/contributor to] attraction in a gravitational field, distinct from the ratio between force and acceleration. Mundanely, the force and time required to set two objects in motion at the same rate of acceleration are greater for a heavy object than a lighter one. Gravitationally, mass enters into the relationship between force and acceleration. It affects the magnitude of gravitational attractive forces to cause the accelerations of different bodies in the same gravitational field to be the same. That at a given location all bodies undergo the same acceleration is a peculiarity of gravity, which is not shared by other kinds of force. For instance, in an electric field, particles with different charge-to-mass ratios are accelerated differently. At a single point in 'space' the effects of gravitation and accelerated motion are equivalent.

Weight:

Defined as the force with which a body is attracted to the earth or a celestial body by gravitation, and which is equal to the product of the mass by the local gravitational acceleration. The effective weight of an object depends on the strength of gravitational 'attraction' acting upon it (*e.g.* objects would weigh more than double on Jupiter, due to its 300 times Earth's mass).

The gravitational acceleration in a free fall in Earth's surface atmosphere is roughly 32 feet per second per second (*i.e.* at the third second, 96 feet per second).

"Cosmological Principle:"

That the Universe is homogenous in any view, *i.e.* the vista from Earth same as from any other point, with no purely localized conditions.

"Cosmological Constant"/CC:

Einstein originally considered the Universe as static, initially proposing the CC to account for cosmic acceleration, representing the energy inherent in 'space' itself—that is, an energy existing in a volume of space devoid of matter, roughly equivalent to 10^{-26} kilograms per cubic meter. That 'glue' of the Universe subsequently was said by him to be a blunder (based on later, apparent evidence that galaxies were moving away from each other); however, the CC gained new life when evidence emerged, from charting 40 supernovae explosions plus analyses of radio galaxies, that expansion was speeding up and the Universe appeared going too fast to stop.

As it is considered, the CC is not a force but a property of 'space' itself—even vacuums, where no matter is detectable, betray a hidden energy that expresses itself across distances; but its inexplicable smallness would put it beyond the scales of physical processes to create and observe it. The possibility of the CC is disturbing to physicists, in that, compared to gravity, it would need to be expressed as a decimal point followed by 128 zeros before a 1; and over cosmological distances it eventually would defeat gravity.

5/19/2004: Observations via NASA's orbiting Chandra X-Ray Observatory, focused on distant galaxy clusters, supports earlier findings suggesting that dark energy is Einstein's cosmological constant, reportedly achieving results consistent with it and clear, direct evidence of the Universe accelerating.

GRAVITATION

It long was understood (since Newton and Galileo) that energy of an object hurtling upward does not really decline as its movement slows. The movement steadily diminishes under the effect of gravity; but as the object loses kinetic energy it gains potential energy: at maximum height it is momentarily stationary without kinetic energy and, as it starts falling, potential energy becomes kinetic energy and it reaches ground with all the kinetic energy with which it originally had been hurtled upward. The theoretical interchange of kinetic and potential energies without loss is termed "the conservation of mechanical energy." Some energy is lost through 'air' resistance and friction; however, that loss of mechanical energy is balanced by a gain of heat (it being recognized as a form of energy), and total energy is conserved. That is *the law of conservation of energy*: energy can be changed from one form to another but cannot be created out of nothing or destroyed into nothing; it frequently is termed "the first law of thermodynamics."

The value of the electromagnetic field continuously fluctuates in the quantum field theory of electromagnetism, confining any quantum-mechanical effects of gravitation to a minute scale (*refer to* Planck's constant).

A remaining mystery for Newton had been the seeming force exerted by the sun that kept the planets continually revolving around it; despite deducing that the paths were elliptical, he initially did not know why. Then, in 1687, he published what came to be known as "Newton's law of universal gravitation," which said that every object in the universe attracts every other object with a gravitational force given by the following equation:

$F = \frac{G.M_1M_2}{d^2}$, where G is the "gravitational constant" of 6.659×10^{-8} C.G.S. units (centimeter/gram/second), and

each M is a mass in grams separated by distance d in centimeters.

[Every particle in the Universe 'attracts' every other particle with a force directly proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them. The connecting force is given in *dynes*.]

[The gravitational attracting force between two bodies depends upon, being proportional to the product of, the two masses involved.]

Gravitation was Einstein's focus in developing his General Theory. Newton's formula, based on observation, alone, was correct to a high approximate degree. The derived equations corroborated ellipticity of orbits but treated the paths as fixed planes, relative to the sun. Einstein's theory, while confirming ellipticity, posed that the rotational orbits, themselves, varied position in space, albeit the rate of change was very small (*e.g.* earth's orbit is said to change but 3.8 seconds of arc every 100 years, at which rate it would take 34 million years for a fully changed plane). Newton's formula thus became modified to agree with Einstein:

$F = \frac{G.M_1M_2}{d^{2.00000016}}$ Force = $\frac{\text{Total of Gravitational Constant x Mass 1 x Mass 2}}{\text{Total of Distance x Distance of which the square root is 2.00000016.}}$

Proofs of the General Theory: Three proving factors emerged.

The most convincing involved Mercury, with its greatest velocity and "flattest" orbit relative to the sun. It had been known that Mercury exhibited an unaccountable 43 seconds of arc per century not ascribable to the gravitational effect of other planets. For many years (based on a proposition by French mathematician Leverrier), astronomers searched in vain for another

influencing planet between Mercury and the sun. Application of the revised theory to Mercury over a 100-year period accounted for the previously unexplained 43 seconds of arc.

The second offered proof involved the effect of gravitational mass on a light beam, in that the General Theory predicted that light from a distant star passing through the gravitational field of another mass would be deflected ("bent "), causing the star to appear to change position. Theoretically, that involved "weighing" traveling light *photons* (--*see* Radiation Pressure). The sun, with our solar system's greatest gravitational attraction, was considered the best 'scale.' Einstein suggested the test occur during a total eclipse, in that star light grazing near the shining sun would not be observable, and predicted that light beam deflection would be 1.74 seconds of arc. A May 29, 1919 eclipse provided a number of bright stars, photographed by astronomical expeditions in both northern Brazil and the Gulf of Guinea, which photographs were compared with pictures taken when the sun was not opposite the stars. The two groups found, respectively, that the stars' light had moved an average of 1.98 and 1.6 seconds of arc, considered sufficient to verify the prediction, taken as confirmed also by subsequent observations. (Another difference between Newton's and Einstein's laws of gravitation is that the value for the "bending" of a light ray according to Newton is exactly one-half—0.87 seconds of arc—of the Einsteinian value.)

The third General Theory element to prove was the prediction that the processing of time would slow with increase in mass, Einstein expecting that a second of time on the sun would correspond to 1.000002 seconds.

Effect of Gravitational Mass on Time:

The General Theory predicted that 'time' processing would be slower on a large mass than on a small one. An early testing of the prediction initially considered computing vibration frequencies of light from the sun compared to the same atoms on earth, to determine whether the sun's mass caused an increase in time between vibrations, thus fewer of them, in which case the sun's lower frequencies would shift toward the red end of the visible spectrum. The expected shift in the sun test was inconclusively within limits of measurement. Then, In 1925, based on light from the extremely dense white dwarf star B Sirius, a frequency red shift of the expected amount was reported as constituting proof, that a strong gravitational field does slow down atomic time processes.

According to one school, predictions of how fast orbiting neutron stars lose energy in radiating gravitational waves, to spiral toward each other, is seen as a major triumph of the general theory, and the existence of gravitational waves (unlike concepts of 'strings' or 'extra dimensions') is undoubted, allegedly confirmed to an accuracy of many decimal places.

Speed necessary to escape Earth's gravitational pull: 17,500 miles/hr.

News Report: 11/23/2007: Report concerning study revealing underground tremors linked to tidal changes, and discussion of lack of understanding how or why effects of gravitation should reach deep into Earth's interior. Despite the expectation that the weight of water at high tide more likely would damp down and weaken the tremors, they instead were stronger at high tide and weaker at low tide"—one guess being that "a change in the weight...of water...alters what presses down on the Earth and causes detectable pulses in the periodic tremors that occur in very weak unknown faults." (*cf.* Faraday).

CRYOGENICS

The branch of Physics that explores the effects of dramatically low temperatures on the production and behavior of substances, initially impeded by inability to produce temperature as cold as it is intergalactically.

Experiments some years ago touched on the arena of controlled fusion, a crucial problem being confinement of plasmas too hot for containment by any known material. At the opposite end of the spectrum were experiments with *cryogenic* magnets, involving the possibility that supercold temperatures might be able to contain plasmas within their fields without direct contact with them. "If so," commented a researcher, "we will have reached the ultimate in absurdity of science, a 'bottle'—269 degrees C cold, to contain a process involving millions of degrees of heat." (*Reference:* Life Science Library, *Matter,* p. 44-45.)

"Absolute Zero:" -273.1 degrees C; 0 degrees Kelvin (-459.65 degrees F.), "coldest possible" temperature in the universe; the point at which atoms appear to come to a virtual

standstill, no longer move and fuse into a single mathematical wave form (a 'macroscopic quantum state").

Superconductivity: Electrical energy resistance of a metal or alloy decreases as the temperature falls and for certain conductors approaches vanishment as it reaches its 'transition temperature," near absolute zero-virtually perpetual motion of current (flow, once begun, literally can go on forever). A strong magnetic field ordinarily cancels superconductivity with rare exception *(e.g.* an alloy of Niobium and Tin). Different single metals have different critical points for superconductivity.

Superfluidity: "Superfluids" possess 0 viscosity. The behavior of superfluidity is not understood; it can manifest as 'particles' and 'waves' at the same time. Superfluid, cryogenized Helium (Helium "2") defies gravity, will spurt through cracks gases can't, spreads out instantly in all directions, and crawls up and out of containers. It refracts light so minimally it is impossible to see its surface in a clear container.

Viscosity: Property whereby a fluid tends to resist relative motion within itself. If different layers of fluid are moving with different velocities, "viscous" forces come into play, tending to show down the faster-moving layers and to increase the velocity of the slower-moving layers. For two parallel layers a short distance apart in the direction of flow, the viscous force is proportional to the velocity gradient between layers. The constant of proportionality is called the *coefficient of viscosity* of the fluid.

5/25/97: Report of a new kind of gyroscope that overcomes issues of variations in the Earth's spin because of its faster-moving atmosphere ("superrotation") and shifting angular momentum due to tides, etc. The device uses superfluid helium 4 (roughly speaking, in a rotating container on the turning planet, it continually adjusts it motion to compensate for the tiniest changes in that rotation).

Superfluid helium 4: A helium isotope atom of two protons and two neutrons, helium 4 is so cold that its atoms lose individual identity, described as "fusing into a single mathematical wave form-a "macroscopic quantum state," flowing perfectly without friction. Its rotation, measured as angular momentum, is innately oriented to the 'fixed, unturning Universe-centrifugal force and gravity do not confuse its sense of spin. Mathematically, it must be taken as acting like one atom and, like an atom with strictly quanticized behavior, the entire mass of fluid can have an angular momentum of zero, 1, 2, 3, etc. but nothing in-between.

If helium 4 is in a rotating container on the surface of the turning planet, it continually adjusts its motion compensatory to the tiniest change in the planet rotation. Tiny tornado-like vortices that form in liquid helium 4 have been photographed, as its flow organizes itself to maintain its angular momentum at a precise integer value. An increase in the length of the tiny corridors the helium traverses as it adjusts its overall flow in synchronicity with the 'fixed' Universe is expected to lead to time-measuring instruments with a precision in the parts-per-billion range.

Cryopumping: First, an initial, good vacuum is obtained by conventional methods, rough pumping that removes only part of air, followed by long process in which a 'diffusion' apparatus strikes gas molecules with a heavy material like mercury vapor or oil. Then cryopumping tales over--a permanent refrigerating surface inside the vacuum chamber, backed by cryogenic liquidcarrying pipes (originally liquid nitrogen, although cryopumping with hydrogen or even liquid helium produces a better vacuum), to condense and remove thin gases still drifting about the chamber by locking them down as ice. Although a vacuum of high degree can be obtained with liquid nitrogen, neon, hydrogen and helium can remain in gas form. Cryopumping with liquid hydrogen or liquid helium produces a more near perfect vacuum.

LIGHT

Einstein postulated that the energy content of light waves was deposited in tiny 'lumps/photons, the size of which had to do with their wave length and Planck's h, interpreting Planck's formula to imply that photon energy and wavelength were inversely proportional.

Photons" are activated when electrons are dislodged from a sensitive surface exposed to light energy:

$$E = \frac{hc}{\lambda}$$

Where E = photon energy/elementary quantum of energy

h = Planck's constant
c = speed of light
λ =photon wavelength.

Photons have momentum/p determining energy, allowing:

pc = hc

thus

p=h

Refer to Subatomic Quanta and Quark Particles Photons.)

Maximum SpeedNelocity (C): Through a vacuum, 186,326 miles per second; slightly less in air; in water (3/4 sFeed) 139,500; in glass (2/3 speed) 124,000.

C^2 (186,326 miles/sec. X 186,326 miles/sec.) = 34,717,378,276 miles/sec.

Light travels more slowly, however, through a transparent medium like water, so that high-energy particles passing through can exceed the velocity of light in that medium. (When it does, it throws back a 'wake' of light termed "Cherenkov radiation."

Pressure: It further has been reasoned that photon light energy exerts a pressure on the receiving surface, albeit too tiny to affect the gravitational connection of earth and sun.

Spectra/Spectrum: The result obtained when radiations of electromagnetic waves are resolved into their constituent wavelengths or frequencies, in the visible wavelengths region being the colored bands produced when lain light is passed through a prism or diffraction grating. Plain light radiation passed through a semitransparent medium produces an *absorption spectrum, certain wavelengths/bands being absorbed by the medium. Only certain wavelengths or 'lines'* appear in a *line spectrum.*

Spectra formed by bodies releasing radiations are termed *emission spectra.* Emission and absorption spectra are a means of identification of substances. Such spectra arise as a result of transitions between different states of atoms or molecules, electromagnetic waves simultaneously being emitted or absorbed. The frequency v of the emitted or absorbed radiation is given by *E1* (energy of the state before transition) *minus E2* (the state after transition) = hv *(h being Planck's constant). When E1 is* greater than *E2* electromagnetic waves are emitted; in the converse, absorbed.

Light Year: The distance traveled by light in one year, approximately 6 x 1012 miles (six million million miles).

Miscellaneous News Reports:

7/20/2000: Report of convincing demonstration that, under certain laboratory circumstances, the speed of light can be pushed beyond its limit heretofore accepted, a laser pulse through a vapor of cesium atoms traveling 310 times the distance it would have covered through a vacuum. According to the report, "the effect is possible only because light has no mass."

10/5/2005: A Nobel co-winner this year was leader in 1983 at a conference that defined the speed of light as the distance light travels in 1/299,792,458 second.

10/5/2005: Nobel award to co-recipients who pioneered "the frequency comb technique," demonstrating how lasers with different frequencies could be made to cancel out each other like the teeth of a comb, allowing passage of "femtosecond" light pulses *(0.0000000000000001* of a second).

ELECTRICITY: General term for all phenomena caused by *electric charge,* whether static or in motion. **Turbine:** Motor in which a shaft is rotated steadily by the impact upon its blades of a current of steam, air, water or other fluid directed from jets or nozzles. **Generation:** The process of collecting and converting energy to electrical form. First- employed plants were powered by the kinetics of flowing water *(hydroelectric)* or combustion of fossil fuels *(e.g.* coal-, gas- or petroleum-fired). Later sources include plants powered by steam--: either from burning fossil fuels, boiling water by *fission,* and underground pressured steam or a transfer production of steam from underground hot water *(geothermal).* New methods also employ *solar parabolic troughs* or *solar power towers* (concentrating sunlight to heat a transfer fluid to produce steam), wind- and tidal-driven turbines, and solar *photovoltaic panels* that convert sunlight directly to electricity. More advanced studies/developments include *betavoltaics* (electricity production from radioactive decay) and fluid-based extraction from nuclear reactors (*magnetohydrodynamic/MHD.*)

Electric Charge: Explained as follows:

Two kinds: positive and negative. Unlike charges attract, like charges repel. The elementary positive [“]particle[“/charge] is termed *positron,* which “has only a transient existence.” The elementary negative [“]particle[“/charge] is termed *electron.* Electrons flow toward positrons. (Whereas initially, based on Franklin’s theorizing, it was assumed that a circuit flowed from positive [‘excess’ state] to negative [reciprocally ‘lesser’ state], electrons flow from negative terminal to positive.) Important to remember that “positive” and “negative” are relative terms; two substances charged the same way will reject each other; “opposing” charges are required for attraction (*e.g.* electrolysis reveals the copper in copper sulfate blue crystals by dividing the molecule, copper gathering at the negative pole).

Electric charge is measured in *electrostatic units* or in *electromagnetic units,* the practical unit of which is the *coulomb* (definitions below).

Substances are said to possess electric charge when (a) forces exist between them; (b) they are acted upon by forces when moving in a magnetic field that has a component at right angles to their direction of motion.

Electric field of a charge: The region near an electric charge, in which a force is exerted on a charged particle; completely defined in magnitude and direction at any point by the force upon unit positive charge situated at that point.

Heating effect: Heat energy is generated “at the expense of electrical energy” when an electric current flows through a conductor of finite resistance. The quantity of produced heat is proportional to the conductor’s resistance, and is summed by formulae calculating *calories per second,* equal to the potential different in volts (*e)* times the current in amperes (*i)* divided by 4.2, or, the current in amperes *(i)* times the resistance in ohms *(r)* divided by 4.2.

Electric current: The flow of energy in electrical form flowing along a conductor. In metals, the current is said carried by electrons; in *electrolytes,* by *ions.*

Current, Direct/DC: “Continuous current” (formerly termed “Galvanic” current); the unidirectional flow of electric charge, characterized by *poles* termed positive and negative; Only storage batteries (and Faraday’s Dynamo/generators) provide true DC. High frequency direct constant current flows uniformly throughout the cross-section of a uniform wire that carries it.

Current, Alternating/AC: Current that reverses direction of flow at regular intervals; having alternately positive and negative *values* termed “Single-Phase Alternating Current.” In that materials of high conductivity do not allow propagation of electromagnetic waves, as the accelerating electric charge radiates the waves, AC current is forced away from center toward the outer surface of the wire, a phenomenon called “skin effect.” At very high frequencies the current no longer flows *in* the wire, but effectively flows *on* the wire surface.

Current, Full-Wave Rectified Single-Phase AC: A “rectifier” device is so connected that AC current flows unbrokenly with no intervals, transforming AC into DC (although amplitude may fluctuate). May be termed “half wave DC.”

Conductor: A body which, given an electrical charge, distributes that charge over itself. Materials that transmit electricity, heat or sound is called a *conductor.* How a particular substance affects passage of a steady current through the conductor is called its *resistance.* Resistance is measured in *ohms.* The force that acts on a mass is measured in *dynes.*

Electrode: Conductor via which electric current enters or leaves;

Cathode: 'Negative' electrode (*e.g.* cathodes emit electrons when heated; can be a heated filament or a filament indirectly heated by a separate filament).

Anode: 'Positive' electrode (attracts electrons).

(*Refer also to* Electric Charge.)

Electric potential: Electric potential of a point is the work necessary to bring unit positive electric charge from a distance to that point.

Potential Difference/PD: Difference of electric potential between two points. If the points are joined by a conductor a current will flow between them and the PD equals the work performed when a unit positive electric charge is moved from one of the points to the other. Also referred to as electromotive force, EMF, the practical unit of both being the *volt.*

Electric displacement: A value of flux: take an uniform electric field of strength *E* in ["]free["] space—that is, a field in which the electric *flux* through unit area perpendicular to the field is *E*—and, when a *dielectric* is introduced into the field, the electric flux at any point in the medium becomes modified by the interaction of *E* and the atoms of the dielectric, yielding a new value *D,* the electric displacement.

Flux: The *flux* of a vector quantity through an area (electric intensity, magnetic intensity, etc.) is the product of [is determined by] the [nature of the] area and the component of the vector at right angles to the area.

Dielectric: Non-conductor of electricity, insulator—substance in which an electric field gives rise to no net flow of electric charge but only to displacement of charge.

"Edison effect:" Current made to flow in only one direction when passed through a vacuum.

Arc, electric: Highly luminous discharge accompanied by a temperature of over 3000 degrees C produced when a current flows across a gap between electrodes. Arcs form between two similar metallic surfaces, *e.g.* the common carbon arc between two carbon rods.

Ampere/Amp: Unit of electric current.

Absolute Ampere*:* 10^{-1} electromagnetic units of current. One international ampere = 0.99987 absolute amperes. (The former international ampere was defined as the unvarying current, which, when passed through a solution of silver nitrate, deposits silver at the rate or 0.00111800 grams per second.)

Electrostatic unit: A quantity placed one centimeter from an equal quantity in a vacuum repels it with a force of 1 dyne.

Coulomb: Unit of quantity of electricity; quantity of electricity transferred by one ampere in one second. *Absolute coulomb* = one absolute ampere in one second; 10^{-1} electromagnetic units; 3 x 10^{-9} electrostatic units.

Resistance: The electrical resistance of a conductor is the ratio of the potential difference between the ends of a conductor to the current flowing in the conductor. The practical unit of resistance is the ohm.

Ohm: Unit of electrical resistance. The *absolute ohm* is 10^{9} electromagnetic units of resistance—that resistance in which energy is dissipated at the rate of one watt by the flow of one absolute ampere of current. (The former international ohm [= .00048 absolute ohms] was defined as the resistance, at 0 degrees C of a column of mercury 106.3 cm. in length, of mass 14.4521 gm., and of uniform cross-sectional area.)

Georg Simon Ohm found that the quantity of transmitted current was inversely proportional to the length and directly proportional to the cross-sectional area of the transmitting wire. Ohm's Law: "The flow of current though a conductor is directly proportional to the potential difference between the ends of the conductor and inversely proportional to the resistance." The ratio is termed the resistance of the conductor. For a potential difference of *E* volts and A current of *I* amperes, the resistance, *R,* in ohms is equal to *E/I.*

Volt/V: Unit used to express the electrical *force* causing current flow (unit of electromotive force and potential difference). In direct current, one volt times one ampere equals one watt.

Absolute volt: 10^{8} electromagnetic units of potential—that potential difference which, applied across the ends of a conductor having a resistance of one absolute ohm, causes a current of one

absolute ampere to flow. (The former international volt was similarly defined in terms of the international ohm and international ampere, one international volt = 1.0035 absolute volts.)
Watt/W: Unit used to express electrical *power*; the rate of work done in *joules* per second (the energy expended per second by an unvarying electric current of one ampere flowing through a conductor the ends of which are maintained at a potential difference of one volt. Equivalent to 10^7 ergs per second.

The power in watts is given by the product of the current in amperes and the potential difference in volts, 1000 watts = one kilowatt; 746 watts = one horsepower.
Dyne: Absolute unit of force which, acting upon a mass of one gram, imparts to it an acceleration of one centimeter per second per second (one dyne against one gram of mass moves it one centimeter per second per second.)
Erg: Work done by a force of one dyne acting through a distance of one centimeter.
Joule: Work done in one second by a current of one amp flowing through a resistance of one ohm. One *joule* = 10^7 *ergs.*

THERMODYNAMICS and HEAT

Thermodynamics studies the movement of energy and how energy instills movement, involving statistical analyses of the collective effects on particles of temperature, pressure and volume, based upon thermodynamic laws concerning the exchange of energy between systems into heat or work.

James Prescott Joule culminated preceding scientific efforts with careful data to most accurately calculate the amount of 'work' that entered a system and the amount of heat realized: a particular quantity of work always produced a particular quantity of heat, which he termed "the mechanical equivalent of heat:" 41,800,000 ergs of work produced one calorie of heat.

The full Universal temperature scale ranges from absolute zero to an estimated hundreds of millions of degrees. Observable physical effects of change of thermal content (in addition to risings and fallings of temperature) are: change of state from solid to liquid (melting); solid to gas (sublimation); liquid to gas (evaporation and boiling); expansion; and evolution or absorption of a quantity of heat when an electric current flows across the junction of two different metals ("Peltier effect").
Heat: Kinetic energy possessed by virtue of molecular translation, rotation, and/or vibration, and transmitted by conduction (*see* Electricity), convection and/or radiation (*see* Radiation/Radiant Energy).
Thermal Energy: A counter-intuitive term, it loosely is used to describe energy related to heating effects. *Thermal* is defined as any spontaneous flow of energy (energy in transit) from one to another object caused by a difference in temperature between the two.

(Thermionics: Process of producing electron emission through the action of heat.)

SOUND

Sound 'waves,' caused by a vibrating source, are transmitted in a longitudinal 'pressure wave motion' (as opposed to transverse electromagnetic waves), through a material medium such as air. The vibration/displacement takes place in the direction of the propagation of the 'waves.' The velocity of sound is independent of pitch; it is a function of the temperature and nature of the propagating medium. In gases it is independent of the pressure. In air at 0 degrees C, sound travels 1120 feet/sec. (760 miles/hr.; .2111 mi./sec.; 000001135 the speed of light).

Two simultaneous different pitches produce periods of intensified sound separated by periods of silence. "Sonoluminescence," the generation of light by concentration of sound waves, is observable in interactions of water bubbles with the believed subatomic realm of quantum physics.

There is a legend older than that of the Moonstone. It tells of a great guru with perfect concentration, who, gazing at a candle's flame, saw the multitudes of its images converging through the intervening planes of the visual field.....

PERCEPTION[4]

Each creature's visual modality yields perception uniquely suited to its life. Human perception has been studied more than that of all other animals, yet understanding remains incomplete.

The "phenomenal model" theorized that subjective learning and experience were the dominant determinants of human perception, with little of a concrete world picture conveyed by eyes to brain--that vision largely was a "gestalt" product, a construct of psyche. Aspects of that model have not been abandoned altogether, but modern theory accepts that vision processes must involve one-on-one cellular stimulation--to distinguish, for example, an O from a C.

Reason does suggest that eye receptor cells register and convey images of an absolute reality, a one-on-one perception of components of the visual field. The problem is the seeming absence of a conveyor. That difficulty would vanish if the environment were a closed matrix (a view tenable under Einstein's original concepts[5]).

How might human perception, then, marry with an all-pervaded field, within which co-functioning physical laws yielded true visual effects? Such a theorized medium would need to be a matrix through which all types of electromagnetism work. The effective force of vision-producing energy is not concomitant with the speed at which light travels. Visible light reflections occur in only 1/1000th of the full electromagnetic spectrum yet manifest, nonetheless, within intense magnetic sub-fields—in other words, vastly relatively 'slower'.

The minuscule nature of the field, and the enormity with which its actual area is reduced to human visual modality, almost is beyond imagination. There appears to the eyes a rich saturation of detail and texture, while far beyond sighting in the visual field exists an equal

[4] The accompanying Glossary and Observations sections are integral parts of this brief text.
[5] Einstein did not conclude that a pervasive medium was non-existent--only that it would not be detectable, in that only *relative* motion was. A static medium of absolute motion *relatively* would be 'motionless' (obviating the necessity of a Michelson-Morley 'wind').

complex of forms and creatures, as electron microscope images witness. Lying on earth's surface, focus fixed on the light of the moon, the full sky image converges to a lens diameter scarcely larger than the dash in this sentence--30 times narrower than a single shining bulb seen amid a horizon of hills.

On the premise that a static medium exists, an all-encompassing model could incorporate the concept of *photons,* the theorized energetic quanta that give rise to all electromagnetic forces. Calculated as bearing neither mass nor charge, 'photon' reactions most recently have been observed as seeming to originate in the very processes/environment that yield their effects.

The suggested model would incorporate the following propositions:

1. The electromagnetic environment is constituted of point-on-point, multi-directionally-intersecting static planes within which all action occurs rectilinearly.

2. The electromagnetic environment conveys an exponential number of omnipresent images. The image of a distant mountain in a lake at one's feet is but one of its reflections; in the meadow beyond lie others unseen, upon the grass.

3. The visual modality is keyed to a particular range within the 'denser' medium.

4. Light does not "bend." Refraction redirects its lines rectilinearly at angles beneath instrumental perception in the electromagnetic medium.

5. Neither convergence nor accommodation is a matter of will; fixation is an automatic response to the medium. Only choice of object or area of view is subjective.[6]

6. The eyes automatically efferently accommodate to and precisely interpolate planes, each received array being a specific 'slice' of the visual field converging toward them.

7. The image accommodated and registered depends upon position of viewer, position of viewer's eye(s), and bearing light.

8. The refractive agents of the eyes redirect lines for requisite diminishment of images but do not effect inversion of them.

9. Binocular sight is not the result of the eyes intercepting identical images. Varying exact point-on-point interceptions of segments of the planed field had by each eye combine

[6] Only very minor subjective elements, such as squinting, are possible.

through decussation in the optic chiasma to convey via the post-chiasmal tracts the focused horopter against its background. Combinations focus to focus are determined by the accommodated angles of the axes of the pupils/lenses (plane fixated) and the relative positions of the eyes and head.

10. "Size constancy" is a concerted proportionally plane-by-plane diminuition of relative apparent size of objects over distance.

11. Given instruments fine enough, the number of converged conveyed planes of reflection from any horopter mathematically is calculable.

12. Rainbow phenomena are caused by 'telesprobing' transverse energetic action within the medium, when an object's direct intervention with the source of illumination causes deflection of diminishing bands of source strength to extend beyond the object to reflect toward the viewer.[7]

13. Color perception results from a combined holding between atomic surfaces presented[8] and light-borne pressure within the field; effects of incident quantities include full reflection (bright light off of chrome), entrance of an amount certain (heat), and total absorption.

Were it possible to perceive the spatial totality of that which contains all, obviously the view would be vastly different from that afforded to the human visual modality.[9] That does not change, however, conveyance of the reality it possesses.

Humankind's subjectivity to a fixed quarkian matrix of image conveyance is equal to the impossibility of Consciousness to exert its will over Perception. However, pitting both against Physics' fundamental laws invites a comprehension of refined clarity, as any scene is seen through the finest glass, polished.

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[7] The obvious example is a sky rainbow, when the intensity of the sun's rays is displaced transversely by the intervention of earth, and the concertedly diminished band strengths are reflected back. Other examples are, perception of spectral rings around the full moon, the result of intervening atmosphere, and spectral rings discernible around the shadow below of an airplane, seen from the window when the sun is overhead.

[8] Dictated by its internal composition.

[9] Given the small distance between the eyes, the co-operation granted them for widest possible binocular vision poses wonder whether a deeper universe view would be afforded by telescopes at wide distances functioning binocularly.

PERCEPTION GLOSSARY[10]

Notes:

For discussion purposes, occasionally the term, *redirected,* is supplied for "bent" as to light action, and the term, *frequency (*peak-to-peak) or *track*, for "wavelength" and "wave." A millimeter (mm) is equal to 0.0394 inch; a nanometer (nm), one-millionth of a millimeter.

* * *

"a, The"

Theorized all-pervading constituent of a universal quantum energy grid, the instantaneity of which does not admit isolation.

ABERRATION

Failure of a lens to produce an exact point-on-point correspondence with the object(s) desired to be focused. (For chromatic aberration, *see* Binary Optics.)

ABSORPTION

See Light.

ACCOMMODATION

Infinitesimal adjustments in lens shape in the normally functioning eye, to meet focus with *horopter* and cause a clear image at the retina. The chief agent in accommodation is the ring muscle, which, when it contracts, draws on *ciliary processes* to relax the *suspensory ligament* of the lens, allowing it to become more convex, while the pupil at the same time contracts. *See* Binocular Vision, Ciliary Processes, and Suspensory Ligament.

ADDUCTION

Drawing inward of the eyes.

AFFERENT

Inward direction, as of nerve stimuli.

AFTER-IMAGE

The eye's projection of a residual image impression of a concentratedly received, external stimulus. Different sizes of an after-image obtain if broadcasted to plane distances varying relative to the lens accommodation through which the original image registered.

When an image (such as of a bright globe) is 'burned' deeply into retinal cells, a certain period is required to restore the cells to normal, during which the image continues to be registered along the optic nerves. If the eyes then are turned upon a blank surface, a combined perception occurs in brain--the area of surface surrounding the projected after-image registers, but the part of the surface in the region of the after-image cannot.

ANTERIOR

Front side of a structure.

ASTIGMATISM

Failure of achievement of sharp focus on the retina due to imperfect degree of corneal refraction.

AXONS

Processes that conduct impulses; herein, the word "fiber" generally is used.

BINARY OPTICS

"[B]inary optical devices [are] fabricated by methods alien to those used for producing most lenses [and] work according to a somewhat different set of principles: they control light by diffraction rather than refraction. A conventional lens brings light to focus [because] rays...strike the surface of the glass at a more oblique angle and so are bent*[redirected*] more strongly than those passing through center. ...[A] device based on binary optics breaks up the wave*[track]* front of incoming light at each point on the lens surface and reconstitutes it [to travel] in the desired direction of focus. Most refractive optical systems...suffer from...inherent shortcomings such as spherical aberration...focus at different points along the optical axis, causing a blurred image. ...

[10]This glossary is for purposes of the within discussion and does not presume to be, nor can it substitute for a full text on the eye.

"The simplest binary optical structure is the prism, which appears under the microscope as a series of tiny staircases. When a light [track] falls on the prism's surface, the [track], in essence, is broken up into secondary...fronts. Each...front is delayed in proportion to the thickness of the staircase at that point (the maximum thickness is just enough to delay a...front by one full [track peak-to-peak] length). When these...fronts interfere, they produce a new...front at an angle to the incoming one. ... Instead of the few millimeters of glass required to [redirect] light in a conventional prism, however, the binary optical version requires as little as two microns of material. ... By choosing the steepness, and spacing, of the staircases properly, designers can eliminate spherical aberration completely. ...

"Conventional lenses focus blue light more strongly than red light; this phenomenon is known as chromatic aberration. Binary optical elements in contrast focus red light more strongly than blue. By combining conventional and binary optics into a single element it is possible to cancel the aberration over a modest range of wavelengths." Veldkamp, Wilfrid B. and McHugh, Thomas J., "Binary Optics," *Scientific American,* May 1992, pages 92ff.

BINOCULAR RIVALRY

A disruption of fusion caused by competing incoming images.

BINOCULAR VISION/BINOCULARITY

Vision in which the image conveyed to brain is by a combination of receptions of retinal cells of both eyes and nerve fibers that both *decussate* and do not *decussate*. (*See* Optic Nerves, Optic Tracts, Accommodation, and Convergence.) Although the potential range of the *double eye* is constant, its operation, despite both eyes being open, is not (such as a fully *monocular* registration when eyes are turned sharpest to one side).

It long has been taken that, in binocular vision, the eyes register identical images from the horopter that fuse in the occipital cortex after traveling optic pathways. However, inexplicable anomalies of vision deficiencies *vis-a-vis* damage to varying portions of the optic nervous system suggest a different model of image receipt and conveyance.

Hering dealt extensively with the inseparable compensations of ocular muscles. "[T]he mode of eye movement is not solely the result of a free will.... On the contrary, its important movements are predetermined by the inborn muscle system." Hering, Ewald, Bridgeman, Bruce, Transl., Bridgeman, Bruce and Stark, Lawrence, Editors, *The Theory of Binocular Vision,* NY and London: Plenum Press, 1977, page 152.

"[T]he position and range of binocular accommodation depth varies to the degree that it is determined by one or another head position with one or another position of the *fixation* plane." *Ibid*, page 193.

"[F]acts are indeed available to support the assumption of an inborn relationship between the focusing innervation and the innervation of the adductors." *Ibid,* page 195.

"Helmholtz has not made note of this entire area of facts, for he makes the assertion that accommodation associates itself with convergence only through learning. His proof for this opinion is restricted to mention of the fact that the relationship of both abilities can be somewhat reduced artificially. ...[T]his proves nothing because it also applies to many other reflexes which are doubtless inborn." *Ibid,* page 196.

BLIND SPOT

Blank area that occurs in the visual field under a specific combination of convergence and accommodation; taken (questioningly?) as corresponding to the *optic disk.*

CAMERA OSCURA

The projection in a dark box or dark room of an inverted image of a field caused to enter through a tiny hole.

CILIARY PROCESSES

The ciliary muscle processes are a circled frill behind the iris around the margin of the lens, anteriorly continuous with the circumference of the back of the iris, and connected posteriorly to the suspensory ligament of the lens. In near vision, the ciliary processes cause relaxation of the suspensory ligament—the lens becomes more convex, the pupil contracts. In distance vision, the ciliary processes cause tensing of the suspensory ligament—the lens flattens, the pupil expands. Evidence is convincing of a common pathway for the conjoined operation of accommodation, convergence and pupil constriction, through the oculomotor nerve with synapses at the ciliary ganglion. *See* Accommodation, Eye, and Suspensory Ligament.

COLOR VISION

The photoreceptor cones of the retina are taken as the processors of color perception, the various perceivable colors and their hues a result of the light frequency acting upon the cones. It is advanced that a specific number of cone types sensitive to different portions of the visible spectrum (which ranges approximately from 380 to 750 nm) act in varying concerts to yield particular colors and hues. A simple explanation of color perception, however, is yet to be had.

The Young-Helmholtz theory (based on producing various spectral hues by mixing of lights and adjusting relative frequencies) initially postulated three color-sensitive cones—red, green and blue (or violet; the "trichromatic" theory). Subsequently, more color-specific cones have been posited; but the range of affecting frequencies remains wide, and not all colors perceivable have been achieved in the different methods of study employed. (It has been estimated that the solar spectrum contains approximately 1,000 distinguishable hues and two million tints and shades.) Meanwhile, an "opponent process" theory suggests that, instead of combinations of individual cone responses, the visual system registers differences between cone responses.

Separate from, but parcel to color perception is that the property of color is not situated *per se* in a body, but is reflected according to the object's physical composition against light frequency (*i.e.* a red apple is red intrinsically, not essentially; a green leaf that appears black in dim light contains neither 'black' nor 'green', but intrinsically appears green when lighted).

CONSENSUAL RESPONSE

Involuntary reaction/response to stimulation.

CONVERGENCE

Conjoined *adduction* of the eyes that maintains alignment of the visual axes as focus is brought to nearer points ("medial rectus" muscles contract; "lateral rectus" muscles relax; the lines of the axes form a triangle toward the horopter). At near focus each eye is turned inward approximately 1.5 to 2 mm.

Moving the eyes in unison to the right, left, up and down is a matter of willing the respective muscles; convergence is not. Convergence--from which eyes normally do not divorce themselves--is a fixed operation automatically compensatory to accommodation/change in lens shape. The axes of the pupils never align with the axes of the sockets Convergence is married and automatically compensatory to accommodation. When focus is fixed on a near object, and contraction of the ring muscle adjusts the lens to that plane's necessary accommodation, a directly respective equal contraction of the internal rectus muscles effects convergence correspondent to the change in lens shape.

Unequal convergence inhibits binocular fusion. Hering described a girl who "could never accommodate for the distance of the fixated object if she saw binocularly, although the near point of her two eyes singly was only ten inches from her face. If she could make accommodation independent of convergence she would have been able to see everything sharply up to a foot." Hering, Ewald, Bridgeman, Bruce, Transl., Bridgeman, Bruce and Stark, Lawrence, Editors, *The Theory of Binocular Vision,* NY and London: Plenum Press, 1977, page 195.

See Binocular Vision and "Double, etc." Eye.

DECUSSATION

An intermingling of nerve fibers; *see* Optic Nerve and Optic Tracts.

DIRECTIONALITY

See Rod/Cone Interaction and Rod/Cone Directionality.

DIVERGENCE, OF THE EYES

Conjoined lessening of *convergence.* Provides alignment of visual axes as focus changes to farer distances.

DIVERGENCE, OF IMAGES

The divergence possible of images can be observed by broadcasting *after-images* to varying distances. Diverging images also must be omnipresent in nature but cannot be apprehended by the eyes, which only can process converged or direct rays.

DOUBLE (or 'Third') EYE

The binocular effecter of a composite image from received impulses conveyed to brain by varying combinations of nerve fibers of both eyes, determined by the relative positions of eyes, head and fixated horopter. *See* Binocular Vision/Binocularity.

DUPLICITY THEORY

Holds that cones work only at higher light intensities and give sharp, colored vision, while rods function in dim light and mediate colorless blurred vision. Cone to rod vision is believed not to be abrupt but to occur in transitional ranges of frequency intensities, during which rods and cones function together to different degrees. "The sensitivity of the dark-adapted eye is fairly close to the absolute limit set by the quantum properties of light. Near the absolute threshold, the actual retinal pattern of light stimulation is very coarse [in that] quanta acting upon the retina are few and far between, large numbers of receptors remaining entirely unstimulated by light." Pirenne in Davson, *ibid,* page 28.

EFFERENT

Outward direction, as of nerve stimuli.

Efferent fibers from cells in the nucleus of oculomotor nerve (III) run to the ciliary ganglion and enervate intrinsic muscles of the eye's iris sphincter. There is evidence that the final pathway for accommodation, convergence, and pupil constriction is a common one through nerve III with synapses at the ciliary ganglion.

ELECTROMAGNETIC SPECTRUM

See Light and 'Waves', Wavelengths'.

EYE, COMPOSITION

Structure *Dimensions*

Sclera:

Tough white covering of the eye which along with the cornea forms the eye's external protective covering.

Cornea: 11.5 mm diameter.

Transparent outer coat/'shell' over the eyeball; forms the anterior wall of the aqueous chamber; not of parallel thickness throughout; peripherally, outside of the *limbus,* it flattens; an agent of *refraction.*

A certain degree of *refraction* occurs through the cornea, which consists of four layers (briefly described): (1) outer, epithelial, polyhedral cells aligned in columns; (2) corneal substance proper, alternating right-angle lamellae interstitially connected into stellate spaces; (3) anterior elastic lamina which resembles the proper substance but is interwoven more closely; (4) posterior elastic lamina similar to the anterior lamina but a single layer of nuclear, polygonal, flat and perfectly transparent cells.

Limbus: 4.0 mm diameter.

Central area of the cornea.

Anterior chamber:

Region behind the cornea, to iris and pupil; contains acqueous humor.

Acqueous humor:

Clear, watery fluid (protein and water) within the anterior and posterior chambers; an agent of *refraction.*

Iris:

Colored membrane suspended immediately in front of the lens, its open circular center forming the pupil. It and the lens are oriented slightly downward and nasally with respect to the cornea.

The iris "rides high" over the lens. It responds to tiny involuntary circular and radiating muscular fibers. Circular/sphincter fibers surround the margin of the pupil. Radiating fibers converge from circumference toward center. (*See* Ciliary Processes.)

Pupil: 3-4.0 mm is given as an average diameter, but can vary 1 to 8 mm.

Aperture in iris center, around the lens. It, along with the iris and lens, is oriented slightly downward and nasally with respect to the cornea. The axes of the pupils never align with the eye sockets.

Posterior chamber:

Small spaces anterior to the lens and posterior to the iris; they contain acqueous humor.

Suspensory ligament:

Thickened hammock-shaped lower portion of the eye casing ("capsule of Tenon"); slung beneath the lens, attached to the sides of the lens equator and to the bones at sides of the eye. The ciliary processes cause it to effect changes in lens convexity.

Lens: 9-10.0 mm diameter at greatest accommodation.
3.0 mm at smallest accommodation.
4 mm thick.

Biconvex, avascular, colorless, crystalline and almost completely transparent in nature; suspended between acqueous and vitreous humors; an agent of *refraction*. Convexity changes through ciliary processes to accommodate the full range of focus, from near (greater convexity) to far (lesser convexity); but convexity always is greater on the backside in all states of focus. *Refer to* Refraction.

The upper border of the lens is inclined forward slightly and its equator is more distant from the corneal base on the temple side; *in toto* the lens is slightly tilted nasally, so the temporal half is wider.

The lens is composed of concentric layers of transparent, prism-like polygonal cells, the dentations of which fit into each other precisely in breadths of 1/5000th inch. (The cosmopliant lens' admission of images can be compared to the invisibility of the boundaries of anisole liquid and flint glass due to the affinity of their respective surfaces.)

Unlike a camera's fixedly ground angles of receipt, the human lens can accommodate an infinite number of accommodations through intricately balanced intraocular alliances via the third and fifth central nerves. The angles of incidence alter with each miniscule change of lens shape and its surface angles, married with the correspondent vergence. (*See* Ciliary Processes,)

The lenses of an average person over age 45 commence to lose pliancy, which results in loss of the acute accommodation necessary to receive clearly the planes of projection of the ink of the letters on this page, cognition registering fuzziness of diverging projections in-between. ("Moire" and similar illusions are examples of 'interference' with resolution between planes that works against focus. Items under development to compensate for loss of lens elasticity include lenses that automatically move forward within the eye, similar to a specie of fish, and lenses that bulge into the pupil, similar to diving water birds.)

Vitreous humor:

Transparent, colorless, gelatinous substance, that fills the area between lens and retina, which area constitutes two-thirds of the eye's body. Refraction occurs in the vitreous.

Retina:

The retinal surface extends a full area that reaches around the back of the eye to a point on each side (at the "ora serrata"), just short of a line parallel with the bottom edge of the lens. The central region, which includes the *macula,* is 5 to 6 mm in diameter.

The retina is composed of layers of cells, neuronal connections, and vascular system, from the external membrane of which the processes of the light-sensitive photoreceptive *cones* and *rods* "appear to thrust as if through a sieve." (*Gray's Anatomy,* page 1112.) Each retina has some estimated 7,000,000 cones and 120,000,000 rods.

Cones: 12-30 seconds diameter.

Retinal photoreceptor cells with an angular directional property--responsible for visual acuity and perception of color in lighted sight. The densest arrangement of cones is in the *fovea* (estimated at 147,000 per square millimeter), falling off very rapidly from there, to a 10-degree circle around the macula, to about an estimated 5,000 per square millimeter, and increasingly less to retinal ends at the ora serrata. *See* Color Vision, Rod/Cone Interaction, and Duplicity Theory.

Rods:

Retinal receptor cells predominantly are involved with peripheral vision and vision under decreased illumination. The rods rise from zero at the fovea to an estimated 160,000 per square millimeter at the 10-degree circle around the macula, from there diminishing to an estimated 30,000 per square millimeter at retinal peripheries (ranging six to 30 times more numerous outside the 10-degree circle). Opposed to cones, the angular directional effect appears absent (or very small for the range of retinal angles of incidence accessible through the pupil; *see* Rod-Cone Directionality and Rod-Cone Interaction.

Macula: 1.5 mm (seen as 0.2 mm) horizontal diameter; less, vertically
("Macula lutea.")

Avascular oval area at optic center, housing the *fovea,* where most discriminative vision is registered; somewhat horizontally oval in shape. It is situated about two *optic disk* diameters

temporally of and slightly below the optic disk. The macula contains the longest, finest cones, with several strata of ganglionic cells as opposed to a single layer elsewhere; the long cone fibers in the outer nuclear layer are arranged in apparent curved lines. Outward from the macular region multiple cones begin to connect to one cell.

Fovea: 0.4 mm diameter. (some reports say 0.5 mm diameter).
Situate about 4 mm lateral and 1 mm inferior to center of optic disk.
(Also termed "fovea centralis" and "foveola.")

Deep conical depression at center of macula, region of acutest vision; correspondent with the axis of the pupil and all consisting densely of the finest cones, each with its own bipolar cell/'private' line to the optic nerve. The cone fibers are almost horizontal in direction; outward from center the cones decrease gradually in number, with multiple ones connected to one cell. (The area immediately surrounding the fovea within the macula is termed the "parafovea.")

At night-illumination levels the fovea generally is 'blind' and peripheral rod vision operates,although to some degree images can be had 'out of the corner' of the eye, in extrafoveal regions. (*See* Duplicity Theory.)

Retinal nerve fibers, transmission by:

A greater number of retinal nerve fibers—some 53 percent—have been found to enter the optic disk on its temporal side, with some 47 percent entering the optic disk on the nasal side. The optic disk, opthalmoscopically visible, is situated 3 mm. nasally inward from the inner edge of the macula. *See* Optic Nerves and Optic Tracts.

Reflexes:

The three reactions in near vision are *convergence, accommodation,* and *constriction of the pupil;* in distance vision, *divergence, accommodation,* and *expansion of the pupil.*

Rhodopsin/"Visual Purple":

Rodopsin and other pigments detected in cones and rods display different absorption characteristics which it is believed account for their different behavior depending on the degree of luminosity.

In general also see Rod/Cone Directionality, Rod/Cone Interaction, and Duplicity Theory.

EYE, IMAGE CONVEYANCE

See Optic Nerves and Optic Chiasma.

FIELD DEFECTS

Defects in the registration of the visual field have been studied extensively, and some anomalies under the standard model have been observed in hemispherical brain studies, such as inexplicable retention of sight of visual field areas when the site of modality damage would dictate otherwise--in particular, those related to damages of the optic chiasma or optic tracts (different from loss of single eye vision from a cause anterior to the commissure). The following are but brief commentaries.

Although "the visual field defects caused by processes in the chiasmal area are typically bitemporal defects," in this 37-patient study of visual field defects related to optic chiasma disease, "[A]ttention [was] drawn to the frequent occurrence...of atypical, *i.e.* not obviously bitemporal, visual field defects.... In particular, the number of cases in which a central defect is present...is larger than [the researchers] had expected. ... In ten of the 27 patients with chromophobe adenoma, atypical defects were found (27%). It is remarkable that unilateral central defects were found in three cases. ...an atypical defect was found in five of the nine [meningioma] cases (55%)." Greve, E. L. and Raakman, M.A.C., "On Atypical Chiasmal Visual Field Defects," *Second International Visual Field Symposium, Tubingen, September 19-22, 1976,* Greve, E. L., Editor, Publishers the Hague, Dr. W. Junk, 1977, pages 315ff.

"Cases occur in which the field defects do not indicate the site of lesion clearly." Reed, M.B., M.S., etc., Howard and Drance, M.B., Ch.B., etc., Stephen M., "Chiasmal Lesions," *The Essentials of Perimetry Static and Kinetic, 2nd Edn.,* London, etc.: Oxford University Press, 1972, pages 124ff.

"If the tumour spreads sideways and damages the uncrossed chiasmal fibres, the eye on the side suffering the greater damage will show the greater contraction of the nasal field." Fisher, M.D., Norman F., "The Optic Chasm and the Corpus Callosum: Their Relationship to Binocular Vision in Humans," *Journal of Pediatric Opthalmology and Strabismus*, Vol. 23, No. 3, May/June 1986, pp. 136ff.

FIXATION PLANE

See Horopter.

FOCAL DISTANCE/LENGTH

The distance between the lens and the focal point.

FOCUS/FOCAL POINT

The point at which rays are converged after passing through a lens.

FUSION

Integration of visual impulses, taken in binocular vision as occurring in the cortical area.

FREQUENCY

See Light.

HEMIANOPSIA

Blindness of one-half the field of vision, of one or both eyes.

HOROPTER

"Horopter" commonly is found described as "a three-dimensional curve [?] of points in space from which light is brought to register on the retina."

HYPERSTEREOSCOPIC PHOTOGRAPHY

Images obtained with two cameras positioned at widths greater than that of the two eyes.

HYPEROPIA/HYPERMETROPIA/"FARSIGHTEDNESS"

Failure of an incoming image to reach focal point due to imperfect refraction/conveyance of light rays (too long a focal distance from cornea to retina).

INVERSION OR REVERSAL OF IMAGES

See Refraction.

LENS POWER, GENERALLY

A lens that brings rays one meter (focal distance) from it to a focal point has the power of one diopter.

LIGHT

Directed light energy creates a field of *electromagnetic radiation* around it that vibrates at right angles to its propagation (*transverse* 'waves'/frequencies). The vision-effecting light force is not the same as the speed at which light is known to travel, which is slowed by certain substances (*e.g.* atmosphere, water, glass, diamond). Vision production occurs in only 1/1000th of the total electromagnetic spectrum.

Christian Huygens in the late 1600s proposed that light acted like a 'wave' instead of a steady stream, backed up by Thomas Young's 1807 demonstration that light passing through a slit could spread out and interfere with light passing through another opening, seeming to spread like a wave with beams radiating outward as well as directly. Einstein advanced the theory in 1905 *vis-a-vis* the *photoelectric* effect (in which ultraviolet light causes *electrons* to be emitted from the struck surface) and concluded that light was made up of a stream of energy packets called *photons.* Light's seeming manifestation as either 'particles' or 'waves' (*refer to* Physics Glossary) suggests more complexity than reflected by explanatory models.

Response to radiation depends on the striking frequency and the surface and composition of the substance struck: it can be *absorbed* (cause heat), be *reflected* in different modes, *refracted* to different degrees (and possibly in combinations of those), or be *transmitted.* Materials possess different degrees of transparency to different frequencies; whereas ordinary glass transmits gamma and x-rays, it does not, lower frequency ultraviolet and infrared light.

Rene Descartes concluded that light is "nothing else but a certain movement or an action, received [via] a very subtle material that fills the pores of other bodies.... ...[T]he action of this subtle material can be much more impeded by particles of air...than by those of water...and still more by water than by those of glass, or of crystal. So that, the harder and firmer are the small particles of a transparent body, the more easily do they allow the light to pass; for this light does not have to drive any of them out of their places." Page 82.

See 'Waves', Wavelengths' (terms commonly employed for light vibrations/oscillations.)

MONOCULAR VISION/MONOCULARITY

Registration and conveyance of images by only one eye.

MOSAIC

A term sometimes used for the composite retinal cells' image receipt at a given instant.

MYOPIA/"NEARSIGHTEDNESS"

Incoming image attains a focal point before reaching the retina due to the eye's imperfect refraction/conveyance of light rays (too short a focal length from cornea to retina). Aging progression of myopia has been attributed to vitreous chamber elongation.

OPTIC DISK 1.55 mm average diameter.

Ophthalmoscopically visible surface of the optic nerve in each eye, where meet all the ganglion cell axons and enter the optic nerve; situated about two of its diameters nasally of and slightly above the macula; a pale, well-defined round (or slightly vertical oval) that is the brightest part visible in the normal retina seen under examination; a white central depression (cup) occupies approximately one-third of its diameter. *See* Optic Nerves.

OPTIC CHIASMA (Commissure)

Some 12 by 8 mm; a junction in the cranium, where portions of the fibers received by each eye's optic disk *decussate.* before intermingling of fibers in, and continuing via the opposite side's optic tract, to the occipital cortex. The chiasma is a relatively small structure, some 12 by 8 mm.

Results of injuries to the occipital cortex pose some anomalies in the standard model (*see* Field Defects) relating to the portions of the visual field assumed received and conveyed by decussating fibers (with some wondering whether fibers that do not decussate in the commissure may, in the "corpora quadrigemina"). *Binocular rivalry* is another unexplained phenomenon.

(Decussation of temporal fibers is lesser in creatures with 'side' eyes, such as rabbits.)

OPTIC NERVES

Optic nerves arise at the center region at back of the brain--the "area striata"/"visual projection area." Following the path of received images, the impulses registered by retinal cells are fed i forward from the area striata re to image receipt, a trunk of optic nerves (*optic tract)* travels the brain on each side. Passing through a relay station ("geniculate body") the tracts loop inward , through the passing through a relay station ("geniculate body"). Each tract contains a certain number of nerve fibers that have undergone decussation in the optic chiasma, from which the trunks diverge and continue on each side to the *optic disks,* where nerve fiber transmission of image originates.

he majority of optic nerve fibers are retinal afferent; some, efferent from brain; and some small fibers are afferent for the ciliary and iris sphincter muscle fibers.

OPTIC TRACTS

The trunks of optic nerves beyond the optic chiasma, which carry fibers both directly from the optic disk of the eye on the respective side and decussations from the opposite side.

PANORAMIC VISION

The wider visual field of specific prey animals that have eyes situated at the sides of their heads. (The wide-set panoramic eyes of cuttlefish also rotate by special musculature, to give it deadly binocular aim.)

PARALLAX

The apparent difference of direction of a distant celestial object as seen from two different points.

PERCEPT

An impression of an object obtained by use of the senses.

PERCEPTIBLE/PERCEPTIBILITY

Capable of being perceived.

PERCEPTION

Result of perceiving; registration of observation; awareness of environmental element(s) through physical sensation.

PERCEPTION, PHENOMENAL MODEL OF

Theorizes that there are as many perceptions of the world as there are perceivers--that perception essentially is a construction that takes place in the brain through nervous system assimilations, learning, and psychological influences. Proposed substantiations for this model have included the ability to artificially stimulate perceptions, and perception variations between individuals.

PERCEPTION, STRUCTURAL/STRUCTURALIST MODEL OF

Theorizes that vision reception is caused by elemental sensations on a 'one to one' basis; that qualitative differences are determined by specific receptors in the visual modality (objects are seen directly) and that, with painstaking observation and analytical introspection, the elementary components of the process can be isolated.

PERCEPTION, OF "THIRD DIMENSION"

Analytic attempts to deal with perception of three dimensions based on a two-dimensional retinal plane date to the 17th century Bishop Berkeley, it subsequently being suggested that distance perception required "non-visual" elements—that perception of 'space' involved learning (*e.g. size constancy* as a matter of judgment).

PERCEPTUAL

Of, relating to, or involving sensory stimulus (as used herein, opposed to abstractive grasping of an idea, etc.).

PERIPHERAL VISION

Non-focused reception of visual field portions outside the area of focus.

PHOTOPIC SIGHT

Lighted vision effected via retinal cones.

PHOTORECEPTOR CELLS

See Eye, Cones and Rods.

POSTERIOR

Back side of a structure.

PRESBYOPIA/"OLD SIGHT"

Blurred near vision, common to aging, caused by loss of lens pliancy/accommodation.

PROPRIOCEPTION

Of, relating to, or stimulation arising within the organism.

PROPRIOCEPTIVE

Beneath the threshold of consciousness; subconscious; reflexive.

RANDOM-DOT STEREOGRAM ILLUSION

A sudden appearance of an image or shape above the plane of the paper when one continues to gaze on the illustration.

REFLECTION

Essentially defined by the "Law of Reflectance" as the repulsion light frequency equal to that with which it strikes a non-absorbent surface, that angle of reflection being equal to the angle of strike.

REFRACTION

Redirection of light rays as they pass from one to another density, as through one eye component into, through and from another. Reckoning the complicated operation of refraction is founded upon the optical theses of *Rene Descartes*, from which the following quotes are salient:

"...[W]hen its [light's] rays pass obliquely from one transparent body to another which receives them more or less easily than the first, they are deflected [redirected] in such a manner that they are always less inclined to the surface of these bodies on the side of the one that receives them most easily than on the side of the other, and this exactly in proportion to the ease with which the one rather than the other receives them." Page 80.

"...[T]he surfaces of transparent bodies which are [appear] curved deflect [redirect] the rays passing through each of their points in the same way as would the flat surfaces that we can imagine touching those bodies at the same points." Page 83.

"...[E]xperiment shows that the one [transparent medium of the eye] we call the crystalline humor [lens] causes almost the same refraction as glass or crystal, and that the other two [the acqueous and vitreous] cause slightly less, about the same as ordinary water, so that the rays of light pass more readily through the [lens] than through the two others, and yet more easily through these two than through the air." Page 84.

"[T]he objects we look at do imprint very perfect images on the back of our eyes." "...its parts are reversed, i.e., in a position quite the opposite to that of the objects." Pages 91, 97.

"The retina is normally transparent, and some of the incident light is reflected at the vitreoretinal interface [of vitreous and retina]. ... On examination with the direct ophthalmoscope,

the concave foveal surface produces a clearly visible inverted image of the [examination] lamp." Vaughan and Asbury, page 116.

(Commonly, the Law of Refraction is defined as, the angle at which light exits passage through a refractive object is the same as was the angle of its entry to the perpendicular of the object.)

(Laser alteration has been employed in attempting to correct refractive index of the cornea.)

RETINOTOPIC PRINCIPLE

Point-on-point nerve fibers have a specific and stable arrangement from retina through visual pathways. (Walsh, M.D., F. F. C. S., Frank, B. (Ed.), and Hoyt, M.D., A.B., Fletcher, Wm., Clinical Opthalmology, Vol. 1, 3rd Ed., Baltimore, MD:The Williams & Wilkins Co., 1969.)

ROD/CONE DIRECTIONALITY

"[D]irectional sensitivity of the retina [discovered in 1933 by Stiles and Crawford]...is essentially a property of the cones. For the rods the directional effect as a rule is absent or very small for the range of retinal angles of incidence accessible through the pupil." Pirenne, M. H., as quoted in Davson, Hugh, Ed., *The Eye,* Volume 2, The Visual Process, NY and London:Academic Press, 1962, page 31.

"Experiments on the *parafovea*...showed that while the parafoveal cones also have a strong directional sensitivity, the rods contained in the same area are almost non-directional. The operative factor therefore must be the *angle* at which the light beam strikes the cones. For a human pupil 8 mm. in diameter the greatest value of this angle for peripheral entry differs by about 11 degrees from the angle for central entry." Pirenne in Davson, *Ibid,* page 33.

"[T]he image of the field is always formed on the same part of the retina and the stimulus is always received by the same rods and cones. The changes observed are caused merely by changing the angle at which the light beam from the field strikes a given, fixed, region of the retina.... The explanation is that, for all positions of entry, the rods are stimulated to the same extent, since they are almost non-directional. But the cones contained in the retinal area receiving the field image are less strongly stimulated for peripheral than for central entry. Thus when peripheral entry is used, provided the field luminance has been properly adjusted, the cones are not stimulated at all, or at any rate their stimulation is insufficient to give rise to a sensation of colour. ... The Stiles-Crawford effect...shows the similarity between both foveal and peripheral cones, which are directional, as against the rods, which are almost non-directional." *Ibid,* page 34.

ROD/CONE INTERACTION

Until late 1960's it generally was assumed that there was no interaction between cone and rod signals and that rod-cone interaction entirely was a property of monocular, not binocular pathways.

"At issue is whether rod-cone interactions are properties of monocular or binocular visual pathways. ... Backgrounds always were presented to the left eye. Test stimuli were presented either to the left eye (monocular conditions) or the right eye (dichoptic conditions). ... Results imply that the rod-cone interaction that has been studied monocularly with overlapping backgrounds is a property of monocular but not binocular pathways. ... ...[D]efinitive identification of the locus or loci of rod-cone interactions in humans awaits further investigation." Buck, Steven L. and Pulos, Elizabeth, "Rod-Cone Interaction in Monocular but Not Binocular Pathways," Research Note, *Vision Research,* Vol. 27, No. 3, pages 479-482, 1987, UK:Pergamon Journals, Ltd.

Another study provided evidence that rod signals occur in pathways used by cones, but it is impossible to distinguish the pathways between the many ganglion cells that receive input from both rods and cones. Results, however, were consistent with "an alternate arrangement whereby some ganglion cells with small receptive fields receive inputs only from cones, while others, with larger receptive fields, receive inputs from both rods and cones." D'Zmura, M. and Lennie, P., "Shared Pathways for Rod and Cone Vision," *Vision Research,* Vol. 26, No. 8, 196, pages 1279-80.

Further, "The classic duplicity theory of the retina, that rods and cones behave independently, has been challenged by recent studies.... ... Recently there are a growing number of findings which indicate that synaptic organization in the retina varies according to the

adaptive state." Sugita, Yoichi and Kyoji, "Rods Also Participate in Human Color Vision," *Tohoku J. exp. Med., 1988, Jan. 154(1),* pages 57-62.

"Although the structure of rod and cone processes [can be] described in most extensive detail, it is not yet possible to equate their remarkable features with functional studies with any degree of confidence. Their stacked disks [ultra-structured segments] have been likened to photomultiplier[s]...intensifying the electrical energy derived from photochemical processes, but this merely is an attractive analogy." *Gray's Anatomy,* page 1113.

SACCADES

Smooth shiftings in point of gaze, such as following text across a page.

SCATTERING

Reflections of light in multiple directions from a rough surface. (The sky's blue color is ascribed to Earth's in-effect 'rough' atmosphere's scattering of higher-intensity light.)

SCOTOMA

A blind or partially blind area in the visual field.

SCOTOPIC SIGHT

Dark-adapted dim-lighted vision mediated by retinal rods.

SIZE CONSTANCY

The fact that, while objects at farer distances appear diminished in size, they are not conceived as 'shrinking' in nature. (*See* Perception, of "Third Dimension.")

SPECTRUM

The result obtained when an electromagnetic radiation is resolved into its constituent frequencies, *e.g.* the colored bands produced when light is passed through a prism or diffraction grating. (Plain light radiation passed through a semitransparent medium produces an *absorption spectrum*--certain bands/frequencies being absorbed by the medium; spectra formed by bodies releasing radiation are termed *emission spectra;* and only certain color lines appear in a *line spectrum.*)

VERSION

Voluntary movement of the eyes in conjugate gaze. *Dextroversion*=movement to right; *levoversion*=movement to left; *supraversion*=up or down; *destrocycloversion*= torsional (wheel-like motion)—*dextrocycloversion*=to the right clockwise; *levocycloversion*=to the left counterclockwise.

VISUAL MODALITY

The operative structure and functioning components of vision.

'WAVES', WAVELENGTHS'

These terms imply a curve to the behavior of electromagnetism's frequencies/tracks, which extend from one billionth of a meter (as in gamma rays) to meters (as in radio transmission), sight-causing frequencies ranging between 400 to 700 billionths of a meter. An 'angular' concept of electromagnetic action of frequency intensities correspondent to straight-line, 'peak-to-peak' lengths is not contradictory to current measuring of 'wave' vibration length (also as 'peak-to-peak' or 'trough-to-trough')--that is, the distance occupied by one complete vibration/impulse.

ZONULE

Collection of numerous fine tissue strands stretching from the ciliary processes to the lens equator, holding the lens in place.

OBSERVATIONS, PERCEPTION

Detaching awareness from focus is necessary to certain observations.

Observation 1

Marriage of vergeance and lens accommodation simply is observable.

Hold a pencil (or finger) several inches *directly before the center* of one eye and keep the other closed, change monocular focus from the pencil to the opposite side, and note how the closed eye automatically moves also in the correspondent direction.

Observation 2

Accommodation and convergence are determined by the balance of light force exerting between the eyes and the plane of focus.

Try not permitting focus to attach to an unchosen plane such as a wall opposite upon awakening or interposed face of an awakener, and try to force focus on a surface like highly polished chrome being struck by strong sunlight.

Observation 3

Full utilization of binocularity with both eyes open is not constant in that at different times the visual field is conveyed in various combinations of binocular and monocular receipts or fully monocularly, depending on the relative positions of head and eyes.

Observing the limit of binocularity. Turn open eyes as far as possible to one side and note where focus comes to reside fully monocularly in the eye on that side despite both eyes being open.

Observations 4

Projecting images exist to be captured at every plane and from every angle of the field. The image registered by the eyes is a direct yield of the focused plane and its dictated accommodation.

A. At a distance six to 10 feet from a vertical object (lamp pole, narrow tree trunk) hold up two pencils (or fingers) one beyond the other. Keep the near one within a foot of the face, the other at comfortable arm distance slightly higher than the first, and note that:

a) the three objects cannot be lined up binocularly--binocular focus on one results in a double image of the other two;

b) the double images shift as binocular focus changes from one object to another, as follows:

While focused on the far object/horopter, as either eye closes the extra images of near and middle objects both disappear *on the side opposite the closed eye*.

With binocular focus on the near object/horopter, as either eye closes the extra images of the middle object and distanced object both disappear *on the side of the closed eye*.

However, while focused on the middle object/horopter, with right eye closed the *near left* and *distanced right* extra images disappear (and vice-versa naturally with left eye closed.)[11] This is demonstrated further in B.

B. Have available a tall stick (a broom handle will do) and arrange on the wall three brightly colored sheets: (a) two 6-inch squares of the same color separated by 34 inches, 60 inches above the floor; (b) one 12-inch by 8-inch rectangle of a different color centered between the others 50 inches above the floor.[12]

Sit on a chair the back of which is 12 to 13 feet away from the wall. Stand the stick before you approximately 12 inches from the face. Focus binocularly on the stick and adjust it until double images of the rectangle appear on each side of the stick and double images of the squares appear above each rectangle. Note how, with right eye closed, the right rectangle and left square images disappear and vice-versa when the left eye is closed.

Observations 5

A binocular sight registered by brain is not a fusion of identical images one from each eye but combined from each eye's interceptions of different planes and segments of the visual field to effect the widest binocularity affordable of it. The portion of horopter-forward from right is received by the left eye (and vice-versa) and the portion beyond the horopter is received by the eye directly on its side.

[11] Differing degrees of separation between double images are observable with varying objects (*e.g.* telephone and flag poles) and distances (try it with the moon as the far object).
[12] The height of the wall objects might need to be adjusted concomitant with the heights of stick and viewer.

Keep head in reading position above the page and close one eye. Turn the open eye sharply to the side of the closed eye and note the fuzzy image on the side of the closed eye (caused by brow and nose). With both eyes open and slightly adducted, note there appears an outline on each side of view. The space between narrows and widens as eyes alternate with adduction and focus, and the text beneath horizontally overlaps when the eyes do adduct. Slowly returning focus to the page, it *appears as if* one reads 'between one's nose.' [13]

Observations 6

Nature devised human eyes to normally obtain a complete view. The seeming uniocular apprehension of a 'blind spot' correspondent with the optic disk of each eye results from the incident rays of the unseen object not received as normally they would be by the closed eye.

A. Hold a pencil *directly before the center of* the left eye at a point from the face that obtains a double image of the pencil while eyes are focused directly forward beyond it. Slowly bring the pencil toward the face without turning head or eyes and note that the left member of the double image disappears, its reflection bypassing receipt by the right eye. (Vice-versa, of course.)

B. Obtain the clearest image of this print through a magnifying glass with your head directly over the portion magnified, and note the narrowed oval area between overlapped rims within which binocular focus covers an approximate dozen characters. Additional characters similarly magnified are noticeable peripherally in the remaining rim areas to the sides of the oval but binocularly are readable only if the glass is moved to bring the oval of focus over them. Slowly bring the glass toward the face and note how the oval narrows, and when moved toward the page widens until it disappears. [14] Lastly, while binocularly focusing the print clearly within the oval, close one eye, shift the other to the side, and note the content of the then *monocularly* registered image.

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[13] To elaborate, if each of two pairs of coins one larger than the other (*e.g.* quarters and dimes) are arranged overlapped to form a center oval (as if to depict, respectively, distance flatter-lens and near convex-lens views), while the ovals do represent the double-eye visual cortex view, they do not, where component rays are received in each eye. (Was the Mayan practice of flattening brow and bridge of nose of infants connected with achieving a wider than natural binocular field?)

[14] A related observation is had through eyeglasses: With eyes centrally focused over the page, note the elongated ellipse formed by the outer rims, adduct the eyes, and note the overlapped center portions of the lenses.

Observations 7.

Refractions through the eye's agents do not cause images to cross and invert but redirectly reduces them in projection.[15] *Perception of an inverted image on the retina is a reversed reflection off of its concave surface, although naturally-unperceived "reversed"-inverse images*[16] *are ubiquitous in nature.*

A. Hold a magnifying glass at a distance certain from a shelf of assorted objects until seen through the glass is a naturally-refracted-and-conveyed reversed-inverted image not naturally receivable by eyes but captured where it exists relative to the glass.

B. Similarly, onto a white sheet of paper, held up behind a magnifying glass while standing with back to a well-lighted window, bring a reversed-inverted image of the scene beyond the window.

Observation 8.

The apparent proportionally relative diminuition or enlargement of image components with changes of horopter distances ("size constancy") is in mathematical concert with the distance to the horopter.

A. On a mirror approximately 15 inches away from your eyes, place marks on the top of forehead and tip of chin of your reflected image. Measure and compare the actual lengths of your actual face and the reflected one.[17]

B. Is rough calculation possible of the ratio of distance-to-image diminishment?[18]

Cut four cardboard spheres of diameters 3, 6, 9 and 12 inches.[19] Lay a length of masking tape 100 inches from a bare wall and mark it off in cumulative inches from the wall. Have available a 15-inch stick and another stick long enough to reach three inches below eye level when stood upright on the floor. Affix the 3-inch sphere, the "sighter," to the top of the long stick.

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[15] The ground surface angles of corrective lenses capture and convey to the eye the needed adjustment in refraction.
[16] Not merely inverted head-to-toe.
[17] *e.g.* a face 7 actual inches yields a 3-1/2 inch reflection.
[18] *Rough* it only can be, given the inordinate fineness of light's active dimension; perhaps lasers offer a surer method.
[19] The areas (pi x radius^2) of these circles are, respectively, 7.0685775, 28.27431, 63.6171975, and 113.09724.

Pin one of the larger spheres on the wall above where the measure begins and position the sighter upright on the floor tape. Adjust your position until, monocularly, the sighter at 15 inches from the eye (judged with the short stick) covers precisely the sphere on the wall. Note the inches of distance from the wall at which the sighter stick stands. Subtract the sighter area from the area of the sphere it has covered and divide the remainder by inches distance.

Repeat with the other two larger spheres.

Does a correlation of factors emerge?

Bibliography and Sources[20]

Asimov, Isaac, *Biolographical Encyclopedia of Science and Technology,* New York: Avon Books, 1976 (used extensively).
Beard, M.D., Crowell, Quickert, M.D., Marvin, *Anatomy of the Orbit (A Dissection Manual),* Birmingham: Aesculapius Publishing Co., 1969.
Berger, Melvin, *Lights, Lenses and Lasers,* New York: G. P. Putnam's Sons, 1987.
Bergmann, Peter G., *The Riddle of Gravitation,* New York: Chas. Scribner's Sons, 1987.
Calder, Nigel, *Einstein's Universe,* New York/Harmondsworth, Middlesex, U.K.: Penguin Books, 1979.
Buck, Steven L., Pulos, Elizabeth, "Rod-Cone Interaction in Monocular but Not Binocular Pathways," *Vision Research, Vol. 27, No. 3,* England: Pergamon Journals, Ltd., pp. 479ff.
Chester, Michael, *Particles, An Introduction to Physics,* New York/Scarborough, Ontario: New American Library, 1980.
Coleman, James A., *Relativity for the Layman,* New York: William-Frederick Press; Harmondsworth, Middlesex, U.K., etc.: Penquin Books, 1954 (used extensively).
Davson, Hugh, Ed., *The Eye, Volume 2, The Visual Process,* New York/London: Academic Press 1962 (used extensively).
DeWitt, Bryce S., "Quantum Gravity," *Scientific American,* Vol. 249, No. 6, December 1983.
Fisher, M.D., Norman F., "The Optic Chiasm and the Corpus Callosum: Their Relationship to Binocular Vision in Humans," *Journal of Pediatric Opthalmology and Strabismus, Vol. 23, No. 3,* May/June 1986, pp. 136ff.
D'Zmura, M., Lennie, P., "Shared Pathways for Rod and Cone Vision," *Vision Research, Vol. 26, No. 8,* pp. 1279ff.
Einstein, Albert, *Ideas and Opinions,* New York, NY: Crown Publishers/Bonanza Books, 1954 (used extensively).
Warwick, B.Sc., Ph.D., M.D., Roger and Williams, D.Sc., M.A., M.B., B.Chir., Peter L., Eds., *Gray's Anatomy,35th British Edition,* England: Longman Group Ltd. 1975 (used extensively).
Gregory, R. L., *Eye and Brain,* New York/Toronto: World University Library, 1973.
Greve, E. L., Raakman, M. A. C., "On Atypical Chiasmal Visual Field Defects," *Second International Visual Field Symposium,* Tubingen, September 19-22, 1976, Greve, E. L. Ed., Publishers the Hague, Dr. W. Junk, 1977, pp. 315ff.
Hering, Ewald, *The Theory of Binocular Vision,* transl. Bridgeman, Bruce; Bridgeman, Bruce and Stark, Lawrence, Eds., New York/London: Plenum Press, 1977.
Kestenbaum, M.D., Alfred, *Applied Anatomy of the Eye,* New York: Grune & Stratton, 1963.
Lapp, Ralph E., et al., *Matter,* New York: Time Life, 1965.
Lavoisier, Fourier, Faraday, Hutchins, Robert Maynard, Ed., Chicago/London/Toronto: Encyclopedia Brittanica, Inc., Wm. Benton, Publisher, 1952 (used extensively).
Morgan, Alfred, *First Book of Radio and Electronics,* New York: Scribner's Sons, 1977.
Morrone, M. Concetta, Ross, John and Burr, David C., "Apparent Position of Visual Targets during Real and Simulated Saccadic Eye Movements," *Society for Neuroscience*, Vol. 17, No. 20, October 15, 1997, pp. 7941-7953.
Newton's Philosophy of Nature, Selections From His Writings, Thayer, H. S., Ed., New York/London: Hafner Publishing Co., 1953.
Olscamp, Paul J., Transl., *Discourse on Method, Optics, Geometry and Meteorology, Rene Descartes,* Indianapolis:The Bobbs-Merrill Co., Inc., Library of Liberal Arts, 1976 (used extensively).
Reed, M.B., MS., etc. Howard and Drance, M.D., Ch.B. etc., Stephen, M., "Chiasmal Lesions," *The Essentials of Perimetry Static and Kinetic, 2nd Edn.,* London, etc.: Oxford University Press, 1972, pp. 124ff.
Sugita, Yoichi and Kyoji, "Rods Also Participate in Human Color Vision," *Tohoku J. exp. Med.,* 1988, Jan. 154(1), pp. 57ff.
Uvarov, E. B., *A Dictionary of Science* (revised with assistance of Chapman, D. R.), Baltimore/ Harmondsworth, Middlesex, U.K.: Penguin Books, 1962 (used extensively).
Vaughn, D. and Asbury, T., *General Opthalmology,* Los Altos, CA: Lange Medical Publications, 1977 (used extensively).
Veldkamp, Wilfrid B., McHugh, Thomas J., "Binary Optics," *Scientific American,* May 1992, pp. 92ff.
Visser, Matt, *Modern Physics Letters A;* "Sakharov's Induced Gravity: A Modern Perspective," arXiv:gr-qc/0204062, received 4/15/2002.
Weather and Climate, Dempsey, Michael W., Ed., England: B.P.C. Publishing Ltd., 1971.
Webster's Seventh New Collegiate Dictionary, Springfield, MA: G. & C. Merriam Co., 1967.

http://www.en.wikipedia.org (Quantum Electrodynamics 2008)
http://astro.berkeley.edu.
http://www.colorado.edu/physics/2000
http://imagine.gsfc.nasa.gov/docs

Miscellaneous news reports and journal articles available in the compiler's library.

[20] Additional non-quoted sources are not included. Extensive use of certain sources for the within definitions is noted.