

## What is Light and What is Life?



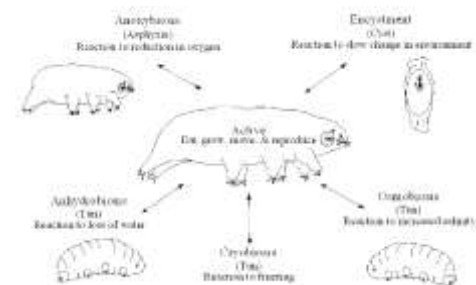
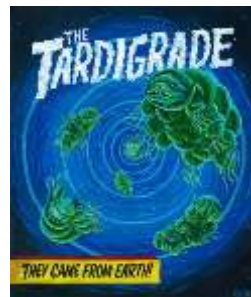
**Science** is a way of looking at the world around us in order to make sense of who we are, where we came from, and to help us understand and plan where we are going. **Erwin Schrödinger** stated that the value of natural science “*is the command of the Delphic deity...get to know yourself.*” The science of biology is an analysis of the question, **what is life?** The science of physics is to a large extent an analysis of the question, **what is light?** We will look at these two questions to see the value as well as the limitations of science in understanding the world around us and our place in that world.



**Life** can be **operationally defined** by a biologist as 1) the ability to **assimilate** matter and energy from the environment; 2) the ability to **transform** the environmental input into **usable energy** and **molecules**; 3) the ability to **expel toxic waste**; 4) the **ability to move**; 5) the **ability to sense and respond** appropriately to the environment, and 6) the ability to **reproduce hereditary** information with only **near perfect fidelity** so that species are able to **evolve** gradually by **natural selection** or in jumps by other mechanisms.

An operational definition is a suite of measurable quantities associated with a meaningful phenomenon, such as life, that cannot itself be directly measured *in toto*. The operational definition of life is **valuable** in that it is **general** and applies to almost any living creature and excludes most nonliving objects. It is also **valuable** in that it **reduces** the complexity of life into six essential processes—each of which can be studied based on the **assumption of materialism** and quantified using the laws of **physics** and **chemistry**.

However, there are **limits** as well as **value** to any operational scientific definition. If we do not see the limits of the current definition, we may conclude that an extremophile such as a **tardigrade** is not alive when it is in the midst of an extremely long period of dormancy during which it does not eat, does not grow, does not expel toxins, does not respond to the environment, and does not reproduce or evolve. There are intellectuals who I know that are so concerned with **accurately defining life** that they are not sure if they themselves are alive or not! When we sit with them for dinner, my wife wonders “*as long as they do not believe they are alive, why she can’t have their dessert!*”



If something is not fundamentally real, it cannot be fundamentally meaningful. Norman Robert Campbell (1920), a physicist who was interested in the truth and meaning of science, reminds us in *The Philosophy of Theory and Experiment (Physics: The Elements)* that “*The meaning of a proposition—a phrase which I have often used without explaining it—is simply the set of thoughts which it calls to mind; the meaning of two propositions is different if they call up different thoughts. Now it is meaning in this sense which alone is important to science, and since it will be readily admitted that meaning in this sense has little*



*or nothing to do with logical form, such form is of very little importance for science.”*

Dismissing the reality of life because we cannot form a perfect and infallible mathematized or logical definition of life is acknowledging **the importance of the measureable over the meaningful** and an inability to recognize that we never have **complete information**, whether theoretical or observational, before we have to make a decision. In my opinion, dismissing the reality of life is truly **missing the big picture, not seeing the forest for the trees and throwing out the baby with the bathwater**. Ferris Jabr (<http://ferrisjabr.com/Welcome.html>), a science writer for *Scientific American* and *The New York Times*, two reputable outlets, captured the intellectual view:

[The Opinion Pages](#) | Op-Ed Contributor

**SCIENTIFIC  
AMERICAN™**

**Why Nothing Is Truly Alive**

**Why Life Does Not Really Exist**

*“Recently, however, I had an epiphany that has forced me to rethink why I love living things so much and reexamine what life is, really. For as long as people have studied life they have struggled to define it. **Even today, scientists have no satisfactory or universally accepted definition of life.** While pondering this problem, I remembered my brother’s devotion to K’Nex roller coasters and my curiosity about the family cat. Why do we think of the former as inanimate and the latter as alive? In the end, aren’t they both machines? Granted, a cat is an incredibly complex machine capable of amazing behaviors that a K’Nex set could probably never mimic. **But on the most fundamental level, what is the difference between an inanimate machine and a living one? Do people, cats, plants and other creatures belong in one category and K’Nex, computers, stars and rocks in***

*another? My conclusion: No. In fact, I decided, life does not actually exist.”*

<http://blogs.scientificamerican.com/brainwaves/2013/12/02/why-life-does-not-really-exist/>

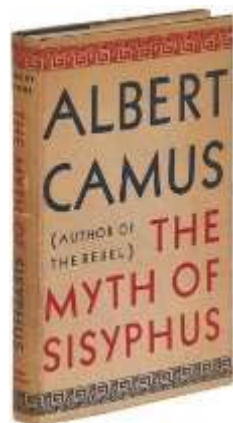
Likewise, in a *New York Times* article, Zabr concludes “*Why is it so difficult for scientists to cleanly separate the living and nonliving and make a final decision about ambiguously animate viruses? Because they have been trying to define something that never existed in the first place. Here is my conclusion: Life is a concept, not a reality.... We must accept that the concept of life sometimes has its pragmatic value for our particular human purposes, but it does not reflect the reality of the universe outside the mind.*”

[http://www.nytimes.com/2014/03/13/opinion/why-nothing-is-truly-alive.html?\\_r=0](http://www.nytimes.com/2014/03/13/opinion/why-nothing-is-truly-alive.html?_r=0)

I wonder if Zabr, who assumes that George Berkeley’s (1710) dictum, “ESSE is PERCIPI,” to *be is to be perceived* is true, has life insurance.

If human life is not real how can it possible have meaning as an essential quality? If a life is not essentially meaningful and we exist, as atoms do, without being alive, why do we all agree that it is wrong to dismember a child but OK to take apart a K’Nex project? According to **existentialism**, **existence is prior to essence**. Consequently, **Søren Kierkegaard** (1813-1855) states that there is no eternal or external source of meaning and each individual is responsible for giving meaning to life and to live it in a way that does justice to the given meaning.

**Absurdism** is taking existentialism to the extreme in declaring that the world is **fundamentally meaningless and unintelligible**—devoid of eternal truths or values. Consequently, the search for meaning is futile and the only real problem, according to Albert Camus (1955), is whether or not to commit suicide. Camus concludes *The Myth of Sisyphus* like so: “*This universe henceforth without a master seems to him [Sisyphus] neither sterile nor futile. Each atom of that stone, each mineral flake of that night-filled mountain, in*

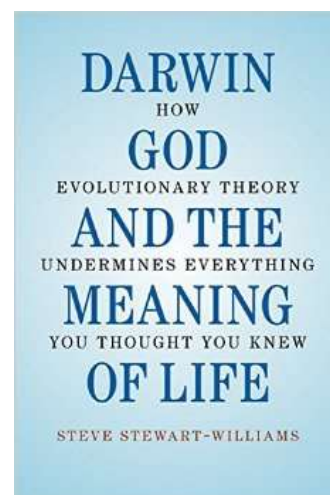


*itself forms a world. The struggle itself toward the heights is enough to fill a man's heart. One must imagine Sisyphus happy.”*

**Evolutionary humanism** also rejects the idea of the absolute and embraces the supremacy of the individual’s mind. According to Julian Huxley (1961), evolutionary humanism has “*nothing to do with Absolutes, including absolute truth, absolute morality, absolute perfection and absolute authority,*” however, “*the evolution of mind or sentiency is an extremely rare event in the vast meaninglessness of the insentient universe, and man's particular brand of sentiency may well be unique. But in any case he is highly significant. He is a reminder of the existence, here and there, in the quantitative vastness of cosmic matter and its energy-equivalents, of a trend towards mind, with its accompaniment of quality and richness of existence; and, what is more, a proof of the importance of mind and quality in the all-embracing evolutionary process.*” See the evolution of the Humanist Manifesto (I, II, and III):

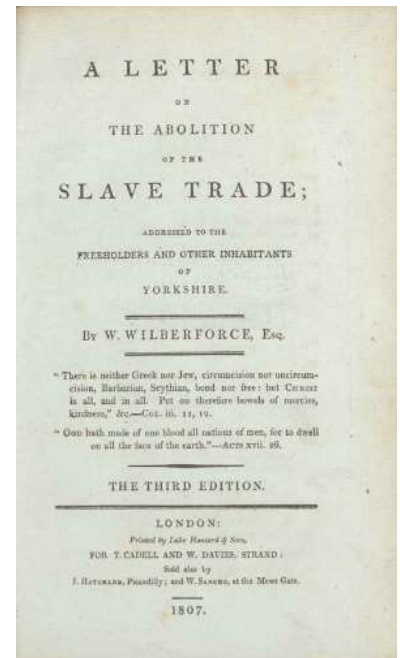
[http://americanhumanist.org/Humanism/Humanist\\_Manifesto\\_III](http://americanhumanist.org/Humanism/Humanist_Manifesto_III)

Evolutionary humanism, which is existential, has evolved to a form of **nihilism**—the personal philosophy that existence has no meaning at all. According to Steve Stewart-Williams (2010) “*Darwin showed us that there is no reason to think that there is a teleological explanation for life. We are here because we evolved, and evolution occurred for no particular reason. Thus on a Darwinian view, not only is our species not as special as we had once thought, but **our lives are ultimately without purpose or meaning.** Life just winds on aimlessly, a pointless, meandering sequence of events. Sometimes it’s pleasant, sometimes not, but it lacks any overall purpose or goal or destination.*”





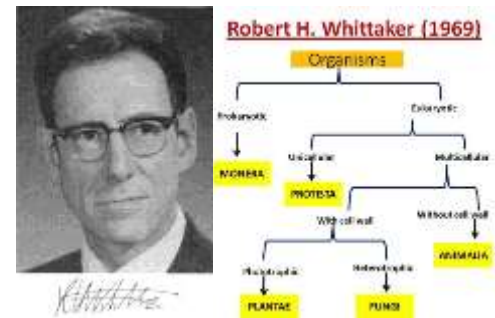
Is the meaning of life summarized by the *Struggle for Existence*, the title of the third chapter in Charles Darwin's (1859) book *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*? I believe that human life has meaning beyond that of existence as **John Newton** acknowledged when he realized that (Genesis 1:26-27) “*God said, ‘Let us make mankind in our image, in our likeness’ .... God created mankind in his own image, in the image of God he created them; male and female he created them.*” With this realization, John Newton ceased to be a slave trader, wrote *Amazing Grace*, and influenced **William Wilberforce** to tirelessly shepherd two bills through Parliament—one that outlawed the slave trade and another that outlawed slavery itself in the British Empire.



What causes a man such as William Wilberforce to fight for the freedom of genetically unrelated people? How does evolutionary theory that posits that the purpose of life is limited to the transmission of as many of our genes as possible to the next generation explain the actions of Wilberforce? Could evolutionary theory be limited or incomplete? Could there be something more than evolutionary theory? **I offer William Wilberforce as an example that there is a teleological explanation for life.** Samuel Wilberforce, Williams's son, who has been reduced by evolutionary biologists as “soapy Sam,” continued to fight against slavery in America and pointed out the relationship between slavery and evolutionary theory. Samuel Wilberforce (1860), who grew up with the responsibility to fight for the freedom of others wrote “*man's gift of reason; man's free-will and responsibility; man's fall and man's redemption; the*

*incarnation of the Eternal Son; the indwelling of the Eternal Spirit,—all are equally and utterly irreconcilable with the degrading notion of the brute origin of him who was created in the image of God” in his review of **On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life.***

I believe that bacteria (monera), protists, fungi, plants, animals and human beings are alive—and the diversity between these groups requires different meanings of life in terms of **consciousness** and **conscience**. For example, plants are **conscious** in that they sense the environment (from the French *environer*, meaning to circle, to enclose, to surround) and use the information content of the environmental light to respond appropriately. There is a unity of life and Raoul Francé (1905) described plants as “*mankind in the making.*” There is also a diversity in life and a difference between living plants and living humans is that living humans have a greater **consciousness** and strive **to understand** the external world and our place in that world.



Humans also have a **conscience**—a knowledge **within** oneself, an **inner light**, an **inner sense** of right and wrong, a moral sense, **integrity**, **intention**. Living humans also strive to understand our inner world—our “*invironment.*” The character of a human being is defined by a person’s consciousness, conscience, credibility and courage of convictions, and the natural state of a person is to be free to make choices—to live and let live.

I believe that it is reasonable to question the completeness of Charles Darwin's (1859, 1872) strictly **materialist** theory of evolution by **natural selection** or the **survival of the fittest** that states that nature is red in tooth and claw and the **incessant and perpetual struggle for existence** gave rise **gradually** to the characters of human beings.



Alfred Russel Wallace (1869), cofounder of the theory of evolution by natural selection wrote, "This subject is a vast one, and would require volumes for its proper elucidation, but enough, we think, has now been said, to indicate the possibility of a new stand-point for those who cannot accept the theory of evolution as expressing the whole truth in regard to the origin of man. While admitting to the full extent the agency of the same great laws of organic development in the origin of the human race as in the origin of all organized beings, there yet seems to be evidence of a Power which has guided the action of those laws in definite directions and for special ends. And so far from this view being out of harmony with the teachings of science, it has a striking analogy with what is now taking place in the world, and is thus strictly uniformitarian in character. Man himself guides and modifies nature for special ends. The laws of evolution alone would perhaps never have produced a grain so well adapted to his uses as wheat; such fruits as the seedless banana, and the bread-fruit; such animals as the Guernsey milch-cow, or the London dray-horse. Yet these so closely resemble the unaided productions of nature, that we may well imagine a being who had mastered the laws of development of organic forms through past ages, refusing to believe that any new power had been concerned in their production, and scornfully rejecting the theory that in these few cases a distinct intelligence had directed the action of





the laws of variation, multiplication, and survival, for his own purposes. We know, however, that [[p. 394]] this has been done; and we must therefore admit the possibility, that in the development of the human race, a Higher Intelligence has guided the same laws for nobler ends.

Such, we believe, is the direction in which we shall find the true reconciliation of Science with Theology on this most momentous problem. Let us fearlessly admit that the mind of man (itself the living proof of a supreme mind) is able to trace, and to a considerable extent has traced, the laws by means of which the organic no less than the inorganic world has been developed. But let us not shut our eyes to the evidence that an Overruling Intelligence has watched over the action of those laws, so directing variations and so determining their accumulation, as finally to produce an organization sufficiently perfect to admit of, and even to aid in, the indefinite advancement of our mental and moral nature.”

Alfred Russel Wallace (1913) also said, "***Evolution can account well enough for the land-grabber, the company promoter, the trust, and the sweater, but it fails to account for Raphael and Wagner, Swedenborg, Newton, Florence Nightingale, or others of this character.***" According to **Theodosius Dobzhansky** (1977), "*Altruism and heroism are possible only in a being which is free to choose a course of action.... There is no way, at least no simple way, for natural selection to promote true altruism which is a freely elected way of behavior that benefits others at a detriment to the individual's own behavior.*"



Samuel Wilberforce (1860) questioned whether Darwin's claims were supported by sufficient evidence; and Richard Owen (1860) questioned whether the gradualism that characterized Darwin's theory of the origin of species was

sufficient for speciation. Is it good teaching practice to follow the recommendations of the National Center for Science Education (<http://ncse.com/evolution/education/anti-evolutionism-classroom>): “A science teacher's professional responsibility is to teach science. Denigrating evolution or stating that ‘some scientists reject evolution’ misrepresents the mainstream, consensus view of the scientific community.” The NCSE (<http://ncse.com/evolution/education/teach-controversy>) believes that “evolution should not be treated as controversial within a science class. It is not scientifically controversial, nor are resources for each side of comparable quality – evidence for evolution comes from peer-reviewed literature whereas evidence against evolution is built on flawed assumptions and popularized misconceptions.” I believe that **defining evolution** and then teaching the **limitations** as well as the **value** of evolution helps develop critical thinking skills and more penetrating science.

Our personal philosophy may determine how much evidence we require from science to explain the fundamental nature of the world we live in. Is the world a gift and “*the meek shall inherit the earth; and shall delight themselves in the abundance of peace*” as David wrote in Psalm 37 or is it better described by Charles Darwin who wrote to Joseph Hooker on July 13, 1856, “*What a book a devil's chaplain might write on the clumsy, wasteful, blundering low & horridly cruel works of nature!*”

In response to the question “*What's the point of living with what we're going through here—having one war after another?*” from Marion Block, a freshman at Oberlin College

April 22, 1951

Miss Marion Block  
May Cottage  
Oberlin, Ohio

Dear Miss Block:

The question “Why” in the human sphere is easy to answer: to create satisfaction for ourselves and for other people. In the extra-human sphere the question has no meaning. Also the belief in God is no way out for in this case you may ask “Why God?”

Sincerely yours,

*A. Einstein*

Albert Einstein.

(<http://www.dbanderson.com/blog/MarionAnderson.pdf>), Albert Einstein (1951) answered that in the human sphere, the answer is easy—“*to create satisfaction for ourselves and for other people.*” He also said, that for the “*extra-human sphere the question has no meaning.*”



Is it meaningless to ask what is **the source** of the meaningful and defining characteristics of humans such as **conscience—the inner light**? Just because science can be used to create radios, TVs, nuclear bombs, and smartphones, does not mean that science provides all the answers to questions. After all, whenever there is heartbreak or a disaster, we ask the artists and the clergy, not the scientists, to comfort us. Artists and the clergy have provided us with meaning and value at a time when scientists have told us that **human beings are so insignificant**. While ordinary citizens are told by Julian Huxley (1961) that we have “*been ousted from [our] self-imagined centrality in the universe to an infinitesimal location in a peripheral position in one of a million of galaxies*” and by Carl Sagan (1980) that we sit “*on an insignificant planet of a hum-drum star lost in a galaxy tucked away in some forgotten corner of a universe,*” scientists have a **privileged position** and a special seat at the table—where the scientific answers are considered to be **beyond question**. **John Stuart Mill** (1859) in “*On the Liberty of Thought and Discussion*” and **Paul Feyerabend** in “*How to Defend Society against Science*” remind us how important it is for a healthy science to ensure that nothing and no one is **beyond question**.



I believe that our behavior and the quality of our life depends on what we consider to be real and what we consider to be an illusion. I believe **freedom**—

rights with responsibility—is real and that we live our lives differently if we think that our life is an illusion—equivalent to a “life” in a video game. In deciding what makes a good life, each one of us has the **right and**



**responsibility** to choose which scientific answers are valuable and which answers are limited or perhaps even wrong. I think that it is foundational that *“from everyone who has been given much, much will be demanded; and from the one who has been entrusted with much, much more will be asked (Luke 12:48)”* and that real freedom comes from making personal decisions about our responsibilities. I think that **the golden rule** should be the foundation for each of us when we decide what our rights are and what our responsibilities are. **Norman Rockwell** wrote, *“I’d been reading up on comparative religion. The thing is that all major religions have the Golden Rule in Common. ‘Do unto others as you would have them do unto you.’ Not always the same words but the same meaning.”* Science is not enough because it does not provide us with such good foundational principles that can describe a Wilberforce. Science is enough to derive the law of reflection, but can evolutionary theory express the fundamental importance of love as well as 1 Corinthians 13:12-13: *“For now we see only a reflection as in a mirror; then we shall see face to face. Now I know in part; then I shall know fully, even as I am fully known. And now these three remain: faith, hope and love. But the greatest of these is love.”*

In the State of the Union Address given on January 6, 1941, Franklin D. Roosevelt defined human rights or freedoms when he said, *“In the future days,*



*which we seek to make secure, we look forward to a world founded upon four essential human freedoms.*

*The first is **freedom of speech and expression**— everywhere in the world. The second is **freedom of every person to worship God in his own way**— everywhere in the world. The third is **freedom from want**—which, translated into world terms, means economic understandings which will secure to every nation a healthy peacetime life for its inhabitants— everywhere in the world. The fourth is **freedom from fear**—which, translated into world terms, means a world-wide reduction of armaments to such a point and in such a thorough fashion that no nation will be in a position to commit an act of physical aggression against any neighbor—anywhere in the world. That is no vision of a distant millennium. It is a definite basis for a kind of world attainable in our own time and generation. That kind of world is the very antithesis of the so-called new order of tyranny which the dictators seek to create with the crash of a bomb.”*



Viktor Frankl (1959), who was Number 119,104, wrote in *Man's Search for Meaning*, “We who lived in the concentration camps can remember the men who walked through the huts comforting others, giving away their last piece of bread. They may have been few in number, but they offer sufficient proof that everything can be taken from a man but one thing: the last of the human freedoms — to **choose** one's





*attitude in any given set of circumstances, to **choose** one's own way....I became acquainted with those martyrs whose behavior in camp, whose suffering and death, bore witness to the fact the last inner freedom can't be lost. It can be said that they were worthy of their sufferings; the way they bore their suffering was a genuine inner achievement. **It is this spiritual freedom — which cannot be taken away — that makes life meaningful and purposeful....**The way in which a man accepts his fate and all the suffering it entails, the way in which he takes up his cross, gives him ample opportunity—even under the most difficult circumstances—to **add a deeper meaning to his life**. It may remain **brave, dignified and unselfish**. Or in the bitter fight for self preservation he may forget his **human dignity** and become **no more than an animal.**”*

To me, it is a fundamental fact of life that life is fundamentally meaningful or purposeful, and we have the freedom and responsibility to decide for ourselves what is meaningful and purposeful and what is not. Neil deGrasse Tyson (<https://www.youtube.com/watch?v=7pL5vzIMAhS>), Richard Dawkins (<https://www.youtube.com/watch?v=SIfMuSpwfBQ>), Daniel Dennett (<https://www.youtube.com/watch?v=ayJH0HSmlSQ>) and Christopher Hitchens (<https://www.youtube.com/watch?v=bx1yXvcT2kw>) believe that **chance and chaos are fundamental** but human beings are capable of creating meaning and purpose, particularly through science, in the fundamentally chaotic world. Believing in the fundamental nature of chance and chaos requires just as much faith as believing in the fundamental nature of truth and meaning requires faith. Both views are founded on assumptions that can be supported but not rigorously tested. Modern academia embraces science that supports the idea that chance and chaos are fundamental. Science that questions the idea that chance and chaos are fundamental is typically ridiculed or silenced.

**Science** is a human endeavor that is based on our diverse personal philosophies. On the other hand, **scientism** states that the scientific method based on reductionism and materialism that will eventually reduce all phenomena to particle physics or mathematics is the only valid method of gaining knowledge about the world. **Julian Huxley** (1927) wrote in his book *Religion without Revelation*, “*What the sciences discover about the natural world and about the origins, nature and destiny of man is the truth for religion. There is no other kind of valid knowledge. This natural knowledge, organized and applied to human fulfillment, is the basis of the new and permanent religion.*” In *Surprised by Joy*, **C. S. Lewis** (1955) tells us how scientism was his religion until he was thirty years old. “*You will understand that my rationalism was inevitably based on what I believed to be the findings of the sciences; and those findings, not being a scientist, I had to take on trust—in fact, on authority.*” I want you to think critically about issues and develop a conditional certainty without relying on any authority. There is no absolute unassailable proof for the fundamental meaning and purpose of life or for the fundamental nature of chance and chaos. They both take a leap of faith. I think that a healthy science would have room for both views and that you would be free in a democratic society to choose yours.



Life can be defined by the operational definition of life I gave above but the meaning of life requires more. Human beings are able to assimilate matter and energy, move, and reproduce but we can chose to do these in a meaningful and loving way. This meaningfulness and origin of this choice is outside of evolutionary theory, but just because it is outside of evolutionary theory does not mean that meaning and origin do not exist. In the story of the Ship of Theseus we

learned that Aristotelian theory states that there are more than one reason or cause that something exists. The material cause, the formal cause, the efficient cause, the first cause, and the final cause. Many intellectuals do not see the limits of evolutionary theory and extrapolate from its value to the idea that anything that cannot be explained by evolutionary theory is not real. My common sense logic tells me that all theories are approximate, simplifications and incomplete. Thus they cannot undermine the existence of those things that they cannot explain. I believe that each of us has a **sense of truth** and using that sense, you get to choose which Laws of Nature are fundamental and true.

**D. H. Lawrence** wrote about the sense of truth in two poems:

***The Deepest Sensuality:***

*The profoundest of all sensualities  
is the sense of truth  
and the next deepest sensual experience  
is the sense of justice.*

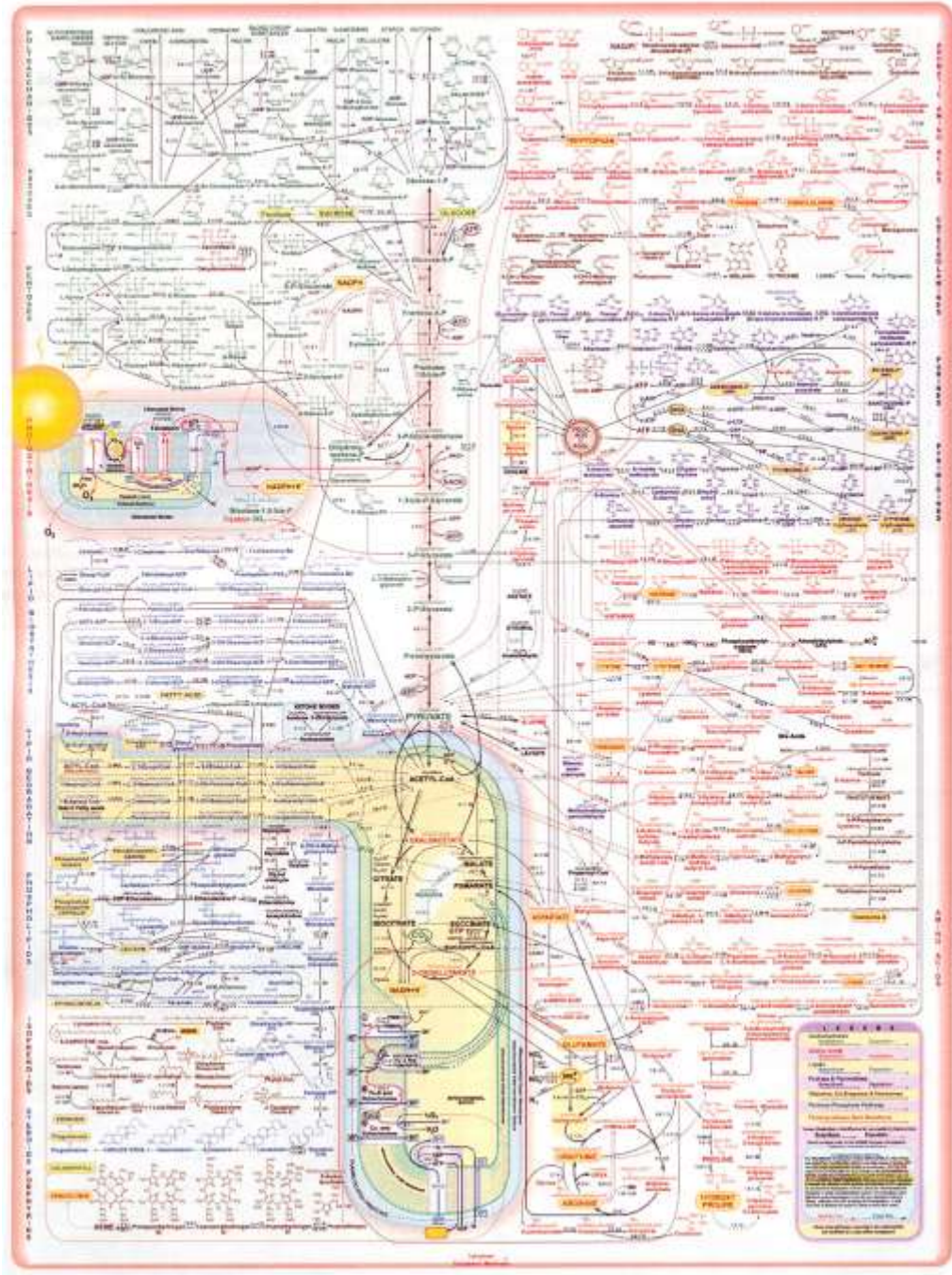
***Sense of Truth***

*You must fuse mind and wit with all the senses  
Before you can feel truth.  
And if you can't feel truth you can't have any other  
Satisfactory sensual experience.*



Science is based on personal philosophy and you get to use your sense of truth to choose if reality is merely a fabrication of the conscious mind and the theories of biology are eternal and true; or if there is a true and fundamental reality that is consistent with your own experience and observations, and it is the biological theories that approximate reality that are fabrications of the mind.

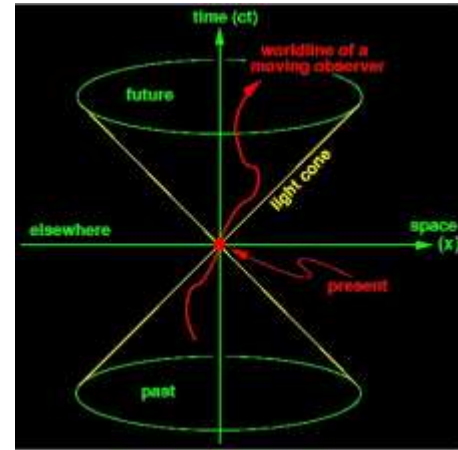
So **what is life?** To me, life is fundamentally real and fundamentally meaningful. Otherwise, what is the use of even studying life and the details of glycolysis, the Krebs cycle and DNA replication?



Read to the tune of *Is that all there is?*

<https://www.youtube.com/watch?v=LCRZZC-DH7M>

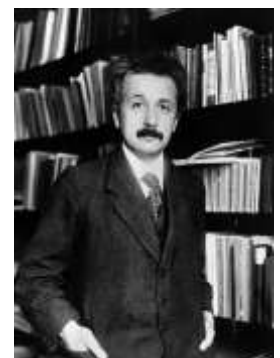
As intellectuals were using biology to tell us that life is neither real nor meaningful, they were also using physics to tell us that space and time are illusions, held by those who cannot imagine traveling at speeds close to the speed of light. Hermann Minkowski (1908) wrote in a lecture entitled, *Space and Time*, “*The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are radical. Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality.*” The intellectuals’ idea of relative spacetime depends on their understanding of the physics of light. Here I will discuss the physics of light and offer evidence against the relativity of an interdependent spacetime and for the reality of the commonsense notion of absolute Newtonian time and Euclidean space.



**What is light?** Isaac Newton considered light in terms of its physical nature and in terms of “*Light—for the glory, truth and knowledge wherewith great and good men shine and illuminate others.*” Here I will talk about the physical nature of light, and the importance of understanding light in terms of the Laws of Thermodynamics.



In the paper describing the research for which he explicitly got the Nobel Prize, **Albert Einstein** (1905) wrote, “*the energy of a light ray spreading out from a point is not continuously distributed over an increasing space, but consists of a finite number of **energy quanta which are localized at points in space, which move without dividing, and which***

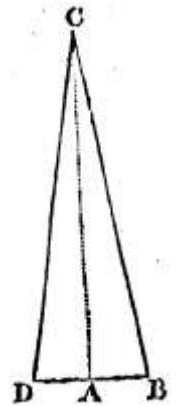




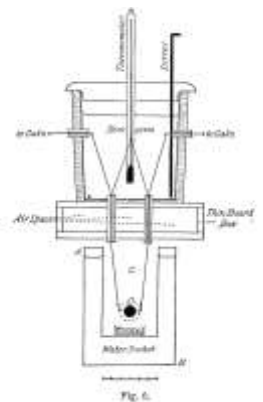
*can only be produced and absorbed as complete units.*” These energy quanta became known as **photons**.

While I admire Albert Einstein, I believe that it is still rational to question his conclusions. I am going to show you why I think that the photon is **not a point** in space but it has extension or “bigness” as Isaac Newton would say; and why I think that the photon is **not an elementary particle** but is divisible and composed of **two component parts**. But first I will present to you the widely-accepted quantum mechanical model of the photon as a point-like elementary particle.

The **quantum mechanical photon** is a **mathematical point** characterized by the following four quantities: **speed**, **energy**, **linear momentum**, and **angular momentum**. The speed ( $c$ ) of a photon in free space is currently defined as a constant equal to  $2.99792458 \times 10^8$  m/s. The speed was first estimated by **James Bradley** (1729) who noticed that the apparent position of stars depended on which direction the earth was moving as it orbited the sun. From this “aberration,” Bradley concluded that light travels 10,210 times faster than the earth in its orbit. This meant that “*one Particle of Light*” would take 8’ 12” to propagate from the sun to the earth.



The **energy** of light was measured by **Ernest F. Nichols** (Cornell) and Hull (1903) by irradiating a blackened disc of silver, obtained from Tiffany & Co. and measuring its rate of temperature increase. The First Law of Thermodynamics was used to convert heat energy to radiant energy.



The **energy** ( $E$ ) of a single photon could be determined by dividing the total energy of light by the number of photons that make up the light. But how do you express the energy of a photon? According to the wave theory of light, the energy is related to the amplitude of a wave. However, as we will see, the energy of a photon is related to its wavelength and is given by the following equation:

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

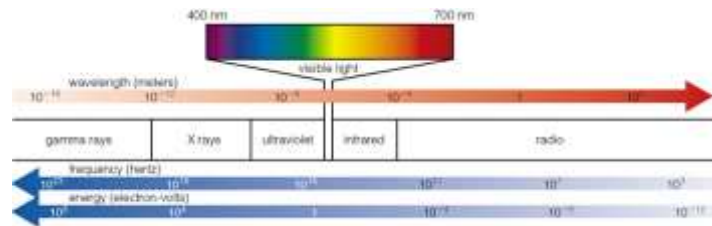
where  $h$  is Planck's constant ( $6.62606957 \times 10^{-34}$  J s) and  $\lambda$  is the wavelength of the photon.

The wavelength of a photon represents its **wave-like properties**. Since the **frequency** ( $\nu$ ) of a wave is equal to the ratio of its speed to its wavelength ( $\nu = \frac{c}{\lambda}$ ), the energy of a photon in free space that is traveling at a speed  $c$  is given by:

$$E = h\nu.$$

High energy photons such as photons in the X-ray (0.01 nm-10 nm) and UVC (100-280 nm) ranges have **short wavelengths** and low energy photons such as photons in the infrared (700 nm-1mm) and microwave (1 mm-1 m) ranges have **long wavelengths**.

The wavelength of photons is necessary to explain their ability to **interfere** in order to produce the beautiful iridescent colors observed in thin plates and in the tail feathers of a peacock. The wavelength of photons is also necessary to explain the **diffraction of light by small and microscopic objects**.



The explanation of interference demands that the energy or intensity of light depends on the **amplitude** of the light wave—being proportional to the **square of the amplitude** and not related to the **wavelength** or **frequency**. However, experiments performed in the later part of the 19<sup>th</sup> century by Philipp Lenard led to the idea that the energy of light is a function of the wavelength or frequency of light.

**Philipp Lenard** (1900,1902) showed that in a vacuum, the **photoelectrons** ejected from a metal by **ultraviolet light** could be accelerated or retarded by an electric field. The greater the electric field needed to retard the electrons, the greater the kinetic energy of those electrons must have been. Philipp Lenard showed that the **kinetic energy** of the ejected **photoelectrons** was related to the **frequency** of the incident light and not to its **intensity**. The **light intensity** however determined the amount of current generated by the incident light. Since the current is a measure of the number of electrons propelled from the metal, the **number of electrons** ejected from the metal is related to the light intensity.

Albert Einstein (1905) presented an equation to describe the photoelectric effect. The modern form of Einstein's equation for the kinetic energy ( $KE = \frac{1}{2}mv^2$ ) of the electron becomes:

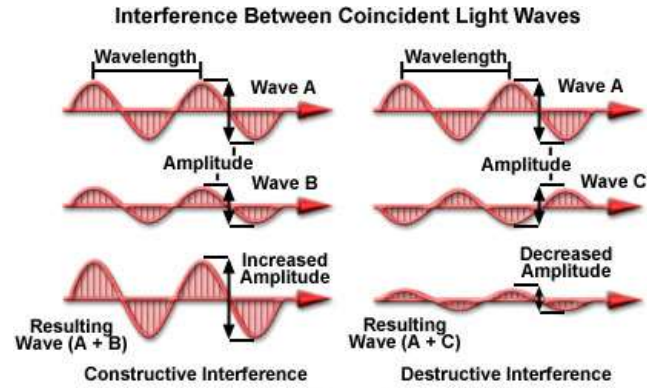
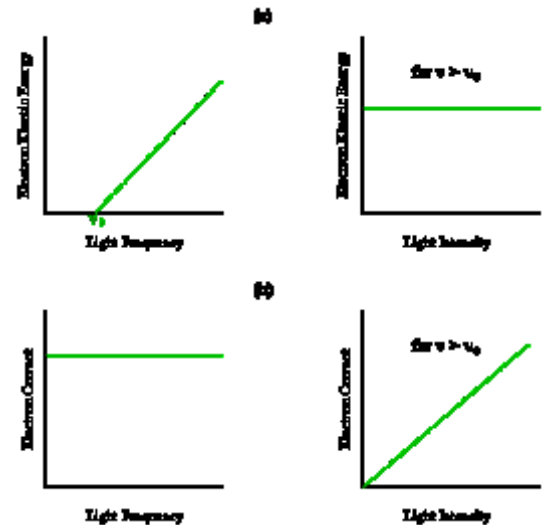
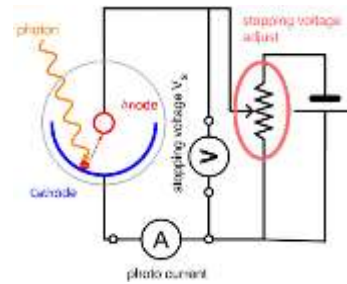
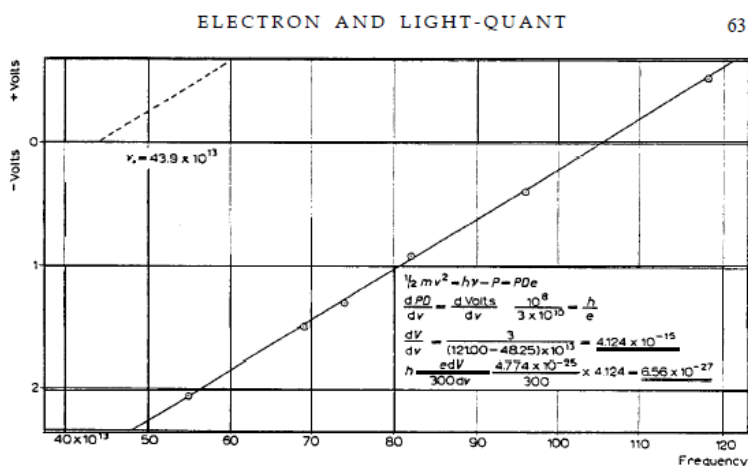


Figure 1



$$KE = h\nu - W.$$

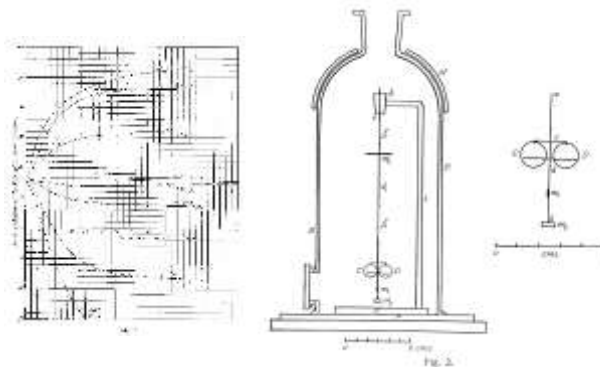
**Robert Millikan** (1915, 1924) provided the experimental proof that confirmed the validity of Albert Einstein's equation "*after ten years of testing and changing and learning and sometimes blundering.*" The **slope** of the line that related the kinetic energy of the photoelectrons ejected from a metal to the frequency of the incident light was equal to Planck's constant and the product of the x-intercept and Planck's constant was equal to the **work function**.



These experimental confirmations of Albert Einstein's heuristic proposal that the energy of a photon was related to its wavelength or frequency, but not its amplitude was quite a blow to the wave theory of light. However, Robert Millikan said in his Nobel lecture, "*...the general validity of Einstein's equation is, I think, now universally conceded, and to that extent the reality of Einstein's light-quanta may be considered as experimentally established. But the conception of localized [point-like] light-quanta out of which Einstein got his equation must still be regarded as far from being established...It may be said then without hesitation that it is not merely the Einstein equation which is having extraordinary success at the moment, but the Einstein conception as well. But until it can account for the*

*facts on interference and the other effects which have seemed thus far to be irreconcilable with it, we must withhold our full assent.”*

Energy is a **scalar quantity** that only has **magnitude** and was easy to work with algebraically, while linear momentum is a **vector quantity**, with direction and magnitude, and was more difficult to work with, especially in the fledgling field of quantum theory. Nichols and Hull (1901,1903) measured the linear momentum of light (actually the radiation pressure) by shining light on a mirror hung on a fiber made of quartz and silk and measuring its deflection.



**Johannes Stark** (1909) also took into consideration the unidirectional nature of light propagation and related the linear momentum of a photon to its energy. The linear momentum ( $p$ ) of a photon is related to its energy ( $E$ ) by:

$$p = \frac{E}{c}$$

and since  $E = \frac{hc}{\lambda}$ ,

$$p = \frac{h}{\lambda}$$

Since the linear momentum of a photon is inversely proportional to its wavelength, photons with very short wavelength such as photons in the X-ray range (0.01-10 nm) will have very large linear momenta.



FIG. 30.—THE COMPTON EFFECT  
The photograph shows the change of wave-length of ether-waves, lines blue toward red, because of scattering by free electrons.  $\alpha$  and  $\beta$  are the initial characteristic X-ray lines of molybdenum,  $\alpha'$  and  $\beta'$  these same lines after suffering scattering in aluminum.





**Arthur Compton** (1923) scattered X-rays from the electrons of graphite (carbon) and measured the wavelength of the scattered X-rays with a diffraction grating spectrometer. He discovered that the wavelength of the scattered X-rays were longer than the wavelength of the incident X-rays.

Arthur Compton realized that the wavelength of the X-rays would get longer if X-rays were considered to be particles with energy and linear momentum; and that both energy and linear momentum were **conserved in a collision**. If the X-ray photon had enough linear momentum to cause the electron to recoil, then the scattered X-ray photon should have a smidgen less momentum than the incident X-ray photon. Arthur Compton found that the red shift in the wavelength of the scattered radiation was perfectly consistent with the **Doppler effect** since the recoiling electron was actually moving away from the incident and scattered X-ray photons.

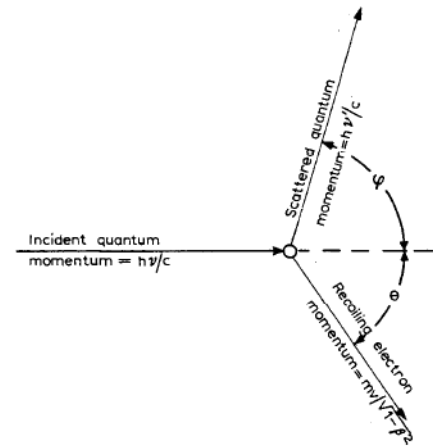


Fig. 9. An X-ray photon is deflected through an angle  $\phi$  by an electron, which in turn recoils at an angle  $\theta$ , taking a part of the energy of the photon.

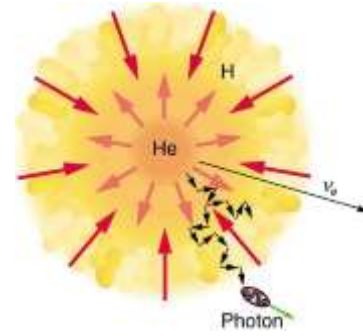
The fact that energy and linear momentum are conserved in collisions between photons and electrons supports the **particulate nature of the photon** and also suggests that the photon has some kind of mass associated with it. Since photons propagate at the speed of light, the momentum ( $mv$ ) is given by the following equation:

$$p = mc$$

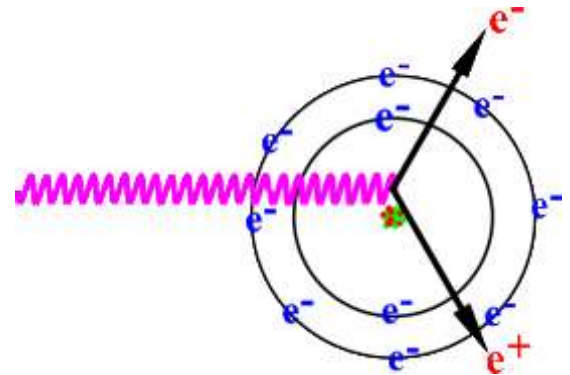
And since  $E = pc$ ;

$$E = mc^2.$$

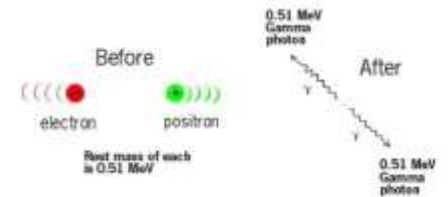
This equation states that mass and energy are transformable and that a small decrease in mass like that which occurs in the **core of the sun when four protons are fused into helium**, results in a large release of energy.



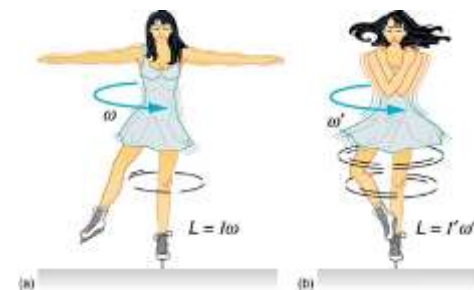
The relationship between energy and mass comes from the definitions of a photon's energy and linear momentum. In fact, when a photon with a very short wavelength enters the strong electric field of an atom, the photon is transformed into an **electron** ( $e^-$ ), which is a particle and a **positron** ( $e^+$ ), which is an antiparticle in a process known as **pair production**.



Conversely, when an antiparticle such as a positron collides with a particle such as an electron, they annihilate each other and are transformed into photons in a process known as **pair annihilation**. The annihilation of electrons and positrons take place every day in hospitals that perform **PET (positron emission tomography) scans** to look for cancerous cells.



**The First Law of Thermodynamics states that energy is conserved.** There are other **conservation laws** that are equally important. These include the **conservation of linear momentum** and the **conservation of angular momentum**. Richard Beth (1936) showed that light has mechanical linear momentum using a torsion balance. He shined polarized light



through a transparent birefringent disc suspended on a quartz fiber and measured the amount of rotation of the disk for light with a given polarization.

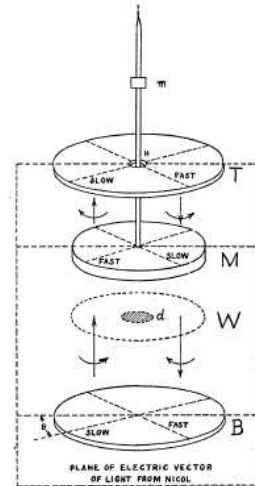
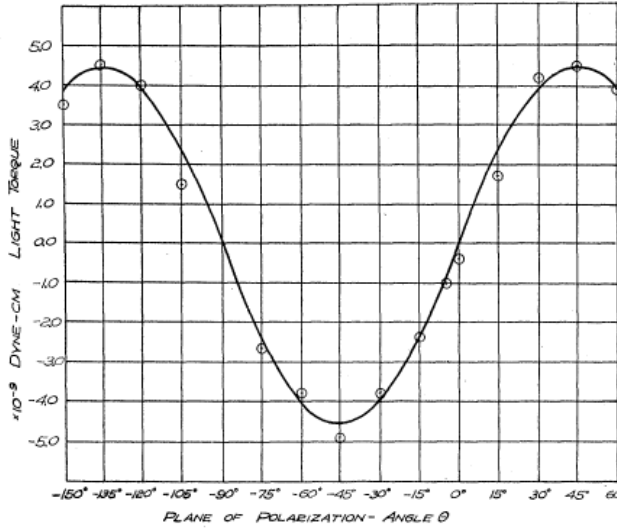


FIG. 3. Wave plate arrangement.

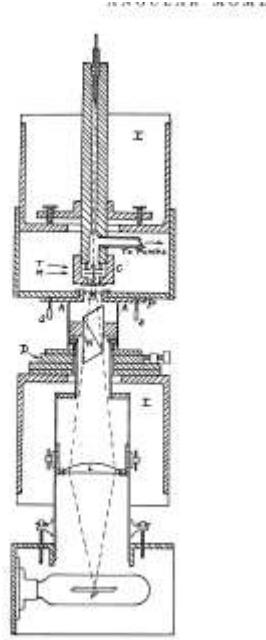


FIG. 1. Diagram of apparatus.

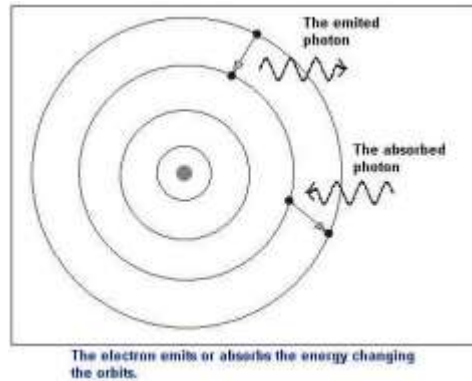
The **spin angular momentum** ( $L$ ) for each and every photon given by the following equation:

$$L = \frac{h}{2\pi} = \hbar$$

where  $\hbar$  is known as h-bar. Interestingly, the spin angular momentum, which is a vector quantity, is unique in terms of conserved quantities in that it is the only property shared by all photons, independent of their frequency and wavelength.

We have discussed the energy, linear momentum and angular momentum of a photon. The fact that these are **conserved quantities** means that following an interaction of a photon with an object such as a gas molecule, a metal or a pigment, the energy, the linear momentum and the angular momentum of the photon and the object must be the same as it was before the interaction.

**Niels Bohr** (1913) used the idea of quantized angular momentum to describe the planetary model of the atom, and wrote *“In any molecular system consisting of positive nuclei and electrons in which the nuclei are at rest relative*



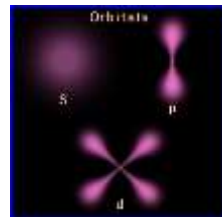
*to each other and the electrons move in circular orbits, the angular momentum of every electron round the centre of its orbit will in the permanent state of the system be equal to  $h/2\pi$ , where  $h$  is Planck's constant.”*

**Arnold Sommerfeld** (1923) suggested that **angular momentum**, which was then known as the moment of momentum, must not only characterize the atomic system but must be **conserved** when it emits a photon. Arnold Sommerfeld wrote, *“...in the process of emission..., we demanded...the conservation of energy. The energy that is made available by the atom should be entirely accounted for in the energy of radiation  $\nu$ , which is, according to the quantum theory of the oscillator, equal to  $h\nu$ . With the same right, we now demand the **conservation of momentum and of moment of momentum: if in a change of configuration of the atom, its momentum or moment of momentum alters, then these quantities are to be reproduced entirely and unweakened in the momentum and moment of momentum of the radiation.”***



Currently, the accepted theory of quantum mechanics treats an electron of an atom as if has **no independent existence in space and time until it is measured**. In *Introduction to Quantum Mechanics*, David Griffiths (2005) describes: *“The orthodox position: The particle wasn't really anywhere. It was the act of*

measurement that forced the particle to 'take a stand' (though how and why it decided on the point C we dare not ask). [Pascual] **Jordan** [1934] said it most starkly, 'Observations not only disturb what is to be measured, they produce it.... We compel (the particle) to assume a definite position.' This view (the so-called Copenhagen interpretation), is associated with Bohr and his followers. Among physicists it has always been the most widely accepted position." One moonlit night as Einstein walked with Abraham Pais in Princeton, Einstein asked Pais, "Do you really believe the moon is not there when you are not looking at it?" The Copenhagen interpretation is a choice and one made by the consensus. Einstein never accepted it as told by Werner Heisenberg (1983) and Philipp Frank (1947).



Einstein: "A new fashion has now arisen in physics. By means of ingeniously formulated theoretical experiments it is proved that physical magnitudes cannot be measured, or, to put it more precisely, that according to accepted natural laws the investigated bodies behave in such a way as to baffle all attempts at measurement. From this the conclusion is drawn that it is completely meaningless to retain these magnitudes [position and momentum] in the language of physics."



Philipp Frank: "But the fashion you speak of was invented by you in 1905!"

Einstein: "A good joke should not be repeated too often."

Frank went on to say, "then in a more serious vein he [Einstein] explained to me that he did not see any description of a metaphysical reality in the theory of relativity, but that he did regard an electromagnetic or gravitational field as a physical reality, in the same sense that matter had formally been considered so."



*The theory of relativity teaches us the connection between different descriptions of one and the same reality.”*



A. PICCARD E. HENRIOT P. EHRENFEST EG. HERZEN Th. DE DONDER E. SCHRÖDINGER E. VERSCHAFFELT W. PAULI W. HEISENBERG I.H. FOWLER L. BRILLOUIN  
P. DEBYE M. KNUDSEN W.L. BRAGG H.A. KRAMERS P.A.M. DIRAC A.H. COMPTON L. de BROGLIE M. BORN N. BOHR  
I. LANGMUIR M. PLANCK Mme CURIE H.A. LORENTZ A. EINSTEIN P. LANGEVIN C.ME. GUYE C.T.R. WILSON O.W. RICHARDSON

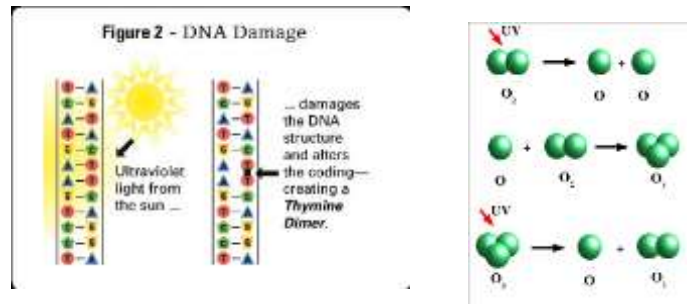
**For the champions of the Copenhagen interpretation, reality was a free creation of the imagination but the laws of physics were eternal and true. For Einstein, it was not reality that was a free creation of the imagination but the laws of physics.** According to Frank (1947), *“In the name of progress in physics he [Einstein] claims the right to create any system of formulations and laws that would be in agreement with new observations.... For Einstein the basic theoretical laws are a free creation of the imagination, the product of the activity of an inventor who is restricted in his speculation by two principles: an empirical one, that the conclusions drawn from the theory must be confirmed by experience, and a half-logical, half aesthetic principle, that the fundamental laws should be as few in number as possible and logically incompatible.”*

The quantum mechanical photon is a mathematical point that is characterized by four numbers that represent **speed, energy, linear momentum, and angular momentum**. Such a photon with the short wavelength of gamma rays may transform into an electron positron pair. Such a photon with the slightly longer wavelength of X-rays may collide with an electron and cause it to recoil. In

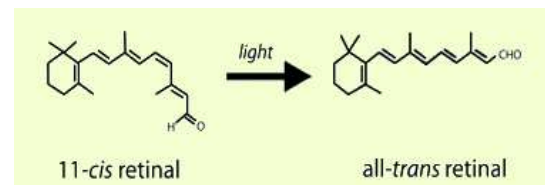
the process, the wavelength of scattered light will be shorter than the wavelength of incident light. Such a photon with the longer wavelength of ultraviolet light will propel an electron from a metal in a phenomenon known as the photoelectric effect.

Such an ultraviolet photon could also **split a diatomic oxygen molecule or an ozone molecule in the stratosphere** or the hydrogen bonds of two **adjacent thymine bases in DNA** so that they form a TT dimer.

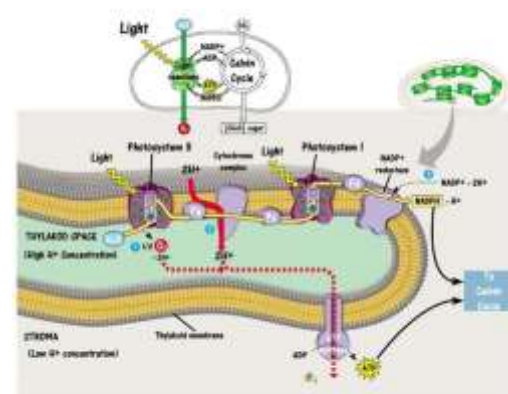
It is intuitive to visualize the quantum mechanical photon participating in the above-mentioned processes.



A photon of visible light could be **absorbed** by the 11-*cis* retinal of rhodopsin and photopsins and induce a rotation of a bond to form all *trans* retinal in the **visual process**. It is intuitive to visualize the quantum mechanical photon absorbed in this process as a particle.



Likewise a photon of visible light could be absorbed by a **chlorophyll molecule** in the chloroplast of a mesophyll cell in the leaf of a plant and transform the radiant energy of an absorbed photon into redox energy when an electron in the reaction center is propelled away from the positively-charged nuclei of the atoms that make up the reaction center chlorophyll to an acceptor in the **photosynthetic** process. It is intuitive to visualize the quantum mechanical photon absorbed in this process as a particle.

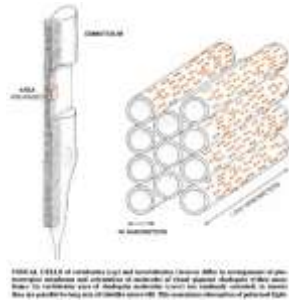


But when we consider the interaction of visible light with the molecules that make up the **thin layers** in the **blue feathers of a blue jay** or the **diffraction grating** in the exoskeleton of a scarabaeid



beetle, it is impossible to visualize how the quantum mechanical **point-like** photon could produce the iridescent colors as a result of **thin film interference** and **diffraction**.

It is also impossible to visualize how the **absorption** of a quantum mechanical photon would make it possible for a honey bee to detect the **linear polarization of the skylight** in order to do the waggle dance and inform the other honey bees which direction the plants rich in nectar are.

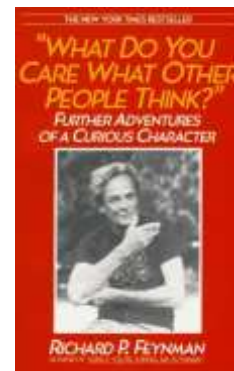
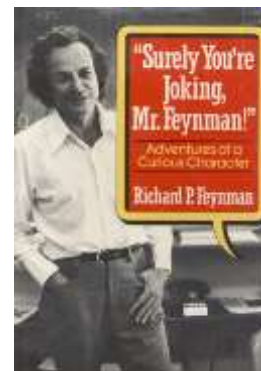
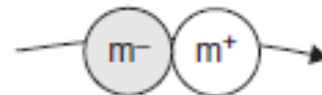


Neither the quantum mechanical model of a photon nor the classical wave model of light is sufficient on their own to explain all the observable interactions of light with matter. The quantum mechanical model assumes that a monochromatic photon is a mathematical point and the wave theory assumes that a monochromatic photon is an infinite plane wave.

According to Hendrik Lorentz (1923) *“The discrepancy between these estimates of the size of a quantum, according to which it would be too big to enter our eye, and, on the other hand, the notion that it is small enough to be captured by a single electron, is certainly very wide. Yet the laws of the two classes of phenomena about which we have reasoned, the phenomena of interference and those of photo-electricity, are so well established that there can be no real contradiction between what we deduce from one class and from the other; it must after all be possible to reconcile the different ideas. Here is an important problem*

for the physics of the next future. We cannot help thinking that the solution will be found in some happy combination of extended waves and concentrated quanta, the waves being made responsible for interference and the quanta for photo-electricity.” I will show that it is possible to take the best parts of both theories to get a **pictorial and realistic model of a photon that will describe photons from gamma rays through radio waves**, and will be approximated by the quantum mechanical photon in the gamma ray region and by the wave theory in the radio wave region of the spectrum?

I start with the **assumption** that the photon may *not* be an elementary particle, but a **binary structure** consisting of a particle of matter and an antiparticle of antimatter. The **particle** and **antiparticle** have equal and opposite mass (M), charge (C) and sense of rotation (P). The sum of two masses or two charges that are equal in magnitude but opposite in sign is **zero**. Thus a photon in free space, where it does not interact with anything and cannot be measured, is **massless** and **charge-neutral**. Because both the sense of rotation and the mass are opposite, the angular momentum of the two particles do not cancel each other but add to each other such that the binary photon has angular momentum. I define the conjugate particles of matter and antimatter as differing in charge, sense of rotation and **mass** which gives **CPM symmetry** (Wayne, 2012). The **standard model of physics** defines the conjugate particles of matter and antimatter as differing in charge, sense of rotation and **direction in time** which gives **CPT symmetry**. According to **Richard Feynman** (Cornell, 1988), “Every particle in nature has an amplitude to move backwards in time, and therefore has an anti-particle...”



<i>Charge</i>	<i>Parity</i>	<i>Time</i>
<i>C</i> (+ or -)	<i>P</i> (+ (clockwise) or – (anticlockwise))	<i>T</i> (+ (forwards) or –(backwards))

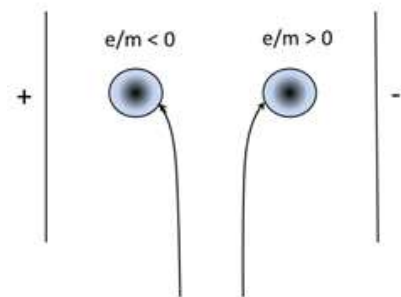
<i>Charge</i>	<i>Parity</i>	<i>Mass</i>
<i>C</i> (+ or -)	<i>P</i> (+ (clockwise) or – (anticlockwise))	<i>M</i> (+ or -)

Newton’s Second Law was written only for bodies with positive mass which was reasonable because no other substance besides matter was known. I have generalized **Newton’s Second Law** to include masses that are positive and negative. Negative mass is a legitimate although an unwelcomed concept in physics and the cosmologist **Hermann Bondi** (1957) characterized many of its properties. I have defined matter as having a positive mass and antimatter as having a negative mass. According to the Newton’s generalized Second Law, the ratio of force ( $F$ ) to acceleration ( $a$ ) of a body is given by:



$$m = \frac{F}{a}$$

where mass is a scalar quantity with sign and magnitude and force and acceleration are vector quantities with magnitude and direction in space. For positive mass, the vector of acceleration is **parallel** to the force vector, and for negative masses, the two vectors are **antiparallel**. A positive mass will accelerate toward an attractive force ( $qq < 0$ ) and a negative mass will accelerate away from an attractive force. A positive mass will accelerate away from a repulsive force ( $qq > 0$ ) and a negative mass will accelerate toward a repulsive force.





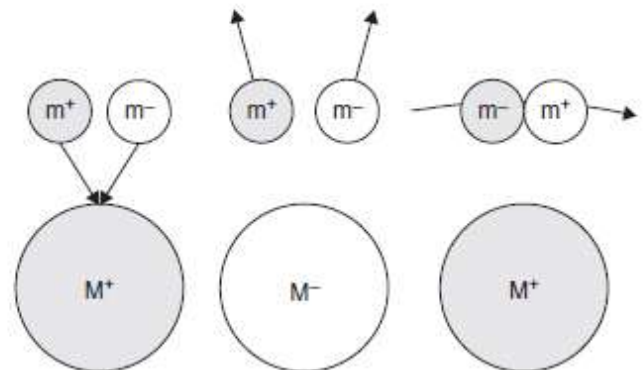
How do particles of negative and positive mass interact with themselves and with each other? At the onset, if we consider the particles to have mass but not charge then we can use **Newton's Law of Gravitation** in a generalized version to describe the causal force and **Isaac Newton's (1687) Second Law** in a generalized version to determine how any two particles, with masses of arbitrary sign, respond to the causal force and accelerate relative to each other.

By equating the gravitational force ( $F_g$ ) to the inertial force ( $F_i$ ) we get:

$$\frac{G}{r^2} m_1 m_2 = F_g = F_i = m_2 g$$

where  $r$  is the distance between the two masses,  $G$  is the gravitational constant ( $6.673003 \times 10^{11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ ),  $m_1$  is the mass of a large body like the earth or the sun,  $m_2$  is the test mass, and  $g$  is the acceleration due to gravity of the test mass relative to the large body. The test mass accelerates toward the large body when  $g > 0$ , and the test body accelerates away from the large body when  $g < 0$ . The direction of the force and the acceleration for any combination of masses can be obtained by plugging masses of various signs into the above equation.

For example, when the mass of a large body is positive, there will be an attractive force ( $F_g > 0$ ) between it and a positive test mass. Consequently, the positive test mass will accelerate toward the large positive mass ( $g > 0$ ). When the mass of a large body is positive, there will be a repulsive force ( $F_g < 0$ )



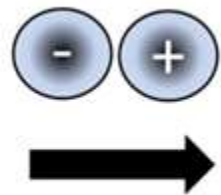
**FIGURE A.1** Direction of acceleration between a large body mass and test masses.

between it and a negative test mass. Consequently, the negative test mass will accelerate toward the large positive mass ( $g > 0$ ).

When the mass of a large body is negative, there will be a repulsive force ( $F_g < 0$ ) between it and a positive test mass. Consequently, the positive test mass will accelerate away from the large negative mass ( $g < 0$ ). When the mass of a large body is negative, there will be an attractive force ( $F_g > 0$ ) between it and a negative test mass. Consequently, the negative test mass will accelerate away from the large positive mass ( $g > 0$ ).

Now for the interesting part that is relevant for the binary photon. If the magnitudes of the masses of a negative mass particle and a positive mass particle are the same, the positive mass particle will accelerate away from the negative mass particle ( $g < 0$ ) and the negative mass particle will accelerate toward the positive mass particle ( $g > 0$ ). Consequently, the negative mass particle will chase the positive mass particle.

I suggest that the gravitational force between the two conjugate semi-photons that make up the binary photon provides the motive force that causes a photon to move. While this is the only dynamic answer I know of to the question “**what causes light to move?**” it contradicts the widely held assumption that the gravitational force, which is the weakest of the four fundamental forces (e.g. strong, weak, electromagnetic, gravitational), is unimportant when it comes to subatomic distances. The proposed involvement of the gravitational force in binding the two conjugate semi-photons of the binary photon together and in propelling the binary photon through Euclidean space and Newtonian time may provide insight to

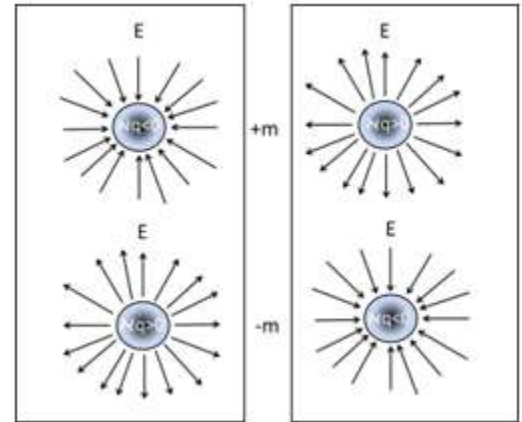


direction of propagation

explore the connection sought by Faraday (1846), Maxwell (1865) and Einstein (Pais 1982) between the gravitational and electromagnetic fields.

If the conjugate semi-photons that constitute the binary photon only had the properties of mass, the binary photon would accelerate to infinite velocity.

Consequently, the conjugate particle and antiparticle that make up the binary photon must also have charge that could interact with the electric permittivity ( $\epsilon_0$ ) and magnetic permeability ( $\mu_0$ ) of the vacuum in order to

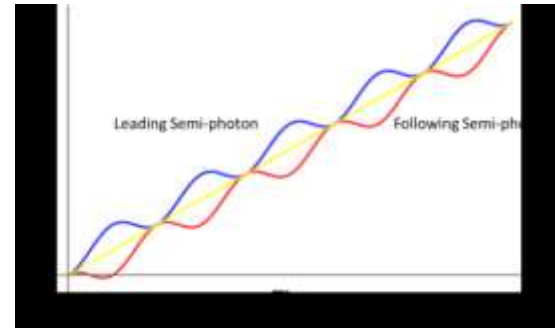
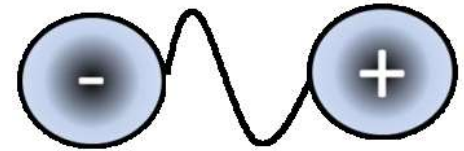


constrain the velocity of the photon to the speed of light. The existence of charge within a photon seems reasonable since the **photon is the carrier of the**

**electromagnetic force**. However, the electric field radiating from the charges of the particle and antiparticle must be equal in magnitude and opposite in sign to ensure that the charge of the binary photon is neutral overall. The direction of the electric field that radiates from a charge depends on both the sign of the charge and the sign of the mass. The gravitational force-induced movement of the charged particles causes a magnetic field according to Ampere's Law and an oppositely-directed electromotive force according to Faraday's and Lenz's Laws that is responsible for reducing the velocity of the binary photon to the speed of light ( $c =$

$\frac{1}{\sqrt{\epsilon_0 \mu_0}}$ ). Michael Faraday (1846) wrote: *“Neither accepting nor rejecting the hypothesis of an ether, or the corpuscular, or any other view that may be entertained of the nature of light; and, as far as I can see, nothing being really known of a ray of light more than of a line of magnetic or electric force, or even a line of gravitating force.”*

I assume that the center of gravity of the binary photon, which can be considered to be its rest frame, propagates at the speed of light  $c$  along the  $z$ -axis as a function of time. As a result of the gravitational force on a moving charge inducing an oppositely-directed electromotive force, the binary photon may have internal longitudinal motions that were predicted by Wilhelm Röntgen (1896) and George FitzGerald (1896) and consistent with Einstein's (1909a) "*oscillation energy of frequency  $\nu$  [that] can occur only in quanta of magnitude  $h\nu$ .*" Indeed de Broglie (1924) wrote, "*Naturally, the light quantum must have an internal binary symmetry corresponding to the symmetry of an electromagnetic wave....*" I have described the predicted sinusoidal oscillations with an antisymmetric normal mode using wave equations. The positions of the leading ( $\phi_{leading}$ ) and following ( $\phi_{following}$ ) semi-photons travelling along the  $z$  axis as a function of time and given by the following formulae:



$$\begin{bmatrix} \phi_{leading}(t) \\ \phi_{following}(t) \end{bmatrix} = \begin{bmatrix} ct + \frac{\lambda}{4}(1 - \cos(2\pi\nu t)) \\ ct - \frac{\lambda}{4}(1 - \cos(2\pi\nu t)) \end{bmatrix} [\hat{z}]$$

In order for the semi-photons with mass ( $\frac{h\omega}{2c^2} = \frac{hc}{2\lambda c^2}$ ) to oscillate in a sinusoidal manner with angular frequency ( $\omega = 2\pi\nu$ ), there must be a restoring force characterized by a spring constant ( $K$  in N/m). The angular frequency of the oscillator is related to the spring constant according to the following formula:

$$\nu = \frac{1}{2\pi} \sqrt{\frac{K}{m}}$$

Solving for K, we find that the spring constant that provides the restoring force to the semi-photon is equal to the ratio of a constant ( $2\pi^2hc$ ) to the cube of the wavelength:

$$K = \frac{2\pi^2hc}{\lambda^3}$$

The longer the wavelength, the lesser is the spring constant, and the more the binary photon approaches a floppy wave. On the other hand, the shorter the wavelength, the greater is the spring constant, and the more the binary photon approaches a “hard” mathematical point.

The velocities of the leading ( $v_{leading}$ ) and following ( $v_{following}$ ) semi-photons along the direction of propagation as a function of time are obtained by differentiating the positions of the semi-photons with respect to time:

$$\begin{bmatrix} v_{leading}(t) \\ v_{following}(t) \end{bmatrix} = \begin{bmatrix} c + \frac{\pi c}{2} \sin(2\pi vt) \\ c - \frac{\pi c}{2} \sin(2\pi vt) \end{bmatrix} [\hat{z}]$$

Heretofore, the wave-particle duality of the quantum mechanical photon has been unintuitive. Friedrich Hund (1974) wrote “*one way of explaining quantum theory in physical terms these days consists in regarding it as a completely non-intuitive unification or two intuitive pictures, i.e., classical particles and classical waves of fields.*” William Bragg (1922) described the situation like so: “*On Mondays, Wednesdays and Fridays, we use the wave theory; on Tuesdays, Thursdays and Saturdays we think in streams of flying quanta or corpuscles.... Some day we shall piece all the maps together.*” By considering the photon to be a binary photon composed of two conjugate particles, instead of an elementary particle, it becomes possible to visualize simultaneously the wave and particle nature of the photon or what Arthur Eddington (1928) and Charles Galton Darwin, Charles Darwin’s grandson, called “*wavicles.*”



The longitudinal wave propagating along the  $z$  axis with a maximal spatial extension of  $\lambda$  and an average spatial extension of  $\frac{\lambda}{2}$  is possible if the photon is composed of two particles as opposed to one. Consequently, the binary photons that make up radio waves (1 m – 100 km) and microwaves (1 mm – 1 m) are predicted to be very long and binary photons that make up gamma rays (<0.01 nm) and X-rays (0.01-10 nm) are predicted to be very short—approximating a mathematical point. The binary photons that make up the visible light effective in photosynthesis and vision are predicted to be intermediate in length.



The possibility that a real photon has transverse extension in addition to longitudinal extension comes from an intuitive and mechanical understanding of angular momentum as a mechanical property that means something more than just a number. What would the radius of the binary photon be in order for it to have its observed angular momentum? While this question cannot be answered using current quantum mechanics (Landau and Lifshitz 1958), to answer this question, I went back to Niels Bohr's Correspondence Principle which sets a classical quantity equal to a quantum quantity.

In the point-like quantum mechanical photon the **angular momentum** and **spin** are just numbers without any mechanical analog such as rotational kinetic energy or an explanation of what is spinning since a mathematical point cannot spin. According to Landau and Lifshitz (1958), "*in quantum mechanics, some 'intrinsic' angular momentum must be ascribed to an elementary particle, regardless of its motion in space. This property of elementary particles is peculiar to quantum theory..., and hence is essentially incapable of a classical*

*interpretation. In particular, it would be wholly meaningless to imagine the ‘intrinsic’ angular momentum of an elementary particle as being the result of its rotation about ‘its own axis’, if only because we cannot ascribe any finite dimensions to an elementary particle.’*

If you start with meaninglessness you end with meaninglessness. Thus I am assuming that the numerical quantum definitions of angular momentum and spin have outlived their usefulness and are now too simplistic. Since the binary photon is allowed to have extension, we can calculate its radius ( $r$ ) to get an idea of what is spinning. If the binary photon has angular momentum and spin, what would the radius of the binary photon be in order for it to have its observed angular momentum ( $\hbar$ ) and spin (1) of a boson? To answer this question, I have used Niels Bohr’s **Correspondence Principle** which sets a classical quantity equal to a quantum quantity. Classically, the angular momentum of a particle is equal to  $mvr$ , where  $m$  is the mass of body,  $v$  is its angular velocity, and  $r$  is its radius.

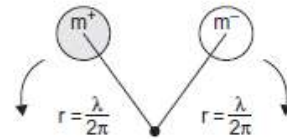


FIGURE A.2 The radius of a rotating mass with angular momentum of  $\hbar/2$ .

The mass of each semi-photon that composes the binary photon is one-half of the total mass of the binary photon, and is given by:

$$m = \frac{h\nu}{2c^2}$$

Using the Correspondence Principle where  $v$  is the angular velocity and  $r$  is the radius of the each semi-photon that composes the binary photon, we get:

$$L = \frac{\hbar}{2} = \frac{h}{4\pi} = mvr$$

for a semi-photon with angular momentum equal to  $\frac{h}{2}$ . We can calculate the radius of the semi-photon by letting  $v = 2\pi\nu r$  and inserting the mass  $m = \frac{h\nu}{2c^2}$  of that semi-photon to get:

$$\frac{h}{4\pi} = \frac{h\nu}{2c^2} 2\pi\nu r^2$$

After cancelling and rearranging, we get:

$$r^2 = \frac{c^2}{(2\pi)^2 \nu^2}$$

Since according to the dispersion relation,  $\frac{c^2}{\nu^2} = \lambda^2$ , we get:

$$r^2 = \frac{\lambda^2}{(2\pi)^2}$$

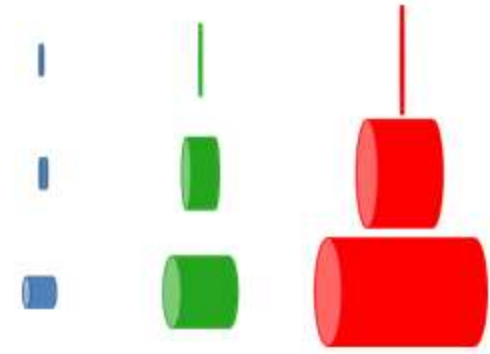
And after taking the square root of both sides, we get:

$$r = \frac{\lambda}{2\pi}$$

That is, the radius of the binary photon is equal to the wavelength of light divided by  $2\pi$  and the circumference ( $2\pi r$ ) is equal to the wavelength. The radius of the binary photon is identical to the radius of the semi-photon, since for the binary photon, the angular momentum is equal to  $\frac{h}{2\pi}$  and the mass is equal to  $\frac{h\nu}{c^2}$ . The diameter ( $d$ ) of a cylinder- or needle-like binary photon is approximately equal to one-third of its wavelength.

$$d = 2r = \frac{\lambda}{\pi} = 0.32 \lambda$$

This equation, which is based on the assumptions that the binary photon has mechanical energy, linear momentum and angular momentum, describes the “bigness” of a binary photon with a given wavelength. When the wavelength of a binary photon approaches zero, so does its diameter and the “bigness” of the binary photon approaches the size of a mathematical point. When the wavelength of a binary photon approaches infinity, so does its diameter and the “bigness” of the binary photon approaches infinity. A binary photon of monochromatic 500 nm light has an *average* length of 250 nm and a diameter of 160 nm. The lateral extension is why two “close” binary photons can interfere at the surface of a thin film to cause the iridescent colors of **frogs, butterflies** and **birds**; and interfere at the surface of the striations to cause the iridescent colors of **scarabaeid beetles**. The “bigness” of a binary photon with a wavelength of 400 nm is smaller; and the “bigness” of a binary photon with a wavelength of 600 nm is larger than the bigness of a binary photon with a wavelength of 500 nm.



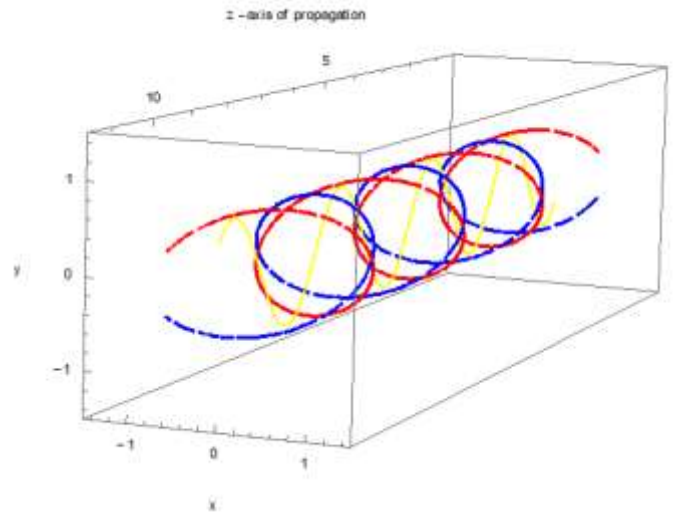
In order for the binary photon to have a non-vanishing angular momentum that is equal to  $\frac{h}{2\pi}$ , the two semi-photons, with masses of opposite signs, have to rotate perpendicular to the axis of propagation with opposite senses. Using the calculated radius, I have incorporated the rotation of the two semi-photons that make up the binary photon into the wave equation that describes the time-varying positions ( $\phi$ ) of the two semi-photons:

$$\begin{bmatrix} \phi_{leading}(t) \\ \phi_{following}(t) \end{bmatrix} = \begin{bmatrix} \frac{\lambda}{2\pi} \cos(2\pi vt) & -\frac{\lambda}{2\pi} \sin(2\pi vt) & ct + \frac{\lambda}{4}(1 - \cos(2\pi vt)) \\ -\frac{\lambda}{2\pi} \cos(2\pi vt) & -\frac{\lambda}{2\pi} \sin(2\pi vt) & ct - \frac{\lambda}{4}(1 - \cos(2\pi vt)) \end{bmatrix} \begin{bmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \end{bmatrix}$$

The velocities of the two particles can also be modeled by taking the derivative of the predicted positions of the semi-photons with respect to time.

$$\begin{bmatrix} v_{leading}(t) \\ v_{following}(t) \end{bmatrix} = \begin{bmatrix} -c \sin(2\pi vt) & -c \cos(2\pi vt) & c + \frac{\pi c}{2} \sin(2\pi vt) \\ c \sin(2\pi vt) & -c \cos(2\pi vt) & c - \frac{\pi c}{2} \sin(2\pi vt) \end{bmatrix} \begin{bmatrix} \hat{x} \\ \hat{y} \\ \hat{z} \end{bmatrix}$$

The three-dimensional internal movements of the binary photon look like  
so:

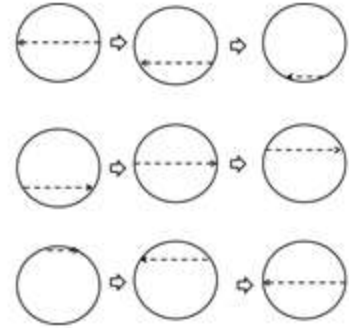


The **spinning and oscillating masses** of a binary photon not only allow us to visualize what is spinning and why nearby photons can interfere, but once we take the charges of the spinning masses into consideration we can also visualize and understand the **electromagnetic wave-like property of polarization**. Using a form of **Coulomb's Law** that has been generalized for positive and negative

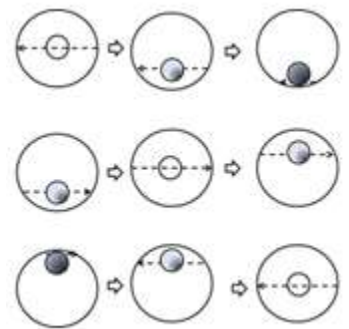


masses, we find that the electric field vectors from a positive mass with a positive charge points away from the center and the electric field vectors from a negative mass with a negative charge points towards the center.

As the two conjugate particles of the binary photon rotate, their electric fields are **superimposed**. At 0 (N) and 180 (S) degrees, the electric field vectors **destructively interfere** and at 90 (E) and 270 (W) degrees, the electric field vectors **constructively interfere** to give a linearly polarized wave. The azimuth of polarization of the binary photon depends on the azimuth of the line between the two particles of the binary photon when they are maximally separated. The **electric fields** are obtained from the **position vectors** of the semi-photons and the **magnetic fields** are obtained from their **velocity vectors**.

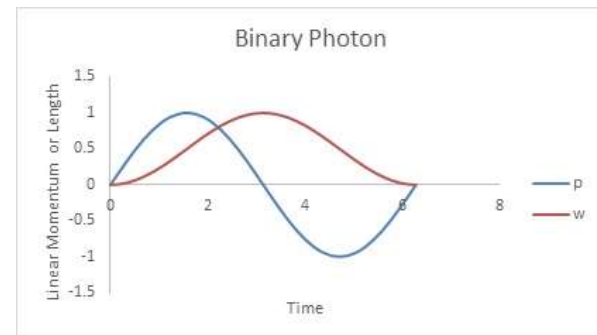


The longitudinal electric field can also be presented in terms of the distance between the semi-photons and the longitudinal magnetic field can also be presented as the product of the masses and velocities (i.e. linear momentum) of the semi-photons.



While the energy, linear momentum and angular momentum of the photon must be constant in three dimensions, the longitudinal length and linear momentum of the binary photon vary over a cycle of vibration.

The time-varying wavelength ( $w$ ) and linear momentum ( $p$ ) of the binary photon may provide the **hidden variables** that allow the complete description of optical processes that was heretofore enshrouded in a mathematical point. A precisely defined state of the linear momentum and the position of the binary photon can be calculated in



principle. The product of the velocity variation ( $\frac{\pi c}{2} + \frac{\pi c}{2} = \pi c$ ) along the axis of propagation of the binary photon and its mass ( $\frac{hc}{\lambda c^2}$ ) gives its variation in linear momentum ( $\Delta p = \left(\Delta \frac{hc}{\lambda c^2} \pi c\right)$ ). The product of the variation in linear momentum and the variation in the length ( $\Delta z = \Delta \lambda$ ) of the binary photon along the axis of propagation results in an equation comparable to the uncertainty relation:

$$(\Delta \lambda) \left(\Delta \frac{hc}{\lambda c^2} \pi c\right) = \pi h$$

Since the two rotating semi-photons are in a plane including the propagation axis only twice during a cycle ( $\frac{2}{2\pi}$ ), then the product of the length variation and the momentum variation in the plane that includes the axis of propagation is:

$$(\Delta \lambda) \left(\Delta \frac{hc}{\lambda c^2} \pi c\right) \left(\frac{2}{2\pi}\right) = h$$

This is exactly the form and the result introduced by Heisenberg to describe the reciprocal relationship between momentum and position. Heisenberg called the relationship the Principle of *Umbestimmtheit*, which could stand for the Principle of Indeterminacy, Indefiniteness or Uncertainty in the following equation:

$$\Delta p \Delta z = h$$

where  $\Delta$  represents the uncertainty due to the wave nature of light. After multiplying by  $1 = \frac{c}{c}$ , we get:  $\Delta p c \Delta \frac{z}{c} = \Delta E \Delta t = h$ , which is interpreted to mean that energy ( $\Delta E$ ), even a universe, can be **created out of nothing** for a short time ( $\Delta t$ ) as long as the product of energy and time is equal to Planck's constant.

The Principle of Uncertainty has led to the counterintuitive elevation of chance and the promotion of paradoxical interpretations of reality supported by the maxim “*shut up and calculate*” (Mermin 1989). The Uncertainty Principle has also replaced the **Principle of Causality** and led to the Copenhagen interpretation of

quantum mechanics. The binary photon fulfills the hope of Louis De Broglie (1957) who wrote “*It is possible that looking into the future to a deeper level of physical reality we will be able to interpret the laws of probability and quantum physics as being the statistical results of the development of completely determined values of variables which are at present hidden from us.*” The way linear momentum and length vary and the way the transverse electric and longitudinal magnetic fields oscillate above and below the axis of propagation may provide the hidden variable that will result in a return to the Principle of Causality. Could the binary photon lead to the **real thing** that Einstein referred to when he wrote to Born on December 4, 1926: “*Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the ‘old one’ . I, at any rate, am convinced that He is not playing at dice.*” The lack of causality that quantum mechanics brought to physics worried Einstein for the rest of his life. On December 22, 1950, we wrote to Schrödinger:

*Dear Schrödinger,*

*You are the only contemporary physicist besides Laue, who sees that one cannot get around the assumption of reality—if only one is honest. Most of them simply do not see what sort of risky game they are playing with reality—if only one is honest. Most of them simply do not see what sort of risky game they are playing with reality—reality as something independent of what is experimentally established. They somehow believe that the quantum theory provides a description of reality, and even a complete description; this interpretation is, however, refuted, most elegantly by your system of radioactive atom + Geiger counter + amplifier + charge of gun powder + cat in a box, in which the  $\psi$ -function of the system contains the cat both alive and blown to bits. Is the state of the cat to be created*

*only when a physicist investigates the situation at some definite time? Nobody really doubts that the presence or absence of the cat is something independent of the act of observation. But then the description by means of the  $\psi$ -function is certainly incomplete, and there must be a more complete description. If one wants to consider the quantum theory as final (in principle), then one must believe that a more complete description would be useless because there would be no laws for it....But it seems certain to me that the fundamentally statistical character of the theory is simply a consequence of the incompleteness of the description. This says nothing about the deterministic character of the theory; that is a thoroughly nebulous concept anyway, so long as one does not know how much has to be given in order to determine the initial state....*

*Best regards! Yours,*

*A. Einstein*

The binary photon model describes and explains **why light moves**, why electromagnetic radiation shows the **wave-particle duality**, why **short wavelength** light behaves more like a **particle** and why **long wavelength** light behaves more like a **wave**, the ability of light to interfere, and why light is **polarized** and it provides a path to the **Principle of Causality** from the **Uncertainty Principle**. I agree completely with Einstein's view that the uncertainty principle is not fundamental and the laws of quantum mechanics are incomplete. However, I also believe that the Special Theory of Relativity is not fundamental, as I will describe below. The wave-like nature of the binary photon is also subject to the **Doppler effect** discovered by **Christian Doppler**.



Curiously, even though the Doppler effect is readily perceived when there is relative motion, whether one is looking at the water waves produced by a

swimming swan, the water waves striking a cattail, the sound waves produced by the siren on a fire truck, or the light coming from a distant galaxy, standard theories rarely, if ever, include the Doppler effect as a primary consideration in the study and description of relative motion. The analyses done by my colleagues and me (Maers and Wayne, 2011; Maers et al., 2013) are unique in that we incorporate the second order Doppler effect from the beginning (Wayne, 2010).

Albert Einstein lived at a time when **fast moving coal-powered trains and telegraphic communication based on electromagnetic waves that traveled at**

**the speed of light** made time seem as if **time were relative**. Imagine someone living at that time who was one thousand miles away



telling you that their train or a telegram was going to arrive at 12 o'clock noon. Which 12 o'clock noon, the noon of the person telling you or the noon of the person waiting for the train or the telegram? Even worse imagine two trains were running towards each other on a single track without realizing that they could crash because they both thought the other would be there at a different time.

The confusion led to the creation of **standard time**, based on astronomical time reckoned at the Greenwich Observatory.

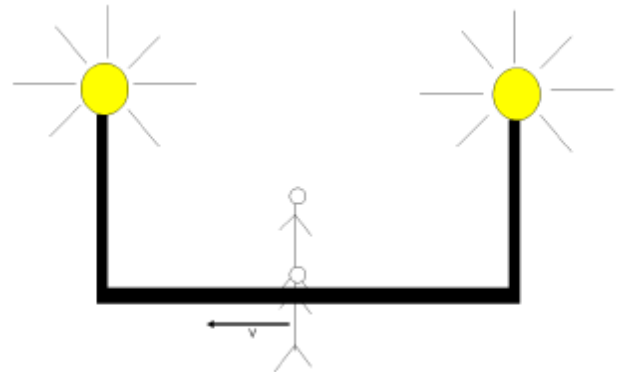




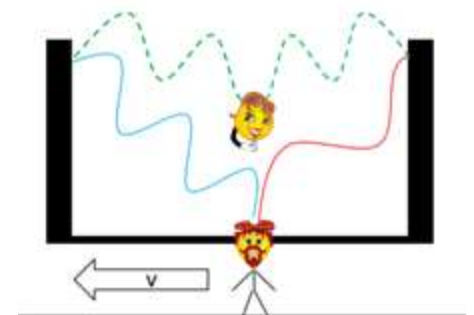
In his book *Relativity: The Special and the General Theory*, Albert Einstein (1920) used a **train analogy** to describe the foundations of the Special Theory of Relativity to a general audience in an intuitive nonmathematical way.

According to the **Special Theory of Relativity** time is relative. This was demonstrated by **Albert Einstein** by comparing the observations of a person on “a very long train travelling along the rails with the constant velocity  $v$ ” with the observations made by a person on a “railway embankment.”

Suppose that the observer in a railroad car midway between a lamp mounted on the back of the railroad car and an identical lamp mounted on the front of the railroad car saw the two lamps come on **simultaneously**, then the observer standing on the railway embankment, who is moving backwards at velocity  $v$  relative to the train would see the lamp on the back of the railroad car come on before the lamp on the front of the railroad car comes on. Since there was only one simultaneous event observed by the person on the train, but two non-simultaneous events observed by the person on the embankment, Albert Einstein concluded that time was relative and depended on the relative velocity of the observer.



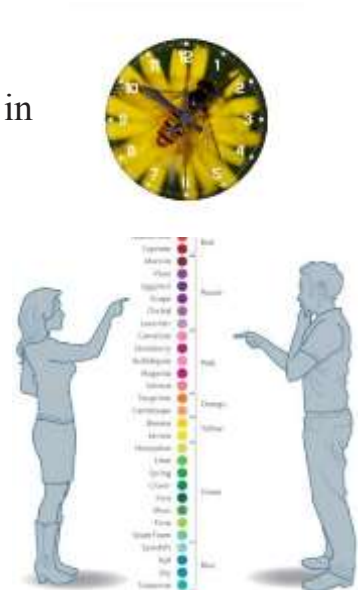
Working at a time when transformations between local times and standard time were being made by engineers and telegraph operators, Albert Einstein was immersed in the relativity of time. Combined with the fact that he considered light to be a mathematical point where wavelength was just a number, Albert Einstein considered the **relativity of time** to be a more reasonable explanation than the **relativity of color** due to the Doppler effect. By contrast,



I am immersed in a time of Doppler radar, Doppler weather, Doppler ultrasound and Doppler MRI. How could I not look at the train metaphor in terms of the Doppler effect and the relativity of color?

According to my theory (Wayne, 2010), if the person in the railroad car midway between the lamps on the back and front of the railway car sees the lamps come on simultaneously, he or she would see them to be the same color. By contrast the person on the embankment would see the lamp on the back of the train to be bluer and the lamp on the front of the train to be redder as a result of the Doppler effect and the relative motion between the train and the person on the railway embankment. While the velocities of the blue-shifted and red-shifted light are the same and equal to  $c$ , the speed of light in free space, the amplitude (or probability of finding a photon) of the blue-shifted wave arrives at the observer before the amplitude (or probability of finding a photon) of the red-shifted wave arrives at the observer. Consequently, the person on the platform would not observe the two lamps coming on simultaneously, but because of the difference in the wavelengths that results from the Doppler effect, the person on the railway embankment would observe the blue-shifted light from the lamp at the back before observing the red-shifted light from the lamp at the front.

By considering the Doppler effect as a fundamental consideration in deriving the **Laws of Nature**, I have described the relativity of simultaneity in absolute Newtonian time. My understanding of the **geological record** as well as my observations on the dependability of time for the **entrainment of flowering** in plants to the revolution of the earth around the sun, for the **bees' clocks to synchronize with the flowers' clocks**, and for entraining the **sleep-wake cycle** to the rotation of the earth makes me think that time is not fundamentally relative but

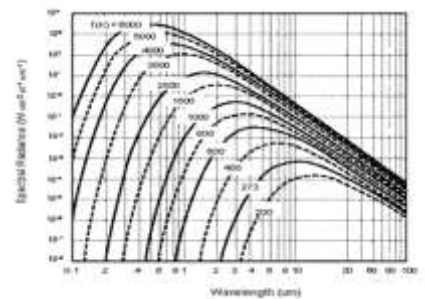


would exist even if there were no person to measure it. On the other hand, Albert Einstein, and most physicists since, considered the relativity of time to be a fundamental consideration in deriving the Laws of Nature and the **relativity of color due to the Doppler effect** to be a triviality.

The Doppler shift can be experienced everywhere. I bet you can tell the direction the elephant is walking from the Doppler shift in the water waves. The Doppler effect experienced by the binary photon can also be used to describe and explain why particles with a charge and/or a magnetic moment cannot go faster than the speed of light (Wayne, 2010). In order to calculate the number of Doppler-shifted photons that will collide with or scatter from the moving particle, we have to remember Max Planck's blackbody radiation law.



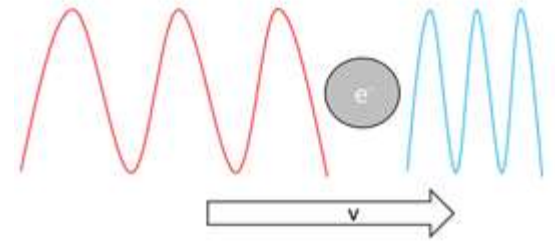
**Max Planck** discovered the function or law that related the **spectral distribution of light** emitted by a blackbody to its **temperature** and in doing so discovered the constant now known as Planck's constant.



According to **Max Planck's blackbody radiation law**, the greater the temperature of a cavity, the greater the number of photons in the cavity and the shorter their wavelength. This means that at any temperature greater than absolute zero, which according to the **Third Law of Thermodynamics** developed by **Walther Nernst**, is unattainable, there will be photons. This means that there will be binary photons in any space through which a particle with charge and/or magnetic moment moves.



If a particle is moving through a sea of photons, often called a **photon gas**, then the binary photons that collide with (particle terminology) or scatter from (wave terminology) the front of the moving particle will be blue shifted as a result of the



**Doppler effect** and the binary photons that collide with or scatter from the back of the moving particle will be red shifted as a result of the **Doppler effect**. Since the energy ( $E$ ) and linear momentum ( $p$ ) of the binary photons depend on their wavelength according to the familiar equations:

$$E = \frac{hc}{\lambda} \qquad p = \frac{h}{\lambda}$$

the blue-shifted binary photons that collide with or scatter from the front of a moving particle will push the particle backwards more than the red-shifted binary photons that collide with or scatter from the back of the moving particle will push the particle forwards. The faster the particle moves the greater is the **opto-mechanical counterforce** provided by the binary photons through which the particle moves. **This means light itself prevents a particle with charge and/or magnetic moment from moving faster than the speed of light.** This is why the limiting speed for particles with a charge and/or a magnetic moment is the vacuum speed of light. The speed of light is set by the electric permittivity ( $\epsilon_0$ ) and magnetic permeability ( $\mu_0$ ), the electrical and magnetic constants of the vacuum:

$$c = \sqrt{\frac{1}{\epsilon_0 \mu_0}}$$

A biologist knows that anything that moves has to move through some resistive medium whether it is a *Euglena* swimming, a substrate diffusing towards an enzyme or a chloroplast moving towards the brighter part of a cell. By

considering the Doppler effect to be fundamental in deriving the laws of physics, I have been able to describe and explain the opto-mechanical counterforce that prevents particles with a charge and/or magnetic moment from exceeding the speed of light in absolute Newtonian time.

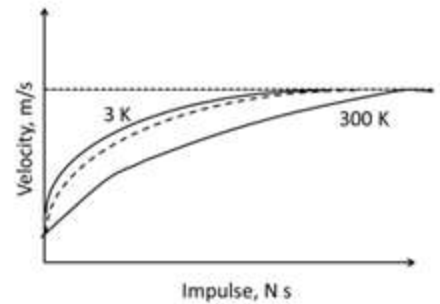
Einstein considered the relativity of time to be more fundamental to relative motion than the Doppler effect with its relativity of color. Consequently, by not considering the possibility that a moving particle must by necessity move through Doppler-shifted photons, Einstein concluded that particles do not go faster than the speed of light because time is relative. According to Einstein, the faster a particle goes, the shorter is the time it reckons the motive force to be accelerating it and the less it accelerates. The fact that the limiting speed of a particle is the same as the speed of light is not explained but given by fiat.



I have just provided you with the theory of the binary photon that eliminates the need to assume the **relativity of time and space as a fundamental truth** but requires you to assume the primacy of the Doppler effect along with the **relativity of color**, occurring in absolute Newtonian time and Euclidean space as a fundamental truth.

According the **opto-mechanical model** of how binary photons limit the speed of a moving particle to that of light, the greater the **temperature** of the space through which the particle moves, the greater the **number of binary photons** and the greater is the **opto-mechanical counterforce** or the **resistance** to acceleration. Consequently the opto-mechanical counterforce hypothesis is a testable hypothesis since the counterforce exerted on the moving particle increases with temperature. If the speed in which a particle is accelerated by a force *is not* temperature

dependent, then the Special Theory of Relativity gives a better explanation of the limiting speed of particles. If the speed in which a particle is accelerated by a force *is* temperature dependent, then my theory of the opto-mechanical counterforce provided by binary photons gives a better explanation of the limiting speed of particles. I really look forward to someone measuring the impulse-velocity relationship at 3 K and 300 K in a linear accelerator. According to the opto-mechanical counterforce theory, the force needed to accelerate a particle to a given velocity should be 10,000 times greater at 300 K than at 3 K.



There seems to be an undeniable **arrow of time** when we look at the geological record and the development of plants and animals, yet according to the standard model of physics, **time is an illusion** because the fundamental equations of physics do not have an arrow of time.

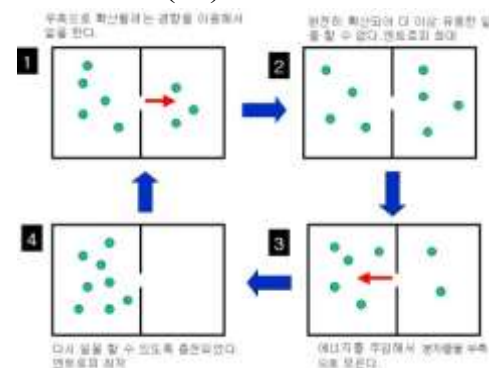
According to **Brian Greene** (2004), “*Even though experience reveals over and over again that there is an arrow of how events unfold in time, this arrow seems not to be found in the fundamental laws of physics.*” This is



because the reversibility of time is the

foundational assumption and **only** equations which are quadratic in time ( $t^2$ ) are

allowed to be called fundamental. This means that the fundamental equations also assume that friction does not exist and this is why the Second Law of Thermodynamics, which according to me foundationally describes and explains





the observed unidirectional arrow of time, is not considered to be a fundamental law of physics.

By including the opto-mechanical counterforce produced by Doppler-shifted binary photons that affects any object composed of particles with a charge (e.g. electrons, protons) and/or a magnetic moment (e.g. neutrons), I have been able to combine **Newton's Second Law of Motion** with the **Second Law of Thermodynamics** to produce a fundamental, relativistic and irreversible law of motion (Wayne, 2012). It states that **processes are irreversible** because of the opto-mechanical Doppler force that radiates away binary photons, particularly in the infrared that collide with or are scattered by any moving object. These binary photons cannot be rounded up to reverse the natural process.

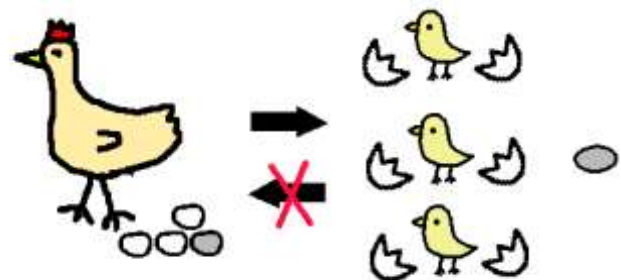
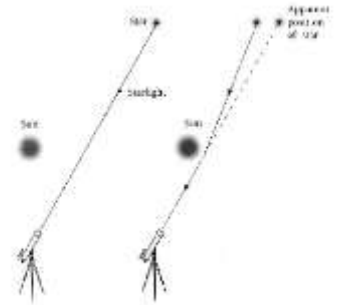
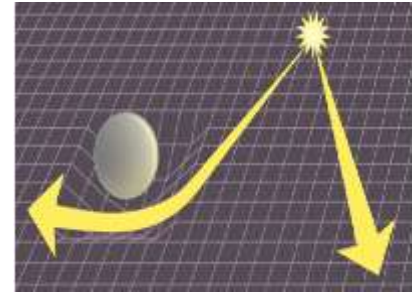


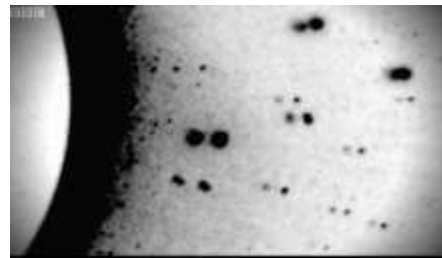
Figure 3

Since the Doppler effect was so useful as an alternative explanation of the kinematics of the relativity of simultaneity, and the Dopplerized binary photon was so useful as an alternative description and explanation of the dynamics involved in the limiting speed of light and why natural processes show an arrow of time even though the fundamental equations of physics do not, I have recently put the model of the binary photon to a test by describing and explaining the observed magnitude of the **gravitational deflection of starlight**—the *experimentum crucis* in favor of the General Theory of Relativity, in terms of the binary photon.

By assuming that the gravity was not a Newtonian force that influenced massive objects directly, but that gravity influenced the movement of mathematical point-like objects by **warping an interdependent space-time**, through which they moved, Albert Einstein predicted that starlight would be bent by the sun twice as much as was predicted by Johann von Soldner (1801) using the Newtonian Model that gravity is a force that interacts with massive particles and that light itself was corpuscular.



**World War I** prevented the planned test of the two models. Almost immediately after the armistice, **Arthur Eddington** turned his telescope towards the heavens and measured the deflection of sunlight by comparing the positions of stars near the sun made visible during the day as a result of a solar eclipse with the positions of the same stars at night.



Arthur Eddington measured that the deflection of sunlight was exactly what Albert Einstein had predicted and this led to the acceptance of the General Theory of Relativity that was based on the assumption that space and time are interdependent and relative. Arthur Eddington (1919) wrote to Albert Einstein “...all of England has been taken by your theory. It has made a tremendous sensation. It is the best possible thing that could have happened for scientific relations between England and Germany.” John Burdon Sanderson Haldane (1924), of peppered moth fame, wrote “I do not doubt that he [Einstein] will be believed. A prophet who can give signs in the heavens is always believed....Einstein has told us that space, time, and matter are shadows of the fifth dimension, and the heavens have declared their glory.” The New York Times covered the news:



**The New York Times.**

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ECLIPSE SHOWED  
GRAVITY VARIATION

Diversions of Light Rays Accepted as Affecting Newton's Principles.

HAILED AS EPOCHMAKING

British Scientist Calls the Discovery One of the Greatest of Human Achievements.

Copyright, 1919, by The New York Times Company.  
Special Cable to THE NEW YORK TIMES.

LONDON, Nov. 8.—What Sir Joseph Thomson, President of the Royal Society, declared was “one of the greatest—perhaps the greatest—of achievements in the history of human thought” was discussed at a joint meeting of the Royal Society and the Royal Astronomical Society in London yesterday, when the results of the British observations of the total solar eclipse of May 29 were made known.

**The New York Times.**

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LIGHTS ALL ASKEW  
IN THE HEAVENS

Men of Science More or Less Agog Over Results of Eclipse Observations.

EINSTEIN THEORY TRIUMPHS

Stars Not Where They Seemed or Were Calculated to be, but Nobody Need Worry.

A BOOK FOR 12 WISE MEN

No More in All the World Could Comprehend It, Said Einstein When His Daring Publishers Accepted It.

Thompson states that the difference between theories of Newton and those of Einstein are infinitesimal in a popular sense, and as they are purely mathematical and can only be expressed in strictly scientific terms it is useless to endeavor to detail them for the man in the street.

“What is easily understandable,” he continued, “is that Einstein predicted the deflection of the starlight when it passed the sun, and the recent eclipse has provided a demonstration of the correctness of the prediction.”

**The New York Times.**

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JAZZ IN SCIENTIFIC WORLD

Prof. Charles Lane Poor of Columbia Explains Prof. Einstein's Astronomical Theories.

“I have read various articles on the fourth dimension, the relativity theory of Einstein and other psychological speculation on the constitution of the universe; and after reading them I feel as Senator Brandegee felt after a celebrated dinner in Washington. ‘I feel,’ he said, ‘as if I had been wandering with Alice in Wonderland and had tea with the Mad Hatter.’”

# The New York Times.

NEW YORK, TUESDAY, NOVEMBER 15, 1916. THIRTY-TWO PAGES.

## A NEW PHYSICS, BASED ON EINSTEIN

Sir Oliver Lodge Says It Will Prevail, and Mathematicians Will Have a Terrible Time.

## SPACE OF FOUR DIMENSIONS

In Which Gravity Ceases to be a Force and Becomes a Quality.

## ATTEMPT TO MEASURE IT

Its Radius Put at 10,000,000 Light-Years, or 50 Times the Distance to Farthest Star Cluster Known.

So complicated has this revolutionary theory proved that even some of the most learned have been confounded.

Hence the new physics, declared Sir Oliver, required our co-ordinates, not merely length, breadth, and thickness, but time. Gravity, too, ceases to become a force but becomes a quality in a fourth dimensioned space.

# The New York Times

NEW YORK, TUESDAY, NOVEMBER 15, 1916. THIRTY-TWO PAGES.

## As all common folk are Amateurs suavely informed by the Will Be President of the Royal Resentful. Society that Dr. EIN- STEIN'S deductions from

the behavior of light as observed during an eclipse cannot be put in language comprehensible to them, they are under no obligations to worry their heads, already tired by contemplation of so many other hard problems, about this addition to the number. Still, al-

# The New York Times.

NEW YORK, MONDAY, DECEMBER 5, 1916. 16 PAGES.

## GIVEN THE SPEED, TIME IS NAUGHT

If Man Moved with the Velocity of Light He Might Remain Unchanged for 1,000 Years.

## THE THEORY OF RELATIVITY

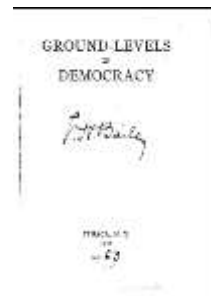
Among Other Things, It Makes Simultaneity of Two Widely Separated Events Impossible.

clearly. We shall find it leads to a world confused with a certain topsyturviness; but if these English scientists are right in feeling that the theory is strongly supported we may be forced to conclude after all that our world is in just such a topsy-turvy condition, and that we must learn the theory of relativity in order to understand it.

The *New York Times* reported that “if those English scientists are right in feeling that the theory is strongly supported we may be forced to conclude after all that our world is in just a topsy-turvy condition, and that we must learn the theory of relativity to understand it.” Unfortunately, they also

reported that “As all common folk are suavely informed by the President of the Royal Society that Dr. Einstein’s deductions from the behavior of light observed during an eclipse cannot be put in language comprehensible to them, they are under no obligation to worry their heads, already tired by contemplation of so many other hard problems....” It seemed that the common

folk would never again be able to understand the world unless they joined the 12 wise men who could understand the Theory of General Relativity. This elitist attitude was quite a change from Liberty Hyde Bailey’s (1916) who



promoted the people's understanding of science and the scientific spirit as a way to promote democracy.

According to **Subramanya Chandrasekhar**, Ernest Rutherford told him on May 29, 1919, *“The war had just ended, and the complacency of the Victorian and Edwardian times had been shattered. The people felt that all their values and all their ideals had lost their bearings. Now, suddenly, they learnt that an astronomical prediction by a German scientist had been confirmed...by British astronomers. Astronomy had always appealed to public imagination; and **an astronomical discovery, transcending worldly strife, struck a responsive chord.** The meeting of the Royal Society, at which the results of the British expeditions were reported, was headlined in all the British papers: and the typhoon of publicity crossed the Atlantic. From that point on, the American press played Einstein to the maximum.”*



Do the eclipse results show unequivocally that *“space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality.”* Could a rational person still believe that time and space are absolute and independent? I will show you that the model of the binary photon moving through absolute Newtonian time and Euclidean space predicts the **double deflection—the same observed result** predicted by Albert Einstein's General Theory of Relativity using an interdependent spacetime.

Since the binary photon has angular momentum and radial extension, then it must have rotational motion, which means rotational energy. Thus I applied the **equipartition theory** which was originally introduced by **Rudolf Clausius** to explain the specific heat of diatomic gasses to the binary photon.

I assume that the total energy of the photon is **equally partitioned** between the **translational energy** and the **rotational energy**.

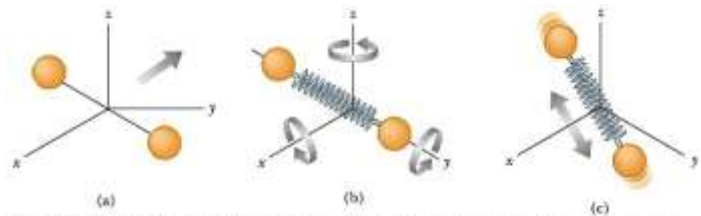
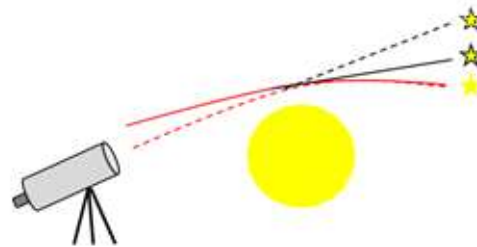


Figure 21.6 Possible motions of a diatomic molecule: (a) translational motion of the center of mass, (b) rotational motion about the various axes, and (c) vibrational motion along the molecular axis.



If the total energy of a binary photon is equipartitioned between the translational energy and the rotational energy, then the binary photon would have one-half of the expected translational energy. If a binary photon had infinite translational energy, it would not bend. If a binary photon had zero translational energy, it would fall into the sun.



If a binary photon had one-half the expected translational energy because half of its total energy is partitioned into rotational energy, it would bend twice as much in a gravitational field and exhibit a double deflection—consistent with observation.

That is, my model of the binary photon that travels through **absolute space and time** gives the same prediction as Albert Einstein's General Theory of Relativity which assumes that mathematical point-like photons travel through an interdependent and relative space-time. Thus there is no need to assume that spacetime is relative.

The complexity of a spacetime that cannot be pictured resulted from a simplistic version of light that did not take the Doppler effect expanded to second order into consideration and considered the angular momentum to be merely a number. The General Theory of Relativity, as complicated as the mathematics is,



skimped on the assumptions. The simplistic assumptions led to complications in the results and made a pictorial understanding of the results impossible. Again you get to choose what you consider reality to be and choose which Laws of Nature you think approximate reality better. And remember what Lorentz (1923) said in a lecture given at the Royal Institution, *“One of the lessons which this history of science teaches us is surely this, that we must not too soon be satisfied with what we have achieved. The way of scientific progress is not a straight one which we can steadfastly pursue. We are continually seeking our course, now trying one path and then another, many times groping the dark, and sometimes even retracing our steps. So it may happen that ideas, which we thought could be abandoned once for all, have again to be taken up and come to new life.”*

One more complication. The old idea of linear momentum of the photon was developed by Johannes Stark and the old idea of the Doppler effect as it was applied to was developed by Philipp Lenard. These two became horrible Nazis who persecuted Jewish scientists. Together (1924) they wrote, *The Hitler Spirit and Science*, in which they discussed the unique spirit carried in the Aryan-German blood—the *“spirit of total clarity, of honesty towards the outer world, and at the same time inner uniformity; that spirit which hates any compromising activity because it is insincere. But we have already recognized early on and revered this—to us exemplary—spirit in the great scientists of the past as well: in Galileo, Kepler, Newton, and Faraday. We admire and revere it in the same way also in Hitler....”* Lenard (1935) wrote in the *Forward* to his *German Physics*, *“In reality, as with everything that man creates, science is determined by race or by blood....It is important to examine the ‘physics’ of the Jewish people a bit here, because it stands as a conspicuous counterpart to German physics, and because for many, the*



latter will only be brought into the right light by identifying its opposite. As with everything Jewish, Jewish physics also only recently came under some unbiased public scrutiny. It has remained hidden for a long time and developed haltingly. At the end of the war when Jews in Germany began to dominate and to set the tone, the full force of its characteristics suddenly burst like a flood. It then promptly found avid supporters even among many authors of non-Jewish or of not really pure Jewish blood. To characterize it briefly, let me best refer you simply to the activities of its undoubtedly most prominent representative, to the unquestionably pure-blooded Jew A. Einstein. His 'relativity theories' attempted to transform and dominate the whole of physics; but they have now already completely played themselves out against reality. Apparently they never were even intended to be **true**. The Jew conspicuously lacks any understanding of **truth** beyond a mere superficial **agreement with reality, which is independent of human thought**. This is in contrast to the Aryan scientist's drive, which is as obstinate as it is serious in its quest for truth. The Jew has no noticeable capacity to grasp reality in any form other than as it appears in human activity and in the weaknesses of his host nation. Astonishingly, truth and reality do not appear to be anything at all special or different from untruth to Jews, but are equivalent to any one of the many different theoretical options available. It is obvious that this attitude is thus totally inappropriate for science; yet this fact was concealed through computational tricks.... Jewish 'physics' is therefore only an illusion and a degenerate manifestation of fundamental Aryan physics." Should I drop my research because it follows in the footsteps of Nazis—something that is definitely not politically correct? Do Lenard's words have both value and limitations? Is the search for the truth about light more or less important than the politics of science? Would the success of my work denigrate Jews and justify Nazis? Wait a minute I am Jewish and I believe that the Nazis were the epitome of evil on earth.

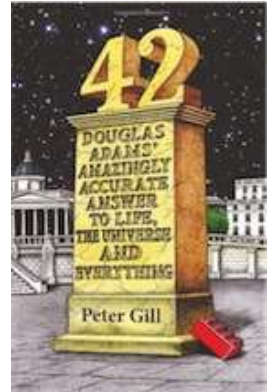
The fact that my model of the binary photon is consistent with physical observations and the biological understanding of time satisfies me. I also teach the value of questioning authority to fight against any form of totalitarianism.

In the first lecture I also told you that I love science and the ability of the scientific method for helping us question, understand, and appreciate the world around us. I am a staunch supporter of questioning any and all authority in order to help us understand and appreciate the world around us (and prevent totalitarianism). I told you that I would try to provide you with as much personal experience as possible concerning light and life so that you do not have to believe a single thing I say but have enough experience to trust your knowledge while understanding both the value and limitations of what you know. I then presented Goethe's phrase, *Thatige Skepsis*, which was defined by T. H. Huxley as "*An Active Skepticism in what which unceasingly strives to overcome itself and by well directed Research to attain to a kind of Conditional Certainty.*" On the right is a reproduction of Huxley's quote on the inside back cover of the notebook that contained his diary. It can be found in the book, *T. H. Huxley's Diary of the Voyage of H.M.S. Rattlesnake*, edited by his grandson, Julian Huxley.

A DIARY OF THOMAS HENRY HUXLEY  
The second, here reproduced in facsimile, is the quotation inscribed by Huxley on the inside back cover of the notebook containing the Diary. It is so intensely characteristic of his attitude of mind throughout his active life that I can think of no fitter end to this volume.

*"Thatige Skepsis"*  
*"An Active Skepticism in that which unceasingly strives to overcome itself and by well directed Research to attain to a kind of Conditional Certainty."*

We have to be aware of the difference between reality and the Laws of Nature that describe reality. We also have to be aware of the simplifications used to derive the Laws of Nature when we apply them to our lives. This reminds me of a story from *The Ultimate Hitchhiker's Guide to the Galaxy* by Douglas Adams: “Forty-two!” yelled Loonquawl. “Is that all you’ve got to show for seven and a half million years’ work?” I checked it very thoroughly,” said the computer, “and that quite definitely is the answer. I think the problem, to be quite honest with you, is that you’ve never actually known what the question is.” “But it was the Great Question! The Ultimate Question of Life, the Universe and Everything,” howled Loonquawl.



This quantitative answer is too reductionist and unsatisfying for me. Which reminds me of another story. When Max Born’s wife Hedwig asked Einstein, “Do you believe that everything can be pictured in a scientific [mathematical] manner?” Einstein answered, “Yes, it is conceivable but it would be of no use. It would be an inadequate means of expression—like representing a Beethoven symphony in terms of curves of air pressure” (Born 1965).



Perhaps the answer to the ultimate question is a little more subtle and close to home as Victor Frankl (1959) wrote about his time in Auschwitz when he connected light and life: “Another time we were at work in a trench. The dawn was grey around us; grey was the sky above; grey the snow in the pale light of dawn; grey the rags in which my fellow prisoners were clad, and grey their faces. I was again conversing



*silently with my wife, or perhaps I was struggling to find the reason for my sufferings, my slow dying. In a last violent protest against the hopelessness of imminent death, I sensed my spirit piercing through the enveloping gloom. I felt it transcend that hopeless, meaningless world, and from somewhere I heard a victorious ‘Yes’ in answer to my question of the existence of ultimate purpose. At that moment a light was lit in a distant farmhouse, which stood on the horizon as if painted there, in the midst of the miserable grey of a dawning morning in Bavaria. ‘Et lux tenebris lucet’—and the light shineth in the darkness. For hours I stood hacking on the icy ground. The guard passed by, insulting me, and once again I communed with my beloved. More and more I felt that she was present, that she was with me; I had the feeling that I was able to touch her, able to stretch out my hand and grasp hers. The feeling was very strong: she was there. Then, at that very moment, a bird flew down silently and perched just in front of me, on the heap of soil which I had dug up from the ditch, and looked steadily at me.”*

In the first lecture we also discussed the historical and cultural relationship between light and truth. **Isaac Newton** wrote in *The First Book Concerning the Language of the Prophets*, “Light—for the glory, truth and knowledge wherewith great and good men shine and illuminate others.” What kind of knowledge did Newton illuminate? Newton (1687) wrote in the General Scholium of his *Principia*, “This most beautiful system of the sun, planets, and comets, could only proceed from the counsel and dominion of an intelligent and powerful being...and from his true dominion it follows that God is a living, intelligent, and powerful being.”



**Thomas Jefferson**, who along with the other founders used the Laws of Nature crafted by Isaac Newton to craft a government, wrote *“The most effectual means of preventing the perversion of power into tyranny are to illuminate, as far as practicable, the minds of the people . . . . Light and liberty go together. I look to the diffusion of light and education as the resource most to be relied on for ameliorating the condition, promoting the virtue, and advancing the happiness of man. Enlighten the people generally, and tyranny and oppressions of body and mind will vanish like evil spirits at the dawn of day.”*



I hope that my lectures have fulfilled James Clerk Maxell's goal as a teacher. In his inaugural lecture at King’s College, the 29 year old **James Clerk Maxwell** (1860) said *“In this class, I hope you will learn not merely results, or formulae applicable to cases that may possibly occur in our practice afterwards, but the principles on which those formulae depend, and without which the formulae are mere mental rubbish. I know the tendency of the human mind is to do anything rather than think. But mental labour is not thought, and those who have with labour acquired the habit of application often find it much easier to get up a formula than to master a principle....My duty is to give you the requisite foundation and to allow your thoughts to arrange themselves freely. It is best that every man should be settled in his own mind, and not be led into other men's ways of thinking under the pretence of studying science. By a careful and diligent study of natural laws I trust that we shall at least escape the dangers of vague and desultory modes of thought and acquire a habit of healthy and vigorous thinking which will enable us to recognise error in all the popular forms in which it appears and to seize and hold fast truth whether it be old or new.”*





In this class, I have tried to teach you how to think not what to think by providing you with observational evidence, historical and textural evidence and mathematical evidence to help you critically think about light and life so that you can define a set of Laws of Nature that you as a unique individual believe to be true in describing and explaining light and life.

**John Keats** worried that science destroyed our appreciation of the beauty in the world:

*Lamia* (excerpt from Part II)

*Do not all charms fly  
At the mere touch of cold philosophy?  
There was an awful rainbow once in heaven:  
We know her woof, her texture; she is given  
In the dull catalogue of common things.  
Philosophy will clip an Angel's wings,  
Conquer all mysteries by rule and line,  
Empty the haunted air, and gnomed mine -  
Unweave a rainbow, as it erewhile made  
The tender-person'd Lamia melt into a shade.*



I hope that the science I have taught you has enhanced your appreciation of the beauty, design and meaning found in the real and natural world. And I believe that the natural world that exists in real space and real time is real.

I want you to know the prelude to the song, *As Time Goes By* written by Herman Hupfeld in 1931. Unfortunately, the prelude is not well known since it was left out of the most famous version of *As Time Goes By* sung by Dooley Wilson in *Casablanca*. The prelude reminds us that, when it comes to time, biology trumps physics and “*The simple facts of life are such They cannot be removed...*”

*As Time Goes By* (Words and Music by Herman Hupfeld)

*This day and age we're living in  
Gives cause for apprehension  
With speed and new invention  
And things like fourth dimension.  
Yet we get a trifle weary  
With Mr. Einstein's theory.  
So we must get down to earth at times  
Relax relieve the tension*

*And no matter what the progress  
Or what may yet be proved  
The simple facts of life are such  
They cannot be removed...*



It can be heard in other versions sung by Mavis Rivers  
<https://www.youtube.com/watch?v=B2WwilQbRZM>, Binnie Hale (1932)  
[https://www.youtube.com/watch?v=kx\\_hBIHoIaw](https://www.youtube.com/watch?v=kx_hBIHoIaw),  
Rudy Vallee <https://www.youtube.com/watch?v=vm-vwjnUNmo>,  
Tony Bennett [https://www.youtube.com/watch?v=qj\\_EEZHaMEQ](https://www.youtube.com/watch?v=qj_EEZHaMEQ) and  
Johnny Mathis <https://www.youtube.com/watch?v=7-v1N8MAe84>.

Bishop Berkeley (1710) wrote “*But, say you, surely there is nothing easier than for me to imagine trees, for instance, in a park... and nobody by to perceive them.... The objects of sense exist only when they are perceived; the trees therefore are in the garden...no longer than while there is somebody by to perceive them.*”

James Boswell (1833) told the following story in *Life of Samuel Johnson*: “*After we came out of the church, we stood talking for some time together of Bishop Berkeley's ingenious sophistry to prove the non-existence of matter, and that every thing in the universe is merely ideal. I observed, that though we are satisfied his doctrine is not true, it is impossible to refute it. I never shall forget the alacrity with which Johnson answered, striking his*



*foot with mighty force against a large stone, till he rebounded from it, 'I refute it  
THUS. '''*

And an electron is there whether someone is there to measure it, the moon is there whether someone is there to see it, and a tree does make a noise when it falls whether someone is there to hear it or not. Ronald Knox provided an answer to why objects, such as electrons, the moon and trees exist in space and time, even if there is no human observer.

***God in the Quad*** by Ronald Knox

*There was a young man who said, "God  
Must think it exceedingly odd  
If he finds that this tree  
Continues to be  
When there's no one about in the Quad."*

***REPLY***

*Dear Sir:*

*Your astonishment's odd:  
I am always about in the Quad.  
And that's why the tree  
Will continue to be,  
Since observed by  
Yours faithfully,  
GOD.*

In the movie, ***Dead Poets Society*** (1989), **Robin Williams**, as John Keating, said, *"We don't read and write poetry because it's cute. We read and write poetry because we are members of the human race. And the human race is filled with passion. And medicine, law, business, engineering, these are noble pursuits and necessary to sustain life. But poetry, beauty, romance, love, these are what we stay alive for. To quote from Whitman, "O me! O life!... of the questions of these recurring; of the*



*endless trains of the faithless... of cities filled with the foolish; what good amid these, O me, O life?" Answer. That you are here - that life exists, and identity; that the powerful play goes on and you may contribute a verse. That the powerful play \*goes on\* and you may contribute a verse. What will your verse be?"*

**John Lubbock** (1893) began his essay on *The Beauties of Nature* with "We are told in the first chapter of Genesis that at the close of the sixth day 'God saw every thing that he had made, and, behold, it was very good.' Not merely good, but very good." **Louis Armstrong** (1967) sang it like this:



### **“What a Wonderful World”**

By George David Weiss and Bob Thiele (as George Douglas).



*I see trees of green, red roses, too,  
I see them bloom, for me and you  
And I think to myself  
What a wonderful world.*

*I see skies of blue, and clouds of white,  
The bright blessed day, the dark sacred night  
And I think to myself  
What a wonderful world.*

*The colors of the rainbow, so pretty in the sky,  
Are also on the faces of people going by.  
I see friends shaking hands, sayin', "How do you do?"  
They're really sayin', "I love you."*

*I hear babies cryin'. I watch them grow.  
They'll learn much more than I'll ever know  
And I think to myself  
What a wonderful world*

*Yes, I think to myself  
What a wonderful world*

*Oh yeah.*

<https://www.youtube.com/watch?v=E2VCwBzGdPM&feature=kp>  
<https://www.youtube.com/watch?v=2nGKqH26xlg>



We can use the images of light and life to explain many things. Mike Evans (Cornell, 1953) wrote a book entitled, *the mirror and the lamp: Romantic Theory and the Critical Tradition*. The title came from William Butler Yeats, who, in the *Introduction to The Oxford Book of Modern Verse*, wrote, “*The swing from Stendhal has passed Turner; the individual souls, the betrayal of the unconceived at birth, are among her principle themes, it must go further still; that soul must become its own betrayer, its own deliverer, the one activity, the mirror turn lamp.*”  
Be the lamp!



I will end the way John Milton (1667)  
began *Paradise Lost*:

*Illumine, what is low raise & support;  
That to the highth of this great argument  
I may assert eternal Providence,  
And justify the wayes of God to Men.*



Thank you for your time this semester and see you on Tuesday, May 17<sup>th</sup> at 9 AM in Trillium, when we will share our creative writing stories with each other.