DOUBTING DARWIN:

Considering Time And Natural Selection

By

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Abstract

This paper evaluates comments by Charles Darwin that nature granted time of long duration, time which was necessary for the workings of natural selection. Western Civilization's writings on time and attributes associated with it (nature, structure, shape, measure, duration, etc) do not demonstrate time as nature's product. Rather, historical sources subscribed to the presence of time and attributes produced by human activity. This activity is described here in terms of cultural continuity and cultural change. Examples from three historical periods support this proposition. After Macedonian and Roman conquests in Antiquity, known agents of acculturation fused philosophical speculations, conventions, and religious beliefs from different civilizations to create a variety of Pagan concepts of time and attributes. Following Christianity's ascension in Rome's Empire, Christian reinterpretations of Pagan beliefs accepted the presence of time and its attributes, but replaced Pagan content with expressions of Christian faith. In post-Renaissance Europe, Christian denominations held to a Christian concept of time, albeit with altered attributes, while natural philosophers accepted the presence of time and reinterpreted it and its attributes by replacing some Christian content with increasingly secular convictions, some of which were accepted as ecclesiastical doctrine. Given evidence that the presence of time and attributes associated with it are products of human activity (i.e., cultural continuity and cultural change), and absent any demonstrations to the contrary, doubting Darwin may be warranted

"We are prepared...to find that in *time*...the

confines of the universe lie beyond the reach of mortal ken."[1]

INTRODUCTION

The quote concerning time beyond mortal ken comes from Charles Lyell's concluding remarks in his *Principles Of Geology*. It is important here because Charles Darwin considered Lyell's conception of time as unquestionable fact.[2] In a letter to Asa Gray, an American naturalist, Darwin wrote that "We have almost unlimited time: no one but a practical geologist can fully appreciate this..."[3] In his *The Origin Of Species* Darwin estimated that "...in all probability a far longer period than 300 million years has elapsed since the latter part of the Secondary Period."[4] He enlarged on this by estimating a past that was "...incomprehensibly vast..."[5] This incomprehensible past beyond mortal comprehension contained infinite generations "...which the mind cannot grasp, must have succeeded each other over the long roll of years."[6]

In private correspondence Darwin wrote that natural selection depended on the presence of time of long duration because "...the power of selection stands in the most direct relation to time and in the state of nature can only be excessively slow."[7] In *Origins* he wrote that this time was given by nature: "Though nature grants vast periods of time for the work of natural selection, she does not grant an indefinite period."[8] Darwin made clear in these statements that the presence of time of long duration was granted by nature and that his theory of natural selection required such time.

But a review of the literature on time in Western Civilization does not demonstrate the presence of the kind of time Darwin required. Rather, historical literature provides evidence supporting the proposition that, in Western Civilization, time and the attributes associated with it (nature, structure, shape, measure, duration, etc) are products of human activity. This activity is described here in terms of cultural continuity and cultural change. Historical evidence is presented sufficient to establish the viability of this proposition and its description and to suggest that neither support Darwin's theory of natural selection.

Before giving evidence in support of this, some ideas governing presentation need mention. Edward Tylor, a British anthropologist of the late 19th century, defined culture for anthropology as "...that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits acquired by man as a member of society."[9] Cultural continuity is provided by people subscribing to the presence of time and its attributes throughout most of the history of Western Civilization. Cultural change describes how the contents of concepts of time and attributes associated with it were altered during Western Civilization's history. These changes are products of human activity, described here as acculturation, changes of cultural focus, reinterpretations consistent with those changes, and replacements of older content with newer. This descriptive framework comes from basic anthropology.[10] Finally, distinguishing between time and attributes associated with it elaborates on an observation made by Antiphon, a contemporary of Socrates. A fragment of Antiphon's writings observes that chronos, time in our translation, "...is both a conception (noema) and a measure (metron)."[11] The rest of the material presented here supports the proposition that time in Western Civilization is a product of human activity and not a presence granted by nature.

A SKETCH OF A CULTURAL HISTORY OF TIME IN WESTERN CIVILIZATION

Acculturation In Antiquity

Acculturation is considered a transfer of ideas, practices, or things from one cultural tradition to another. An example of acculturation is the rise of Asian martial arts in the United States. Prior to the mid-twentieth century, these sports were relatively unknown. Following World War II they became part of American culture. Similar acculturation occurred with concepts of time and attributes in Western Civilization's Antiquity.

Six cultural traditions figure in a discussion of time in Antiquity. Three were south of the Mediterranean Sea, the other three were north. While the southern traditions of Mesopotamia, Egypt, and Judaism wrote of what we call the past and the future, they seem to have had no concept of time as a presence encompassing all events. Rather, they had practices and beliefs that became, through acculturation, attributes associated with time. One tradition north of the Mediterranean Sea, Greece, had a concept of time as a presence encompassing all events, but did not develop—with one exception—transportable measures of time. With Macedonian conquests, Greek philosophical speculations about chronos (time) were linked to Mesopotamian and Egyptian practices and beliefs. The set of speculations, practices, and beliefs spread because astrology depended on astronomy. Other examples of acculturation, for example Julius Caesar's calendar, came with Roman conquests.

The first tradition to be considered resided in Mesopotamia. This is because history, written records, started at Sumer about 3,500 B. C. Sumerian writing, cuneiform script, was unique. Most surviving documents record business transactions. Basic to these fired clay

tablets was counting in sexagesimal form, a number system unique to Sumer.[12]

Sumer's cuneiform writing and sexagesimal numerical system were used by all political dynasties in Mesopotamian history and were basic in Mesopotamian astronomy and calendar making. In astronomy a 19 year lunar/solar cycle was known from the early 5th century B. C.[13] In 383 B. C. Kidinnu, a Babylonian astronomer, calculated 235 lunar cycles matched up with 19 solar years if extra months were stuck in at fixed intervals.[14] Other astronomers devised the 360^0 circle, the Zodiac, and fixed lines of solar latitude which, when transferred to earth, created the fictional equator, Tropic of Cancer, and Tropic of Capricorn.[15]

A second tradition of Antiquity, Egypt, created several different calendars. One calendar was lunar, another was based on Sirius's helical rise, and a third correlated lunar cycles and Sirius. The third calendar created a calendar of 12 months, each of 30 days, with an additional 5 days at the end of each calendar cycle. Egyptian religious leaders and their followers recognized the lunar/Sirius calendar fell short of the solar cycle, but resisted reform until Roman conquest.[16]

Egyptians of Antiquity divided daylight and dark into 12 equal parts because they believed in a "...strict symmetry between our world and the nether world...thus 12 hours of the night of the nether world ought to correspond to 12 hours of daylight for us."[17] Each hour "was under the guidance of a particular god..."[18] Lists of Gods and Goddesses vary. In one account Amseth governed the first hour of light, in another Nunut and Shu do so.[19] Daylight and dark were not of equal length save on the instant of equinox. Between equinoxes Egyptian hours varied in length depending on the season. These twenty four seasonal units were measured by water clocks, shadow clocks, and consecutive risings of various stars. Intervals between star risings were called "... *wnwt*, a term conventionally translated as 'hours.'"[20]

A third tradition, the Judaic, resided in territory between Mesopotamia and Egypt. Judaic Scriptures are the main source of information for this cultural tradition. Scriptures give a day by day account of creation, but contain "...no abstract philosophy of time."[21] Instead there are a number of words for an appointed time, right time, or right season.[22] This led to stressing the "...God-given content of certain moments of history" rather than conceptions of time.[23] Those certain moments mostly record Jehovah's actions with regard to his Chosen people's keeping or breaking covenant.

Something like a shadow clock is mentioned in Judaism's Scriptures. Hezekiah asked Isaiah for a sign of Yahweh's favor. They agreed to shadow moving backward as a sign. "So the prophet Isaiah called to the **LORD**; and he made the shadow which had descended on the dial of Ahaz recede ten steps."[24] The 'dial of Ahaz' and turning back ten steps seems a kind of shadow clock for daylight use while "...nights may have been divided into watches."[25]

An extra-Scriptural source, the Geezer calendar, listed 12 months and secular agricultural activities occupying them.[26] The Geezer calendar may have been used during the 10th century B. C.[27] After the Babylonian Captivity the Geezer calendar was replaced by Kidinnu's lunar/solar calendar.[28] In all, Judaism's Scriptures contains a story of creation and hints of a shadow clock. In addition, non-Scriptural sources mention an agricultural calendar and its replacement.

Documents from Ancient Greece reveal an abiding belief in chronos, a word we translate as time. Those documents also reveal a lack of agreement on the content of chronos and attributes associated with it. Plato's *Timaeus* was the first extended treatment of time in Western Civilization. The narrator, Timeaus, asked that "If we can furnish accounts no less likely than any other...we should...accept the likely story and look for nothing further."[29] Socrates,

normally a skeptic in Plato's writings, agreed and Timeaus proceeded.

A creator imposed number and geometrical proportion on pre-existing being, space, becoming, and four bits of stuff (fire, earth, water, and air) to create a biological cosmos "...a single visible living creature, containing within itself all living things..."[30] This living creature was "...one world alone, round and revolving in a circle..."[31] From this circular motion came time as Timeaus's creator:

> ...took thought to make, as it were, a moving likeness of eternity, and, at the same time that he ordered the Heaven, he made, of eternity that abides in unity, an everlasting likeness moving according to number—that to which we have given the name Time.[32]

The moving members of heaven were created to "...define and preserve the numbers of time[33] with the moon defining months and the sun the year.[34]

Aristotle, Plato's student, gave four versions of time in his *Physics.* The first version was to doubt time existed because neither past nor future existed and the "now," which separated past and future, was not part of time.[35] His second version linked time and change. He ended this account with a circular definition: "...we measure change by time, but we also measure time by change."[36]

His third and fourth versions of time involve human perception and cultural tradition. Time as a product of human perception began with use of a fable: those who sleep in the sanctuary of the heroes of Sardinia wake up and do not understand that time has passed because they have not noticed its passage.[37] This lack of understanding was due to not noticing change while asleep because "...without any change...in our minds, time does not seem to pass..."[38] Time, in human perception, was defined as "...a number of change in respect to before and

after..."[39] Time as number brought Aristotle to time as a product of human intelligence: "If nothing else except mind (and in particular the part of mind which is intelligence) is such that it can number, it is impossible for there to be time if there is no mind..."[40]

Time as cultural tradition resembles part of Plato's 'likely story'. Plato followed Greek astronomical tradition by describing the movements of moon and sun around a stable earth as defining months and years. Aristotle followed his teacher in his fourth version of time. "The reason, then, why people think of time as the change in the heavenly sphere is because all other changes are measured by this change."[41] This description, too, is circular: change requires time and time is measured by change.

Greek measures of chronos included gnomons, stable vertical rods astronomers used to measure the length and direction of the sun's shadow. They also used water clocks. By the 5th century B. C. Greek astronomers "...could divide the day and night up into twelve 'seasonal' hours that varied with the length of daylight."[42] Most people ignored gnomons and water clocks and divided "...the day and night into rough sections rather than precise hours."[43]

Ancient Greek calendars were seasonal. These calendars were marked by natural events—migratory birds passing overhead, stars rising and setting. Hesiod's *Works And Days*, for example, set out a seasonal calendar in poetic form. The swallow appeared when spring was just beginning,[44] the crane's voice gave signal for plowing and rainy weather.[45]

Other Greek calendars were tied to astronomical cycles centered on lunar/solar revolutions around a stable earth. However, Greek city-states maintained individual calendars of which our knowledge "...is surprisingly meagre."[46] A systematic lunar/solar calendar, the 19 year Metonic cycle, was probably derived from Mesopotamia because Meton, a Greek astronomer, followed Mesopotamian practice in placing "...equinoxes and solstices at 8^0 of their

respective zodiacal signs."[47] Documentation for this act of acculturation is not overwhelming. "No written work by Meton survives; and we have to reconstruct what did...such reconstruction involves some guesswork..."[48] A second Greek astronomer, Callippus (or Kallippus) altered Meton's 19 year cycle to create a solar year that contained 365.25 days.[49]

A fifth cultural tradition, Macedonia, dominated the world known to Greece during Aristotle's life. Alexander the Great, Aristotle's student, conquered large territories that included the Persian Empire and Egypt. Macedonian practice was to found cities of mixed populations. Within those cities a historical process called Hellenization, acculturation to anthropologists, took place as Greek conceptions incorporated local traditions. Well documented acculturation was evident in Hellenistic astronomy.

Two men, Hipparchus and Ptolemy, are textbook examples of acculturation. Hipparchus was the first Greek astronomer known to use Mesopotamian records.[50] These records were essential for his theory of lunar eclipses. In one of Ptolemy's accounts[51] of a lunar eclipse that Hipparchus described from Mesopotamian records, Hipparchus used an Athenian political event, an Athenian lunar month, an Egyptian month, Egyptian seasonal hours, the Mesopotamian Zodiac, and solar positions given in time degrees (i.e. four of our minutes[52]) that refer to positions in the Mesopotamian division of a circle into 360^0. For his own purposes, Ptolemy placed Hipparchus's account within his own historical scheme for assigning dates (the Basilon Canon, or King's List) and converted seasonal hours to equinoctial, or equal, hours. Equinoctial hours were based on the fiction of a mean solar day of exactly 24 equal hours measuring 360^0 of the heavens rotating around a stable earth. Ptolemy's Basilon Canon created a historical sequence to place numbers on cyclical astronomical processes.

Caesar's calendar is another example of acculturation affecting an attribute of time.

Julius Caesar decided that reform of Rome's traditional calendar was necessary. He followed guidance given by the astronomer Sosigenes. Sosigenes first advised that Caesar make the calendar reflect the seasons. So Caesar lengthened 46 B. C. to 445 days to set the start of the year at spring equinox. Sosigenes then advised that the start of the year be kept at spring equinox by inserting a day every four years. This created a Roman year of 365.25 days.[53] The only historical precedent for a 365.25 day year was Kallippus's reworking of Meton's 19 year lunar/solar cycle.

Caesar's calendar marked certain days as special. Many of these days celebrated Pagan Gods. With Christianity's triumph in Rome's world, Pagan celebrations were stricken from the calendar of 395 A. D. and replaced with Christian holidays.[54] This change marked an objective change in cultural focus and the beginning of Pagan time's Christian reinterpretation. This reinterpretation accepted time's presence, by replacing Pagan content with expressions of Christian faith.

Time In Western Christendom

St. Augustine wrote *Confessions* in 397-398[55] while serving as assistant Bishop of Hippo, now Bone, Algeria. In *Confessions* he began the Christian reinterpretation of Pagan concepts of time and attributes by replacing Pagan content with expressions of Christian faith. This began with his conceptualization of time as God's product. "No moment of time passes except by your will."[56] However, defining time confounded Augustine: "I know well enough what it is, provided no one asks me; but if I am asked and try to explain, I am baffled."[57]

To get beyond bafflement, Augustine asked how he could measure time. His answer

was “It is in my own mind, then, that I measure time. I must not allow my mind to insist that time is something objective....It can only be that the mind, which regulates this process, performs three functions, those of expectation, attention, and memory. The future, which it expects, passes through the present, to which it attends, into the past, which it remembers.”[58] This explanation may be the first completely subjective definition of time in Western Civilization.

Augustine kept his concept of time as God’s creation in his *The City Of God Against The Pagans*, but replaced his idea of subjective time with real, sacred time. God “...is the Creator and Ordainer of time...”[59] He also made clear that time’s presence came with creation of physical matter: “...the world was not made in time, but simultaneously with time.”[60] This creation is congruent with Plato's ‘likely story,’ but not with Judaism’s Holy Scriptures.

Augustine confronted this dilemma by equating Plato’s God of *Timeaus* with Judaism’s Jehovah. Augustine began his equation by writing of a trip he claimed Plato made to Egypt. During his stay, Plato was versed in Judaism’s Scriptures by an interpreter—which accounted for a “...certain resemblance...”[61] between *Genesis* and *Timeaus.* But Augustine's major reason for believing that *Timeaus* and *Genesis* described the same God was that both accounts described their respective Gods as immutable.[62] Further proof was that Plato’s God constructed the world according to numerical principals “And we read in our own Scriptures that it is said to God, ‘Thou hast ordered all things in number, and measure, and weight.”[63] By Augustine, the Gods of *Timeaus* and *Genesis* were the same because both were immutable and they created their worlds according to number.

Augustine’s choice to equate Gods of different traditions created an oxymoron. Christian belief retained Judaic tradition: an all powerful God created a universe *ex nihilo*, or from nothing. Traditional Pagan cosmologies, including Plato’s, saw God as a “...*demiourgos* or

craftsman..."[64] shaping existing materials according to a design. An all powerful God creating all from nothing cannot be equated with a Greek craftsman ordering existing material—yet one part of Augustine's argument relied on this identity.

Another difficulty attended Augustine's equation of creation as described in *Genesis* and *Timeaus.* Plato's craftsman created a biological universe, a living organism, and time together. Augustine used Plato's account to reinterpret Judaism's *Genesis.* This use of Pagan philosophy was warned against by the Apostle Paul and labeled heresy by Tertullian.[65]

Augustine also tried to help set Christian time's duration. He used Scripture to compute that a historical time of less than six thousand years had not "...passed since the creation of man."[66] He repeated this with "...six thousand years have not yet elapsed since the creation of the first man, called Adam."[67] But Augustine's computations were contradicted by Apostle Titus who, in Augustine's account, wrote of eternal times in the past.[68]

Augustine emphasized that Christianity's real, sacred, historical time was based on Scriptural doctrine. He quoted Origin, an early Church Father, who used a verse from *Ecclesiastes* to create a Christian version of circular time. Augustine rejected Origin. "God forbid, I say, that we should believe this. For Christ died for our sins once, and 'being raised from the dead dieth no more; death hath no more dominion over Him."[69] Further, "...by following the straight path of wholesome doctrine, we may escape I know not what false and circular paths discovered by wise men who are both deceived and deceiving."[70]

Augustine used the Alexandrian calendar to measure Antiquity's annual solar revolution.[71] But neither it, nor Caesar's calendar, was adequate for predicting the dates of Easter. In 525 Dionysius Exiguus (Dennis the Short), a Scythian monk residing in Rome, was asked by the Pope to design an ecclesiastical calendar capable of doing so. Dionysius did so by

extending a set of tables created by Cyril, an Alexandrian cleric. Dionysius added one element to Cyril's tables: Cyril numbered years after the Roman Emperor Diocletian; Dionysius numbered his years *Anno Domini* (Year of Our Lord) because he wanted the count of years to reflect Christian faith, not the regnal years of Pagan Emperors.[72] Since Caesar's calendar was inaccurate and the dates of Christ's incarnation (conception) and nativity (birth) are uncertain (Matthew and Luke gave events that, when dated by secular history, disagreed), Dionysius's Christian year count was based on faith.

Faith also determined the Venerable Bede's extension of Dionysius's year count. Bede's *The Reckoning Of Time* gave all matters necessary to calculate the Christian year and practical priests consulted Bede's tables for a given year *Anno Domini* to learn the Julian calendar date for Easter. In 1064, one year beyond Bede's calculations, Bede explained that his Great Paschal Cycle recurred every 532 years while the "...years of our Lord's Incarnation continue to increase in their particular column..."[73] Here a chronology of faith, the historical years since Christ's incarnation, perpetually gives Julian calendar year, month, and day numbers to circular ecclesiastical events that repeat every 532 years. Bede's calculation was the second use of history as a way of assigning numbers to cyclical events sketched here. The first was Ptolemy's Canon of Kings, which he used to assign numbers to cyclical astronomical events.

Bede also used dates before Christ. In his *Ecclesiastical History*, Bede wrote "Britain had never been visited by the Romans...before the time of Gaius Julius Caesar, who, in the 693 after the building of Rome, but the sixtieth year before incarnation of our Lord..."[74] Such specificity required a reliable date for the incarnation, but such was not available. Bede's 'before the incarnation of our Lord' expressed Christian faith, as did Dionysius's 'Year of our Lord'.

The acceptance of Christian time in Western Europe was linked to proselytizing activities

pursued by both warrior kings and priests. Clovis, a Frank, converted to Roman Catholicism in 496[75] and used Catholicism as one reason to war against other German tribes because "It grieves me that these Arians should hold part of Gaul."[76] His descendants ruled Gaul until Pepin II of Heristal replaced them in 687. Pepin, a Catholic, encouraged missionary work among Pagans. Willibrord, an English monk schooled in *Anno Domini* chronology, came to Pepin's court. *Anno Domini* chronology was taught to both Pagan converts and Frankish nobles.

One Frankish noble was Charlemagne. He used *Anno Domini* in royal documents. His second Saxon Capitulary read, in part, "In the 797th year of the incarnation of our Lord Jesus Christ..."[77] Charlemagne also required conquered Saxons to adopt Christianity. He issued a *Capitulary on the Region of Saxony* which read, in part "If anyone forms a plot with pagans against Christians or wishes to remain with them, in hostility to Christians, he is to be put to death; and whoever consents to this same action, in treachery against the king or the people of the Christians, is to be put to death."[78] Charlemagne's victories and his massacre of 4,500 prisoners at Verdun gave his words credibility.

A significant event in the annals of using *Anno Domini* chronology occurred in 967 when Pope John XIII used it to date papal documents "...but the employment of this dating system by the papal chancery remained sporadic until the pontificate of Nicholas II (AD 1058-1061)."[79]

But only in Christian Western Europe. In Northeastern Europe Lithuania resisted Christianity and its Northern Crusades until an arranged marriage between a ten year old Polish princess of Catholic faith and the Pagan Lithuanian King, Jogaila, led to his baptism. On March 4, 1386 Jogaila was crowned King of Poland and one religion, with one concept of time and its attributes, commanded allegiance in most of Western Europe. In Muslim Spain an Islamic conception of time and a calendar based on Mohammed's activities challenged Christianity until

Christian reconquest of Spain in 1492. Thereafter Christian time and its attributes were Western Europe's standard.

Modern Times

However, there was a problem with Christian time's ecclesiastical calendar—it gave erroneous dates for Easter. One proposed correction for this embarrassment was put forward by a Polish Catholic Priest, Nicolaus Copernicus. He proposed to gain accurate calendar dates for Easter by reforming an earth-centered astronomy. Using ideas first expressed by Pagan philosophers, Copernicus set out an astronomy centered on the sun.[80] The result was his *On The Revolutions of Heavenly Spheres.* Copernicus's book did not replace Ptolemaic astronomy, but it led Tycho Brahe, a Danish astronomer, to make thousands of observations, observations that Brahe lacked the mathematical and analytical skills to set in order. So Brahe hired Johannes Kepler, who was a near-sighted German unable to make astronomical observations himself, but had the abilities to create a mathematical description of Brahe's physical observations. Kepler's analysis compelled acceptance in scientific circles.

Ecclesiastical circles resisted altering Ptolemy's astronomy. In part resistance was due to Bruno, a monk who preached a sun-centered solar system based on an Egyptian religion of Antiquity. Bruno's heresy was seen as enough of a threat to Church teachings to merit burning at the stake. The Church also banned Copernicus's *Revolutions*. When Galileo used a sun-centered astronomy in his *Dialogue on the Two Chief World Systems*, the Church forced him to recant.

The Church solved its calendar dilemma by reforming Caesar's calendar internally. In 1578 Pope Gregory XIII sent an abstract of proposed calendar reform to Catholic Monarchs for review and approval. Approvals were given and on February 24, 1582 Gregory signed a Papal

Bull requiring his calendar reform be used in realms served by the Catholic Church.[81] With Britain's 1753 acceptance of Gregory's reform, Caesar's altered Pagan calendar marked Christian dates in Western Europe and in Western European colonies across the globe.

Despite reform, a minor embarrassment remained. Gregory's reformed calendar presents dates not in accordance with the solar year.[82] So Christian calendar dates remained in error, although in less error than dates based on Caesar's calendar.

A similar discrepancy surfaced in clock representations of numbers created by Hellenistic astronomers. Christiaan Huygens, a Dutch scientist, had a pendulum clock built to his specifications in winter, 1656-1657. Its face contained three dials.[83] In his description of his pendulum clock, Huygens identified one dial as marking 12 hours. Two complete cycles of the dial's pointer represented a 24 hour day, a grouping first used as Hellenistic astronomy brought Egyptian seasonal hours into one unit. A second dial gave each hour 60 minutes (from medieval French for first division). A third divided minutes into 60 seconds (from medieval French for second division).[84] These numbers portrayed a mean solar day that occurred on only four days per year.[85] Huygens provided tables to correct for time measured by solar position and mean time measured by his clock.[86] The dials on Huygens' clock, as well as any clock making similar display, portrays a fiction occasionally in accord with astronomical events.

Time In British Mathematics And Physics

British mathematicians and physicists who were contemporaries of Galileo and Huygens invented a concept of time that owed nothing to physical events but was used to mathematically describe the physical world. Isaac Barrow, a mathematician, began the invention with "...because *Mathematicians* frequently make use of Time, they ought to have a distinct idea of

the meaning of that Word, otherwise they are Quacks."[87] He began his distinct idea of time by echoing Critias, Plato's uncle. Critias wrote that "Time is unwearied and full in its eternal flowing, and is generated by itself alone."[88] Barrow, a man with knowledge of Greek literature, claimed that "Time flows perpetually with an equal tenor."[89] Since flow requires time, these conceptions are circular.[90]

Barrow claimed that time was quantity[91] and proposed representing quantitative time with a geometric right (straight) line because time was a quantity stretched out in length "...whose Parts will exactly answer to the proportionable Parts of Time, as Points do to the respective Instants of Time, and will aptly served to represent them."[92] The proportionable parts of time were set by "...celestial Motions, especially of the Sun and Moon: So that those Times are equal, when the same Hour-Glass is run out once, twice, or any equal Number of Times..."[93] Points on the line represent instants of time. Barrow then made a claim that goes beyond celestial motions as time's measure. He held that space and time existed before creation. In his words "...Time existed before the World began, and does exist together with the World in the Extramundane Space..."[94] where God is present.

Another Englishman, a natural philosopher named Walter Charleton, embellished Barrow's ideas of time. First he agreed that common time was tied to physical events: "...Custom hath so prevailed, as we compute the flux of **Time** by the diurnal and annual revolution of the Sun."[95] This custom was a mistake because time was "...devoid of all relation to Corporiety, and absolutely independent on the Existence of any Nature whatever."[96] Charleton also indicated that time was absolute because "...Time is constantly the same through the Universe."[97]

Distilling Critias, Barrow, and Charleton yields an absolute time flowing in equal tenor

without reference to anything external with God somehow involved. Isaac Newton made that distillation. He wrote that "...God created time"[98] but demanded more of time than God's work. His *Principia* conceptualized time as:

> Absolute, true, and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year.[99]

Newton's absolute time suffered the same defect afflicting Critias and Barrow because his definition is "...not conceptually valid, on account of the fact that the definition of flow involves that of Time as a necessary component, and hence imparts circularity to the definition."[100]

There is another problem as well. Newton partially justified his conception of absolute time by appeal to astronomy's equation of time.[101] However, astronomy's equation simply gives the difference between solar position, as represented by sundial shadows, and mean solar time, a creation of men. Neither equation nor mean solar time, which are products of human activity, support Newton's absolute time.

Time In British Empiricism

British Empiricism considered that all knowledge is based on experience. This philosophical speculation challenged Newton's Absolute Time, a concept without reference to experience. John Locke, the founder of British Empiricism, wrote that "...we get the notion of succession..." by reflecting on ideas appearing one after another in our understandings.[102] Locke used succession, a parade of ideas, to derive duration, the distance "...between the appearance of

any two ideas in our minds..."[103] The distance between two ideas required "...some common measure..."[104] to be considered time. Locke selected the diurnal and annual revolutions of the sun as his common measure.[105]

Locke's conception of time suffers logical and empirical difficulties. Logically succession is a kind of change and change requires time. Circular definitions are logically suspect. Empirically, linking a succession of ideas to duration, which—when measured—constitutes time is a psychological association of ideas without possibility of empirical demonstration.

While Locke's ideas on time were not congruent with Newton's, no argument ensued. But Newton's Absolute Time strained "...the sacred writings..."[106] and drew George Berkeley's attention. Berkeley, an Anglican Bishop with credentials as a British Empiricist, published his *Principles of Human Knowledge* in 1710. There-in he noted that time, place, and space "...are what everybody knows, but having passed through the hands of a metaphysician...become too abstract and fine to be apprehended by men of ordinary sense."[107] Newton, the author of "...a certain celebrated treatise of *mechanics*..." wherein time, space, and motion are explained as having existence without the mind "...and that they are ordinarily conceived with relation to sensible things, to which nevertheless in their own nature the bear no relation at all."[108] Bishop Berkeley disagreed. God was "...intimately present to our minds..." and produced all that was in them because we are absolutely dependent upon God.[109] Works of nature were also dependent on God.[110]

Berkeley's comments came from the Anglican Church and posed serious threat for Newton because he was a heretic, an Arian Christian rather than an Anglican.[111] Newton salvaged his situation in his second edition of *Principia* published in 1713. It closed with a

pious General Scholium that professed the true God "...endures forever, and is every where present; and by existing always and every where, he constitutes duration and space."[112]

Newton's altered conceptions of time (duration) and space drew comment from Gottfried Leibniz, a natural philosopher and mathematician. Leibniz and Newton became embroiled in several controversies. One concerned Leibniz's criticisms of the philosophical and theological implications of Newton's works. In a letter Leibniz denied that space and time are real, absolute things: space is "...something merely relative, as time is..." because "...instants, consider'd without...things, are nothing at all; and they consist only in the successive order of things..."[113] In another letter Leibniz held that "Nothing of time does ever exist, but instants; and an instant is not even a part of time. Whoever considers these observations, will easily apprehend that time can only be an ideal thing."[114] Newton prevailed in this controversy.

David Hume made a final contribution to British Empiricism's idea of time. He claimed no knowledge "...can go beyond experience, or establish any principles which are not founded on that authority."[115] His account of time followed those of Locke and Berkeley: time was derived from a succession of ideas. Space and time both were "...merely those of the manner or order, in which objects exist..."[116] Ideas of space were conveyed to the mind by "...impressions of atoms or corpuscles..." while "...indivisible moments of time must be filled with some real object or existence, whose succession forms the duration, and makes it be conceivable by the mind."[117] Research has not discovered credible accounts of experiences with impressions of atoms, corpuscles, or indivisible moments of time.

Immanuel Kant

Immanuel Kant, a German philosopher, took issue with British Empiricism in his *Critique Of Pure Reason.* He began his *Critique* by noting "Hitherto it has been assumed that all

our knowledge must conform to objects."[118] This assumption created problems that Kant proposed to correct by following Copernicus's example.[119] The Copernican analogy led Kant to write that "...objects must conform to our knowledge."[120] Finally "...the object (as the object of our senses) must conform to the constitution of our faculty of intuition..."[121] which depends on our "...cognitive faculties..."[122]

Kant posited time as a form "...of sensible intuition..." that is prior to experience.[123] *A priori* knowledge meant that "Time is not an empirical concept that has been derived from any experience...Time is a necessary representation that underlies all intuitions."[124] Time is "...a purely subjective condition of our (human) intuition (which is always sensible, that is, so far as we are affected by objects) and in itself, apart for the subject, is nothing."[125]

Kant's time has three different modes: "...*duration, succession,* and *co-existence.*"[126] He repeated part of this as "All appearances are in time; and in it alone, as substratum (as permanent form of inner intuition), can either coexistence or succession be represented."[127] Kant then wrote of change and noted "...change does not affect time itself, but only appearances in time. (Coexistence is not a mode of time itself; for none of the parts of time co-exist; they are all in succession to one another.)"[128] This appears a contradiction, as does his comment that time's modes consist of duration, successive series, and simultaneous existence.[129]

Kant also wrote that his subjective time had a relational structure where one part of time takes definition for another part of time.[130] But since our inner intuition "...yields no shape, we endeavor to make up for want by analogies. We represent the time-sequence by a line progressing to infinity..."[131] The line progressing to infinity may have referred to the work of John Wallis, a contemporary of Barrow, Charelton, and Newton.

A Second Variety Of Mathematical Time

John Wallis invented a way of representing numbers geometrically. We call his invention a number line with negative and positive numbers separated by 0. Negative numbers were "...lengths opposite in direction to lengths represented by positive numbers."[132] But Wallis had doubts about his invention because "...it is not possible that any *Magnitude* can be *Less than Nothing* or any *Number Fewer than None*."[133] Wallis had invented a geometrical way of presenting numbers, published his results, and then declared his invention impossible.

He did much the same for what we now call imaginary numbers. In 1685 he introduced a way to geometrically represent a number that was "...neither greater than zero, nor less than zero, nor even equal to zero. It is number that is not located *anywhere* on the number line."[134] But Wallis indicated that the square roots of negative numbers were "...no more absurd than negative numbers; and since the latter can be represented on a direct line, it should be possible to represent..."[135] the square roots of negative numbers on a line as well. He did so by drawing a second line, vertical and perpendicular to his first horizontal line, with both lines intersecting at zero. He placed his imaginary numbers on his vertical line.

The Abbe Adrien Quentin Buee identified Wallis's invention with time in a paper published as part of the 1806 Philosophical Transactions of the Royal Society of London. Buee argued that a line such as Wallis's "...could have either of two opposite directions; a quantity of money could be a possession or a debt; a period of time could refer to the future or the past."[136] Buee did this by identifying "...the linear temporal continuum, as represented by a straight line..."[137] On his straight line Buee identified 0 as representing the present, positive numbers as representing the future, and negative numbers as representing the past.[138] Buee's use of Wallis's number line "...is in agreement with the mathematical view of Time as being a continuum

divisible theoretically *in infinitum*."[139]

Time In Geology And Natural Selection

Time's duration was set in Western Christendom by men's interpretations of the Bible. Among the first to challenge time's Christian duration was Georges-Louis Leclerc Buffon, a French naturalist. He used natural processes operating in the present to explain geological deposits that he thought were created in the past.[140] This contradicted *Genesis*, as did his conclusion that "...the more we extend time, the closer we shall be to the truth."[141] French theologians forced Buffon to recant any claim that the earth's duration exceeded the date derived from interpretations of Scripture.[142]

James Hutton, a Scottish geologist, established the idea of geological time of immense duration in the English speaking world. He wrote of a circular process in which erosion swept land into the sea where it consolidated and then rose above sea-level. Volcanic eruptions added to land formation. All this required "...an indefinite space of time..."[143] Hutton's space of time demanded an indefinite duration because "...with respect to human observation, this world has neither a beginning nor an end..."[144]

Hutton's theory went against the prevailing idea of the world's duration. For those following the Anglican faith, this was set by James Ussher, Archbishop of Armagh, in the 17th century. Ussher reckoned the world was created on October 23 "...in the year of the Julian Calendar 710..."[145] Ussher later translated his Julian date into more familiar numbers and determined the creation of the world occurred "...in the beginning of the autumn of 710 JP or 4004 BC…" on October 23.[146] Ussher's chronology and dates were included as annotations in the King James version of the Bible until the 20th century.

Sir Charles Lyell expanded on Hutton's theory in his *Principles Of Geology*. Lyell

explained this in a letter to Roderick Murchison written on January 15, 1829. "...*no causes whatsoever* have...ever acted, but those *now acting*: and that they never acted with different degrees of energy from that which they now exert."[147] Lyell's equation of ancient and modern processes operating at uniform rates and intensity came to be known as uniformitarianism.

The first volume of Lyell's *Principles* was published in 1830. On its first page Lyell proposed an analogy between history and geology: both subject matters were composed of successive events occurring in time.[148] Given the importance of time in his long succession of events in the natural world, Lyell sought to avoid conflict with organized religion which viewed time as "...sanctioned by the implicit faith of many generations, and supposed to rest on scriptural authority."[149] Lyell wrote that his geological time was circular in shape and when past eras recurred "Then might those genera of animals return, of which the memorials are preserved in the ancient rocks of our continents."[150]

Lyell followed Hutton's theory: water erosion deposited land into the sea, earthquakes and volcanoes created new lands. But Lyell departed from Hutton in estimating time: geological time could not be measured by "...the annual revolution of our planet around the sun"[151] but could be estimated with "...evidence afforded by...fossil organic contents..."[152] found in geological strata.

Lyell depended on the presence of time to explain geological strata and their fossil organic contents. In comments on Europe's chalk formations he wrote that "Time has been required, and a succession of geological periods, to raise it above the waves in so many regions..."[153] He repeated that geological change was time dependent in another passage: "All the changes produced by these various means require *time* for their completion."[154]

In other passages Lyell attempted to define what he meant by time. One attempt relied

on belief: "...until we habituate ourselves to contemplate the possibility of an indefinite lapse of ages having been comprised within each of the more modern periods of the earth's history, we shall be in danger of forming most erroneous and partial views in Geology."[155] In other attempts to clarify his definition of time Lyell wrote of "...an indefinite lapse of ages..."[156] and "...during an immense lapse of ages..."[157] In his concluding remarks, Lyell summarized that, just as space cannot be assigned limits "We are prepared, therefore, to find that in *time* also, the confines of the universe lie beyond the reach of mortal ken."[158]

Lyell's geological time creates several difficulties. First, it is not certain that time has cyclical shape. Second, Lyell's entire argument depends on the presence of time. In his explanations the presence of time gave structure to his assemblages of mineral and fossil strata. But Lyell did not demonstrate the presence of time. Rather, he wrote that we must habituate ourselves to an indefinite lapse of ages within his Recent and Tertiary Periods. His assertion amounts to time based on faith.

Charles Darwin subscribed to Lyell's faith. In a letter to Leonard Horner Darwin made this explicit. "I always feel as if my books came half out of Lyell's brains..."[159] He also expressed his faith in the first edition of *The Origin Of Species*: "He who can read Sir Charles Lyell's grand work on the Principles of Geology...yet does not admit how incomprehensibly vast have been the past periods of time, may at once close this volume."[160] But one man refused to believe and made issue of Lyell's geological time and Darwin's faith in it.

Time Debates

Sir William Thomson, a nineteenth century British physicist of towering reputation, did not habituate himself to geological time beyond mortal ken because he calculated the sun had not supported life on earth during a past of incomprehensible duration. His mathematical physics

put the sun's age between 100,000,000 and 500,000,000 years. Thomson's calculations doomed the theories of Hutton, Lyell, and Darwin "...unless new sources, now unknown to us, are prepared in the great storehouse of Creation."[161]

Thomson expanded on his objections when he presented a paper to the Geological Society of Glasgow on February 27, 1868. He got straight to his point: "A great reform in geological speculation seems now to have become necessary"[162] because geological time exceeded time as calculated by natural science. He supported his claim with evidence that the earth's slowing diurnal revolutions denied uniformatarianism's tenet of natural processes acting at the same rate in the past as in the present. He also presented mathematical evidence that led Thomson to claim "...that a great mistake has been made—that British popular geology at the present time is in direct opposition to the principles of natural philosophy."[163] Thomson concluded with an estimate that "...life on earth, all geological history showing a continuity of life, must be limited with some such period of past time as one hundred million years."[164] Thomson's conclusion denied Darwin the 300 million years he considered a minimal estimate of time elapsed between 1859 and the latter part of geology's Secondary Period.[165]

Thomas Huxley, sometimes known as 'Darwin's Bulldog' for his support of natural selection, responded to Thomson in 1869. Huxley asked whether British geologists were prepared to plead guilty to "...the severe judgement thus passed...by so high an authority as Sir William Thomson..."[166] Huxley pled not guilty and gave reasons for his plea. Thomson had limited past time to some such period as 100,000,000 years. Huxley asked "...has it ever been denied that this period *may* be enough for the purposes of geology?"[167] Huxley answered by noting a discussion of his question was 'greatly embarrassed' by the vagueness of Thomson's limits because "...does this mean that it may have been two, or three, or four hundred million

years? Because this really makes all the difference."[168] Huxley continued his attack on Thomson's paper and, in later essays, Thomson replied.

Huxley's criticisms of Thomson did not satisfy Darwin. He wrote James Croll, the resident geologist in the Edinburgh office of the Geological Survey,[169] for an estimate of the earth's age because "...I am greatly troubled at the short duration of the world according to Sir W. Thomson, for I require for my theoretical views a very long period *before* the Cambrian formation."[170] Croll's response apparently gave Darwin no support because, in his Sixth Edition of *The Origin Of Species,* Darwin wrote that estimates given by Thomson and Croll for time's past duration denied natural selection the time necessary for its workings. To rescue his theory, Darwin asked that "...other elements...be introduced in the problem."[171]

Ernst Rutherford, a physicist, introduced some other elements in a 1905 paper. Rutherford claimed that radioactive decay gave a past of five thousand million years "...a period of time which probably both geologists and biologists would consider sufficient for the processes of organic evolution."[172] Lyell's geological time and Darwin's theory of natural selection seemed secure.

Or perhaps not. Rutherford devised ways of measuring radioactive decay that revolved around a half-life of emissions. This half-life, an invention of Rutherford's, was basic to all his estimates of age based on radioactive decay. He made this clear in his discussion of helium. Helium is produced as radium undergoes radioactive decay. Rutherford wrote that "The amount of helium in the mineral will steadily increase with time, and the total amount present should be proportional to the age of the mineral and the amount of radium contained in it."[173] Rutherford used this reasoning to calculate the age of a mineral, thorianite, found in Ceylon:

...it can be calculated with some confidence that the mineral thorianite is at least

500 million years old, *i.e.* this interval of time must have elapsed since the formation of the mineral in the earth's crust.[174]

He expressed confidence that, with further effort "...this method will prove of the utmost value in determining with accuracy the age of the radioactive minerals and indirectly of the geologic strata in which they are found."[175] Rutherford's reasoning was accepted and radioactive decay is considered a kind of clock to measure vast amounts of time past.

Before considering Rutherford's conception of time, another facet needs exploration. In his 1905 paper Rutherford wrote about an experiment in which a radium solution was heated and a heavy radioactive gas emanating from the solution was collected in a small glass tube. After standing a few hours, heat from the glass tube was found to decrease at a rate "...in geometrical progression with time, falling to half value in about four days."[176] This mixture of geometric progression dependent on time, half-life, and proportions of minerals as a means of estimating the age of geological strata deserves attention, as does Rutherford's means of representing time.

Three different essays in the first volume of his collected papers present charts.[177] All charts are in the form of a mathematical plane composed of two intersecting lines—one horizontal the other vertical with an intersection at zero. Although Rutherford's lines do not extend past zero, his charts are recognizable as the upper right quadrant of John Wallis's invention of geometrical representation of positive and negative numbers separated by zero. Identifying the horizontal axis with time, as Rutherford did, is simply a continuation of Buee's interpretation of Wallis's work.

A number of things can be said about Rutherford's presentation of radioactive decay. First is that his mathematical time conceptualizes time as a geometric line. Such time is linear, uses 0 as a present to distinguish between past and future, and is infinitely divisible, permitting

no gaps. Lyell and Darwin conceptualized time differently.

Lyell opted for a cyclical conception of time to encompass his cyclical geological processes and speculated that extinguished species might cyclically reappear. Darwin conceptualized his time as granted by nature. Darwin's natural selection was in the most direct relation to time and, in a state of nature, was excessively slow. A geometrical time line to guarantee the presence of time for Lyell's geology and Darwin's natural selection is not appropriate because mathematical time is an invention of men; in particular, the inventions of Wallis, Buee, and perhaps Kant.

Another difficulty with Rutherford's estimate was that present solar radioactive decay guaranteed a past of five billion years and a long future. This estimate accepted time as a continuum capable of mathematical expression. The temporal continuum of mathematical physics, as represented by a number line, may be open to question because:

> In most problems of mathematical physics it is customary implicitly to assume linearity of the temporal continuum, so that instants and periods are respectively regarded as points and sections of a homogeneous number system.[178]

This requires practitioners of mathematical physics to tacitly assume "...that temporal relations are analogous to pure numbers and exactly expressible thereby..."[179] These implicit and tacit assumptions may weaken the case for mathematical physics guaranteeing the presence of time of immense past duration granted by nature.

An additional problem in Rutherford's analysis was noted in Aristotle's circular definition that "...we measure change by time and time by change."[180] Rutherford followed Aristotle when he wrote the amount of helium produced by radium's radioactive decay increased steadily with time and present amounts should be proportional to the age of the mineral. But

changes in concentrations of helium depended on time and time was measured by changes in concentrations of helium.

Despite these reservations the arguments of Lyell, Darwin, and Rutherford were accepted as fact. Time's past duration was no longer set by interpretations of Scripture or Thomson's inadequate scientific data, it was set by secular reinterpretations. The strength of this reinterpretation of time was acknowledged by the Catholic Church in 1908 when doctrine was changed to claim the world was "...of immense antiquity...and the Catholic is quite free to follow the teaching of science."[181] Secular reinterpretation of time had replaced interpretations of Scripture in a large segment of Christianity.

In 1905 Albert Einstein conceptualized time as simultaneity in Special Relativity and, in 1915 conceptualized time as a space-time continuum in General Relativity. While influential in physics, these conceptualizations may not be applicable to Darwin's theory of natural selection. A biologist, Hans Kalmus, explained that modes of thought "...which refuse the notion of time as Parmenides and Zeno did or which consider the time scale as equivalent to the three Cartesian coordinates may perhaps have their uses in some branches of physics but are quite unprofitable for the student of evolution" because "Organic evolution...implies the most common current idea of time—something unidirectionally connecting an earlier situation ***A*** with a later situation ***B***."[182] With Special Relativity's simultaneity lacking direction and General Relativity's time scale, which is equivalent to the three Cartesian coordinates, deemed quite unprofitable for students of organic evolution, at question is whether the most common current idea of time is adequate for organic evolution, the task assigned it by Kalmus.

This question has at least three answers. One is that Darwin was specific about the time required for his theory: nature grants incomprehensibly vast periods of time for the workings of

natural selection. However, the most common current idea of time, a product of human activity, does not meet Darwin's specifications. A second answer is found in two recent publications concerning time. Two special editions of *Scientific American* were devoted to time. Paul Davies, a physicist with credentials in cosmology and astrobiology, wrote an article that was included in both editions. Davies noted that "...neither scientists nor philosophers really know what time is or why it exists."[183] A third answer to the question whether the most current idea of time is adequate for organic evolution disagrees with both Kalmus and Davies. This is the answer presented in this essay, namely that time in Western Civilization is a product of human activity describable in terms of cultural continuity and cultural change.

CONSIDERING TIME AND NATURAL SELECTION

This essay opened with a quotation from Mr. Lyell's *Principles Of Geology* indicating that he was prepared to find that in time the confines of the universe lie beyond the reach of mortal ken. Quotations from Mr. Darwin's letters and the first edition of his *The Origin Of Species* demonstrated that he agreed with Lyell's view on time. Darwin also wrote that nature granted a past of incomprehensible vastness that was necessary for his theory of natural selection. This essay then presented the proposition that time and attributes associated with it are products of human activity describable in terms of cultural continuity and cultural change. Information from Antiquity, Western Christendom, and post-Renaissance Western history was presented in support of both proposition and description. Research discovered no comparable account in the literature concerning time in Western Civilization. Given evidence that the presence of time and attributes associated with it are products of human activity, and absent any demonstration to the contrary, doubting Darwin's theory of natural selection may be warranted.

Should these doubts be strengthened by on-going research focused on 20th century conceptions of time seemingly capable of supporting natural selection, Darwin's theory is in peril of being regarded as a creation myth.

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