Science & Philosophy Volume 7(2), 2019, pp. 15-26

Solar Cycles, Light, Sex Hormones and the Life Cycles of Civilization: Toward Integrated Chronobiology

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Abstract

The emerging discipline of complexity science, applied to the social sciences, seeks to study the rise of human civilization as a part of a natural, evolving biological system that exploits energy resources to fuel its growth into a complex social system. In order to understand the whole system, the reductionist approach, typical to Western science, must be supplanted. The atomistic study of various scientific fields as separate mechanical parts of the system must be broadened, creating a more holistic view of human culture as an integral part of larger universal process of evolution and creation. In this article I wish to integrate the various scientific fields, including physics, chronobiology (studying the effect of solar cycles on biological growth), biology, evolutionary psychology, and the social sciences, to achieve a unified understanding of our cultural evolution.

Keywords: sex hormones, cultural evolution, evolutionary psychology.[2]

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[2] Received on December 17th, 2019. Accepted on December 28, 2019. Published on December 30th, 2019. doi: 10.23756/sp.v7i2.483. ISSN 2282-7757; eISSN 2282-7765.

1. Introduction

In his book, *Consilience: The Unity of Knowledge* (1998), biologist E. O. Wilson, the father of sociobiology, suggests a new synthesis of knowledge from different specialized fields of human endeavor to reach a greater understanding. Hormones—a word meaning *impetus*—are actually the drivers of biological processes as well as forces that structure the sexual organization of human societies. The primary human sex hormone is testosterone. Not only does testosterone fuel the passion for reproduction and play a critical role in the length of our lives, but it is also an integral component to the mechanism of human civilization—its triumphs and its tragedies. In order to understand the forces that drive the life cycles of human cultures and that form the engine of history, I propose that the profound transformations in social mood that bring the rise and fall of civilizations is caused by biological cycles and directed by hormones. Hormones regulate and control the way the human mind perceives the world, understands the nature of the good, and forms social organizations and political orders accordingly.

Our body is a complex biological system composed of various specialized cells working in social cohesion and harmony, synchronized according to hormonal cycles that regulate our sexual reproductive life cycles: from birth to puberty and adolescence, when humans reach sexual maturity, to the years of mating, raising offspring, and aging, until death. Individual humans bond to form complex social groups, such as the family unit, nations, and entire civilizations, which coordinate our organization through cultural norms. Humans develop intricate social institutions, such as religion and politics, in order to divide resources and labor to facilitate growth.

2. Energy and Human Evolution

In order to grow, biological organisms require energy, which we consume from our environment. Our evolution is a process of adaptation, directed to adapt us to environmental change. Hence, to understand the physical and biological underpinnings of our sexual and social organizational patterns, repeated throughout evolution and history, it is necessary to understand how energy is available and how it is utilized for the growth of the human superorganism. In his article “Energy and Human Evolution” (1995), David Price writes:

Life on Earth is driven by energy. Autotrophs take it from solar radiation and heterotrophs take it from autotrophs. Energy captured slowly by photosynthesis is stored up, and as denser reservoirs of energy have come into being over the course of Earth's history, heterotrophs that could use more energy evolved to exploit them, Homo sapiens is such a heterotroph; indeed,

the ability to use energy extrasomatically (outside the body) enables human beings to use far more energy than any other heterotroph that has ever evolved. The control of fire and the exploitation of fossil fuels have made it possible for Homo sapiens to release, in a short time, vast amounts of energy that accumulated long before the species appeared. (p. 301)

This writing will begin by exploring the role of solar cycles in driving the biological and social growth processes of human civilization.

3. Integrated Chronobiology

The two primary hormones that, along with solar activity, are involved in the co-regulation of human growth, social mood, social status, sexual behavior, and dominance are serotonin and testosterone. In the daily circadian rhythm, both serotonin and testosterone rise in the morning and fall at night, when serotonin is being converted to the sleep hormone, melatonin. The levels of these hormones are regulated by the master hormone regulator, the hypothalamus, and are synchronized with solar cycles.

Serotonin is the most ancient hormone, involved in photosynthesis in plants, oxygen utilization, and growth cycles. Evolutionary psychiatrist Emily Deans (2011) describes some of this process:

Tryptophan hydroxylase may be the oldest enzyme to attach oxygen to other molecules. Since oxygen is generally quite reactive and toxic biochemically, this was an early way to safely get rid of excess oxygen created by photosynthesis in primitive organisms. The light receptors in the human (and other animals) retina are very similar to serotonin receptors and were first thought to evolve a billion years ago. Serotonin is the oldest neurotransmitter, and the original antioxidant. There are 20 different serotonin receptors in the human brain, and serotonin receptors are found in all animals, even sea urchins.

In other animals, serotonin is involved in swimming, stinging, feeding modulation, maturation, and social interaction. In general, it is thought of as a growth factor for animal brains. In humans, deficiency of serotonin is implicated in autism, Down syndrome, anorexia, anxiety, depression, aggression, alcoholism, and seasonal affective disorder.

In the opening lines of the Torah, Moses recorded the creation of the world, attributing to our benevolent Creator the first command of creation: “Let there be light.” The scripture continues, “…and there was light. And God saw the light, that it was good: and God divided the light from the darkness.” (Genesis 1:3, 4) Light is primal to life and to its very creation. It is no surprise, therefore, that light, and specifically bright light (more than 2,500 *lux*) has a direct effect on our ability to create life. Beginning in the 1980s, studies have confirmed that bright light

exposure directly affects sex hormones. A 2003 study showed that when young men were exposed to 1 hour of bright light in the blue spectrum (BL), early in the morning for 5 days, the luteinizing hormone, a precursor to testosterone, increased by almost 70% (Yoon, Kripke, Elliott, & Youngstedt, 2003). Improving testosterone production has many positive effects, including a decrease in depression and low sexual desire and function (Bossini et al., 2009). It is also possible that BL exposure in the early morning could stimulate ovulation in women (Konstantin, Danilenko, & Samoilova, 2007). Notably, the color of light makes a significant difference in these and other studies. Light in the blue part of the spectrum is most effective when assessing testosterone production. Faryadyan et al. (2014) found that blue light has been shown to significantly increase the serum testosterone levels in rat babies when the mother was housed where predominantly blue rays affected her. The male rats in the study were born with statistically significant higher levels of testosterone than those that had lived in white or black boxes. Green light also created higher testosterone levels in new-born rats, but not as high as the blue.

Light therapy and serotonin-increasing medications are both effective treatments for depression that occurs with low levels of sunlight. Light exposure increases serotonin in humans. Serotonin levels are lowest in midwinter and higher on bright days no matter what time of year. 10,000 *lux* light therapy decreases suicidal ideation in some people that can occur from low serotonin levels (Means, 2011). In a meta-analysis of research on serotonin and depression, Young (2007) reports that such bright light treatment is effective in treating year-round depression and premenstrual and pregnancy depressions.

Furthermore, ultraviolet-B sunlight rays trigger the production of vitamin D, which is a catalyst for testosterone and serotonin production. Vitamin D—a steroid hormone—is correlated with conception rates, both peaking in the same months in respective hemispheres. Peak sun exposure in the northern hemisphere in June and July leads to peak vitamin D levels in September and October, given the six to eight weeks it takes for the body to convert sunlight to hormone. Those are the months when testosterone levels are highest and when conception rates are highest. An interesting exception to this pattern can be found in Scandinavia where sunlight is so pervasive in the early summer—twenty hours a day in June and July—that there is more of a bright-light effect, which causes the peak of conception rates to correlate with light exposure (Brody, 1981).

Like testosterone and serotonin, melatonin has also been shown to play a role in reproductive capability in both humans and animals. And like those hormones, melatonin production is light-dependent. Studies suggest that BL treatment can diminish activity in the human pineal gland, which in turn supports greater melatonin secretion as well as positively influencing sexual

function (Bossini et al, 2013). In a placebo-blind study, the group treated with BL reported up to 3 times greater sexual satisfaction than those treated with a placebo, compared to their reporting prior to the treatment (Bossini et al, 2013).

In addition to specific light sensitivity, it seems that life on earth is sensitized to other facets of our sun's activities. The strength of the earth's magnetic field, for example, or the actual position of the sun in the galaxy, or the occurrence of sunspots all play roles in creating and sustaining life. The earth's magnetic field, which is created by its core, protects the earth from solar particle storms by deflecting them into loops called the Van Allen belts. When solar radiation is particularly strong and the magnetic field is more highly activated, a section of the brain's hippocampus senses these changes and signals the pineal gland to produce melatonin and the hypothalamus to produce growth hormones. Scientist Maurice Cotterell (2017) argues for the *solar hormone theory* that asserts the sun controls fertility in women, coordinating its twenty-eight-day rotation with women's twenty-eight-day fertility cycle.

4. The Impact of Solar Energy on Human Cultures

Given that light energy is essential for biological life to grow, it is not surprising that human culture all over the world associates light with a good and optimistic social mood. In Western Judeo-Christian theology, as depicted in Genesis 1, God is the Creator of light, and creation of this world is associated with the good and the kingdom of light. In contrast, Satan is the ruler of the kingdom of darkness and evil. In Chinese philosophy and in astrology, yin-yang represents the feminine-masculine principles in nature, wherein the feminine is associated with the moon, darkness, less energy, and passivity, and the masculine is more connected to the sun, high-energy, and the active element of creation.

The hormonal mechanisms previously discussed are responsible for translating variations in seasonal solar cycles into behavioral adaptations to the environment. Solar cycles vary not only on a seasonal basis but also on much longer annual cycles, such as the 7-year and 70-year cycles. These are eras of mass social mood driven by recurring waves of testosterone rise and decline. Light causes our master hormone regulator, the hypothalamus, to control the release of growth, sex, and stress hormones throughout our body, the coordinator that synchronizes physical light-energy and the neuro-psychological motives that drive human activity.

Periods of rising solar radiation levels signal our primitive mammalian brain that the environment accommodates a growth cycle, spurring testosterone, serotonin, melatonin, and dopamine levels and propelling us to expand. In this cycle, humans seek dominance in their own societies and over the rest of the natural world in order to acquire resources and reproduce. By contrast, periods of declining solar radiation impel humans, through decline in growth hormones, to

shrink into a mode similar to hibernation during winter in order to conserve resources and wait for a better opportunity to grow again. Adaptation to a changing environment is at the core of biological evolution. These hormonal cycles have been influencing human behavior for thousands of years, across the globe, by the great force that synchronizes our hormones: the sun.

In the schema of Western history, the period when Roman civilization collapsed has been referred to as the Dark Ages, whereas the period demarking the rise of modern civilization is called the Enlightenment. As depicted in Figure 1, rising solar activity correlates with the culture of reason and liberty of the Enlightenment, exemplified in the thinking of English Puritans, from the natural philosophy of Newton and John Locke's ideal of liberty (1680s) to the Founders of the United States in 1776 with the Declaration of Independence.

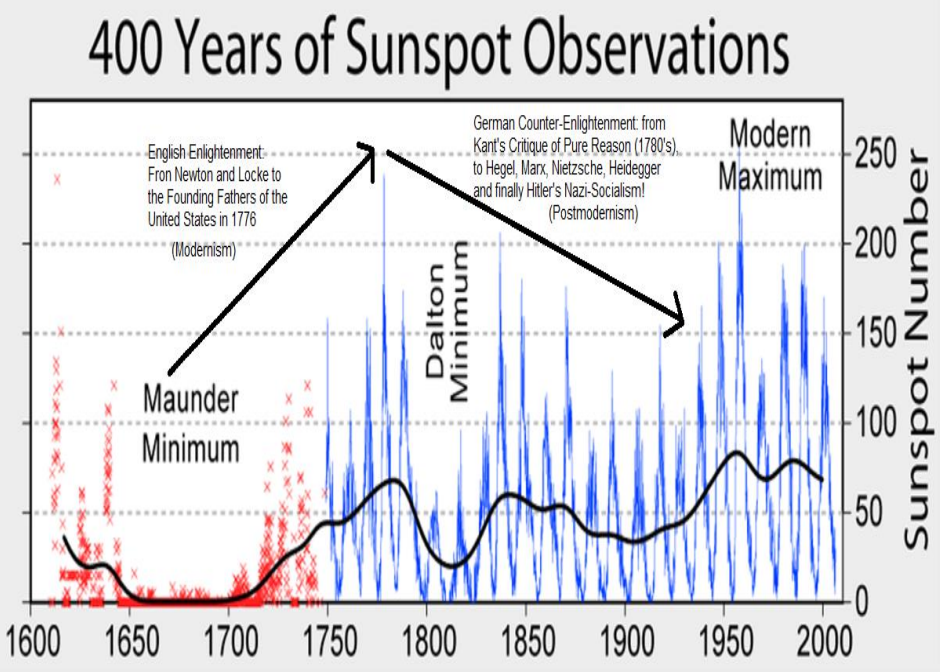

Figure 1: 400 Years of Sunspot Observations

However, as solar radiation peaked and began a long period of decline from the 1780s to 1930s, the period of philosophical modernism gave way to postmodernism. This brought us to the period of the German counter-Enlightenment, the assault on reason and individualism led by Kant's *Critique of Pure Reason* (1780), to Goethe, Hegel, Marx, Nietzsche's existentialist philosophy, Heidegger, and finally culminating in Hitler's Nazi cult. Moreover, when solar activity declined into the 1930s, it led to the economic period of the Great Depression. The concomitant social mood of psychological

depression and social conflict is evident with the rise of National Socialism in Germany, and communism and fascism in the USSR and Italy, respectively, leading to WWII.

During the Enlightenment period of the 1680s –1776, the leading English Puritan intellectuals, such as Newton, Locke, and Thomas Jefferson were Unitarians, who identified with the biblical archetype of God the Father, the Creator who commands, "Be fruitful and multiply and have dominion over nature" (Genesis 1:28)—a high-testosterone posture of dominance and fertility. This is evident in the Declaration of Independence of United States, written by Thomas Jefferson, also a Unitarian, who wrote, "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable rights, that among these are Life, Liberty and the pursuit of Happiness." As high testosterone and serotonin levels are associated with positive mood trends, this explains the culture in pursuit of happiness. The negative social mood during the Counter-Enlightenment period of German philosophy led to Goethe's character Faust, who makes a pact with Satan to enslave humanity. This stood in contrast to the Enlightenment philosophy of God-given liberty to mankind. In addition, the existentialist philosophy of Friedrich Nietzsche and Martin Heidegger was nihilistic, proclaimed the death of God, and characterized life as devoid of meaning and purpose, rendering reason impotent to know the reality.

In further contrast to the ideals of the English Puritans during the Enlightenment, Catholicism is more feminine with the exaltation of Mary the Mother of Jesus, a more feminine archetype. The Augustinian doctrine of Original Sin correlated with a cultural fall into the Dark Ages, when sex was considered an evil and there was a rise of the ideal of priests as celibate monks. However, this tradition was radically altered during the Protestant Reformation by Martin Luther, who disavowed his celibacy to marry a nun and have a family of five children. This suggests that a rise of testosterone levels led to a change in social norms and belief systems during this historical period starting from the Renaissance in the mid-fifteenth century, the very meaning of which is a rebirth of civilization, leading to the Protestant Reformation in 1517, and culminating with the Enlightenment during the eighteenth century.

5. Impact of Testosterone on Demographic Trends

Because there is a lack of historical data on hormone levels in human populations dating back more than 40 years or so, other available statistical information can be used as a guiding measure to analyze changing hormones levels. Changing fertility rates through the history of civilization is a reasonable indication that testosterone levels oscillate in up-down cycles, causing the rise and decline cycles in population size. These trends in societal growth and decline offer

at least a cursory view of the parallels in fertility rates and the ideas that drove Western civilization.

The graph in Figure 2 depicts 450 years of the demography of England and Wales and stands as an excellent visual of how fertility rates have correlated with social trends. Throughout these years, life expectancy has risen while the total fertility rates have fallen at an intriguingly similar pace. The rhythm and flow of fertility rates can be seen and correlated with solar activity during this period by looking at Figure 1 and Figure 2. In the Enlightenment period of 1680-1800, fertility rates rose sharply, because light raises testosterone levels. However, during the period following, a rapid decline in birth rates is shown, as solar activity declined into the 1930s. In the 1950s a rise in solar activity again led to the Baby Boom. Since testosterone levels declined from their peak in 1957 until today, a commensurate fall in fertility rates has been identified. Moreover, there is also research indicating that men with higher testosterone levels are more likely to marry than men with lower testosterone. Testosterone drives men to create a family, but later it declines as they care for their children with the feminine quality of empathy (Gray, 2011). Thereby testosterone, regulated by light, regulates the entire reproductive life cycle.

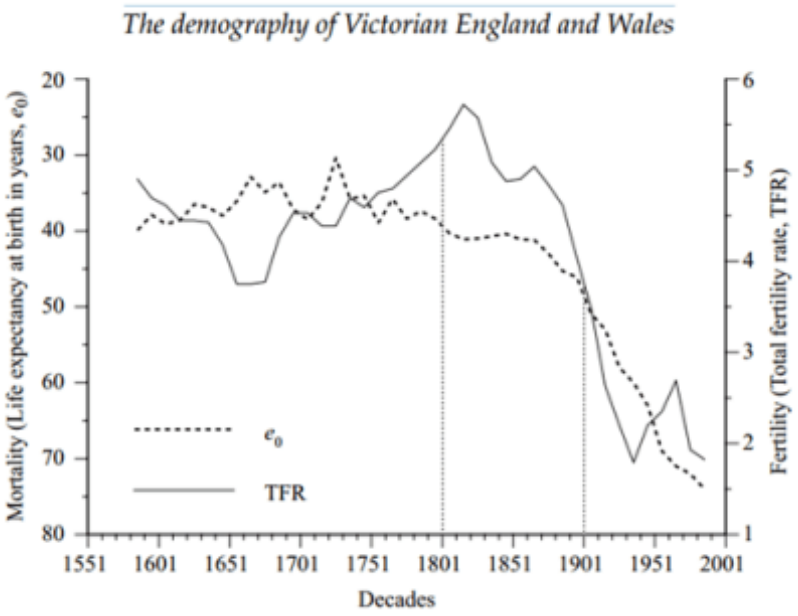

Figure 2: The Demography of Victorian England and Wales. (Used courtesy of Robert Woods and Cambridge University Press, 2000.)

6. How Low Solar Activity causes low Sex Hormones and a global Mental Health Crisis

Falling fertility rates are a signal for collapsing testosterone levels throughout such periods of cultural decline. At the same time, there is an obesity epidemic that is causing a health care crisis due to rapidly rising heart disease, cancer, and diabetes, all caused by high sugar and fat levels. Such indications of an increase in societal stress correlate with an increase in the number of people are taking psychiatric drugs to try and alleviate psychological tension, rising anxiety levels, and depression. In the past 25 years, there has been a four-fold rise in the rate of prescribing antidepressants alone, a statistic that does not even account for those identified with depression yet not using prescribed medication (Szalavitz, 2001) At least one large study of college students that compared them to their counterparts of the 1930s and 40s found that fully 85% of them have worse mental health:

Students today report they feel significantly more isolated, misunderstood, and emotionally sensitive or unstable than in decades past. Teens were also more likely to be narcissistic, have low self-control, and express feelings of worry, sadness, and dissatisfaction with life. (Hutchinson, 2009)

The correlation between depression and obesity rates rising invites the question of whether antidepressant use contributes to obesity. Stress activates the hypothalamic–pituitary–adrenal (HPA) axis, and the HPA axis is also regulated abnormally in obesity. Therefore, this is a common pathophysiological pathway in the conditions of depression and obesity. One study assessed years of relevant research and concluded that animal studies in particular give ample evidence that indeed, “short-term antidepressant treatment and stress, followed by a high-fat diet and long-term follow-up, has an important role in consolidating the role of antidepressant use in weight gain” (Lee, Paz-Filho, Mastronardi, Licinio, & Wong, 2016)

In addition to depression and obesity, the current opioid epidemic is indicative of the rising stress in the current culture. The misuse of and addiction to heroin and prescription opioids in the US alone has become a public health epidemic with a dramatic increase in fatal overdoses impacting the social and economic welfare systems. Between 1999 and 2012, overdose deaths from opioids rose more than fourfold (Substance Abuse and Mental Health Services Administration [SAMHSA], 2012). With depression and suicide rates increase along with opioid addition, life expectancy in the US is decreasing (Xu, Murphy, Kochanek, & Arias, 2016). Xu et al. (2016) highlight that of the 20 categories measured for mortality, the greatest rise in rates was among deaths from “external” causes, such as drug overdoses, alcohol-related liver disease, and obesity-associated conditions

like diabetes. Moreover, the suicide rate has increased 24% between 1999 and 2014, with an uptick in the rate increase after 2006 (Tucci and Moukaddam, 2017).

7. Conclusion

Harvard psychologist Steven Pinker's book, *Enlightenment Now: The Case for Reason, Science, Humanism, and Progress* (2018) calls for a return for the spirit of optimism and the culture of reason as in the Enlightenment, as he states in the back cover:

Far from being a naïve hope, the Enlightenment, we now know, has worked. But more than ever, it needs a vigorous defense. The Enlightenment project swims against currents of human nature--tribalism, authoritarianism, demonization, magical thinking--which demagogues are all too willing to exploit. Many commentators, committed to political, religious, or romantic ideologies, fight a rearguard action against it. The result is a corrosive fatalism and a willingness to wreck the precious institutions of liberal democracy and global cooperation.

However, with solar activity in decline, lack of light causing low growth hormones and diminished levels of happy chemicals in the brain leading to a negative trend in social mood, we are more likely to the see the re-emergence of the trend Pinker warns about, such as greater social conflict, tribalism, and authoritarianism, which have been characteristic of Counter-Enlightenment trends over the past two centuries.

To overcome natural cycles that have synchronized and coordinated our sociocultural evolution through the epochs of history, rooted in our chronobiology, we shall have to engage in a more holistic approach to the study the body of our civilization as a complex social system that evolves according to incoming solar energy cycles. Hormonal factors determine the sexual organization of our society, and we shall have to better understand the yin-yang, feminine-masculine dynamics, which shape both our bodies and minds. Pinker's prescient call at this precarious time of history, may be similar to Sigmund Freud's warning in his 1929 book *Civilization and Its Discontents,* harkening the tension between the individual and civilization, immediately before the onset of the Great Depression that led to global conflict and WWII.

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