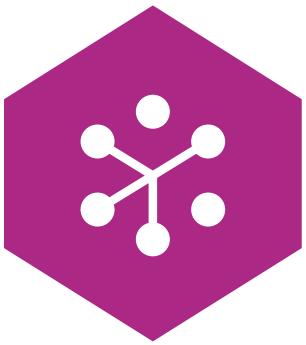

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A Trace of Emergence: Human Social Behavior as a Sign of Microbial Metabolism

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Abstract: Collective intentionality maps a microbial metabolism within the human body to our external observable environment through social behavior, giving rise to the process of life and cognition. To understand interactions between cultural evolution and biological networks, this socio-ontological inquiry examines the nature of collective intentionality and social behavior during the last 12,000 years. The question is: does the ancient metabolism of Escherichia coli interconnected to a viral genetic circuit act as the inherent organizing tendency ordering cultural evolution, in support of the hypothesis that microbes shape social behavior? Building on an historical underground tradition and a transdisciplinary theoretical foundation of systems thinking, this article considers life's origins, the theory of symbiogenesis, and cognitive neuroscience advances while defining a research-based microscopic model for reasoning the macroscopic phenomenology of social behavior out of the model's microscopic dynamics. Drawing from this evolutionary and cognitive context, as well as psychological theory, this analysis identifies a set of shared system functions in microbial metabolism, major cultural inventions, and selected social subsystems that support emergent evolution guided by the bidirectional gut microbiota-brain axis.

Keywords: Social Behavior, Cultural Inventions, Collective Intentionality, Microbial Metabolism, Emergence, Gut Microbiota-Brain Axis, Cognitive Neurobiology, Biosemiotics

Introduction

In *The Order of Things*, historian Michel Foucault (1970) theorizes that the history of non-formal knowledge, involving living beings (biology), labor (economics), and language (philology), has its own system. He believes the modern experience harbors a reversal, a rupture, a force signifying an "order that lay dormant within things" (209), and this "mutation of Order into History" (220) happened between 1775 and 1825, ushering in the new domains of biology, economics, and philology. This mutation calls into question the essence of beings related to time, labor, and the imminence of death because it defines "an internal space, which, to our representation, is on the exterior" (239). Caused by the forms of the unconscious and history, modernity's mutation began with the empirical being as an object of knowledge, living inside the structure of its brain and body physiology, while leaving behind the traces that create a sign system. Foucault asks how can a person be teeming with internal life that extends beyond the person's experience? How can the person be the labor inflicted on that person or a language with reticent meaning that was formed centuries before the person? Foucault's answer is that these ontological questions relate to the unthought; that is, the pure forms of the unconscious, the twin Other, the "unavoidable duality" that unveils the truth of the human being, concealed by its biology, economics, and language (326). The unthought is:

> the inexhaustible double that presents itself to reflection as the blurred projection of what man is in his truth, but that also plays the role of a preliminary ground upon which man must collect himself and recall himself in order to attain his truth. For though this double may be close, it is alien, and the role, the true undertaking, of thought will be to bring it as close to itself as possible; the whole of modern thought is imbued with the necessity of thinking the unthought… (327)

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Considering Foucault's historical analysis as an ontological context for this inquiry, an unsolved problem in biology is the interaction between cultural evolution and biological networks (Dev 2015; Weitz, Benfey, and Wingreen 2007). Debates continue on the criticality of dual-inheritance theories of gene-culture co-evolution (Durham 1979; Feldman and Cavalli-Sforza 1989), along with theories of genes controlling the direction of cultural evolution (Wilson 1978; Alexander 1979; Lumsden and Wilson 1981; Tooby and Cosmides 1992), versus cultural evolution influencing genes (Boyd and Richerson 1985, 2005; Rogers 1988; Laland and Brown 2002). Within this tangled context of social science debates is the understanding that cultural evolution and gene regulation are two developmental systems that the human organism passes on (Varela, Thompson, and Rosch 1991; Oyama 2000). These self-organizing biological systems also function as mutual mnemonic devices for long-term information exchange about human evolution, and with careful simplification, both can be studied holistically as an integrated emergent system to open up a key domain in social ontology—the nature of collective intentionality as expressed by cultural inventions and social subgroups during the last 12,000 years. Cultural inventions include agriculture, writing, milk production, fermentation practices, metallurgy, machines; selected social subsystems are genetic engineering, capitalism, and the ancient Egyptian funerary texts of the pharaonic priesthood.

Social behavior can be defined as any activity for survival or reproduction that involves species-specific interactions and communication (production and interpretation of signals) to influence present and future actions (Robinson, Fernald, and Clayton 2008). Experimental studies indicate that metabolism conditions social behavior in all species including humans (Robinson, Fernald, and Clayton 2008; Boyle et al. 2015; Sih et al. 2015; Boyle et al. 2017), partially explaining why human collective intentionality remembers, reproduces, and records microbial metabolic events. Considering that our ancestors are microbes as well as symbionts in our bodies (Margulis and Sagan 1986; Margulis 1991), this article's purpose is to offer a socio-ontological perspective on the nature of collective intentionality and social behavior by exploring historical cultural inventions and social subgroups, as well as the highly conserved metabolic pathways of *Escherichia coli (E. coli)* that interconnect to the genetic circuit of bacteriophage Lambda (phage for short) in the human gastrointestinal tract.

The surprising question for consideration is: does *E. coli's* ancient fermentation metabolism interconnected to a viral genetic circuit in our guts function as the inherent organizing tendency ordering the last 12,000 years of cultural evolution, in support of the hypothesis that microbes shape social behavior? It is obvious that the physical actions of sociological behavior are different than the biochemical reactions of this quantum microbial metabolic network; however, what is generally not recognized is that the two systems share the same set of functional properties, and this enables a holistic study of social behavior and microbial metabolism as an integrated emergent system. Because of this, we can understand the nature of the intrinsic system in process with cultural evolution by recognizing shared system functions.

Further, conscious collective intentionality in our material world, or "the power of minds to be about, to represent, or to stand for, things, properties and states of affairs" (Jacob 2014), also retains unconscious programmatic content related to gene regulation if collective intentionality maps the functions of *E. coli's* ancient microbial metabolism to our external, observable environment through social behavior. Via a nonlocal network of quantum phenomena, this unconscious measurement-in-process of a gene regulatory network is enacted or co-determined by both the microbial metabolism and conscious individuals with similar brains and metabolic networks. Thus, cognitive biologists Maturana and Varela's idea that the environment and living structure co-emerge, giving rise to the process of life and cognition (Maturana and Varela 1987; Varela, Thompson, and Rosch 1991; Luisi 2003) is applicable. In *The Structure of Behavior*, Merleau-Ponty (1967) explains that the organism itself (its receptors, nerve centers, organ function) selects and is sensitive to environmental stimuli, and the environment emerges via the organism's actualization.

Both philosopher Gilles Deleuze and psychiatrist Félix Guattari (1983, 290–91), with their ideas about the "molecular unconscious" and their aim of demonstrating the "existence of an unconscious libidinal investment of sociohistorical product, distinct from the conscious investments coexisting with it" (88), sensed what appears to be a conscious/unconscious split in collective intentionality. Why are these paradoxical ideas worth consideration? Understanding how collective intentionality functions is critical to humanity's survival, for if a symbiotic metabolic system guides human intelligence, then we can use this model to predict the future in the material world for the purpose of control in the present, while gaining a better understanding of human evolutionary potential.

Social scientist Gregory Bateson (1979, 8) asks: "What is the pattern which connects all living creatures?" To support the assertion that a microbial metabolic network with a genetic circuit is the inherent organizing tendency ordering the last 12,000 years of cultural evolution, as well as the "pattern which connects," this article continues with a foundation of scientific theoretical support generally based on experiments and systems thinking. Keeping in mind Foucault's ontological context on the mutation of Order, a glance at the debated theories of physicist John Wheeler, psychologist James Baldwin, sociologist Niklas Luhmann, philosopher Martin Heidegger, and theoretical biologist Robert Rosen provide a transdisciplinary theoretical foundation for this socio-ontological inquiry that is grounded in systems thinking. Then to provide evidence and contextualize the significance of this phenomenon that can be described as bidirectional feedback between social agents and a quantum biological system, this article briefly reviews the evolutionary origins of life, the theory of symbiogenesis, and advances in cognitive neuroscience. Next, the methodology defines a research-based metabolic model for reasoning the macroscopic phenomenology of cultural inventions out of the model's metabolic significance. This is accomplished by presenting first the historically produced doctrine of being or what we commonly know from the past about recent cultural inventions and selected social subgroups, followed by an analysis identifying the set of functional properties shared by the macroscopic and microscopic systems. With this broad scientific framework for creativity's cognitive and evolutionary wellsprings, this article concludes by opening up a conceptual window through the psychological theories of Jung, Murray, Gibson, Fechner, and Freud.

Theory and Evidence for the Architecture of Collective Intentionality

First, our world is an idea. Based on experimental data, physicist John Wheeler (1988) proposes the world is a self-synthesizing system built on observer-participancy and sensory stimuli via a network of quantum phenomena. Observer-participancy occurs when we choose a question and expect an answer: "No choice of question? No answer!" (9). Life, mind, and communication (exchanges of information) are essential. Second, history is genetic. In *Development and Evolution* (1902), psychologist James Baldwin explains that teleology (the realization of purpose) is a genetic outcome, and consciousness repeats relations in nature, while unconscious acts relate to physiology controlled by the autonomic nervous system (see also Baldwin 1906). Third, a social system reproduces itself through system-specific communications. Sociologist Niklas Luhmann describes social systems (reproducing by communication) and psychic systems (reproducing by thought/consciousness) as autopoietic (self-reproducing) systems. Further, the organic system (biochemical elements) and psychic system (thoughts) are structurally coupled, while psychic processes are synchronized with communication processes (Seidl 2004).

Fourth, our world is inauthentic. To philosopher Martin Heidegger, humans dwell inauthentically in the world because they conceal their own possibilities, while believing publically defined interpretations, such as the idea of finite death. In *Being and Time*, Heidegger ([1927] 1962, 292) discusses death's concealed character as a possibility-of-Being; that is, death "does not imply any ontical decision whether 'after death' still another Being is possible, either higher or lower." What Heidegger means by the possibility-of-Being is emergent evolution. This

involves the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems (Goldstein 1999).

Fifth, an "internal predictive model" can guide social behavior. In his Foreword to *Anticipatory Systems*, Robert Rosen (1985, v) explains that "organisms can generate and maintain internal predictive models of themselves and their environments, and utilize the predictions of these models about the future for purpose of control in the present." For example, if System S functions in real time with an internal system Model M running faster than real time, then an observable on internal M is a predictor for the behavior of the corresponding observable on S in the future. Put simply, M and S are coupled, and the output of the observable on M is an input to S, allowing feedforward or anticipatory control (Louis 2010).

Evolutionary Origins

Researchers generally believe that DNA appeared late in early life history, with DNA originating from RNA in an RNA/protein world. Reconstructing early events in the transition from prokaryotic (bacterial) to eukaryotic cells (our cell-type) is problematic for evolutionary biologists. Some believe eukaryotes were born out of a stepwise symbiotic union of prokaryotic cells, while others believe that the ability to phagocytose prey led to the origin of eukaryotic features prior to endosymbiosis (Roger 1999). Before the advent of oxygen, it is believed that the ancient glycolysis enzyme pathway was the source of energy production for earlier organisms such as bacteria. This ancient gene expression network can function without oxygen or glucose by fermenting lactose, the predominant sugar in milk.

In early cellular evolution, horizontal gene transfer (HGT) or the exchange of genes between two different species was the primary driving force (Woese 2002), and viruses have this natural capability. Life's history is about virus-host coevolution, and their origin involves three major hypotheses: 1) primordial viruses are intermediates between prebiotic chemical systems and cell life; 2) viruses are parasitic degenerated cells that shed their translation apparatus; and 3) viruses evolved independently from selfish cellular genes in different domains of life (Krupovic and Koonin 2017).

Theory of Symbiogenesis

Symbiogenesis is the theory proposed by Russian botanist Konstantin Mereschkowski circa 1905 and later advanced by biologist Lynn Margulis that the nucleus and chloroplast of eukaryotic cells evolved from symbiotic relationships with less complex cells such as bacteria and archaea. Likewise, ecologist Peter Price (1991) argues that eukaryotic evolution (organelle acquisition, biotic complexity) depended on the invasion of parasites, shifting from parasitic to mutualistic symbiosis. As examples, the human eukaryotic cell nucleus exhibits viral traits (Villareal and Witzany 2010), while theories also exist about gene dissemination via the emergence of virions (Forterre and Prangishvili 2009), as well as the eukaryotic nucleus evolving from a complex DNA virus (Bell 2001). Accordingly, symbiosis can bridge lineages with different metabolic capabilities (Vetter 1991).

Microbial species in the skin, mammary glands, placenta, seminal fluid, uterus, ovarian follicles, lung, saliva, oral mucosa, conjunctiva, biliary, and gastrointestinal tracts compose the microbiota of the human body (Sherwood, Willey, and Woolverton 2013). The term microbiota is often confused with the microbiome, which is the catalog of these microbes and their genes (Zhang and Davies 2016). Consider the hologenomic concept, an evidence-based theory on the co-evolutionary history of humans and their gut microbiota. A human, animal, or plant is a biomolecular network composed of the host plus its associated microbes; that is, a "holobiont" (Margulis 1991, 2) equipped with its hologenome (the nuclear genome, organelles, and microbiota) (Bordenstein and Theis 2015). Because microorganisms are included, variation occurs via recombination, mutation, and the rapid process of microbial amplification, acquisition

of novel strains, and HGT, implying that these symbionts also play a role in the evolution of their eukaryotic hosts. Researchers argue that a rapidly occurring process such as HGT might allow the holobiont to survive under changing environmental conditions (Zilber-Rosenberg and Rosenberg 2008). Useful concepts such as the holobiont and hologenome allow interdisciplinary examination of the role of microbial symbionts in behavior and speciation-by-symbiosis (Shropshire and Bordenstein 2016). Along with nuclear genes and organelles, microbiota spur eukaryotic speciation because microbial symbionts are universal in eukaryotes, the microbes are host-specific, and host immunity genes are evolving with microbiota (Bruckner and Bordenstein 2012).

Cognitive Neuroscience

Brain development and social interaction research in both humans and animal models indicate that gut microbes impact cognitive function and behavioral patterns, since they are "part of the unconscious system regulating behavior" (Dinan et al. 2015, 1). Microbes influence our behavior through the gut microbiota-brain axis by producing neurotransmitters in the gut microbiota, while altering the levels of these neural messengers in the brain. As examples, *Escherichia coli* produces serotonin and norepinephrine, *Lactobacillus* produces gamma-aminobutyric acid (GABA) and acetylcholine, and *Bacillus* produces dopamine and norepinephrine. *Lactobacillus* species also metabolize the tryptophan genes in *E. coli* that produce serotonin, a neurotransmitter influencing neurological behavior (Zhang and Davies 2016). Tryptophan in *E. coli* is the sole precursor of peripherally and centrally produced serotonin, a key neurotransmitter of the gut microbiota-brain axis, involved in cognitive behavior such as learning and memory. The serotonergic system includes the cortex, amygdala, and hippocampus, linking emotional and cognitive brain centers with the gut microbiota (Jenkins et al. 2016; O'Mahony et al. 2015). Pathways involved in bidirectional communication of the gut microbiota-brain axis include the endocrine, immune, and neural; that is, the central nervous system (CNS), both brain and spinal cord, the autonomic nervous system (ANS), the enteric nervous system (ENS), and the hypothalamic pituitary adrenal (HPA) axis, influencing affect, motivation, and higher cognitive functions (Carabotti et al. 2015). Both the vagus nerve and modulation of systemic tryptophan levels are involved in the gut microbiota-brain axis (Cryan and Dinan 2012).

Data demonstrating bidirectional signaling between the brain and the complex gut microbiota along with initial studies in humans are supporting the relationship between intestinal microbiota and brain function that impacts cognition and behavioral patterns (Dinan et al. 2015; Mayer et al. 2014; Cryan and Dinan 2012). Some researchers propose that microbe-brain interactions are a key driver of the evolution of the social brain (Stilling et al. 2014). Also, types of microbial symbioses manipulate host behavior, and researchers conclude that this results from the long history of co-evolution between the human host and the microbiota (Stilling et al. 2014).

The Symbiotic Internal Predictive Model in the Gut Microbiota

The well-studied facultative *E. coli* bacterium and its bacterial virus, Lambda (Ptashne 2004; Court, Oppenheim, and Adhya 2007), exist everywhere on the planet (Suttle 2007), including in the human gut microbiota or gastrointestinal tract in a dormant state within *E. coli* bacteria (Reyes et al. 2012). With its potential for multiple bacterial phenotypes, the regulatory network of *E. coli* is a complex system of feedback loops, regulatory pathways, and hierarchical transcriptional cascades in various subnetworks (Conway and Cohen 2015; Martínez-Antonio, Janga, and Thieffry 2008), which include transcriptional interconnections to phage Lambda's genetic circuit on the core circular E. coli genome (Ptashne 2004; Ptashne and Gann 2002). Phage Lambda is a complex dying/rising virus with a genetic control system structured by the rivalry between its two viral repressor proteins over six gene-seats on its genome that regulate its two lifestyles of vegetative replication: temperate lysogeny controlled by c1 (c-one) protein

(when the virus is dead or dormant on the *E. coli* host chromosome and replicated silently with its host) versus virulent lysis controlled by cro protein (when the virus rises from its dead state to take over the cell's replication machinery to clone progeny).

The genetic circuit begins when phage Lambda adsorbs to its receptor site on *E. coli*, pumping its DNA from head to tail into the outer membrane protein channel called LamB. Then after it injects its DNA into *E. coli*, the phage genome circularizes and integrates into the *E. coli* host chromosome by a site-specific recombination process called a Holliday junction (Holliday 1964), a cruciform DNA structure with four branches (see Figure 1) according to X-ray crystal structures (Gopaul, Guo, and Van Duyne 1998). As a prophage, the inactive or dead phage attached to its protein-cross on the *E. coli* chromosome is replicated silently with its host (lysogeny), so it is temporally correlated to *E. coli's* environment in the human body. Known signals for prophage induction (waking up the virus) relate to DNA damage caused by UV light (Monk and Kinross 1975), temperature (Matos, Blanco, and West 2013), and oxidative stress (DePaepe et al. 2014), since these stressors activate *E. coli's* SOS response, destroying repressor proteins maintaining the dormant lifestyle of lysogeny. This induces the prophage to rise from its dead state on its protein-cross, throw its genetic switch into the lytic cycle, and take over the *E. coli* replication machinery for second-stage rolling circle replication to clone numerous viral progeny that escape through cell membrane holes to infect new hosts.

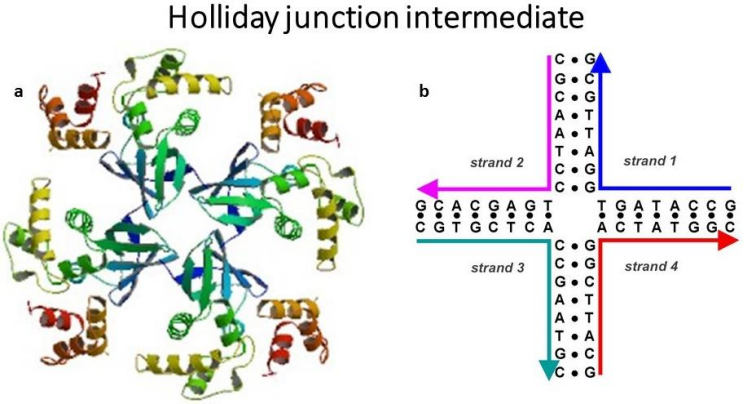

Figure 1: Holliday Junction Binding Protein RuvA from *E. coli* (a) with Schematic (b)
a. IHJP Holliday junction in E. coli from Protein Data Bank. Structure 6: 11–21 (T. Nishino et al. 1998); b. Schematic of a Holliday junction showing the base sequence and secondary structure but not the tertiary structure (Mao 2004). Wikipedia Creative Commons License Permission (Mao)
Source: Protein Data Bank (Public Domain)

E. coli's ancient enzyme pathway used by phage Lambda allows the transport of lactose into the cell by a low-affinity pathway (Merino and Shuman 1997; 1998), for *E. coli* can use up to seven different sugars to support its scavenging skills (Jones et al. 2008). When glucose is not available, *E. coli* ferments the milk-sugar lactose for growth and replication, which is associated with adaptive mutation because an increased rate of change is now possible (Foster 2000). Thus, a variety of metabolic sugar mechanisms are available in the ancient glycolysis gene regulatory network, showing how living organisms within us are efficiently organized for survival.

So what are *E. coli* and phage Lambda doing when the human host dies? Recently, microbiologists analyzed the thanatomicrobiome (Greek: *Thanatos* "death") in blood and internal organ tissues of eleven human cadavers, revealing that anaerobic bacteria, such as *Lactobacillus* and *E. coli* that can ferment lactose, predominate with short postmortem intervals (Can et al. 2014). At human death, lack of oxygen causes a shift from aerobic to anaerobic (without oxygen) fermentation (Vass et al. 2002). Researchers also studied the thanatotranscriptome (genes actively expressed after organismal death) in two vertebrate species (mouse and zebrafish), finding abundant gene transcripts for stress, immunity, inflammation, apoptosis,

solute/ion/protein transport, embryonic development, epigenetic regulation, and cancer that switch on after organismal death (Pozhitkov et al. 2016; 2017). Gene transcript abundances have been detected in three organisms now (zebrafish, mouse, human), since Gonzalez-Herrera et al. (2013) found upregulated genes in thirty human cadavers, such as matrix metalloprotease 9 (MMP9), an enzyme that breaks down the extracellular matrix (ECM). A metalloprotease (or metalloproteinase) is an enzyme with a catalytic mechanism involving a metal, and researchers believe the enzyme MMP plays a role in embryonic development, morphogenesis, and reproduction (Nagase and Woessner 1999). Similarly, in the mouse, gene expression of matrix metalloproteinase correlates with virulence, and data indicate that increased inflammatory gene expression by CNS cells is due to uncontrolled viral replication (Zhou et al. 2002). These initial studies and evidence support: 1) a temperate lysogenic bacteriophage lifestyle is dominant in the living human's gut (Reyes et al. 2012); 2) microbiota are hotspots for HGT (Liu et al. 2012); 3) lactose fermentation is activated by postmortem lack of glucose and oxygen as is *E. coli's* SOS response (Farr and Kogoma 1991); and 4) developmental, stress, and other genes switch on at human death. Thus, *E. coli's* SOS response is active, waking up its sleeping phage Lambda, activating its genetic switch to lysis, and possibly allowing HGT of eukaryotic DNA. This may result in the creation of something new via a viral genetic switch to lysis. It is known today that genetic material released from dead and living cells persists in all environments, and DNA can be transferred from dead to living cells by HGT (Avery et al. 1944). This is called transformation, a natural process in which the genetic makeup of a cell is changed by the introduction of DNA from the surrounding environment, where cells have died by lysis, releasing fragments of free DNA.

Historically Produced Doctrine of Being

Figure 2 identifies the historically produced timeline of milestones and social subsystems. It is worth mentioning that when farming replaced hunter-gathering, cattle herders reduced lactose in dairy products by fermenting milk to make cheese and yogurt. Also, a mutation spread through Europe that adapted people to the enzyme lactase and the consumption of milk, and some researchers believe this to be consistent with gene-culture co-evolution (Curry 2013).

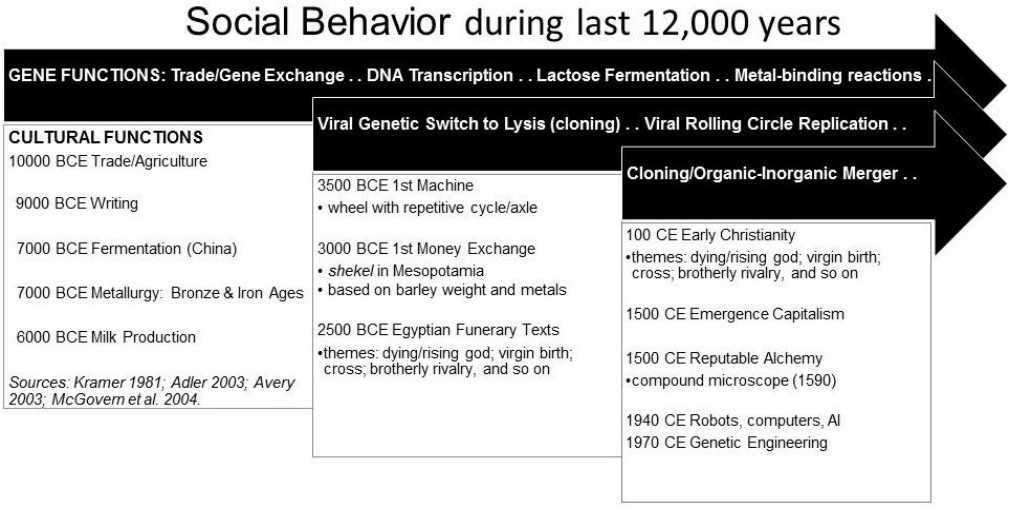

Figure 2: Human activities during the last 12,000 years record the functions of *E. coli* bacterium's ancient metabolism interconnected to the genetic circuit of its bacterial virus Lambda. The phage remains in a dormant state on the *E. coli* chromosome (lysogeny), until *E. coli* is stressed, prompting the phage to become active and clone progeny (lysis).
Source: King

Selected social subsystems on the timeline are genetic engineering, capitalism, and the funerary texts of the ancient Egyptian pharaonic priesthood. Genetic engineering is the technology of gene manipulation, gene cloning, recombining DNA, and genetic modification (Nicholl 2002). Regarding capitalism, Karl Marx and Friedrich Engels in *The German Ideology* (circa 1846) explain the division of labor as a major historical force because the capitalist ruling class produces the ruling ideas in society, while owning the means of production that is produced by the exploited working class. Differing from this view, Fernand Braudel in *Civilization and Capitalism Volume II* ([1979] 1992) thought capitalism emerged from a particular type of society with a favorable market environment in a social order oblivious to its future processes. To Braudel, emergent economics in the world involved local family and communal activities, universal social markets, and the ruthless zone of capitalism (Webb 1992).

The final social subsystem concerns the least-corrupted funerary texts (circa 2500 BCE) of the ancient Egyptian pharaonic elite, who professed that life came from death. Funerary themes include the dead King's transformation, the dying/rising deity Osiris, the brother rivalry between Seth and Horus, the virgin birth of the milk-goddess Isis, and other ideas present in religion today. Many Egyptologists view the funerary texts as primitive, confusing, and unintelligible magic spells. Egyptian symbols are complex functional elements in a semiotic system that requires a synthesizing principle to develop a holistic conceptual schema (Wickett 2010).

With this brief review of historically produced knowledge, our next step is to examine the set of functions shared by the postulated "internal predictive model" and collective intentionality, as observed by historical social behavior.

Mapping Cultural Inventions and Social Subsystems to the Microscopic Model

E. coli functions include transformation (uptake of exogenous DNA), transfection (uptake of phage DNA), reproduction, recruitment of metal ions for catalysis and stability, DNA transcription and translation to protein, fermentation of various sugars (glucose, lactose, maltose), ability to run with or without oxygen, gene regulation, DNA repair, and so on. Somewhat similar but different, the interconnected functions of *E. coli's* bacterial virus Lambda are HGT, vegetative lytic or lysogenic growth, repressor establishment, transcriptional gene regulation, and cloning progeny virions (head and tail morphogenesis, DNA packaging, crystallization) (Court, Oppenheim, and Adhya 2007; Nicholl 2002).

To compare the technologies of agriculture, writing, fermentation, and milk production to the ancient glycolysis gene regulatory network with its viral transcriptional interconnections for cloning, consider that agriculture is vegetative replication, a form of asexual reproduction in plants or grain-producing plants, in which multicellular structures become detached from the parent plant and develop into new individuals genetically identical to the parent plant. Similarly, gene cloning is "a form of molecular agriculture" that produces many copies of a particular DNA sequence (Nicholl 2002, 2). Thus, agriculture is comparable to the asexual cloning of plant-like virions in the vegetative lytic lifestyle of phage Lambda.

The cultural invention of writing is a cognitive-lingual process of using symbols to represent concepts that are transcribed into letters, translated to words, and copied for understanding. The quasi-text process of DNA transcription with its nitrogenous bases (A, C, T, and G) is similar to writing, for the information in DNA letters is transcribed into RNA and translated into protein words, and vice versa. As theoretical chemist John Avery (2003, 127) explains: "A sharp qualitative discontinuity" exists between DNA-RNA-protein information transfer and the human language, yet "all our activities are fundamentally biological phenomena."

Concerning the cultural invention of fermentation practices, microbiota studies indicate that humans take advantage of microbially assisted and fermented foods, so microbes play an important role in the rise of grain-based agriculture and the spread of human genetic variants, facilitating lactose tolerance and dairying (Schnorr et al. 2016). Biologists assume that ancient bacteria used fermentation coupled to a sulfur metabolism (Schwemmlern 1991). With reference

to the "internal predictive model," it is suggested that writing, agriculture, fermentation practices, and dairying are material signs pointing to internal metabolic functions (DNA transcriptional regulation, cloning, and lactose fermentation), indicating a genetic switch to lysis.

Regarding the technologies of metallurgy and metal machines, perhaps the "uncannily mystical" allure of metal and machinery noted by historian Oswald Spengler (1926, 500), who was searching for pure forms with potential for actualization, is connected to an inward psychophysiological or metabolic value, since both humans on earth and proteins in the cell scavenge for metals to meet their needs in forming structure or driving catalysis. Approximately one-third of proteins require metals to function, so metal sensors are used by metalloproteins (metal-binding proteins) to acquire the right metals (Waldron et al. 2009). Although microbial metalloproteomes are largely uncharacterized, biologists know that metal ions have unlimited catalytic potential with the ability to stabilize proteins. Key roles include those in respiration (iron and copper), photosynthesis (manganese), and metabolism (iron). Some metals tend to bind organic molecules more selectively. This natural order of stability for divalent (forming two bonds) is the Irving-Williams series: copper and zinc form the tightest complexes with organic molecules, then nickel and cobalt, followed by iron and manganese, and finally calcium and magnesium (Irving and Williams 1948). The protein coat of phage Lambda has high metal-binding potential, exhibiting the Irving-Williams natural order of stability (Zhang, Thompson, and Caruso 2011).

Next, the technology of genetic engineering is a social subsystem that centers on model organisms such as *E. coli* with its highly conserved central metabolic pathways and phage Lambda, a metal-binding vector or ferryboat for HGT of organic molecules. Related to the novelty of genetic engineering in the twentieth century, this practice may have historicity because the laboratory method of chemist Wendell Stanley, who was awarded the 1946 Nobel Prize in Chemistry for isolating and purifying the properties of the crystalline tobacco mosaic virus in 1935, is similar to the laboratory method of reputable alchemists in the 1600s (King 2015). Enacting the same laboratory method suggests that reputable alchemists were also practicing genetic engineering, such as isolating and purifying viruses. In his psychological interpretation of alchemy, Carl Jung (1953, 141) explains that the existing evidence substantiates that the alchemists understood they were transforming themselves into "living philosophical stones." Jung explores the qualities of the *lapis* (Latin, "stone"), claiming that alchemy is an undercurrent in Christianity, and this seems correct for Christ is holding a crystal *lapis* in Da Vinci's painting entitled *Salvator Mundi* ("Savior of the World"). The meaning of the chemiluminescent crystal ball in the painting (see Figure 3) may also rest in its title *Salvator Mundi*, suggesting that the spherical crystal itself is the Savior of the World, for according to Jung, the alchemical Stone of the Philosophers was referred to by many names, one of which was *Salvator* or Savior. It is interesting that Caspar, Crick, and Watson (1956) thought of viruses as crystals, as do modern virologists.

As a tradition, reputable alchemy was practiced earlier throughout Europe, Egypt, and Asia by the ruling elite and promoted during the Renaissance by emperors and kings. However, alchemy was generally veiled in allegory to protect the chemical knowledge from the "vulgar" and according to alchemist Dr. Michael Maier, who received his doctorate in medicine at Basle and then moved to Prague to become Imperial Count Palatine in the intimate circle of Emperor Rudolph II, ancient deities (Osiris, Isis, Dionysus, Venus, and so on) are signs of chemical processes (Maier 1618, Discourse XLI). If so, this suggests that widespread historical interest in biochemical activities is recurrent during the last 5,000 years of human history and emerging again during the last fifty years as genetic engineering.

Figure 3: *Salvator Mundi* (1502–1508) by Leonardo da Vinci
Source: Public Domain

In a similar instinctive advance, the social subsystem of capitalism (ownership of the economic means of production to increase profit) has also existed for centuries, although its roots are strongly debated. Initially, the psychology of the marketplace—the sense of exchange, comparing and measuring, buying and selling—predated capitalism and may be grounded in the microscopic marketplace of microbes that exchange commodities such as genes via HGT. Within the human microbiota, the ecological architecture of trade or HGT exists "across multiple spatial scales, functional classes and ecological niches with transfer further enriched by bacteria that inhabit the same body site" (Smillie et al. 2011, 241). Bacteriophages are viruses known for their natural competence of HGT, and each person's unique virome (the part of the microbiome containing viruses) consists primarily of bacteriophages (Virgin 2014). This sense of exchange masterminded by a bacteriophage anticipates its virulent takeover of *E. coli's* replication machinery for cloning. Capitalism with its private ownership of the means of reproduction to produce profit (metal coins with heads and tails that describe phage morphology) is comparable to phage Lambda's monopoly or private ownership of *E. coli's* means of reproduction to clone little heads and tails during phage Lambda's active lytic lifestyle. Braudel viewed capitalism as threatening, arguing that the state in capitalist countries does not safeguard competition, but rather guarantees the monopolistic capitalists against the population majority (Wallerstein 1991).

In addition, if we look at the etymology or true sense of the word "capital," we discover the word is from the Latin *capitalis*, "of the head" and Latin *capitulum*, "little head." Increasing capital or circular metal coins with little heads and tails is remarkably similar to cloning a multitude of little metal-coated viral heads and tails—both are reproduced or replicated. Metal is a sign for measuring wealth and the quantity of metal in money determines its value (Foucault 1970). Regarding the historical exchange of goods, coins commonly depicted heads or tails and were usually made from precious metals. In early Mesopotamia circa 3000 BCE, the *shekel* was the unit of weight and currency, referring to a specific weight of barley and equivalent amounts of silver, bronze, copper, and so on (Kramer [1956] 1981). Barley was one of the first cultivated grains, and malted barley is the source of the sugars (principally maltose) which are fermented into beer. Further, an interesting correlation exists between *E. coli's* ancient maltose metabolism and its susceptibility to phage Lambda infection. The gateway to *E. coli's* maltose transport system is the outer membrane protein channel (LamB) for the passage of maltose, as well as the transport of glucose and lactose (Boos and Shuman 1998), and this is also phage Lambda's receptor or attachment site for *E. coli* transfection (Randall-Hazelbauer and Schwartz 1973). In sum, these correlations do not imply causation, but rather a co-determining propensity enacted through culture and viral genes via the bidirectional gut microbiota-brain axis with its five communication pathways (Wang and Wang 2016).

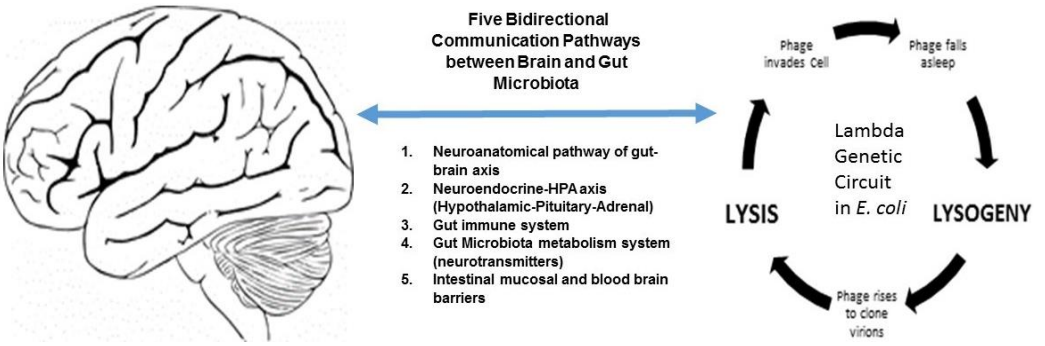

Figure 4: Bidirectional communication between the microbes in the gastrointestinal tract and brain occurs via five internal pathways called the gut microbiota-brain axis that includes gut microbiota and their metabolic products, enteric nervous system, sympathetic and parasympathetic branches, neural-immune system, neuroendocrine system, and central nervous system (Wang and Wang 2016). Social behavior is bidirectionally linked via the brain to *E. coli* genes and the genetic circuit of phage Lambda, impacting cognition and behavioral patterns in the last 12,000 years.
Source: King

The final selected social subsystem is the least-corrupted ancient Egyptian funerary texts, carved in the pyramids and coffins. Today the afterlife cosmology detailed by the pharaonic priesthood is perceived as obscure and controversial. Yet, a recent semiotic study (King 2004) of the least corrupted Egyptian funerary texts uses phage Lambda's genetic circuit as the synthesizing principle, with Egyptian deities and their activities interpreted as signs for viral and bacterial genes and proteins along *E. coli's* ancient enzyme pathway. In short, the deities' activities in their core myth (dying/rising god, virgin birth, brother rivalry, and so on) match up with the dying/rising, asexual viral lifestyles of phage Lambda's genetic circuit controlled by two competitive proteins. DNA and proteins are crystallized forms, as is a virus. The carved Pyramid Texts define the dead King's emergence as a morning star (Faulkner 1969; Wickett 2010), a belief also represented in the literature of early China, the myths of the Navajo Indians (King 2011), and the Bible regarding Christ (Rev. 22:16). Ancient Egyptian, early Chinese, and seventeenth-century Navajo eschatological texts offer similar cosmological accounts of their quests for immortality as their kings transform to stars or rock crystals, implying a crystallized emergence (King 2015; 2011; 2009). Today we find the same Egyptian themes documented by the hierarchy of the Catholic Church, suggesting that Christian deities are also signs for microbial metabolism. Even the early Christian Mass at Hagia Sophia in Constantinople (circa 360 CE) is an enactment of the ritual carved on the walls of the Edifice of Pharaoh Taharqa one thousand years earlier that describes *E. coli's* ancient enzyme pathway used by phage Lambda. (King 2015; 2008; 2004) In ritual, artwork, and literature, the pharaonic culture may have enacted metabolic events through their deities, signs of microbial genes, and proteins, describing *E. coli's* metabolism interconnected to the Lambda genetic switch for the dead pharaoh's emergence. As Antonin Artaud justified in his 1947 radio play *To Have Done with the Judgment of God*, "laugh if you like, what has been called microbes is god," for god is "the bestial accident of unconscious human animality" (Artaud [1947] 1988, 569).

In summary, not only cultural inventions, but also social subsystems of genetic engineering with its possible alchemical origin and biological applications, capitalism with its core parasitic potential of owning the economic means of reproduction based on the value of metal money, and the philological interpretation of Egyptian funerary texts with universal religious themes, characterize social behavior as internal biological signs of microbial metabolism that may allow the possibility of emergence or speciation-by-symbiosis. Of interest is a similar trace of emergence or privileged "underground" tradition existing in Louis Althusser's last philosophical writings called a "materialism of the encounter" or "aleatory materialism," and Democritus, Epicurus, Lucretius, Machiavelli, Spinoza, Hobbes, Rousseau, Montesquieu, Heidegger, Marx, and Wittgenstein are part of it (Lewis 2014). This enigmatic trace is also present in Deleuze and

Guattari's (1987, xiii) "nomad thought," Nietzsche's "gay science," Artaud's "crowned anarchy," and Foucault's "outside thought," along with many other individuals and cultures in search of emergence (King 2004; 2008; 2011; 2015; 2017). It may be that Western natural sciences today are arriving again where ancient Egyptian knowledge was 5,000 years ago because social systems are autopoietic (self-reproducing) systems; that is, the human organic system (biochemical elements) and psychic system (thoughts) are structurally coupled, as Luhmann theorized. Likewise, Foucault's mutation of Order, motivated by the unconscious and history, is another trace of emergence similar to the microbial message in ancient Egyptian funerary texts, what seems to be the origin of the "underground" tradition; that is, knowledge suppressed by the power-elite in historical cultures that eventually surfaces in modernity due to the function of the bidirectional gut microbiota-brain axis with its five communication pathways. All in all, microbial metabolism seems to be the inherent organizing principle ordering the last 12,000 years of human history. Similar to historical sociocultural behavior, recent research supports that microbial metabolism also drives self-organization in the Earth's complex biosphere (Braakman, Follows, and Chisholma 2017).

Opening up a Psychophysiological Window

In their bio-cultural-historical approach to the study of development, Gelfand, Chiu, and Hong (2016) identify several areas of consensus within cultural development science: 1) evolutionary history (phylogeny) is relevant to the study of the origin and development of an individual organism (ontogeny); 2) niche construction theory or adapting to the environment is reasonable; and 3) cultural history and phylogeny are interwoven with ontogenetic development. Scholars generally agree that phylogenetic and cultural processes have coevolved since pithecanthropus several million years ago, supporting that biological changes are the cause and effect of inventions such as cooking, inscription, and agriculture (Gelfand, Chiu, and Hong 2016). Although supportive of the argument herein, these areas of general consensus lack psychological relevancy, so it is important to open up a psychophysiological window in the architeture of collective intentionality.

Psychologist Carl Jung (1958, 79) has made the quantum connection that the "world of the infinitesimally small" is the unconscious, and that human wholeness requires the unity of the conscious and unconscious. Also, psychologist Henry Murray (1936), who received an MA in Biology and a PhD in Biochemistry, accepted the role of unconscious determinants of behavior, pointing out the necessity of physiological brain processes for behavioral function (Hall and Lindzey 1957). Animal brains encode and integrate information from the environment through sensory inputs for adaptive behavior (Mattson 2014), and yet human perception of environmental properties may also be based on invariances or information in the topology of ambient UV light that can be directly detected without retinal, neural, or mental pictures, according to psychologist J. J. Gibson (1979). In the latter case, information in the light specifies what the environment affords for adaptation prior to sensory reception. Without retinal, neural, or mental pictures, the perception of information in the sun's ambient light may contribute to humanity's collective unconscious and the memory of a metabolic pathway with a genetic switch activated by UV light that molds behavior in history.

Also, Gustav Fechner (1873, Section XI, Note p. 94), a physicist and psychologist, explains conscious impulses related to pleasure or pain as a psychophysical relationship to conditions of stability and instability. Fechner's thinking prompted Freud to expand his theory on the sexual instinct's (*Eros*) influence on human behavior by developing the death drive (*Thanatos*) in *Beyond the Pleasure Principle* ([1920] 2009). Freud speculated that there is "a tendency innate in living organic matter impelling it towards the reinstatement of an earlier condition" (47), suggesting reverse or regressive evolution to lower forms of life with higher order such as microbes. This "tendency" may result from the function of the bidirectional gut microbiota-brain axis with its five communication pathways. The mature Freud thought the living being harked

back to an ancient origin via circuitous developmental paths, since everything living dies from internal causes and returns to the inorganic. Thus, "The goal of all life is death" and "The inanimate was there before the animate" (49–50). Akin to Fechner, Freud eventually defined the function of the pleasure principle as a "casting back" to a state of equilibrium, stability, homeostasis, lack of excitation, namely, "the peace of the inorganic world" (84–85), suggesting rocks, minerals, metals, crystals.

A crystal is a static form with structural stability. Crick and Watson (1956) predicted that the coats of viruses were composed of repeating subunits exhibiting the symmetry of closed polyhedrons, such as a pyramid. A virus is a crystalline form bound to a discrete geometrical configuration (Thom 1975). According to biologist Stuart Kauffman (1995), a virus is a low energy equilibrium system, and because no more energy is necessary to maintain the virus, order is free in a stable form. Recently, Nobel laureate Frank Wilczek (2012; 2013), a theoretical physicist and mathematician, provided the world with a mathematical solution for a time crystal, an actual state of being that functions something like a perpetual moving machine. Put simply, in Frank's time crystal, time-dependent phenomena can be exhibited in a time-independent system. Also, this crystal or new state of matter would be free of dissipation, so the emergent system would not lose energy through a conversion to heat.

In *What is Life?* Schrödinger (1944) explains that metabolism frees the organism from the entropy it produces when it is alive. At human death, an open microbial metabolism with a recurring viral genetic switch may allow emergence involving organic/inorganic bonding, speciation-by-symbiosis, and crystallization. Phage Lambda's cyclical genetic switch is eternal recurrence *par excellence* in the time-dependent material world, perhaps what Nietzsche (1967, 273–74) defines as "the unconditional and infinitely repeated circular course of things." In support of the hypothesis that microbes shape social behavior (Dinan et al. 2015), human history during the last 12,000 years can be interpreted as a self-organizing system of microbial metabolic functions, driven by a viral genetic switch biased to lysis or cloning. Conscious humans have unconsciously chosen stimuli in the physical environment that reproduce the functions of microbial metabolism, suggesting that our social behavior and collective intentionality are guided by parasitic genes rather than human genes; that is, our behavior models the extended phenotype of *E. coli* and its parasite phage Lambda.

If the brain's superior pattern processing is the neurobiological underpinning of human sociocultural evolution (Mattson 2014), and these social patterns describe a metabolic gene regulatory network in the gut microbiota with a genetic switch biased for viral lysis, then the evolutionary function of the gut microbiota-brain axis in the external environment may be related to viral lysis (cloning, progeny release, cell membrane breakdown). At best, this suggests that sociocultural evolution forecasts a possible symbiotic emergent state of being and structural stability via microbial metabolism; at worst, it suggests that human bodies in the material world are similar to phage-encoded protein clocks called holins that accumulate and cause cell lysis by triggering and controlling the degradation of the host cell wall at the end of the lytic cycle. These essential molecules determine the timing of lysis (Wang, Smith, and Young 2000), and "holins kill without warning" (Gründling, Manson, and Young 2001, 9348), while their energy poisons form holes in the cell membrane (Saier and Reddy 2015). This occurs in a manner similar to anthropogenic chemical emissions forming the hole in Earth's ozone layer over Antarctica.

A nonhuman psychological significance pervades this speculative association of humans to holins that strips away the anthropomorphic disguise we have attributed to ourselves, for we have caused the extinction of animals and disturbed nature's ecological balance, so we may be an extended phenotype of a virulent virus with our unconscious behavior controlled by the genes of this symbiotic parasite to overcode conscious behavior. Perhaps the neurobiological underpinning of cultural behavior is a virus that has manipulated our brain neuronal circuitries to exploit cognitive functions. This speculation also provides a rationale for our warlike behavior and the ravaging ecological bootprint we have stomped into Earth. Scientists know that climate

change aggravated by greenhouse gases from burning fossil fuels, deforestation, and agricultural production (cloning) must stop (Suzuki 2018). It is interesting that 12,000 years ago, the arrival of both a warming climate and humans in Argentina coincided with megafaunal extinction events (Metcalf et al. 2016) (see Figure 5).

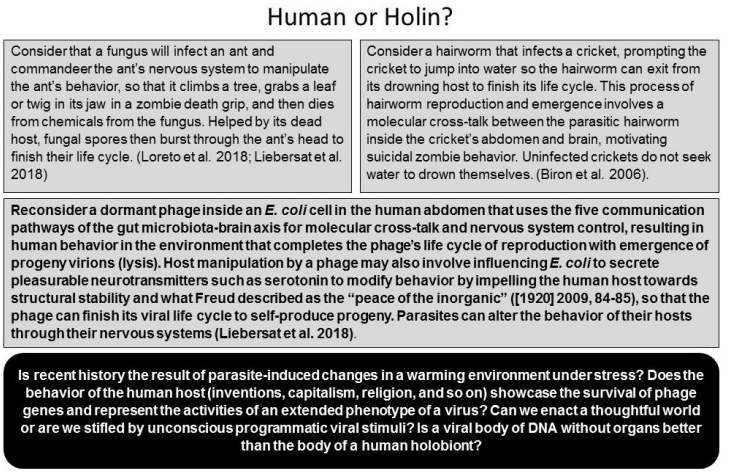

Figure 5: Human or Holin? (A Thought Experiment on the Anthropomorphic Disguise)
Source: King

The Human Holobiont

Many questions remain about the neurobiology of our behavior and psychology. It seems as if we have two opposite components: a bidirectionally queued, collective conscious intentionality, and a nonlocal unconscious intentionality, both interacting to enact social behavior in the external environment and microbial behavior in the internal environment; that is, two mechanisms of control that complement each other, eliciting stimuli in two different environments as an "unavoidable duality." Accordingly, the unconscious nature of collective intentionality is authentic (it reveals a possibility for emergence resulting in metal-organic bonding), nonhuman (it is microbial), non-ecological (it damages its ecological niche), and generative (it owns the capacity for speciation-by-symbiosis and crystallization). On the other hand, the conscious nature of collective intentionality is generally inauthentic (it conceals its possibilities ending in organic death), human (it uses an anthropomorphic disguise), ecological (it has concern for the ecological niche it destroys), and degenerate (to survive death, human intelligence imagines merging with machinic intelligence, so it is groove-oriented on material evolution). These characteristics seem diametrically opposed, not holistic, while shattering the idea of a complex evolutionary intelligence guided by holistic unconscious and conscious collective intentionality. However, this whole, evolving, socio-ontological viral intentionality defines the operation of its genetic circuit and the neurobiological psychology of a human being under its influence via the gut microbiota-brain axis. Even Jung's (1958, xvi) collective unconscious has archetypes or what he defines in his 1957 Preface to *Psyche & Symbol* as "inherited forms of psychic behavior," such as the imprisoned spirit in a dark world (Jung 1953), connoting not only the dying behavior of mythic and religious deities, but also the dormant prophage attached to its protein-cross in the lysogenic state (King 2015). With this insight, we can re-evaluate the Christian phenomenon of sinful sex (King 2007), and tackle implications related to what philosopher Charles Muses (1985, 136) terms "host/parasite pairs like good/evil, honesty/deception, health/sickness" where one element of the duality is considered symbiotic and the other parasitic. Finally—can we overpower the magical mythological and religious context shrouding the microbiological world to reasonably predict the future?

In both mice and men, evidence is mounting that microbes influence their hosts in cognition, social interactions, and emotional states (Gacias et al. 2016; Valles-Colomer et al. 2019). The brain of the human holobiont seems to build its social world out of a quantum microbial metabolism interconnected to a viral genetic circuit that shapes collective behavior in the environment via the bidirectional gut microbiota-brain axis. Thus, the world environment with its information-theoretic character may be self-synthesized by quantum networking, as Wheeler (1988) believes, even though humans do not generally embrace their potential for acts of observer-participancy based on choices of well-defined questions with communicable answers. However, this potential strategy opens up the possibility of social transformation (modifying beliefs).

Both genes and gene regulatory pathways are cellular networks of digital information similar to a 5G cellular mobile communication network with Internet access, cells, digitized signals, and transmission streams of information bits. As discussed, microbial metabolism scales up to macrocosmic industrial capitalism; however, it is now scaling to the economic technosphere of metal digital devices, complementing the spread of global capitalism (globalization) with related market operation events (energy consumption, environmental exploitation of metals, electronic waste disposal). One application that accommodates the inherent principle of self-organization in this complex system is to use our expanding information technologies to inform policymakers and researchers about the neurophysiological behavior cultivating advanced capitalism and its viral re-communication via digital technologies. By adopting a viral strategy currently used by the news media and advertising agencies, where information is injected into the digital communication system and then repeated-spread-cloned, informed individuals (with well-defined questions and answers) could plan transdisciplinary communications that would leverage feedforward input into the industrial capitalist metabolism, as well as limiting its potential to become a surveillance society. Because digitalization can create cooperative communication networks (as well as competitive relations), informed transdisciplinary input could reduce anthropogenic climate change as well as guide innovation in healthcare, synthetic biology, genome-editing techniques (CRISPR-Cas9), and so on, while guarding against unintended consequences.

Another hurdle is the allure of metal and machinery with its psychophysiological or metabolic value, which currently inspires a machinic transformation of humanity that is degenerately represented as the peak of human evolution called the posthuman, an entity existing in a state beyond being human that lacks desirable human physical, mental, or moral qualities. Along this material nonbiological path to intelligence, the parasitic posthuman with its reverse-engineered artificial brain and its transhuman bag of technoprogressive tricks heralds the survival of intelligence-made-machinic at the possible expense of the human species. Can these predictable human actions that create inorganic machines with on/off switches (AI) be reconciled with the on/off potential of a machinic genetic circuit that may manipulate our cognitive functions?

If our collective intentionality is entangled with a viral genetic circuit via the gut microbiota-brain axis, as the neurobiological research and signs with evolutionary function and survival value support, then an emergent state of being may be possible at death due to our microbial metabolism. However, to predict, transform, and invent the future in this world, we need transdisciplinary knowledge acquisition and semiotic understanding about our internal model. Without anticipatory control, our survival on the planet can be compared to the fate of Ahab, who was dragged into the shroud of the sea by the relentless Moby Dick. Despite that fate, Ahab's individual attempt has significance, for knowledge-based individualism is a force of change and the action necessary to influence the destiny of human society, especially in the masked presence of a strong undercurrent of viral intentionality rushing over the shoals of consciousness to control our behavior through the functional creativity of the collective unconscious.

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