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Where There's Life There's Intelligence

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Astrobiologists and other space scientists have become so accustomed to dividing extraterrestrial life into two categories – unintelligent and intelligent – that something might be getting overlooked.[2] It just might be the case that all life is intelligent, at least to some degree. Certainly an extraterrestrial civilization with advanced science and technology should be dubbed intelligent, perhaps even highly intelligent. Yet, even if microbial life either on Earth or off-Earth is considered to be stupid, this does not mean it has zero intelligence.

In what follows, I would like to provide a comprehensive scale of intelligence that includes simple single-celled organisms in continuity with the highest level of intelligence we know, namely, *Homo sapiens*. I propose a seven-trait definition: intelligence includes (1) interiority; (2) intentionality; (3) communication; (4) adaptation; (5) problem-solving; (6) self-reflection; and (7) judgment. Most mammals and certainly human beings exhibit all seven traits. Yet, brainless microbes and simple organisms exhibit the first four traits. By establishing a spectrum of traits, all life from the simplest to the most complex can be dubbed intelligent, even though they differ in levels of complexity. This argument directs the astrobiologist searching our solar system to look for various degrees of intelligence, not *un*intelligent life.

In short, what distinguishes so-called stupid or non-intelligent life from intelligent life is not intelligence per se, rather the degree of complexity of intelligence. The value of my proposed hypothesis is that it might direct astrobiological eyes to look for a third category, namely, intelligence in the middle between simple and complex levels of intelligence.[3]

"Astrobiologists need to have definitions that allow us to be surprised," writes Lucas John Mix; "On the one hand, we need to calibrate our definitions of intelligence (and life) based on what we know. On the other hand, we need to allow the definitions enough latitude to show us what we have not yet seen" (Mix, 2009,

p. 275). By demonstrating a spectrum within the single category of intelligent life, I hope to steer astrobiological eyes to see what might surprise us.

Defining Intelligence

It is not uncommon for those who provide us with definitions of intelligence to begin with the human species in mind.[4] Further, their agenda is to distinguish lower from higher levels of intelligence among people, purportedly to decide who receives and who is denied social benefits such as education.[5] My concern in this chapter is not to applaud smarter people but rather to explore the continuity between human intelligence and intelligence in other species and life forms.

Intelligence is tied to levels of cognitive complexity, contends Lori Marino at the Kimmela Center for Animal Advocacy. Intelligence refers to "how an individual acquires, processes, stores, analyzes, and acts upon information and circumstances" (Marino, 2015, p. 95). Does this definition apply strictly to human beings running around on two legs with complex brains? By no means. Marino notes how the "big five" cognitive domains that allegedly ascribe uniqueness to human intelligence are each shared with one or more other animal species. First, humans enjoy self-awareness, to be sure. Self-awareness includes mirror-self-recognition (MSR) plus metacognition (reporting on one's own thoughts). It is fascinating to note how all the great apes exhibit MSR, and both monkeys and dolphins express abstract forms of self-awareness, including metacognition. Second, even though tool making and tool usage are frequently thought to be uniquely human, we see these traits exhibited as well among many primates, elephants, birds, dolphins, and octopi. Third, culture – where culture is understood as distinctive behavior originating in local populations and passed on to new generations through learning – belongs as well to chimpanzees, dolphins, and even crows. Fourth, the capacity to use numbers is not limited to *Homo sapiens*; the great apes and dolphins demonstrate they can learn to rely on numbers as well. Fifth, symbolic communication is thought by many to be the chief defining characteristic of the human; but the capacity to learn artificial languages – including grammar – has been demonstrated by dolphins, chimpanzees, and parrots. In short, what have been assumed to be traits of intelligence which separate the human species from others are, in fact, characteristic to some degree of other life forms. Intelligence, it is most fitting to say, is a trait we humans share with the rest of life on our planet.

Intelligence was born on planet Earth when life first appeared and began to evolve, contends Marino. Even our brainless ancestors exhibited pre-brain intelligence. "Some of the building blocks of nervous systems and brains are found in single-celled organisms. They sense their environment, briefly store the information, integrate it in different channels of input and then act upon it – producing basic adaptive behavior. These brain-like processes work at a molecular level but they reveal a common ancestry with all modern brains" (Marino, 2015, p. 98).

Marino chides astrobiologists for not refining their understanding of intelligence so as to know better what to look for in space. "Astrobiology should embrace the study of intelligence as a ubiquitous property of life on Earth and one that converts the current impasse to relevant and exciting opportunities for further exploration" (Marino, 2015, p. 107). It is not my task here to chide astrobiologists. Rather, I wish merely to test the hypothesis that where there's life there is intelligence. With such a hypothesis in hand astrobiologists might sensitize their instruments of detection.

Ingredients to a Definition of Intelligence

Shane Legg and Marcus Hutter have collected definitions of intelligence and categorized them. Some capabilities of intelligent beings appear again and again: use of memory, the capacity for learning along with applying knowledge, adjusting to the environment, adapting to changes in the environment, reasoning and problem solving, and such. Intelligence is frequently described as a *mental* capacity that enables a person to comprehend, understand, and reason about things. Because intelligence is so multi-faceted, some cynics define intelligence merely as that which is measured by intelligence tests.

Legg and Hutter prescribe a minimum of three components essential to any definition of intelligence: (1) agency when interacting with the environment; (2) goal setting leading to success or failure; and (3) adaptation to the environment by altering goals. In sum, "Intelligence measures an agent's ability to achieve goals in a wide range of environments" (Legg & Hutter, 2006).

Could such a definition apply equally to two types of creatures, those with brains as well as those without? Must we limit our concept of intelligence to the human model that includes mentation? Not according to Mark Lupisella at NASA's Goddard Space Flight Center. "Intelligence can also be blindly capable . . . intelligence could be nothing more than a high degree of competence without understanding" (Lupisella, 2015, p. 160). Can we come up with a model of intelligence that includes both mental understanding plus a more or less blind capability?

What I am proposing is a definition of intelligence that encompasses all life forms from the simple to the complex. Regardless of how one defines human intelligence, we cannot avoid the assumption that what happens at the human level is in continuity, not discontinuity, with all levels of life in our biological evolution.

Is it credible to hypothesize that life as life is already intelligent? I answer in the affirmative. I proffer the idea that early in our evolutionary history simple life forms provided a necessary, though not sufficient, set of traits which would eventually make human intelligence possible.

Constructing a Comprehensive Definition of Intelligence

I would like to nominate for consideration a list of seven components to be incorporated into a comprehensive definition of intelligence. With this list, I hope to demonstrate that very simple life forms exhibit some, though not all, traits of intelligent creatures. An organism is intelligent when it possesses the following.

(1) *Interiority*: a membrane or barrier which separates the interior from the exterior environment or world; further, the interior maps the exterior to guide intentional behavior.
(2) *Intentionality* initiated from within that relates to the without – that is, goal-oriented behavior risking success or failure.
(3) *Communication* with the environment, including other organisms.
(4) *Adaptation*: the capacity to change in order to adapt and evolve.
(5) Mental activity, including reasoning in *problem-solving*.
(6) Mental activity, including *self-reflection* and *theory of mind*.
(7) Mental activity, including rendering sound *judgment*.

All of the above apply to intelligent human beings, to be sure, even if it appears that some among us are better than others at rendering sound judgment. My hypothesis is that pre-mental life exhibits enough of these traits and, thereby, qualifies as intelligent.

An Interior Structure that Maps the Exterior Environment

My argument is that a continuity of intelligence exists across the spectrum of life forms from the most simple to the most complex. Indeed, intelligence as we human beings experience it includes mental activity replete with abstract or representative deliberation. We do not observe the equivalent of abstract or representative thinking in one-celled organisms. Yet, some traits within human intelligence also appear in simple organisms such as interiority, intentionality, and communication. The first on my list is interiority.

Life, basically defined, is "metabolizing, replicating, and evolving" (Ward & Kirschvink, 2015, p. 35). For life to initiate activity in this fashion, it must distinguish between its interior and its exterior; it must establish organizational closure. Interiority is made possible by this enclosure, by drawing a line between the organism and its surrounding environment. That line could be porous and allow traffic in and out, to be sure; but it is definitional and it makes possible the distinction between internal and external activity, between self and world.

In a rudimentary way, the development of an inner over against an outer – the self-world distinction – makes sentience and intelligence possible. "It is teleogenic closure that produces sentience but also isolates it," according to biological anthropologist Terrence Deacon, "creating the fundamental distinction between self and other, whether at a neuronal level or a mental level" (Deacon, 2012, p. 511). He adds, "Even the simplest bacterium is organized as a self, with the emergence of ententional properties and possibly a primitive form of agency" (Deacon, 2012, p. 469). Deacon ascribes sentience to simple selves, whereas I recognize intelligence at work here.

The sheer evolution of interiority or selfhood should suffice to make my case. But, I might be able to add a related characteristic to strengthen the case, namely, internal mapping of the external world. The internal mapping of the external world seems to be decisive for human intelligence, even if described in other terms. Educational psychologist Jean Piaget, for example, describes intelligence as "assimilation to the extent that it incorporates all the given data of experience within its framework" (Piaget, 1963; Legg & Hutter, 2006). Or, according to a related definition, "Intelligence is a part of the internal environment that shows through at the interface between person and external environment as a function of cognitive task demands" (Legg & Hutter, 2006).

The mapping capacity of intelligence is most visible at the human level where brains are salient. Brain circuitry is organized "to generate a neural model of the world outside the brain," writes Patricia Churchland, "a map model . . . of the environment" (Churchland, 2013, p. 34). Along with a map of the external world, the mammal brain provides us with a GPS (Global Positioning System). "Mammals rely on the capacity to form neural maps of the environment," write May-Brill Moser and Edward Moser; "Like a GPS in our phones and in our cars, our brain's system assesses where we are and where we are heading" (Moser & Moser, 2016, p.28). It's the cortex in humans and the hippocampus in mice that provide the map and GPS.

We humans are most familiar with internal mapping of the world through symbolic speech and abstract thought. Human intelligent thinking is characterized by "symbolic representation and naming of entities, actions, qualities, patterns, and combinations of symbols, allowing recursion and enabling representation and logical analysis of arbitrary relations" (Ellis, 2016, p. 197). In other words, at the conscious rational level we draw representative maps of the world in our minds and then travel the roads we select.

Now, we ask: what about simpler organisms? Might the mapping metaphor apply to single cells without brains? Yes. To extend the map metaphor, biologists studying embryonic development acknowledge that cells "sense their place in the body plan" (Adler & Nathans, 2016, p. 71). There is "a miniature compass within each cell. Without this compass within cells, human heart, lungs, skin and other organs could not develop properly" (Adler & Nathans, 2016, p. 68). Mapping implies a relationship between inner and outer, even with or without mentation. To be intelligent includes an inner that relates to its outer. It includes an interior mapping of what is exterior.

Historian David Christian recognizes the protean value of mapping within intelligence found in the simplest organisms. "The constant restless search of all living organisms for manageable flows of energy is the first source of what we perceive as purposeful activity. To find the energy they need, all organisms must, in some sense, map their surroundings. They must know where the energy is and how to use it. So even the simplest of one-celled organisms can move towards or away from light, or sidle towards chemical concentrations they need. To do that they must map their surroundings, and they do so with purpose.... Both mapping (learning?) and learning with purpose seem to be required by the very notion of evolution through natural selection" (Christian, 2016, p. 42). Mapping, learning, and intending seem to come together in a single package in primitive life forms, with or without brains.

Intentionality

A related capacity that appears frequently in definitions of intelligence we will label *intentionality*. Deacon's term, *ententionality*, is similar: "I will use *entention* to characterize their internal relationship to a *telos* – an end" (Deacon, 2012, p. 27, Deacon's italics). If it moves itself, it's agential. If it's agential, we should look for signs of intentionality, or ententionality.

The inner exhibits intentionality in the form of goal-oriented behavior leading to success and risking failure. Artificial Intelligence researcher, James Albus, describes intelligence in terms of the "ability of a system to act appropriately in an uncertain environment, where appropriate action is that which increases the probability of success, and success is the achievement of behavioral subgoals that support the system's ultimate goal" (Albus, 1991; Legg & Hutter, 2006). Without reference to human mentation, it appears that in a description of intelligence one would need to include intentionality initiated from within a system oriented toward both an ultimate and a subgoal. In short, purposive activity. Does life as life exhibit some level of purposive activity?

Would self-propelled movement count as evidence? Many bacteria initiate movement by projecting a grappling hook (type IV pilus) from their bodies. They attach the hook to another cell or object in the environment, then retract it. With this motion the bacterium pulls itself forward in a machine-like manner. Its movement is self-initiated and appears to be directional. Even though the bacterium presumably has no mentation, might we still call it intentional? (Chang *et al.*, 2016).

With the term *intentionality* I designate the directionality arising out of mapping. The Latin *intendo* suggests pointing to, aiming at, or extending toward.

Philosopher of mind John Searle describes mental states as "directed at, or about, or of objects and states of affairs in the world" (Searle, 1983, p. 1). Might intentionality also characterize non-mental activity in simple life forms, especially the reciprocity between a living organism and its environment?

For another example of non-mental intelligence, let's turn to our simple friend, the amoeba, in this case the single-celled amoebae form *Dictyostelium discoideum.* The signal for individual amoeboid cells to aggregate is cyclic-AMP (adenosine monophosphate or c-AMP), which belongs as well to the human response to different hormones, such as glucagon. The amoebae can sense or detect concentration gradients of c-AMP. Then they crawl up the gradients to gather together with lots of other amoebae, which also have all been releasing c-AMP into the environment. After all the amoebae have moved up the c-AMP gradient and come together, they form an aggregated of eukaryotic amoebae known as a slug. Individuals will find the largest group of their kin in the area via this mechanism.

What have amoebae done to accomplish this? They have: (a) detected not only c-AMP, but its concentration gradient; (b) they have aligned their motility (and all the related intracellular proteins such as actin and myosin found also in muscle cells) along the gradient; (c) they have continued to move up the gradient as long as it exists (if one shifts the gradient experimentally, one can shift migration); (d) they are considered *altruistic social* amoebae because they will give their lives to set up the slug with its fruiting body to the benefit of the next generation of amoebae. The amoebae have certainly acquired information and they apply it in a generous manner. We may ask: is it more than information? Is it actual knowledge? When the amoeboid cell detects the strongest c-AMP concentration coming from the southwest and only a weak signal from the north, it aligns its motility for migration to the southwest. Might we think of this as intentionality utilizing its knowledge – its internal map – of the environment?

What about more complex creatures which incorporate such cell activity within them? What we today know as eukaryotic cells, it seems, are the product of endosymbiosis. Previous more simple cells, prokaryote cells, cooperated, combined, and together produced multi-celled organisms. Did the prokaryotes map their immediate environment and initiate symbiosis? Eukaryotes appear to be the result of cooperative intentionality, a creative intentionality. Only intelligence begets intelligence and, in this case, simple intelligence begets more complex intelligence.

It continues up the scale. Biologists have been studying learning in a wide array of organisms from fruit flies to vertebrates, because there is something there to study. Migrating butterflies and birds find their ways over hundreds of miles. Salmon return to lay eggs up the stream where they were born. Can we give them credit for mapping, intentionality, and even intelligence? Our word "stupid" seems like an insult after witnessing these accomplishments. Even if they can't play chess, they still do amazing things.

If we consider human intelligence to be the epitome of evolution's accomplishments to date on planet Earth, we must remember that it took time. It took 3.9 billion years. And, to some extent, the past is still with us. In the human brain the same signaling system is used that we would find in both amoeboid cells and fruit flies. The evolution of distinctively human intelligence couldn't occur until cells had signaling systems like the one involving c-AMP at the ameboid level. Perhaps our brains should thank the amoeba for getting us started.

Virtue ethicists observe that natural creatures at all stages of evolution exhibit four teleonomic if not teleological ends: (1) individual survival; (2) reproduction; (3) pursuit of pleasure and avoidance of pain; and (4) the well-being of the social group. If any of these four obtain, it appears that even the simplest life forms we know exhibit intentionality and belong in the intelligent category (Mohloeck, 2016). Slime molds display three of the four criteria: first, second, and fourth. Ants display all four. Maßmann identifies this teleological behavior as meaning-making deriving from self-preservation (Maßmann, 2017). [Let me be clear regarding teleology: I am affirming *local* teleodynamics produced by the goal-setting of an organism, not a *global teleology*, which directs the course of evolution in its entirety.]

Perhaps a critic will demure: mammalian let alone human intentionality is so much more complex that amoeba intentionality is not comparable. For mammals, intentionality begins with mentation, with abstract planning. No advance mentation occurs in simple life forms, and maybe not in fruit flies either. How should we handle this demure?

Let's look again at human intentionality. Intentional agency includes two components, according to Searle: internal mapping and causative action. Searle's term, "direction of fit," indicates what I have been calling the internal mapping of the exterior world. Conditions in the exterior world must conform to the map within the mind, world-to-mind, he contends. This, in turn, enables effective agential causation, mind-to-world. When mental activity is involved, agential action may be preceded by premeditation, deliberation, and planning. Prior intention precedes action (Searle, 1983). This means that the reciprocity between mapping and causative action includes a significant component of interior initiation. An intelligent creature is more than merely an object determined by its exterior environment, more than a flag blowing in the wind. Although an intelligent creature reacts to external stimuli, on occasion it initiates action. An intelligent creature maps the world internally and then takes action which in some way affects the external environment.

My critic might try to prevent us from transferring what is obvious in mammalian mental activity to single-celled life forms which, at least to our observation, lack mental activity. This leap, however, may not be over an empty abyss. We may have a bridge, namely, material engagement theory. The bridge builder is Searle critic, Lambros Malafouris. Malafouris embraces the *Theory of Material Engagement* which includes, among other tenets, the notion that mind is extended. Mind is not the private property of interiority. Rather, mind is located in the reciprocity between the organism and its environment. Malafouris locates intentionality not in prior deliberation but only in the action itself, what he calls "intentionality-in-action." He contends that "intention no longer comes before action but it is *in the action*. The activity and the intentional state are now inseparable" (Malafouris, 2014, p. 140).

It is not my objective here to stand by Malafouris against Searle. Nevertheless, what we can gain by appealing to Malafouris is the recognition that intentionality does not necessarily require *prior* mentation. Here it is significant that one can identify intentionality simply by recognizing it in the action itself. *Intention in the action* is something we recognize at the cellular level; not merely at the human level of intelligence.

Brain scientist Walter Freeman makes my point still more forcefully. Even at the human level we find intention in action without prior mentation. "We perform most daily activities that are clearly intentional and meaningful without being explicitly aware of them" (Freeman, 2000, p. 17). If intentionality belongs to intelligence, and if *intention-in-action* can occur without mentation and perhaps even without a brain, then we have opened the door to seeing the continuity of intentionality between mammalian minds and simpler life forms.

We ought not let slip by unnoticed the notion that intelligence might not be only individual. Intelligence could be the term to describe group cooperation, *social cognition*. A fascinating phenomenon frequently observed in nature is how army ants create living bridges to cross a chasm. One after the other, self-selected ants stretch their bodies, connecting to other stretched ants, and build a bridge so that their compatriots may cross the chasm. This is a clear case of problem-solving through intentional behavior, though the intentionality appears to derive from the group rather than the individuals alone. "Researchers found . . . that the ants, when confronted with an open space, start from the narrowest point of the expanse and work toward the widest point, expanding the bridge as they go to shorten the distance their compatriots must travel to get around the expanse"(Kurzweil, 2015). Can we describe such living bridge-building as intelligent? That depends on your definition. Social intelligence fits the definition we are working with in this treatment.

There is one caveat. Acknowledgement of purposive behavior on the part of intelligent creatures does not in itself warrant a teleological interpretation of evolutionary history as a whole. To avoid this unwarranted leap, Deacon endorses use of the term *teleodynamics* to describe local intelligent behavior. "The core property which links the selves of even the simplest life forms with that seemingly ineffable property that characterizes the human experience of self is a special form of dynamical organization: teleodynamics . . . that is, they are *closed* in a fundamental sense with respect to other dynamical features of the world" (Deacon, 2012, p. 468). My limited objective in this section is to observe that all intelligent creatures, including simple life forms, exhibit internal structure, mapping, and intentional orientation.

Within the context of the large scope of evolutionary history, I argue that the appearance of intelligence in early life forms provides a necessary – even if not sufficient – condition for the possibility of human intelligence. One salient trait of human intelligence is our internal mapping of the exterior world. Do our ancestral one-celled organisms prepare us for this development in intelligence? It appears they do.

Communication

Living creatures, no matter how small and simple, exhibit interiority combined with exteroreceptivity and agency. In short, they communicate.

When it comes to human communication, the most salient feature is symbolic communication through language. *Homo sapiens* have been blessed by a co-evolutionary history which has led to a leap forward in intelligence marked by linguistic communication. Deacon along with his colleague, biologist Ursula Goodenough, celebrate ". . . the co-evolution of three emergent modalities – brain, symbolic language, and culture – each feeding into and responding to the other two and hence generating particularly complex patterns and outcomes" (Goodenough & Deacon, 2006, p. 863). Symbolic language connects mouths to ears, which we might call *gap junctions* between organisms.

Mouths and ears are not our only gap junctions. We human beings communicate with one another at many levels: in addition to abstract conversation mediated by language, we communicate through facial expression, physical affection or physical violence, and chemical exchange *in utero*. We presume that human-to-human communication is intentional. Communication is a sign of intelligence. If we observe this same sign at simpler cellular levels, would this tend to support my hypothesis that where there is life there is intelligence?

If communication is a mark of intelligence, then conversation between simple cells would count as a sign of nascent intelligence at the single cell level. Ross Johnson began researching gap junctions in the 1960s. He later teamed up with cell biologists Dale Laird and Paul Lampe to gather evidence of cellular communication in the early 1990s. Hormones, neurotransmitters, electrical current, and such illustrate the "multiple modes of information exchange" (Laird *et al.*, 2015, p. 72). Cellular connectivity is located at gap junctions. Each gap junction is a kind of mouth and ear combination which opens up perhaps 10 000 channels for transmission. Because each gap junction "involves two hemichannels, that would make a total of 120,000 connexins per junction" resulting in "enormous communications conglomerates" (Laird *et al.*, 2015, p. 73). Knowledge of all that cells whisper to one another is not yet in. Research continues. Yet, these scientists offer a relevant conclusion: "Virtually all cells, it turns out, network with their neighbors via extensive collections of channels that directly connect the inside of one cell with the inside of the next" (Laird *et al.*, 2015, p. 72).

In short, communication in the form of interaction between organisms is common to both the most simple and most complex forms of life we know. If communication is a trait of intelligence, then intelligence is co-extensive with life.

Change for Evolutionary Adaptation

All things change, Heraclitus once told us. Intelligent life changes in a particular fashion. It changes by adapting to its environment and, in some cases, changes the environment to suit itself. At the individual level, the organism reorients itself when its surroundings change. At the species level, the changing environment requires of the organism adaptation in the form of reproductive fitness to survive or, in some cases, to give way to a subsequent species. Adaptation energizes the cycle which becomes a spiral through time. This ongoing spiral we dub "evolution."[6]

On Earth 3.9 billion years ago our first ancestors absorbed existing carbon and expelled oxygen. Over time, Earth's atmosphere became partially oxygenated. Life adapted. Newer species began to absorb oxygen and expel carbon dioxide. Astrobiologist Chris Impey acknowledges the particular way in which life exhibits Heraclitus' principle. "If biology starts, it immediately begins to alter its environment. Our Solar System started with three habitable terrestrial planets. Two suffered runaway climate changes that left them barren – one remade itself to stay habitable" (Impey, 2010, p. 168). Would it be excessive to connect intelligence with the attempts by early life forms to adapt through change?

"Intelligence is about making adaptively relevant responses to complex environmental contingencies, whether conscious or unconscious," writes Deacon (Deacon, 2012, p. 492). Deacon can even distinguish intelligence from sentience when asking about the prospect of machine intelligence.[7] Sentience versus machine intelligence is not our issue in this treatment, however. Important to us here in this study is the observation that *intelligence* is the term I use to describe evolutionary adaptation with or without consciousness.

Adaptation over time has led to increased complexity, including increased complexity in intelligence. Evolution "has given rise to organisms more complex than those living on the early earth. They have appeared even though there seems to be no active drive toward greater complexity, and even though complex organisms may not be terribly important in the overall scheme of things" (Christian, 2011, p. 108). In short, the final chapter in the story of evolving intelligence is yet to be written. When the story of intelligence becomes complete, it will begin "once upon a time" with our single-celled ancestors.

Mental Activity, Including Reasoning in Problem-Solving

Human intelligence today can take advantage of 86 billion neurons and 100 trillion synapses in the brain. This unfathomably complex brain did not come from nowhere. It is a product of autopoietic systems – that is, a product of the self-organizing cells we previously dubbed stupid life forms. Even if our biological ancestors were relatively stupid, they were sufficiently intelligent to give birth to us.

It is fascinating to note how early neural cells almost know what to do, so to speak. They join together in the project of creating a brain. Experiments with pluripotent stem cells – derived either from hES (human embryonic stem) cells or iPS (induced pluripotent stem) cells, if left to self-aggregate within the appropriate culture, self-organize into cerebral organoids with tissue architectures that are reminiscent of the human cerebral cortex. Because the cells know what to do, researchers can derive "brain tissue *in vitro*" (Brüstle, 2013, p. 320; Lancaster *et al.*, 2013, p. 373). My point here is this: even though human intelligence is exceedingly more complex than that of simpler cell life, it is that very same simple cell life that intends to make human intelligence possible. This observation supports either preformationism (the view that human intelligence was seeded in the physics of the universe) or autopoeticism (the view that intentional cell intelligence led creatively over evolutionary time to complex intelligence). Regardless, it appears that we may have a maxim: it takes intelligence to beget intelligence, just as it takes life to beget life.

Now, let's turn to problem-solving, which fits on most everybody's list of characteristics of intelligence. Engineers earn their living by solving problems in creative fashion. Our prehistoric ancestors survived because they solved the problems posed by the need for food or shelter along with protecting themselves from dangerous beasts and inhospitable weather. Today's parents delight when their toddler learns how to climb the stairs and, of course, use the toilet.

Human moral decision-making is one familiar form of problem-solving. Human action is the result of motivation, we presume. How should we behave? Let's ask our motives. One recent study interrogates our motives by measuring brain activity while making moral decisions. "Goal-directed human behaviors are driven by motives. Motives are, however, purely mental constructs that are not directly observable" (Hein *et al.*, 2016, p. 1074). Grit Hein and his research colleagues sought to make observable what is unobservable by distinguishing between two types of altruistic giving, one type motivated by empathy and the other motivated by reciprocity (paying what is owed). Through fMRI monitoring the researchers noted no difference in the regions of brain activity, but they did observe what is decisive, namely, the sets of motivations were associated with different connectivities. "Empathy based altruism is primarily characterized by a positive connectivity from the anterior cingulate cortex (ACC) to the anterior insula (AI), whereas reciprocity-based altruism additionally invokes strong positive connectivity from the AI to the ACC and even stronger positive connectivity from the AI to the ventral striatum. Moreover, predominantly selfish individuals show distinct functional architectures compared to altruists" (Gluth & Fontanesi, 2016, p. 1028; Hein *et al.*, 2016, p. 1074). My objective in reporting on this study is to demonstrate that intelligent behavior at the level of mentally motivated problem-solving retains a reliance on the physical substrate, the brain. Without endorsing either reductionist determinism or contracausal free will, I simply reinforce what most of us presume, namely, that mentation is made possible by the brain. This higher level complexity is most likely due to physical enablement.

Mental Activity, Including Self-Reflection and Theory of Mind

Reflective awareness, though not unique to human mentation, offers a nearly indescribable capacity for self-guidance and self-transformation. Reflective awareness also includes *theory of mind* – that is, it includes awareness that other intelligent creatures have an interiority like one's own. It includes awareness of one's own self along with awareness of other selves. Even though this level of human intelligence is launched by brain physiology, it seems to rocket skyward under self-propulsion and self-navigation.

We are capable of literal MSR (mirror self-recognition) when physically looking into a mirror: "Hey! That's me!" In addition, we can engage in MSR with our eyes closed. Our minds are almost uncanny in what they can permit to happen in terms of reflection, reflection on reflection, and reflection on reflection on reflection. Not only are we aware of our awareness, we can make ourselves aware of the awareness of our awareness. In addition, we can distinguish who we are now from who we are not, and we can follow this with a free decision to change ourselves. We can not only adapt, we can self-transform "Hey! That's who I want to be."

Take meditation as an example. Meditation is "the cultivation of basic human qualities, such as a more stable and clear mind, emotional balance, a sense of caring mindfulness, even love and compassion – qualities that remain latent as long as one does not make an effort to develop them" (Ricard *et al.*, 2014, p. 42). Through meditation, the self transforms the self. More: the self transforms the brain. "The adult brain can still be deeply transformed through experience" (Ricard *et al.*, 2014, p. 40). Reflective consciousness permits the mind to influence the brain, even to rewire the brain's circuitry. Despite the fact that our human intelligence is utterly dependent on its home in the brain, intelligence seems to possess a preternatural capacity for going away and coming home again.

Stories take us away and back home again. When listening to a story, our theory of mind permits us to temporarily enter into the thoughts and anxieties and victories of other selves. We enter into the interiority of other intelligent creatures or persons. We empathetically feel the feelings of the story's characters. When the story is over, we return to our own self-world relationship. It appears that our mind flew away from our body and entered temporarily into somebody else's world. Does our mind leave our body? Relevant to this question is the observation that, according to MIT researchers, the amygdale is activated by empathetic listening to a story (Bruneau *et al.*, 2015).

If we convince ourselves that our minds are so independent that they no longer need our brains, then we need to beware. In another chapter in this volume, Alexander Maßmann warns us against Cartesian dualism. According to philosopher René Descartes, the mind flies like a kite above the body. The mind as an immaterial substance enjoys intelligence in a way that is denied to the body, which is a material substance. Against Descartes, argues Maßmann, our mentation must retain its physical mooring.

If our mentation should lose its physical mooring, it would not float on its own. It would sink. Brain researcher Stanislas Dehaene has studied this and he declares that in everyday activity we fail to realize just how much of our activity is guided by "an unconscious automatic pilot . . . We constantly overestimate the power of our consciousness in making decisions – but, in truth, our capacity for conscious control is limited" (Dehaene, 2014, p. 47). Many of today's neuroscientists so emphasize how the brain is on automatic pilot that they say the higher levels of consciousness may be delusional. Or, to say it another way, the string on our kite of consciousness is shorter than we might realize.

This leads us to ask the reductionist question: is human intelligence only brain function? Can we reduce the human self to the sum total of neuronal firings? Some neurophilosophers are happy to pull the kite string so hard that consciousness crashes to earth. One German philosopher, Thomas Metzinger, for example, exhaustively reduces subjective intelligence to brain activity. "Subjective experience is a biological data format, a highly specific mode of presenting information about the world by letting it appear as if it were an Ego's knowledge. But, no such things as selves exist in this world" (Metzinger, 2009, p. 8). Another German philosohper, Ottfried Höffe, in contrast, affirms just the opposite. "The person thinks, to be sure, 'with' his central organ; he acts 'with' the brain, but it is the person, not the brain, that thinks or acts" (Höffe, 2010, p. 245). Which is it? Is the brain so completely in charge that the human self is a delusion? Or, does the self become its own center of intentional activity employing its intelligence? It is not necessary for my purposes here to adjudicate this dispute. It suffices to rely on what is generally accepted in scientific discourse, namely, it is the brain which makes distinctively human intelligence possible. When it comes to complex forms of cognition, a more complex brain accounts at least partially for the leap in human intelligence beyond more simple forms of life.

The leap is always tethered, of course. Even religious insight into transcendent reality never completely leaves its vegetative home. Rabbi Abraham Heschel reminds us, "much of the wisdom inherent in our consciousness is the root, rather than the fruit, of reason" (Heschel, 1951, p. 17).

Mental Activity, Including Rendering Sound Judgments

Up to this point I have tried to show that mammals in general, and humans in particular, share up to four traits of intelligence in continuity with brainless or stupid life forms: interiority, intentionality, communication, and adaptation. When our ancestors developed brains, intelligence became more complex. With the arrival of mental activity sponsored by brains, mammals and especially people developed the capacity for abstract intellectual reflection, advanced planning, and free will.

Perhaps at some legendary threshold in our evolutionary past our forbearers experienced abstract thinking. With abstract thinking they could anticipate alternative futures. With alternative futures in their minds, they needed to select which action to take and which to avoid. Abstract mentation, advanced planning, and free will most likely arrived together in a single package. With these three components to intelligence, our ancestors were required to make judgments. Sound judgments meant safer and more prosperous futures. The capacity for sound judgment was adaptive, no doubt.

Was this development in mental activity dictated by the brain? After all, the brain is composed of cells with intentionality. Yet, it is difficult to imagine that the computational complexity of the brain could, by itself, account for sound judgment. "The mind is more than a computational machine," avers Sante Fe Institute biologist, Stuart Kauffman. "Embodied in us, the human mind is a *meaning and doing organic system*" (Kauffman, 2008, p. 177, Kauffman's italics).

We observe in ourselves and in others that a reciprocity obtains in the relationship between brain and mind. The mind acts on the brain as much as the brain acts on the mind. We have already acknowledged that today's neuroscientists point out pre-reflective effects the brain has on our behavior. What we add here is the reflexive effects the mind has on the brain's mapping and intentionality. One might refer to the mind's influence on the brain as *top-down agency*. "*Top-down agency* refers to the ability to modulate behavior in relationship to conscious thought and intention," contends neurophilosopher Warren Brown (Brown, 1998, p. 117). In other words, our symbolic understanding and our abstract reasoning provide top-down influences on our reasoning process and, in addition, they direct our agency in the world. The self is an intentional agent who takes action and causes changes in the surrounding environment.

Physical cosmologist George Ellis helps to explain this by distinguishing between bottom-up causation as understood by the physicist from top-down causation which we experience when the mind makes decisions that influence brain activity. The mind selects and directs; the mind selects from among alternatives a single direction to be followed based upon the meaningfulness of an anticipated goal. Directed mental activity includes top-down causation as a complement to bottom-up causation. "Interlevel causation, both bottom-up and top-down, is key to brain function. Evolution has selected for it to occur. The underlying physics is channeled and constrained to enable this to happen" (Ellis, 2016, p. 346). Human intelligence is much more than merely brain function, in other words.

Among other things, top-down cognition enables us to imagine alternative futures, render a judgment, and then enlist the will to take a specific action. When asked, we can communicate the reasons for deciding what is best to do. "A *future orientation* is meant to denote the ability to run a conscious mental simulation or scenario of future possibilities for the actions of oneself and others, and to evaluate these scenarios in such a way as to regulate behavior and make decisions now with regard to desirable future events" (Brown, 1998, p. 117). Self-determination produced by top-down agency is not reducible to antecedent neuro-causation; top-down causation is not exhaustively reducible to bottom-up causation. Rather, intelligent human agency is the product of a personal self supervening on the brain by rendering a judgment followed by intentional action.

Genuine knowledge includes judgment. Sound judgment qualifies what counts as knowledge. Jesuit theologian Bernard Lonergan details the distinctions at work in human mentation. Knowledge may be located within consciousness; but it is not in itself consciousness. Knowledge is the result of a process wherein a self assesses experience, engages in active understanding, and renders judgments about what can be known and not known. "Consciousness is just experience, but knowledge is a compound of experience, understanding, and judging" (Lonergan, 1972, p. 106). Sound judgment belongs to intelligence when it is working to distinguish truth from falsity, appearance from reality, risk from safety, hope from fear.

It is via judgment that intelligent deliberation jumps the hurdle from falsity to truth. After our abstract reflection has accessed our perceptions and then filtered them through symbolic language and logical reasoning, we pause just before we take the leap to intellectual judgment. It is the leap of judgment that moves us from mere experience to knowledge. Knowledge is personally satisfying only if it is true knowledge. Knowledge by definition is knowledge of what exists, of what really is. Only via judgment does the human intellect know whether what it knows is in fact knowledge.

Here is the point of this discussion: when a person acts on the basis of intellectual judgment, the physical world becomes changed. Human intelligence becomes one cause among many in the physical history of the cosmos.

Intelligence without Consciousness, Value, or Free Will?

Note what is missing in this list of defining traits of intelligence: consciousness, value, and free will. The first observation I would like to make is this: we could not be human without consciousness, but we could be intelligent without consciousness. Human consciousness is fascinating, even if not necessary for intelligence. To the extent that the brain makes intelligence possible, consciousness functions to organize our brain's mental work space. If we think of our brain as a society of eighty-six billion neurons, some principle of organization is necessary for focused activity. "The function of consciousness," says Dehaene, "may be to simplify perception by drafting a summary of the current environment before voicing it out loud, in a coherent manner, to all other areas involved in memory, decision, and action" (Dehaene, 2014, p. 100). Consciousness arrives on the evolutionary stage along with mental activity, to be sure; but, in itself, consciousness does not define intelligence.

Secondly, what about value? "Human beings are able not only to detect but to be motivated by value," avers philosopher of science Thomas Nagel (Nagel, 2012, p. 112). When our ancestors first considered alternative futures, they needed a criterion – a value – for selecting one over the alternatives for action. Human beings weigh alternatives according to values, to be sure; yet, it appears to me that primitive intelligence arose without this capacity. Valuing arrives when abstract intellectual processing arrives, but in itself valuing does not define intelligence per se. At the human level, of course, we cannot grasp intelligence apart from the values which guide our decisions and actions.

This leads, thirdly, to the following observation: bottom-up physical processes are necessary, though not sufficient, to explain human free will. Key here is that the relevant physics includes indeterminate openness at the quantum level, that is, free will relies on randomness in the underlying physical domain. Quantum physicists tend to replace the Newtonian closed causal nexus with quantum randomness at the sub-atomic level. This basic physical randomness makes it possible for intelligent creatures to anticipate underdetermined alternative futures, select the desirable future from the undesirable according to a value system, and make decisions leading to the actions that will affect the external world. "The existence of both bottom-up and top-down causation in relation to the mind and brain removes the force of the bottom-up arguments against free will... and opens the way for more humane visions of the nature of humanity," avers Ellis (Ellis, 2016, p. 381).

Fourthly, I am not building free will into the definition of intelligence, at least not the contracausal version of free will. "The name *contracausal* reflects a philosophical theory that *really* free choices are not caused by anything" (Churchland, 2013, p. 179, Churchland's italics). Over against the contracausal account, I contend that free will belongs to the multi-level interaction between bottom-up and top-down causes described above by Ellis. In free agency, top-down causation is the focal factor. This makes the person exercising free will one cause among others. Free will and human agency belong inescapably to the causal nexus.

I argue elsewhere that free will is best described as *self-determination*, thereby avoiding appeal to acausality (Peters, 2003). In fact, this is the position I prefer: free will is a form of self-determination, where the free human person deliberates, decides, and acts to change his or her environment. But, is free will necessary to a definition of intelligence per se? No. Like valuing, free will belongs to a complex level of mental activity such as rendering a judgment. I have nothing against positing free will within human intelligence, to be sure. Nevertheless, I believe we can recognize intelligence at more primitive levels even when human free will is not at stake.

Three Possible Holes in My Argument's Boat

I can anticipate three holes in my argument's boat. The first hole takes us back to the evolutionary onset of life on Earth. It is not clear that simple life as we witness it today on Earth represents the earliest form of life. Stupid life may not represent the first transition from abiotic chemistry to living creatures themselves. LUCA, the last universal common ancestor, was already an advanced form of life, "having nucleic acids and proteins, as well as complex metabolic processes. In short, life as we know it represents a single example of a fairly advanced stage of life," say Carol Cleland and Shelley Copley (Cleland & Copley, 2006, p. 165).[8] The lack of evidence of the exact moment of transition from non-life to life in the fossil record is due to some missing files. "It is clear that these oldest traces of life record an evolutionary stage that is far beyond the origin of life or even very primitive cells. It may be difficult to find evidence of such earlier, intermediate life forms due to the lack of older, well-preserved rocks.... Thus, the most important stage in the history of life on Earth is missing. One can hope that, if life ever existed on Mars, rocks containing traces of life's earliest steps there will be discovered" (Cottin *et al.*, 2015). One can only surmise that in these missing files we just might find early life that does not meet our criteria for intelligence. Should these missing files be found and the earliest life forms be shown to be unintelligent, then my hypothesis – where there's life there's intelligence – would fail. This may also falsify my maxim: it takes intelligence to beget intelligence. Discovering the missing link between prebiota and cellular biota could possibly poke a hole in the bottom of my hypothesis boat big enough to sink it.

The second hole might be drilled when determining the status we ascribe to the virus. Is a virus alive or not? With a rogue strand of DNA, for example, a virus lacks the trait of interiority, while it does exhibit intention. If one places the virus in the category of the living, then it would appear to be a form of life without the traits of intelligence I have adumbrated. Experts in virology shy away from declaring that a virus is a life-form, or even declaring it to be non-life. "Alive or dead is a stupid question," contends A. E. Boycott in his 1928 Presidential address to the Royal Society, "because it does not exhaust the possibilities. Our general notion of the universe leads us to expect that we shall meet with things that are not so alive as a sunflower, and not so dead as a brick" (cited by Johnson, 1982, p. 9). The virus may drill a small hole in the bottom of my hypothesis boat, but I don't believe it will sink.

The third hole has to do with what we might expect when searching for intelligent life on exoplanets. If the astrobiologist limits the search for biosignatures, the search might miss perceiving non-biological intelligence. Many of today's astrobiologists work with the assumption that evolution is progressive; this means that exoplanets with evolutionary progress lasting longer than that on Earth will likely have developed more advanced technology. "Other present technological civilizations in our galaxy probably developed much earlier than ours. Therefore, they should be much more advanced than our technology," says University of Arizona planetary scientist Robert Strom (Strom, 2015, p. 11). This means for some space speculators that a highly advanced technological civilization will be post-biological. That is, extraterrestrial intelligence may be located in highly advanced computers, not in flesh and blood.

Astrophysicist Martin Rees, for example, alerts space researchers to look for "intelligent machines" or "robotic fabricators" spread out in space (Rees, 2003, p. 172). Physicist turned astrobiologist Paul Davies similarly speculates that more advanced civilizations on exoplanets may have already evolved beyond biological bodies and inserted their intelligence into machines. If this is the case, then biosignatures would not lead us to intelligence.

My conclusion is a startling one. I think it very likely–in fact inevitable–that biological intelligence is only a transitory phenomenon, a fleeting phase in the evolution of intelligence in the universe. If we ever encounter extraterrestrial intelligence, I believe it is overwhelmingly likely to be post-biological in nature, a conclusion that has obvious and far reaching ramifications for SETI.

(Davies, 2010, p. 160)

If Rees and Davies are correct, then my contention – *where there's life there's intelligence* – would fall short of providing an exhaustive association of life with intelligence. There might exist some intelligence apart from life. If extraterrestrial non-biological intelligence turns out to be post-biological, then the hole it drills in my argument would be shallow.

In sum, three drills could poke holes in this article's argument. Non-intelligent biology either on Earth or off-Earth would poke two holes, while the discovery of non-biological intelligence would poke the other one. As of this writing, however, insufficient empirical evidence exists for anyone to get out the buckets to start bailing.

Conclusion

The hypothesis of this article is this: *where there's life there is intelligence.* In support of this hypothesis, I have delineated seven traits belonging to an inclusive definition of intelligence: (1) interiority; (2) intentionality; (3) communication; (4) adaptation; (5) problem-solving; (6) self-reflection; and (7) judgment. It is clear that most mammals and certainly human beings exhibit all seven traits. I have shown that brainless microbes and simple organisms exhibit the first four traits. By establishing a spectrum of traits, all life from the simplest to the most complex can be dubbed intelligent, even though they differ in levels of complexity. The value of this argument is this: the astrobiologist searching our solar system should look for various degrees of intelligence, not *un*intelligent life.

Elspeth Wilson and Carol Cleland remind us that if we look only through our anthropocentric glasses, we may miss seeing the moral status of extraterrestrial creatures. If we look only through the lenses colored with human rationality, we may miss seeing the warrant for respecting unusual forms of alien intelligence. "Ultimately, those who want to hold up intelligence or rationality as a benchmark for moral status must identify and acknowledge the anthropocentric limitations of this standard" (Wilson & Cleland, 2015, p. 214).

The moral status of extraterrestrial life has not been on the agenda of this essay. Intelligence has. Like Wilson and Cleland, I have sought to find a path around the "anthropocentric limitations" of linking intelligence so closely to our human experience with mentation that we might miss seeing intelligence in different life forms.

Notes

1 I offer a special thank you to colleagues Ross Johnson and Margaret Race for their critical contributions to my writing of this article. I also thank Richard Procunier for his support of the Center for Theology and the Natural Science, which sponsors such research.

2 Here is an example of this assumption at work in astrobiology: "Unlike non-intelligent life, intelligent beings can have intentions" (Michaud, 2015, p. 289). What would happen if we discovered that simple life forms exhibit intention? University of Arizona astrobiologist Chris Impey, to cite another example, distinguishes between non-intelligent life on Earth from intelligent life by adding "thought" to "behavior." Thought adds two traits beyond mere behavior: "the ability to reflect on past experience and the power of abstraction" (Impey, 2007, p. 285). Thought is more than behavior, according to Impey. This is true, obviously. Yet, I hope to show here that behavior when intentional exhibits traits we think of as intelligent. Microbes might be thoughtless, but still intelligent.

3 I'm looking for intelligence in the middle, so to speak, in organic processes. This is a more modest search than that of Stuart Kauffman, who looks for mind in all physical processes at the quantum level. "Mind – consciousness, *res cogitans* – is identical with quantum coherent immaterial possibilities" (Kauffman, 2008, p. 209).

4 Howard Gardner delineates eight types of human intelligence: (1) bodily-kinesthetic; (2) interpersonal; (3) intrapersonal; (4) linguistic; (5) logical-mathematical; (6) musical; (7) naturalistic; and (8) spatial (Gardner, 2000). For our purposes here, it is sufficient to note that not all human intelligence is thought to take the form of cognitive capability directly correlated to the human brain.

5 In *The Bell Curve*, for example, the coauthors proffered an alleged connection between genetics and IQ, adding that variations in intelligence determine class status. They contended that "beyond significant technical dispute" are assertions such as: cognitive ability differentiates some human beings from others; IQ tests measure cognitive ability with sufficient accuracy; high IQ scores match with what we mean by *intelligence* or being *smart*; properly administered IQ tests are not demonstrably biased against social, economic, ethnic, or racial groups; and cognitive ability is substantially heritable. These purportedly undisputable assertions support their thesis: "cognitive ability is the decisive dividing force" between social classes (Herrnstein & Murray, 1994, p. 25). Distinguishing human groups by IQ results in the authors' recommendation that government financial support for early education be increased for the most intelligent – Ashkenazi Jews and East Asians (Japanese and Chinese) – while withdrawn from African Americans and Hispanics (Herrnstein & Murray, 1994, p. 548). American white people are of average intelligence, so they will not be smart enough to see that their tax money goes to benefit those with higher IQs. Significant for us here is to note how the concept of intelligence is generally employed in gradations to measure higher and lower among human beings. What I believe is needed is a minimum definition of intelligence to discern who's in and who's out. And it appears to us that life forms from microbial stages on are in. But, according to *The Bell Curve*, single-celled organisms would not be smart enough to receive pre-school aid.

6 In his chapter in this volume, "Autopoietic Systems and the Theology of Creation: On the Nature of Life," Alexander Maßmann refers to this spiral as the circle of causality (Maßmann, 2017).

7 Artificial Intelligence (AI) is not intelligent, at least at present. Complex, yes. Intelligent, no. AI does not have a mental life as humans do, even though some non-sentient machines can learn. AI is not built "these days" to create second generation intelligence and then become difficult to control, at least according to Yoshua Bengio, who is developing *deep learning* for AI. "Machine learning means you have a painstaking, slow process of acquiring information through millions of examples. A machine improves itself, yes, but very, very slowly, and in very specialized ways" (Knight, 2016).

8 A strong version of my hypothesis – where there's life there's intelligence – would need confirmation in Origin of Life Studies. "We suggest that what OoL [Origin of Life] studies all ultimately address is the onset of the various organizational phenomena that we associate with the living world. This unites all areas of research, from laboratory experimentation to Earth and planetary exploration, theory, and computation"(Scharf *et al.*, 2015, p. 1033).

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