Immunity, Life and Dancing Starlings: A Physician's Perspective

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ABSTRACT: Immune function is the most basic physiological process in humans and indeed throughout the animal kingdom. Interestingly, the vast majority of textbooks of physiology do not include a chapter on immunity. Our species survival is dependent on the diversity of the immune response and the ability for antigen presentation and effector mechanisms to be enormously promiscuous. As physicians, we are likely all too aware of how brief our life span is and the myriad of diseases and events that shorten it. It is not surprising that we question where our life comes from and our relationship within the universe. Many hypotheses have been offered regarding the likelihood that intelligent life exists elsewhere. We propose that such issues be discussed in the context of basic biologic observations on earth, such as the sight of a dense flock of tens of thousands of starlings maneuvering in rapid twists and turns at dusk before settling in trees for the night. The mathematical likelihood for life elsewhere was proposed by Frank Drake in a classic equation whose 'thesis' has stimulated the search for alien civilizations and the nature of life. A fundamental gap in this equation is the presence of a diverse immune response, a feature essential for survival of Life, presumably also extra-terrestrially.

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There is no question more fundamental to physicians than the origin of life and the related question of life elsewhere in the universe. Physicians are all too aware of how brief our life span is in view of the myriad of diseases and events that shorten it. As such, it is not surprising that we all ask the question where our life comes from. Indeed, many analogies can be made. For example, can we learn anything about the nature and scale of the universe, from the sight of a dense flock of tens of thousands of starlings maneuvering in rapid twists and turns at dusk before settling in trees for the night? Already in medieval times, awareness of the extent of the earthly scale had increased when in 1580 Francis Drake, in his thirties and fulfilling a mission declared by Elizabeth I, became the first ever sea captain to personally complete a circumnavigation of planet earth. Landing on the Caribbean coast en route, he died in 1596 of dysentery – in Puerto Rico. Over 400 years later, his (almost) namesake, also in his thirties, Frank Drake, pioneered from 1960 with others, such as Carl Sagan, navigation around the universe. In search of non-terrestrial intelligence and civilizations, they centered this rather longer journey on a radio telescope at Arecibo – coincidentally also in Puerto Rico. The SETI (Search for Extra-Terrestrial Intelligence) organization was founded to propagate this purpose.

In 1960, Freeman Dyson considered a search necessary for alternative artificial stellar sources of thermal radiation; it could also imply the presence of galactic life [1]. In 1972, a message written on a small plaque by Drake and others was placed inside the space probe Pioneer 10 and sent to Jupiter and beyond. It told of earth and its inhabitants [2]. Today, SETI with the aid of NASA is a non-profit institute whose mission is now much more extensive: namely, to "explore, understand and explain the origin, nature and prevalence of life in the universe." However, we are still at a loss to explain the natural marvel of birds flocking at dusk, often tens of thousands of birds, without bumping into each other.

THE MILKY WAY – AND BEYOND

In 1961 Frank Drake had suggested a formula for estimating the scope of the search. This took into account many factors, giving $N = N^* f_p n_e f_l f_i f_c f_L$: N^*, the overall rate of star formation in the Milky Way galaxy, f_p the fraction of those stars with one or more circulating planets, n_e the fraction of the latter capable of sustaining life, f_l the fraction of the latter in which life evolves, f_i the fraction of the latter developing intelligent life, f_c the fraction of the latter with civilizations capable of and wishing to communicate with earth, and f_L the fraction of the life of the latter planets during which their civilizations exist and communicate signals able to reach earth.

Never a hypothesis, clearly the resultant equation involved an ocean of guesswork and has been controversial. At best (or

worst), it encouraged interest and debate on the fundamental concept of space exploration and the question of life elsewhere [3]. Obviously other factors are proposed for inclusion, which almost led to the concept of $N=N^i$. In recent years, though the Drake 'equation' has been in the shadows, more recently the improved Huddle Telescope and newer telescopes have discovered many new planets, large and small. These data have led to a renewed and vigorous search, which continues to stimulate philosophers about life in the universe. It is disappointing, but perhaps not surprising, that after over 50 years of such exploration, the Drake mission remains incomplete.

'GROUND CONTROL TO MAJOR TOM'

Despite all the efforts of SETI members and others, nothing has been heard on earth by ground control. Celestial silence reigns, even though it is commonly estimated that there are roughly 200–500 billion galaxies in the universe and that there may be in the region of 500^{22} habitable planets. Looking at our very local neighborhood, on a very clear night we can see up to about 2500 stars (roughly one hundred-millionth of those in our galaxy), and almost all of them are less than 1000 light years away from us (or 1% of the diameter of the Milky Way). Whether the search is delusional, an illusion or real, those data are mind-boggling and they do appear to support the statistical probability of 'life' and even civilizations 'out there'.

Since 2009, the National Space administration (NSA) has identified well over 3000 likely planets in our galaxy alone [4]. The most easily identified are large ones close to their host stars, but the most common are approaching earth size. Many of these are, usefully, at a distance from their 'suns' that ensures they are bathed in light energy similar to that on earth [4]. Therefore, it is not surprising that humans may desire to explore or exploit space to determine whether we have neighbors of some kind or other. Ambitiously, it has been thought that technological advances at the current rate could enable exploration and colonization of our galactic neighborhood within a few hundred years. However, one can only estimate the cost of that; space exploration and exploitation are already proving very expensive. In view of the current and growing earthly problems, the justification for such ever-increasing strain on mankind's resources has been questioned [5]. So although mere curiosity, just 'looking', not even travelling 'out there', is likely to be much cheaper, a most immediate problem still seems to be not 'how?' but 'why?' There are those who question in principle the SETI search for space neighbors.

THE FERMI PARADOX

Controversy surrounds the much quoted Fermi Paradox: a reference to Fermi's reported verbal wondering why there is an apparent total absence of hard evidence for extraterrestrial intelligence in the Milky Way, even though calculations suggest that the age of the latter supports the presence already of galactic colonization [6-8]. Indeed, there are far older stars than our sun with far older earth-like planets, which in theory could support civilizations far more advanced than our own. One view is that the silence signifies the galaxy is empty, or if not, that messages are not getting through to us from another civilization as they are coded unsuitably. Alternatively, perhaps there is no wish from out there to communicate with earth, in which case planning a costly large radio array to pick up messages would be at the least premature [3]. Bostrom wants nothing to do with the search, since even if there was or is another civilization out there, the evidence could only be negative for earth [6]. In truth, if past galactic civilizations had destroyed themselves it would say little for our own future, and if there is an unfriendly 'neighbor' we would know of a harmful intent too late.

With that non-optimistic approach, we could also assume that a far-off civilization on its own very first steps would expect nothing from earth; and in all events, it would not be worth colonizing a planet that allows life only to very simple organisms. On the other hand, the controversial Great Filter theory claims that at some point in the evolution from pre-life to advanced intelligence, it becomes extremely unlikely or impossible for life to break through a glass ceiling, i.e., there are no super-advanced civilizations. Indeed, planning the search is problematic due to the conflicting concerns, and it becomes even more complicated because of the inherent differences between the outlooks of cosmology and astronomy.

LET THE 'REAL' UNIVERSE STAND UP!

Although some astronomers regard cosmology as merely a branch of astronomy, that what we can see and apparently measure – suns, planets, moons and space detritus – is 'real'. Cosmologists may prefer their view of 'reality': a universe structured fundamentally of strings, maybe of nine dimensions or more, or a holographic 2D entity expressing a 3D volume in which unseen black holes trap light. Dark Matter matters more than what we can see – which also does not include Dark Energy. Yet we do not know how to disentangle entanglement [9]. In 1995, some of the above factors were combined mathematically in terms of thermodynamics; this produced the equations of general relativity without bending space-time – but also without saying anything about space-time constituents [10]. However, it seems that the latter can be regarded as a spider's web of strands of information about the quantum environment through which they pass, while the ends of the strands are joined into loops to give loop quantum gravity, which is not the same as the by now well-known product of string theory [11]. A dramatic finding has been duality of some key aspects of modern physics, e.g., quantum field theory with string theory and fluid dynamics with general relativity [12]. Plainly, academic controversy rages around the very structure and content of the universe, perhaps reflecting the pre-Darwinian hubris which once isolated *Homo sapiens* from the rest of the kingdom of animals.

Figure 1. Starling murmuration. This image, generously provided, was photographed at 16:23 on 10 December 2013 at the Village of Rigg, Nr Gretna, Dumfries and Galloway, Scotland, with a Canon EOS 5D Mark III at 1/50Sec - F2.8 - ISO 2500 by Tom Langlands Photography

ON A WING AND A SONG

The current SETI mandate now extends to search for the origin and nature of 'Life', however we still do not know any more about their essence than we do about the universe. Certainly we know nothing whatsoever about life other than about that on earth, even though a possible non-terrestrial origin (panspermia) has been a common postulation, including a recent proposal that its source is the C60 fullerene ('Bucky-ball') molecule that has now been found in space [13]. Niels Bohr struggled to explain life in quantum terms and considered a philosophical place for purpose, in its source [14]. For Schroedinger "… mind could not cope with this gigantic task …" of relating life to the objective world of natural philosophy "… without excluding itself" [15]. However, for the clinician facing the mundane questions of life, the here and now is all-important. In raising these philosophical questions, we propose that physicians, and indeed all people, should examine amazing fundamental physical processes in birds. Starlings gather in closely flying, highly organized conglomerations, the nature of which is still a mystery [Figure 1]. Some small fishes, too, mass in organized shoals; and sharks sense electric fields as low as 5 nV/cm. Their electroreceptors measure the interaction of the earth's geomagnetic field with the electric field caused by ocean currents [16]. This allows compass orientation through an unambiguous interpretation of the electric potentials induced by the electroreceptors while the animal probes the magnetic field in different directions [17]. However, though fish also exist in a 3D continuum, here we emphasize our closer genetic forebears.

DANCING BIRDS

It has been postulated that the dunlins, a type of shorebird, emulated behavior of a human chorus line in which dancers observed an approaching wave of body movements and timed their own to coincide with its arrival [18]. This proposal ignored flight direction changes that started out of sight, especially from behind. The weakness of the argument may have elicited Potts' further statement that "there was probably nothing extrasensory going on." Why 'probably'? The declaration probably too would be non-acceptable to the physicists and computer modeling experts who in the 1990s became involved in the mystery of flight at 40 miles an hour, during which in a moment a whole flock could make a tight hairpin turn. Why is this? As most birds are aerial creatures, non-modeling flock flight research has to be attempted in a 3D environment. This work is essential, even though technically extremely difficult. It takes into account predator threats and the complex conditions faced, including gravity, natural air turbulence, and that created by closely flying birds themselves. The remarkable collective behavior of groups of many tens of thousands of starlings is well known. This is commonly regarded as individual bird activity without centralized coordination but in the framework of a self-organized system. The first 3D study of flock structure suggested that distance between adjacent starlings was metric in principle [19]. However, more recent massive field studies have shown that each bird positions itself relative to the six or seven birds nearest around it, a topographic approach without regard for the metric distance between them [20,21]. The obvious advantages of tight grouping in which the space between birds may be not much more than their body length are protection from predators and gaining a measure of increased speed from the effect of draft. However, techniques for direct study of huge numbers of close fliers are complex and problematic; much is yet unknown.

Overall starling flock proportions are constant, but how this is initiated and what its function is are not known. It is also not

clear how the individual birds behave so as to maintain that constancy, and if so, what is the nature of external influence on this, if any [22]. It is also not known why the density of birds is highest at the flock's outer edges. A possibly anthropomorphic reason is that it creates a 'wall' discouraging to predators; however, it could equally be asked why is the inner flock less dense? Also, no correlation was found between the longest axis of the flock and the direction of velocity. The global shape of the flocks is also not fully explained by the interactions between individual birds [22]. It has been observed that huge starling flocks form in treed areas, maneuvering for about 15–45 minutes prior to landing, where they settle for the night. The birds would benefit by immediate landing between the trees, thus evading attack by predators. Indeed, why the flying acrobatics? This too remains unexplained.

FLIGHT ACROBATICS AND AN ELECTROMAGNETIC FIELD

Perhaps, like sharks, with their sharp twists and turns at dusk the starling flocks seek compass orientation so that it is established ready for dawn when the flocks take off. Unlike sharks, starlings have no electroreceptors. However, speculatively, the acrobatics are the result of the evolution of a uni-field, a temporary integration of the electromagnetic (EM) brain fields across the flock. A recently developed robust 3D tracking algorithm may further advance understanding of this esthetic starling mystery [23]. Though evolution of language and symbolism and modern means of communication over a distance may have all but eliminated development of potential for direct inter-personal EM communication between human EM brains, that may not be the case for some vertebrates, including some avian species [5]. Extracorporeal unification of the EM fields of huge numbers of their brains may yet be shown to extend across close-formation swarms of tens or hundreds of thousands of starlings. Such fields may be influenced by the effect of power pylons and radio masts. They may also lead to central tranquilizer release during gathering towards and during night roosting – a calming effect, like a walk before bedtime.

In our attempts to communicate with Life elsewhere, it is worthwhile to raise the question of how 'dancing' birds actually make contact with each other. A closed society without inter-special understanding and exposure to infectious agents will never develop an effective means to protect itself from distant civilizations. It is not surprising that NASA attempts sterilization of probes out of fear of contamination. Attempts to communicate and make physical contacts with 'out there' can lead to an infectious catastrophe, far beyond that of an HIV, Zika or influenza epidemic. The long-debated Drake's 'equation' is based on physical principles. Immunity should surely be factored into it.

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References

1. Dyson FJ. Search for artificial stellar sources of infrared radiation. *Science* 1960; 131 (3414): 1667-8.
2. Sagan C, Sagan LS, Drake F. A message from Earth. *Science* 1972; 175 (4024): 881-4.
3. Kuiper TB, Morris M. Searching for extraterrestrial civilizations. *Science* 1977; 196 (4290): 616-21.
4. Petigura EA, Howard AW, Marcy GW. Prevalence of earth-size planets orbiting sun-like stars. *Proc Natl Acad Sci USA* 2013; 110 (48): 19273-8.
5. Goodman G, Gershwin ME, Bercovich D. Mars can wait: facing the challenges of our civilization. *IMAJ* 2014; 16 (12): 744-7.
6. Bostrom N. Where are they? Why I hope the search for extraterrestrial life finds nothing. *MIT Technol Rev* 2008; 72-7.
7. Cirkovic MM, Vukotic B. Astrobiological phase transition: towards resolution of Fermi's paradox. *Orig Life Evol Biosph* 2008; 38 (6): 535-47.
8. Wiley K. The Fermi Paradox, self-replicating probes, and the interstellar transportation bandwidth. *arXiv* 2011; (1111): 6131.
9. Merali Z. Theoretical physics: the origins of space and time. *Nature* 2013; 500 (7464): 516-19.
10. Jacobson T. Thermodynamics of spacetime: the Einstein equation of state. *Phys Rev Lett* 1995; 75 (7): 1260-3.
11. Ashtekar A, Pawlowski T, Singh P. Quantum nature of the big bang. *Phys Rev Lett* 2006; 96 (14): 141301.
12. Maldacena J. The large n limit of superconformal field theories and supergravity. *Adv Theor Math Phys* 1998; 2: 231-52.
13. Goodman G, Gershwin ME, Bercovich D. Fullerene and the origin of life. *IMAJ* 2012; 14 (10): 602-6.
14. Bohr N. Light and life. *Nature* 1933; 133: 421-3, 457-9.
15. Schroedinger E. What is Life, Mind And Matter? In: Mind and Matter. Cambridge University Press, UK, 1967.
16. Meyer C, Holland K. Sharks can detect changes in the geomagnetic field. *J Roy Soc Interface* 2005; 2: 129-30.
17. Kramer B. Electro-reception and communication in fishes. *Prog Zool* 1996; 42: 27-30.
18. Potts W. The chorus-line hypothesis of manoeuvre co-ordination in avian flocks. *Lett Nature* 1984; 309: 344-5.
19. Major P, Dill L. The three-dimensional structure of airborne bird flocks. *Behav Ecol Sociobiol* 1978; 4: 111-12.
20. Ballerini M, Cabibbo N, Candelier R. Empirical investigation of starling flocks: a benchmark study in animal behaviour. *Anim Behav* 2008; 76: 201-15.
21. Cavagna A, Giardina I, Orlandi A. The STARFLAG handbook on collective animal behaviour: Part II, three-dimensional analysis. *Anim Behav* 2008; 76: 237-48.
22. Lebar Bajec I, Heppner F. Organized flight in birds. *Anim Behav* 2009; 78: 777-89.
23. Attanasi A, Cavagna A, Del Castello L. GReTA – A novel global and recursive tracking algorithm in three dimensions. Cornell University Library arXiv:1305.1495 [q-bio.QM].

"All religions united with government are more or less inimical to liberty. All, separated from government, are compatible with liberty"

Henry Clay (1777-1852), American lawyer, politician, and skilled orator