**Comments on *Biology's Next Revolution* (Essay in *Nature*, Vol. 445, January 2007)**
https://guava.physics.uiuc.edu/~nigel/REPRINTS/2007/Goldenfeld%20Biology%27s%20next%20revolution%20Nature%202007%20(PDF).pdf

**Whilst planet Earth and living things upon it still exist, viruses will continue to be involved in evolutionary processes and some may be beneficial to humans.**

1. The essay argues that viruses are "an important repository and memory of a community's genetic information, contributing to the system's evolutionary dynamics and stability [and] have a fundamental role in the biosphere, in both immediate and long-term evolutionary senses". Questionable here is use of the word 'role' with its implication that there is some *purpose* to evolutionary processes on planet Earth – the *ultimate* fate of which, along with any life forms remaining upon it, is *annihilation*. It is an under-recognised fact, nevertheless, that some viruses are potentially useful from a human perspective. An article entitled *The Good that Viruses Do* (Annual Review of Virology, Vol. 4, September 2017)[1] concludes: "Some of the viruses infecting humans are indeed capable of causing severe and often lethal diseases, but other viruses can be manipulated to be beneficial to human health. These viruses offer the potential to cure cancer, correct genetic disorders, or fight pathogenic viral infections. In addition, viruses are used in many genetic studies to determine molecular mechanisms, are used as insecticides, and have been reported to increase drought tolerance in some plants. Virologists must strive to downplay the 'bad' reputation of viruses and promote dialogue on the many 'good' things that they can do." The same, of course, is true of bacteria – whilst some can kill us, we are hosts to many which are harmless or, indeed, beneficial to our health e.g. the bacteria in our guts which aid our digestive processes. The Human Microbiome Project, which published its initial findings in 2012, has suggested that more than half of the cells in the human body are, in fact, *non*-human!

**Genetic transformations can occur 'horizontally' as well as 'vertically'. As with all evolutionary processes, such transformations are *value neutral* – other than from a *human perspective*.**

2. That genes may transfer between organisms not only 'vertically' (via the reproductive process) but also 'horizontally' has been recognised for some time. Horizontal gene transfer (HGT) can occur in a number of ways, two of which are *transformation* (the genetic alteration of a cell through the introduction and expression of foreign genetic material – DNA or RNA) and *transduction* (the movement of bacterial DNA from one bacterium to another by a virus). Whether the result is 'good' or 'bad' depends upon the perspective from which it is viewed. HGT provides a mechanism (mentioned in the *Nature* essay) whereby bacteria can acquire resistance to antibiotics. If 'good' means survival-enhancing and 'bad' survival-reducing, then the acquisition of such resistance appears good for the bacteria concerned but bad for us.

**The 'standard model' of evolution envisages an essentially *blind and unthinking process* whereby the fate of random genetic variations is determined by their fitness for survival within the *natural* environment existing at the time. The environment is now, in part, *consciously engineered* by humans.**

3. The processes driving the evolution of life forms on planet Earth have, *until recently at least*, been essentially *blind* and *unthinking*. There is no morality in 'nature' for the simple reason that the term does not denote an *intentional being* – notwithstanding that many of us entertain an anthropomorphic notion of 'Mother Nature'. The generally accepted model of the evolutionary process is that it works through the selective survival of *random* genetic variations (whether arising vertically or horizontally), such survival being dependent upon how well they are suited to the particular environment in which they happen to occur i.e. upon *natural selection*. The process of natural selection, of course, was propounded by Charles Darwin in his *On the Origin of Species* (1859), although the state of scientific knowledge at the time was such that he could not offer a *genetic* explanation for the variations thrown up when organisms reproduce. The environment into which life forms *now* emerge is in part the product of the consciously chosen activities of humans and, in that sense, *artificial* rather than natural.

[1] https://www.annualreviews.org/doi/full/10.1146/annurev-vi-04-071217-100011

**The possibility has been advanced that environmentally induced changes in how organisms use different features of their physiology may become *heritable* via the reproductive process.**

4. The *Nature* essay provides a flavour of the uncertainty there has been in biology about, *inter alia*, the possibility advanced by proponents of *Lamarckism* – based on ideas attributed (questionably) to French naturalist Jean-Baptiste Lamarck (1744-1829) – that organisms, by their use or disuse of features of their physiology when interacting with their environment, may not only cause those features to change but also *pass on* those changes to their offspring. A related area of uncertainty is *epigenetics* which concerns the potential for heritable traits to be environmentally induced and transmitted *without* changes to DNA sequencing i.e. through changes in how the genes of organisms are *expressed* in their observed properties (the so-called *genotype-phenotype* relationship). An intriguing, if disturbing, test of Lamarckism was conducted by German biologist August Weismann (1834-1914) and described in his *Essays on Heredity* (1889). He bred mice having first (like the farmer's wife) cut off their tails, to see if there were any signs of tail shortening amongst subsequent generations. He found none. The validity of his experiment was contested on the basis of the small sample size involved and that the severing of tails constitutes organ *misus*e rather than disuse. It has been suggested that Weismann might have saved himself his time and trouble (and the mice their mutilation) had it occurred to him that over millennia a large-scale version of his experiment has been conducted, albeit unwittingly, by societies which practise male circumcision – without the slightest evidence so far of the effects predicted by proponents of Lamarckism!

**Our hierarchical classification of life forms is to an extent arbitrary and may need re-thinking.**

5. The doubt which the *Nature* essay casts upon the validity of the concept of a 'species' appears to echo that expressed back in the 19th century by Darwin who considered the distinction between *species* and *varieties* to be arbitrary, stating that "a well-marked variety may be justly called an incipient species" and that "species are only strongly marked and permanent varieties". The authors of the essay argue that new concepts in biology call for a new biological language – although they do not provide a specific proposal for this, merely stating that it would need to be grounded in mathematics and reflect the genomic fluidity (to which viruses contribute) which they describe.

**Evolutionary theory is incomplete if it ignores the impact of conscious human activity upon the environment. Such activity may be triggering a sixth mass extinction.**

6. A surprising omission from the essay is direct reference to the comparatively recent evolutionary change which has the profoundest of implications not just for biological concepts/language but, more importantly, for the future of life on planet Earth. It is, of course, the emergence of a species (*homo sapiens*) with an advanced level of consciousness/intelligence, enabling it to make choices which now impact massively on the natural environment and thus the direction of future evolutionary change. In the geological sciences it is proposed that a new epoch (to be named the *Anthropocene*) should be recognised, dating from the commencement of significant human impact on Earth's geology and ecosystems. In seeking to explain the five mass extinctions (Ordovician-Silurian; Devonian; Permian-Triassic[2]; Triassic-Jurassic; Cretaceous-Palaeogene) which have occurred over the last 500 million years, scientists have not had to bother about the impact of decision-making by conscious beings. This is no longer the case. Humans now have the power to render extinct not only other species but also themselves – whether by intent or as an unwitting side-product of their exploitation of the planet – and have already had a major negative impact on bio-diversity. We are widely considered to be now at the start of a *sixth* mass extinction (the *Holocene*) caused directly by *human activity* which is in turn the product of, and explicable only in terms of,

[2] Occurring about 250 million years ago, this was the largest mass extinction event and has become known as 'The Great Dying'. It is estimated to have wiped out, over an extended period of time, at least 90% of all existing species. The causes of extinction events, both major and minor, remain a matter of speculation. No single cause is identifiable. Possible causes (some of which may have been interrelated and worked in combination) include gigantic volcanic eruptions, sea-level falls, asteroid impacts, global cooling, global warming, methane emissions, plate tectonic movements, ocean overturn (bringing oxygen-deficient water to the surface) and gamma ray bursts (damaging the Earth's ozone layer).

*human belief/value systems*. The physical sciences, as the name suggests, are limited to explaining *physical* processes and are silent on the subject of human social/economic arrangements and activities *per se* and the *normative/moral* issues they raise – whilst having much to say about their *physical consequences* (e.g. climate change and environmental pollution). The *social* sciences, by contrast, focus upon the *purposive* behaviour of humans – as displayed in their interaction with each other and their environment – and the conceptual/ideological constructs which shape it. Arguably, *philosophy* – the 'scientific' status of which is ambiguous and itself a philosophical issue! – straddles the (artificial?) physical/social science divide by questioning the conceptual basis of both fields of study. However, if *homo sapiens* is a casualty of the next (already commenced?) mass extinction – with humbler species such as cockroaches, perhaps, inheriting the Earth[3] – *nobody* (whether physical scientists, social scientists, philosophers or whoever) will be around afterwards to try to explain what happened and *why*.

**Advances in *genetics* increase the potential scope of *eugenics* (i.e. the deliberate manipulation of human biology). This, together with the claims of some forms of *pseudo-science*, raise significant moral issues.**

7. The development and use of techniques of genetic engineering now represent a significant way in which we are altering, for good or ill, the future course of evolution. Of concern is the possibility that our increasing ability to manipulate our own biology/genetics will re-kindle and strengthen an interest in *eugenics* – the attempt to 'improve' human beings (e.g. by selective breeding). The ideas involved have been in circulation for a long time and have attracted the support of a motley crew including T.E. Huxley (Darwin's 'bulldog'), George Bernard Shaw and Adolf Hitler. The appeal of eugenics to racists is obvious, but it has also attracted those who regard it simply as a means to improve the quality of human lives and the potential for humans to 'flourish' by enhancing their mental and physical capabilities and their resistance to illnesses and diseases. Key issues include the standards by which 'improvement' should be measured, how and by whom they should be set, and the implications for existing members of the population who fail to match up to them. We know all too well the potential for prejudice masquerading as 'science' to have the most appalling consequences, including g*enocide*. Even *geneticists* are not safe. In the USSR, biologist Trofim Lysenko promoted a range of untested agricultural techniques (subsumed under the name *Lysenkoism*) based, in part at least, on ideas attributed to Lamarck. Lysenko denied the existence of DNA and believed that changes in farming methods alone could alter the *heritable* traits of crops and livestock. The power to take control of the future which this seemed to confer on humans was, in Lysenko's view, consistent with the revolutionary principles of Marxism-Leninism – unlike the view of evolutionary change as the product of *impersonal/unthinking* processes i.e. of genetic mutation working in combination with natural selection. He won the approval and support of Joseph Stalin and in 1948 genetics was declared "a bourgeois pseudo-science" and its promulgation criminalised – which was ironic as, if anything was a pseudo-science, it was Lysenkoism. Scientists who refused to renounce genetics were sacked from their jobs, many were imprisoned and some even sentenced to death as enemies of the state.

**Whilst *teleological* interpretations of evolutionary processes are to be avoided, it seems impossible from a human perspective to escape the question "but what's the *point* of it all?"**

8. Despite the title of the essay, the proposition that " a defining characteristic of life is the strong dependency on flux from the environment" and that there is "a continuity of energy flux and informational transfer from the genome up through cells, community, virosphere and environment" does not seem particularly revolutionary nor, *within the confines of the physical sciences*, to pose insuperable conceptual difficulties. From a wider (philosophical?) perspective, however, significant issues arise. Already mentioned, is the danger of a *teleological* interpretation of evolutionary processes – i.e. that there is a *purpose* to them and that they represent some form of 'onwards and upwards' progression (cf. the so-called 'Whig interpretation' of history). Fascinating though all natural processes are in their intricacy and

[3] Candidates for the toughest creatures on Earth are *tardigrades* (aka *water bears* or *moss piglets*). Water-dwelling with eight legs and 0.5mm to 1mm in length, they can survive the vacuum of space and extremes of temperature and pressure. A recently discovered species of tardigrade produces a fluorescent substance which appears to protect it from intense UV radiation.

complexity, it seems impossible to escape the question: "Yes, but what's the *point* of it all?" The question is particularly acute in view of the fact that the fate of all *individual* organisms in the very short term, and all *types* of organism – whether classified by species, genus, family, order, class, phylum or kingdom – in the much longer term, is respectively *death* and *extinction*.

***Panpsychism* – the attribution of *consciousness* to *everything* in the universe rather than to just a limited range of life forms, most notably *humans* – turns out, like *pantheism*, to be incoherent.**

9. Humans are liable to project upon the objects of their intentionality – from elementary particles up to the entire universe – features of their own mental processes including desires, choices, intentions and purposes. This is exemplified by proponents of *panpsychism* – the belief that all 'entities' at all levels of complexity are, in some vague and undefined way, *conscious*. Never answered if ever asked, are questions about the *content* of such consciousness and how the consciousness of a particular entity might relate to that of any of which it is either a component or is composed – e.g. how the supposed consciousness of a cloud[4] might relate 'upwards' to that of planet Earth, the solar system, the Milky Way galaxy and ultimately the entire universe or, 'downwards', to that of each of its constituent water molecules, each of *their* constituent hydrogen and oxygen atoms and each of *their* constituent sub-atomic particles. Bearing some resemblance to panpsychism is *pantheism* – the belief that a spiritual force dwells within, and expresses itself through, all features of the natural environment. James Lovelock's *Gaia hypothesis* (named after the goddess in Greek mythology deemed to be the mother of all life on Earth) is open to pantheistic interpretation, maintaining as it does that living and non-living parts of the Earth form a complex interacting system which operates as a *single organism*. As with panpsychism, any attempt to attribute conscious intention or purpose to such an hypothesised entity seems bound to end in incoherence.

**Belief in one or more 'gods' runs into similar conceptual difficulties (e.g. the status of 'miracles').**

10. Distinguishable from pantheism is belief in the existence of one or more 'gods' (usually imagined in vaguely human or animal form), some of which might be associated with particular features of the natural environment – e.g. the association of the Greek god Poseidon with seas, storms, earthquakes and horses or of the Norse god Thor with thunder, lightning, storms and oak trees.[5] Polytheistic religions generally envisage a *hierarchy* of gods, the one at the top often being credited with the role of progenitor – the question of how she/he/it might have come into existence being conveniently ignored. Monotheistic religions – most notably, in order of emergence, Judaism, Christianity and Islam – attribute to a *single* god the role not only of progenitor/creator but also of moral arbiter who determines the fate of humans in an imagined 'afterlife'. Such religions, of course, may be interpreted by their adherents (who tend to split into sects) in radically, as well as trivially, different ways. Some Christians, for example, have sought to 'de-personalise' the concept of God, substituting for it a near pantheistic notion of an all-pervading moral presence.[6] A common difference of view concerns whether God, having created the universe and the 'laws' which govern its physical processes, then stands back and leaves it entirely to its own devices or, alternatively, intervenes on occasions and *breaks* these laws by performing the odd 'miracle' – e.g. to assist favoured individuals, races or nations.

**Why should God, if *caring* and *all-powerful*, be at war with a *care-for-nothing* Nature?**

11. A dilemma for many is to reconcile belief in a *benevolent* god with all the *bad* things which undoubtedly happen in the world – whether their origin is *human* (e.g. wars) or *natural* (e.g. diseases).

[4] If fanciful, we might imagine it singing along with Winnie-the-Pooh: "How sweet to be a cloud / Floating in the Blue! / It makes [me] very proud / To be a little cloud."

[5] Atheism (depending upon how it is defined) and pantheism are not necessarily incompatible. In his tract *The Necessity of Atheism* (1811) the poet Shelley declares: “There is no God. This negation must be understood solely to affect a creative Deity. The hypothesis of a pervading Spirit co-eternal with the universe remains unshaken.”

[6] For example, in his book *Honest to God* (1963) the Anglican Bishop of Woolwich, John Robinson, argued, in line with existentialist theologian Paul Tillich, that God should be seen as ‘the ground of our being’, not as a separate entity (with vaguely human characteristics) existing ‘out/up there’. He was much criticised by traditional Christians, even being accused of atheism.

Particularly random and purposeless would appear to be the occurrence, from whatever cause, of premature death. For many years, this deeply troubled the mind of Alfred Lord Tennyson who, in his poem *In Memoriam A.H.H.* (1850), sought to come to terms with the death from a brain haemorrhage at the age of 22 of his close friend and fellow poet Arthur Henry Hallam. Unable to believe it could serve any divine purpose, he first questions the seeming indifference of "Nature, red in tooth and claw" to *individual* lives. Like many Victorians, however, he was fascinated by the then recent fossil discoveries which evidenced the extinction, contrary to biblical teaching, of whole species of animals (such as dinosaurs) and is forced to recognise Nature's lack of care not just for *individual* lives but for all *types* of life.

"Are God and Nature then at strife,
That Nature lends such evil dreams?
So careful of the type she seems,
So careless of the single life;"

'So careful of the type?' but no.
From scarped cliff and quarried stone
She cries, 'A thousand types are gone:
I care for nothing, all shall go'.

**Religious dogma has hampered progress in the natural sciences. Scientific theories comprise testable *hypotheses*. *Mechanism* and *vitalism* have offered rival theoretical approaches in biology, the status of vitalism being generally downgraded now to that of a *pseudo-science*.**

12. Progress in the physical sciences over the centuries has been hampered by religious dogmatism – as exemplified by the silencing of Galileo for challenging the dogma of an unmoving Earth at the centre of the universe. Biology, as much if not more than any other area of scientific enquiry, has felt the baleful impact of religious dogma. Evolutionary theory was virulently opposed in the 19th century by a religious establishment wedded to belief in God's creation of fixed and immutable species. To this day, creationism still has its advocates and, especially in theocracies, remains an impediment to progress in the life sciences. All scientific theories, of course, are open to challenge by *rival* ones. None are dogmatic if offered simply as *hypotheses* which are *testable* and so *falsifiable*. Amongst biologists in the 18th and 19th centuries, two radically different approaches to the subject of their studies vied for acceptance:

- *mechanism* – the view that the things we classify as living and non-living are basically the same in terms of both their materiality and their subjection to mechanistic physical laws;
- *vitalism* – the view that living things differ fundamentally from non-living things in that they, uniquely, are infused with a 'life force' or 'vital spark'.[7]

Vitalism has had a natural appeal for people of a religious persuasion as it resonates with the notion of a 'soul' or 'self' inhabiting, but distinguishable from and potentially capable of existing independently of, a material body. The demonstration in 1828 by Friedrich Wöhler that urea, an *organic* compound, could be synthesised from *inorganic* components, opened an early chink in the armour of vitalism – later widened by Eduard Buchner's demonstration in 1897 that living yeast cells were not needed for fermentation. Subsequent discoveries in biochemistry – including the role played by enzymes, proteins, vitamins, RNA and DNA – eventually sounded the death knell for vitalism which came to be regarded by the generality of biologists as mere *pseudo-science*. It had long been argued, in any case, that vitalism hypothesised the existence of something which, by its very nature, could not be identified in any scientific test. Being thus unfalsifiable, vitalism could not be considered a *scientific* theory.

[7] This is portrayed dramatically in Mary Shelley's 1818 novel *Frankenstein; or, The Modern Prometheus*. Victor Frankenstein describes the coming to life of his 'creature' thus:
"It was on a dreary night of November that I beheld the accomplishment of my toils… I collected the instruments of life around me that I might infuse a spark of being into the lifeless form… I saw the dull yellow eye of the creature open; it breathed hard and a convulsive motion agitated its limbs."
Comparable in a way with vitalism, is the 18th century theory that things become hot by absorbing a substance called 'caloric'. If we substitute the word 'heat' for 'caloric', this amounts to saying that things become hot by absorbing 'heat' – which is hardly enlightening. It seems equally unenlightening to say that they move by absorbing 'motion' or become living by absorbing 'life'. Might similar issues relate to the concepts, fundamental to physics, of *mass* and *force* – force being *whatever it is* which causes a 'material thing' possessing mass to accelerate and mass being *whatever it is* possessed by a 'material thing' which causes it to resist the effect of a force? Also questionable here, is the concept of 'materiality' or 'matter' – described by Bertrand Russell as "infected by the metaphysics associated with 'substance' and ... not really necessary in dealing with phenomena".

**The *reductionist* implications of mechanism remain problematic. The concept of *emergence*, particularly in relation to 'the high level collective behaviour of complex systems', appears potentially fruitful but remains controversial.**

13. The demise of vitalism has not removed doubts about the validity of a wholly *mechanistic* approach (see Addendum on page 8) to biological phenomena/processes. Questionable in particular is the assumption, implied by such an approach, that all are *reducible* to, and *fully explainable* in terms of, *lower level* phenomena/processes behaving in accordance with mechanistic/deterministic 'laws'. Apart from recognition of the *probabilistic*, rather than deterministic, nature of behaviour at the sub-atomic level, there has been a growing interest in the concept of *emergence* – i.e. that properties may emerge in complex structures which cannot be explained/predicted by the observed properties/behaviour of their lower level constituents. On this basis, it is argued, the properties displayed by the entities we classify as living things have to be accepted simply as what happens when given levels and forms of structural complexity are realised – rather as the properties displayed by water are simply what happens when atoms of hydrogen and oxygen combine in a certain way. Emergence remains a controversial subject and some see it as mimicking vitalism by postulating, when a given level of structural complexity is realised, the sudden appearance from nowhere of the properties we associate with 'life'. The concepts of both vitalism and emergence – and whether the latter might be a form of vitalism in disguise and itself a pseudo-science – are examined in an article published in 1997 in the Journal for General Philosophy in Science.[8] The authors argue that: "On the one hand, many scientists and philosophers regard emergence as having only a pseudo-scientific status. On the other hand, new developments in physics, biology, psychology, and cross-disciplinary fields such as cognitive science, artificial life, and the study of non-linear dynamical systems have focused strongly on the high level 'collective behaviour' of complex systems, which is often said to be truly emergent, and the term is increasingly used to characterize such systems."

**Human intercommunication enhances the potential of consciousness as an emergent phenomenon.**

14. A natural phenomenon to which the concept of emergence appears particularly relevant is *consciousness* – especially *human* consciousness as evidenced in our *sensory/cognitive experience* and *social intercommunication/interaction*. Whilst this appears linked to, affected by, and impossible without, electrochemical activity in our brains, it does not appear wholly *explicable* in terms of such activity or of the 'lower level' phenomena which feature in the theories of particle physics and quantum mechanics – such theories being *themselves* the product of human cognitive activity. The conceptual circularity involved here is discomforting, as is the recognition that, with the evolutionary emergence of conscious beings (us) possessing (we like to think) advanced intelligence,[9] part of what happens in the natural world is now explicable only in terms of human ideas, choices and actions and the belief/value systems which they reflect. These vary widely, and often fundamentally, between people and, especially if held dogmatically, may be the subject of bitter and sometimes violent dispute. For the most part, however, human intercommunication is the vehicle for *co-operation* (commonly linked to mentally-constructed norms, practices and institutions) as well as the *enlarging of human understanding* (including new theoretical approaches in the natural sciences). Such intercommunication may be seen as realising a level of emergence above and beyond that evidenced in individual brains (whilst profoundly affecting their individual mental content). As neuroscientist Michael Gazzaniga argues: "When more than one brain interacts, new and unpredictable things begin to emerge, establishing a new set of rules."[10] Crucially, the social/institutional constructs which arise from human intercommunication exist only as *intentional* phenomena. They have no *necessary* connection with specific physical phenomena and any they might have is merely *contingent*. An obvious example is the social construction we call *money*. There is *nothing* in

[8] Emmeche, C. *et al* (1997) *Explaining Emergence: towards an ontology of levels*. Journal for General Philosophy of Science 28: 83-119, 1997. See: https://web.archive.org/web/20061006171903/http://alf.nbi.dk/~emmeche/coPubl/97e.EKS/emerg.html

[9] The notion of advanced human intelligence is questioned in The Galaxy Song from *Monty Python's The Meaning of Life* (1983) when it suggests we "pray that there's intelligent life somewhere out in space, 'Cause there's bugger all down here on Earth!"

[10] Gazzaniga, Michael S. (2011) *Who's in Charge? - Free Will and the Science of the Brain*. HarperCollins

the bits of metal, pieces of paper and entries in ledgers or on computer databases which makes them money. What makes them money is simply the collective determination of humans to regard them as such. The same is true of the laws which regulate human conduct within societies. They are *mental constructs* and exist only as intentional states within the minds of the members of social groups. Unlike the misnamed 'laws' of physics (in reality *inductive generalisations* based upon *observed regularities* in nature), they can be *changed* as a matter of collective choice and *broken*, deliberately or inadvertently, by individuals.

**Searle's *biological naturalism* avoids the pitfalls of dualism. Evolutionary theory is incomplete if it ignores the impact of mental phenomena and, in particular, of human purposive activity.**

15. The evident *causal efficacy* of our individual and collective decision-making,[11] raises complex issues regarding the relationship between the *mental* and the *neurobiological* processes involved – including the possibility of *causal complementarity*. Gazzaniga suggests: "Mental states that emerge from our neural actions do constrain the very brain activity that gave rise to them. Mental states such as beliefs, thoughts, and desires all arise from brain activity and in turn can and do influence our decisions to act one way or another. Ultimately, these interactions will only be understood with a new vocabulary that captures the fact that two different layers of stuff are interacting in such a way that existing alone animates neither." By the nature of their subject matter, the 'life sciences' (including biology, neurology and psychology) are concerned with phenomena which are commonly divided into two distinct types – the *mental* and the *physical*. Conceiving these as mutually exclusive *modes of existence*, appears to render inexplicable how they might possibly interrelate – a problem recognised but unresolved by 'dualist' philosophers such as René Descartes (1596-1650). What is required, it would seem, is a re-conception of the phenomena concerned. As philosopher John Searle argues: "The worst mistake is to suppose that the common-sense distinction between mental states naively construed and physical states naively construed is an expression of some deep metaphysical distinction… The problem is that the terms have traditionally been defined so as to be mutually exclusive. 'Mental' is defined as qualitative, subjective, first personal, and therefore immaterial. 'Physical' is defined as quantitative, third personal, and therefore material… These definitions are inadequate to capture the fact that the world works in such a way that some biological processes are qualitative, subjective, and first personal. If we are going to keep this terminology at all, we need an expanded notion of the physical to allow for its intrinsic, subjective mental component... We do not live in several different, or even two different, worlds, a mental world and a physical world, a scientific world and a world of commonsense. Rather, there is just one world; it is the world we all live in, and we need to account for how we exist as a part of it... Science does not name an ontological domain; it names rather a set of methods for finding out about anything at all that admits of systematic investigation... So if we are interested in reality and truth, there is really no such thing as 'scientific reality' or 'scientific truth'. There are just facts that we know."[12] Searle (2004) calls his approach *biological naturalism*, arguing that it "provides a naturalistic solution to the traditional 'mind-body problem', one that emphasises the biological character of mental states and avoids both materialism and dualism." Whatever form 'biology's next revolution' might take, it will be incomplete if it does not encompass the nature and causative role of *mental states/processes*, particularly the *human* ones which are now profoundly affecting evolutionary processes on planet Earth and the prospect for the long-term survival of life upon it.

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[11] Something as basic as the whereabouts at any moment of the stuff comprising our bodies, cannot be explained satisfactorily without reference to our *conscious choices* of activity. The occurrence of complex/interconnected events such as those now causing climate change is equally inexplicable without reference to the beliefs, knowledge, intentions and choices of humans acting as members of distinct social/political groups. The idea that all can be explained as the 'upward' causal result of unthinking deterministic or probabilistic behaviour of micro-physical phenomena (as commonly conceived) and that all human knowledge, beliefs, desires, intentions and choices – *and all of our scientific theories* – are mere *epi*phenomena, supervenient upon neurobiological and lower-level activity and devoid of causative effect, is *literally* incredible.

[12] John R. Searle (2004) *Mind: A Brief Introduction*. Oxford University Press.

## Addendum: The Mechanical View of Life

**Extract from: W.W. Sawyer (1943) *Mathematician's Delight*, Penguin Books**

"At one time there was a great craze for explaining everything in terms of machinery. It had been discovered that many facts of nature, in particular the movements of the planets, the tides, and of solid objects on the earth's surface, could be explained by supposing the universe to be made up of hard little balls, attracting each other according to certain definite laws. Instead of saying, 'We have a theory sufficiently correct for certain purposes', philosophers and scientists leapt to the conclusion that they had the whole truth about the universe. Not only the sun and moon, but our brains also, were made out of these hard little balls, and everything we did was a consequence of the way they pulled each other about. Thought and feeling must therefore be pure illusion – this in spite of the fact that the theory itself was the result of thought!

The whole procedure was entirely unscientific. It is obvious to anyone that courage, loyalty, determination, affection are *facts*, just as much as pound weights or spring balances. Without these qualities, it is very unlikely that any race of men or animals could long survive. The scientific conclusion would have been: our theory gives us true results about the movement of the moon and the planets, therefore there is some truth in it, but it does not lead us to foresee the possibility of atoms coming together and being organised into living creatures, *therefore* it is incomplete, *therefore* it overlooks some of the things which atoms actually do.

The root of the matter is perhaps a superstitious feeling that results obtained by looking through a microscope or a telescope are in some mysterious way superior to the knowledge we get in everyday life. We have at times come near to the worship of scientists, to believing that men who work in laboratories can solve all our problems for us. The views of a great scientist on his own science are indeed worthy of respect, for they are based on facts. But by the very act of shutting himself inside a laboratory, a scientist shuts himself out from much of the daily life of human beings. If a scientist realizes this, if he tries to overcome his isolation by paying special attention to current events and by learning the history of mankind, he may be able to apply his scientific training to other departments of life. But if he rushes straight out of his laboratory, full, like any other human being, of prejudice and ignorance, he is likely to make a rare fool of himself."

Note:
Sawyer's choice of words (e.g. his talk of 'hard little balls') in describing the 'mechanical view of life' is, of course, knowingly simplistic. As a specialist in the mathematics of relativity theory and of quantum mechanics, he was fully aware of the complex nature of the reality involved. The male-centric wording of the final paragraph reflects the times when he was writing – although it remains the case that women are substantially under-represented amongst physical scientists (or 'natural philosophers', as they used to be called).