LIFE & MIND

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Life & Mind: A Philosophical Quest

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Organisation as such is conceivable only in relation to a *mind*. Even those who will have it that the organic product itself arises from the wonderful collision of atoms admit this. For in that they derive the origin of these things from blind chance, they also promptly abolish all purposiveness in them and with it all conception of organisation itself ... since purposiveness is conceivable only in relation to a judging intellect.

Schelling, *Ideas for a Philosophy of Nature*

What we can judge about the existence of material things is no more than the consistency of our senses. One has a sufficient basis for judging that we can ascribe nothing to matter apart from being sensed in accordance with certain laws. ... We have no idea of existence, other than that we understand things to be sensed. Nor can there be any other idea of existence, since existence is included in the essence of necessary beings alone. Without sentient beings, nothing would exist.

Leibniz, *De Summa rerum*

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Introduction

This is really two books rolled into one. There was no way of avoiding this connubiality—and I use the word advisedly. To speak of the mind, seeking to explain it and tracing it back to its origins, cannot be done without considering the ultimately relevant fact that it is a person's endowment. And persons are 'forms of life', so that life and mind must be seen as co-existing in a special kind of symbiosis.

Accordingly there are two stories to tell; but it transpires that they are two chapters of one. Mind is engraved as a potential into the emergence of life. Life is engraved as a potential into some chemical aggregations involving the carbon atom. We only know this from hindsight, of course; and it is knowledge of quite recent vintage and still very uncertain.

Neither life nor mind have divulged the secret of their origin to the probing gaze of science. But this is no cause for pledging ourselves to the doubtful dogma that both life and mind are entirely sourced from material conditions; nor should it encourage a return to the spiritualistic notions of former eras that have been abandoned for sound reasons. One good justification for writing this book was the conviction that a change of perspective on these issues might lead to new insights.

Consider therefore that every living thing, in reproducing itself, passes on some kind of memory of an event that lifted it out of inanimate material uniformity and conferred a quite *anomalous* self-animated differentiation on it. And now consider further that every newborn baby is gifted with the memory of some feature that added the unique capacity for self-reflexive awareness to the human brain. It does not look like a superficial coincidence. This kind of thing is a *signature*.

It seems, therefore, that self-reproduction is a key concept.[1] But it also poses pitfalls which our scientific endeavours have sidestepped with only limited success. In our recent obsession

1 This is not contradicted by sterile organisms (e.g. mules, hybrid flora) which are evidently outcomes of self-reproduction, but break the succession.

with genes, we have almost lost sight of the fact that there is no gene for life, nor a gene for mind. We might be told that such genes are not necessary; but if we pursue this line further, we could be forced to announce that genes as a whole are luxury equipment anyway (like the Concorde replacing Kontiki).[2] On the other hand, they are survival strategy par excellence; *aides-memoires* for immensely complicated assembly tasks. So with all due respect to Thor Heyerdahl, we know which side our bread is buttered on—even if we must accept that genes do not explain either life or mind.[3]

Our enquiry is therefore saddled with a vexing dilemma. What kind of perspective do I have in mind as helpful?

Consider another problematic aspect. Human thought is not material; it has no hooks or surfaces to which the flesh can cling and imprint itself. But neither can it be utterly immaterial, for in that case it would not be possible for thought to excite tongue, hands and legs. So is it one or the other, both or neither? These impediments to a thoroughgoing monism or dualism have to be borne in mind.

We end up with two mysteries, each multiplied by two. They don't sum up to anything, but each on its own seems to insinuate almost rebelliously a strong doubt that the origins of life and mind can be retrieved from the functions of chemistry alone.

In the last few years, complexity theory has made its impact and taught us many new lessons, with the result that our horizons have broadened. It certainly offered new perspectives on many formerly intractable problems, not least in the life sciences. Somewhere in that maze, I suggest, the answer lies. Hidden somewhere in the potentials of the biological past a bifurcation occurred that wrenched a clutch of molecular entities out of the inanimate and hurled them into the animate partition of existence. The difficulty for us in such a possibility is its apparent

2 This should be read 'tongue in cheek'. Living bodies are in principle self-assembling; but no later than the rise of eukaryotes, genes must have served to assist with the proper rhythm and sequence of reproduction.

3 This statement will raise eyebrows, for a great deal of current theory subscribes to precisely the opposite proposition. Therefore I ask the reader to patiently await the justification of this claim.

unrepeatability. But one plausible response to this is, precisely, self-reproduction—a performance that renders repetitive initiation superfluous.

There are other difficulties, of course; and two of these, on which my entire thesis rests, are quite inimical to biomolecular science as it stands. First, my proposition that the chemical ensembles in question are shorn of their native functionality and, in this *alienation from their matter status*, acquire the characteristics of self-animation that are the hallmarks of biological entities. But 'life' never lets go of an achievement that has proved its mettle. And so, secondly, that roughly two million years ago, a small but highly intelligent and resourceful breed of chimpanzee faced ultimate sanctions despite a sudden growth spurt of its brain. Yet somewhere in the world, a population or perhaps just one individual, benefited from an ensemble of neurons being pushed to the extremes of its native functions, but with a disproportionately large reservoir of redundant (or obsolete) power, and underwent an analogous transformation—a complete self-reorganisation of which the outcome was a self-reflexively capable mind. And again, this event was somehow embedded in the line of inheritance.

While not disinheriting current thought, this hypothesis nevertheless explains why a mind cannot be found in the brain, and how standard macromolecules became living bacteria. Any fair-minded reader would of course admit at once that discoveries cannot be hectored into making an appearance when we wish them to. Until therefore we discover where (and how) the memory of these transformations is lodged, we have to remain satisfied with hypotheses.

At this moment, therefore, I can only hope that the reader's appetite is whetted. The terrain en route to the chapters where all these strands are pulled together is rocky and difficult, though I've done my best to avoid passing on my migraines to the reader. Most importantly, perhaps, I have sought to circumnavigate the untoward enmity between philosophy and science. I think it is fair to say over the heads of those who have trumpeted the death of philosophy, that nothing of the kind transpired. Philosophy cannot die; but as in all human affairs, the factor that counts is

that people practise it in a relevant way.

My careful wording here reflects a certain modesty that seems apt for an era that has lost much faith, especially in *final truths*. We may recall how the great dogmatist Plato, embarking on his cosmological quest of the *Timaeus*, observed that human beings have no direct view of the divine machinery; his book could therefore only qualify for the epithet *mythos eikos*, or "likely story".[4] An author cannot strictly speaking claim more than this; though it need not prevent him from claiming to have looked a little further and to promise a *more* "likely story".

Let us pass on to a précis of the premises that hold for this work.

1. *The only kind of intelligence known to us is creature intelligence*

When we survey the abundant literature on the mind we cannot fail to be impressed by the disharmony produced by so many voices speaking on one subject. It transpires, however, that a single issue lies at the bottom of these disputes: namely, the unresolved state of what we are to understand by the nature of *intelligence*. Yet of all things on which we must achieve clarity and consensus, this is one we can ill afford to approach with a self-inflicted handicap. One cannot speak of mind without putting intelligence into the picture. And so our first task is prescribed for us: We need to separate the sheep from the goats.

Currently the word 'intelligence' has four denotations. We can dismiss one without ado, which serves merely as a synonym for 'information' ("I have intelligence that *x*"). The next, human intelligence, though frequently typed as a synonym for 'knowledge', is generally admitted as having a wider semantic, and this item will naturally occupy us further. However, the remaining pair comprise genuine problem children. This is because on one hand, the faith of millions props up the notion that spiritual entities such as God are *ipso facto* intelligences, while on the other the faith of technologists in their own ingenuity engendered the peculiar belief that computer algorithms are potentially inde-

4 Plato, *Timaeus* 29c-d.

pendent brains.[5] No proof can be marshalled in support of either of these contentions; but they do give indication of an indefeasible human hankering after metaphysical authorities.[6]

We need to come clean on these foibles without delay. As philosophers we are honour bound to consign metaphysical claimants to the class of 'articles of faith', inasmuch as it is impossible to confirm their actual existence—they are not *facts*. Regarding 'artificial intelligence', it seems rather obvious that the intelligence industry is taking the puns which comprise its *termini technici* rather too seriously and extrapolates human intelligence on its machines. But this is old hat; and historically aware readers will remember that watches, steam engines, telephone exchanges and other devices preceded computers as harbingers of great machine intelligence.

Apparently this leaves human intelligence as the only valid denotation. But at this point we need to beware a further illicit extrapolation. Intelligence and mind are not identities—rather mind is one form of intelligence, so that before we can contemplate the latter, we must accept that it rests on the more rudimentary precedent of a ubiquitous *creature intelligence*. The intelligence of non-human life forms is commonly underappreciated; yet paradoxically the theory of evolution cannot stand up unless it is admitted (see §3 *infra*).

Accordingly the foundations of our enquiry must be laid by putting down the only indubitable fact about intelligence known to us. Namely, that it is an attribute of *living organisms*. All other kinds of intelligence we have to bracket out: myths and metaphors cannot serve us as criteria for a serious agenda.[7]

5 In crude fact, a computer is only a highly ramified logical inference device of the same category as a syllogism or a barometer. We have accustomed ourselves to speak of 'sophisticated' computers, but it is just a *façon de parler*, the kind of personification in which we humans indulge constantly without any harm being done—although in this case we manage to casually suppress that the 'sophistication' is none other than human design ingenuity.

6 Carl Sagan adds a whole chapter on "extraterrestrial intelligence" to his account in *The Dragons of Eden*. But I think we can safely ignore this fancy.

7 As an appendix to the foregoing we need to add another possible definition, that intelligence is "what IQ tests measure". But this *instrumental* definition has the obvious defect that its terms apply only to the presuppositions of intelligence

2. *Intelligence is a default condition of creature life*

This calls for an important point to be aired at once. Not only is intelligence a creature attribute, but *the default condition of creature life*. By a quirk of historical priority, we have imbibed Aristotle's definition of life as characterised by the 'principle of automotion'; and since he did not include intelligence, neither do we.[8] Yet automotion can be problematic, seeing that everything in the universe is constantly active.[9] Moreover, Aristotle overlooked that every living thing is endowed not only with the 'principle of intelligence', but also some 'principle of consciousness' of this difference. Yet he must have known that every creature is capable of the spontaneous recognition and classification of an object as dead or alive. A corrected Aristotelian definition must therefore replace 'auto' with 'intentional'—a word whose denotation includes 'knowing what' and 'knowing how'.

Some little elaboration is necessary at this point, so that this viewpoint on intelligence does not appear to overshoot the mark. In conversation with an entomologist recently, I was assured that the zigzagging escape routes of spiders, cockroaches etc. are perfectly mechanical and so predictable they could be inserted into a computer program. It did not occur to me at that moment to press my interlocutor further, as it would have been valuable to learn if there was nonetheless an *intention* to escape and a certain *know-how* sufficiently effective to fool most predators. However, I don't think we need to wait for an answer. Intention and know-how can readily be observed in the microbial realm as well—a bacterium will seek to engulf a morsel of food but run away from a drop of poison if either is placed in its vicinity. If you render the same service to a nail or a marble, you would be certain that neither engulfment nor zigzagging can occur.

Thus we may safely conclude that the claim stands up—in-

entertained by the community which designed those tests. Under those tenets, the design could never be changed, for it would then no longer measure an IQ. Cf. James R. Flynn, *What is Intelligence?* Cambridge University Press 2007.

8 Aristotle, *On the Soul* 404a, explains that the two chief principles of the soul are to produce animation and sense perceptions.

9 A good witness to this confusion is our designation of a car as an 'automobile'.

tentionality and intelligence are fundamental creature attributes across all forms of life. This does not preclude us from conceding that at the bottom layer of creature life 'intentionality' might serve only as a synonym for the impulse to survive and 'intelligence' to reflect no greater skill than evinced by a barometer. But the skill to act like a barometer is the parent of the ability to make a barometer—and this little paradox will return with considerable force in a later chapter.

3. *Creature intelligence is subject to evolutionary development*

If we can agree on the above points, then we must immediately add that intelligence is moulded by evolutionary emergence, in common with organisms. This should be regarded as self-evident. After all, the skills evinced by a spider are of a higher order than those of a worm; those of a parrot exceed both; and altogether variety is the rule, as in everything in life.

For today's reader the significance of my emendation of Aristotle lies in the fact that those quasi-mechanical terms 'evolution' and 'adaptivity' aquire their meaning from the suppressed backdrop of intentionality. One cannot conceive of any creature struggling for survival and adapting—changing the environment and modifying its living habits in the effort of carving out a survival niche and producing offspring—without presupposing some kind of intelligence at work. I think this aspect has been sorely underestimated. The basic tenet, that evolution is undirected, only receives its full force from the fact that the estimated 1200 billion tonnes of biomass on Earth is a punctiform aggregate of producers and consumers, whose activities create a randomised survival scenario that becomes the less predictable as proliferation increases.[10] Thus creature intelligence moulds the course of evolution as much as cometary impact, vulcanism etc., but none of these aspects amount to a 'script'. For our purpose,

10 The opposite trend, reduction of randomisation, increases directedness; but whatever the residual random factor may be, it would still exceed the capacity of even Laplace's demon. The reader might be stimulated by this train of thought to consider the disproportionate effect of human influence on the habitat in light of the possibility that humans are decreasing randomisation and increasing directedness without knowing by how much and where it leads.

their importance lies in the give-and-take between organisms and habitat that (historically) conduced to the growth in sophistication of sensory and perceptual capacities, eventually peaking in the creative capacity of *Homo sapiens*.

The top rung occupied by humans on this ladder is, however, a problematic issue for another reason, in that it appears to represent a quantum leap from the immediately preceding stages of development. Humans pole-vaulted the endowments of other high-order mammals in flagrant contradiction of the central Darwinian dogma that "nature takes no leaps". It is problematic because physically humans do not differ all that much from other pongidae: Chimpanzees and humans share 98% of their genetic material. Indeed the absence of an intermediate stage to explain the disparity in brain power is such a sore point that more than one anthropologist has wondered aloud whether human mentality is not a freak of nature?[11]

Accordingly we have to choose between declaring a natural law invalid or else accepting that we have missed a crucial element somewhere in the warp and weft of nature's works. These being the terms of our discourse, it is plainly easier to surmise the second than the first alternative. This entails acknowledgement that there are natural processes of which we have gained no cognisance, and it is precisely the issue on which this book endeavours to shed new light.

We presume that nature obeys her own laws. It helps us initially with identifying something that can be said to have actually occurred and can therefore be retrofitted into certain conditions as a *potential*. Some things happen because *they can happen;* some because *they must happen*; yet in some cases *they will not happen* even though it is possible (there may be incompossible circumstances prevailing). Thus, apropos the mind, *it happened because it was possible for it to happen*. Now this is obviously an historical fact; but it seems not to respond to the expected causal

11 The point of this observation is that neither 'super-chimps' nor 'sub-humans' fill this gap. Those humans who have uncharitably had the syllable 'sub' attributed to them, e.g. the natives enslaved by Europeans for several centuries, were even then known to be educable and capable of the same learning as their white masters..

interrogation. Is there another way?

A thought experiment will help. Let us 'roll back' the movie of evolution from the present day down to origins. It will strike us as unexpectedly eventful—by no means a mirror of peaceable gradual accumulation. However, it will eventually settle down to the point when organisms shrink to such minuteness that we need powerful microscopes merely to see them. We will have reached the 'Age of Bacteria', between half and one-and-a-half billion years ago.

From this moment until the movie runs out, the only visible phenomenon is the slow change of the sky's colour from blue to orange.[12] Remarkably, this monotonous finale takes six to seven times longer than the preceding entertainment. And indeed, we could easily miss the emergence of life. It was a silent event, sandwiched inconspicuously between titanic geological upheavals, seething oceans and tumultuous weather patterns.

Nevertheless this quiet incipience draws our attention. All the other events (e.g. geothermal activity) can be explained on mechanical principles. But with the story of life we are somewhat at a loss—and once again we are in the same predicament with explaining the inception of mind. Is this double enigma a fortuitous happenstance or should we read something more into it?

4. *Force at the foundation of matter and all processes*

These matters tend to negate a thought habit that seems ineluctably to be enslaved to a binary mould. Logic dictates that all relations must fall into a yes/no pattern: true or false, black or white, spirit or matter, "to be or not to be". Yet throughout the ages, philosophers and theologians have tried to reduce it to a monism, an 'ultimate substance'—an endeavour continued by science. In the Bible, the source of this attitude, the matter universe is rigidly segregated from its immaterial creator. But science cannot deal with the latter; accordingly it must reverse the order of precedence and seek its solutions in the interplay between matter and energy.

12 Loss of oxygen; increase of ammonia and sulphur (i.e. the cessation of cyanobacterial photosynthesis).

Thus the obvious questions on our lips: "How did mere chemistry change into living things?", but also "How can a standard array of neurons engender a mind?" turn our focus to matter and encourage the presupposition of a hidden potential. But this expectation remains *sans issue* because both life and mind, each in turn, sprang up just once in the history of the Earth, while since then all creatures put living things into the world continually; and similarly all humans transmit a mind to their offspring.[13]

There are two lessons here that we should heed. For convenience, we deal first with matter/energy relations which turn on quite objective, mechanical, measurable quantities of the sort epitomised by water running downhill. No conceivable window opens here to precipitate either life or a mind. Even the commonly accepted conjecture of physics that matter comprises an expansion from virtually nothing into something (*Genesis*, "big bang") is contradicted by every object in the universe testifying to a contraction!

It is a thought leads us back to the notion of an homogeneous, isotropic substrate which, effectively, 'is' the universe *before* we can speak of matter/energy—a condition for which indeed a nomenclature already exists.[14] In quantum cosmology it is called 'residual electric potential', and as we take note of it, we should attend to the way our language functions. A 'potential' denotes something that does not exist. Therefore we know nothing of it until it becomes a discernible feature of an actual existent.[15] And

13 The second half of this sentence answers the first. Life as such may have sprung up myriads of times in that era, but continuous creation became unnecessary from the moment that stable *continuous* self-reproduction had been achieved. Whether this argues for a single surviving ancestral strain or not is a moot issue—neither this nor the argument for a plurality of ancestors can be rendered water tight on account of the massive extinctions that occurred between then and now.

14 Prigogine, *The End of Certainty*, ch. 5-6.

15 A more plain-spoken way of putting this: 'potential' indicates the temporal appearance of properties, qualities, attributes etc. which prior to their appearance were not known or even suspected to be capable of emerging. Using the word in the present tense is, strictly speaking, giving vent to a wish and a promise, taking up hints that are known from previously emerging properties and claiming a right to pronounce them 'hidden' in a present situation. "I have the potential to be a concert pianist" is such an utterance that makes borrowings on

so we have been apprized of a necessary distinction to be made. Energy cannot serve as a residual feature of the universe; it is 'work'. But 'potential' is nothing, a surmise.

Accordingly I am compelled to re-appropriate for this book the concept of *force*. This term has been hijacked by science for its own trade terminology, where it is fused with mathematics and serves in an operational capacity. But it stands in blatant conflict with common language and traditional philosophical usage; and so without compunction I must ask of my scientifically trained readers to put aside their specialist denotation and accept that the majority of readers are likely to entertain ontological or metaphysical associations with it.[16] For present purposes it is indeed indispensable to have this recourse available, because it is essential to differentiate between energy and force; and this has to be done in a less cumbersome way than attaching the prefix 'zero' to various absences of energy.

It transpires that Prigogone's term can be salvaged. For this I lean on the concept of that profound enquirer Leibniz, whose monad is the archetype of theoretical force.[17] Having learnt to heed his warning, I arrived at my definition of matter as a plurality of atoms; and now the opposite course reveals that *force is what is left over when we subtract the energy from objects*. It is the precondition of their existence and their energy—in short, a potential that has become actualised. In contrast to the stringent semantic of potential, this does not indicate "nothing there", but rather "something there, though below the threshold of measur-

superficial similarities between my and Artur Rubinstein's undeveloped talent at a roughly similar age. If I fail, however, the 'potential' may be revealed as a delusion. Prigogine's 'residual potential' is of the same ilk: it can only be understood as a non-existent, indiscernible, theoretical condition and therefore as a concept waiting to be filled with meaning at some time in the future, i.e. if and when it ever serves as an intelligible source of some existing condition.

16 When we speak of the force of character, of persuasion, of an argument, no 'work' is implied. The expression 'forces of nature' has no operational component. A law or contract coming into force is a social construct binding all relevant parties to an agreement. And so on. Plainly all these usages are useless to science, but this does not legitimise scientific nomenclature as solely relevant or exact!

17 An extensive discussion in my book *Leibniz: The Nature of Reality and The Reality of Nature*, Cambridge Scholars 2010, Ch. 4.

able actuals". The self-recommending conclusion is that all existents are precipitates of force. I have no doubt that Leibniz, the prophet of infinite continuity, would have nodded his assent.

Thus our path is smoothed towards a more intelligible explication of our problems. If energy and matter are precipitates of force, then the possibility of life, consciousness and mind precipitating from a cognate potential rescues our thinking from its dependence on the apron strings of an unsound materialism. That is no small gain from these deliberations.

5. *Phase change and memory the keys to identity, mind and consciousness*

The preceding premises converge at last on the key notion of *phase*. Strictly regarded, the term has chemical connotations. Given the right circumstances, water may freeze or vapourise. This is matter being nudged from fluid to solid or gaseous phase. We have known of these phases—plus a further colloid phase that is almost entirely biological—since times immemorial. In this book, however, I have taken account of the need for another group of phases and re-organised the whole categorisation. Biological existents are alive; it is impossible to make do with just one 'animate phase', in which the main players receive no mention. Accordingly I shall be working with a tabulation that puts forth the following sub-divisions:

Homeodynamic phase
Sensitive phase
Conscious phase
Self-reflexive phase

Once they have been explained, I believe the reader will have no trouble with the logic of these nomenclatures. For the moment, I shall therefore content myself with stating the thesis, which is that the inception of life involved a phase change from material to homeodynamic phase, the latter being part of the default definition of life. Analogously the phase of greatest interest to us involved a change from conscious to self-reflexive phase. The memory of this accomplishment comprises, in turn, the key notion behind its success and persistence.

Unpacking these premises is the main agenda of the present

work. However, before I end these preliminaries, a final thesis of the utmost philosophical interest has to be broached.

6. *Life involves the transmission of privilege*

It seems to have been overlooked that the biological phase is characterised by the *initiation and transmission of privilege*. When compared with the matter/energy carousel, it is immediately apparent that the evolution of life is not a mechanical process, but depends on give-and-take, namely the mutual interaction of creatures and habitat based on an underlying 'drive' that impels all life forms on a course of volitional behaviour. This drive is an enabling feature utterly incognisant to a material existent, but cognisable to every living existent. Hence 'privilege' denotes in the first instance the *capacitation of living things for active participation and self-exertion* in the evolutionary process. This is the meaning of their description as 'autonomous agents'.

Further, the result of this evolutionary synergy is an exclusively forward direction of the process. Every act of an autonomous agent is irreversible. When Eddington coined the term 'arrow of time', he had thermodynamic degradation in mind; but this is not a genuine or sustainable conception of time flow. We will discuss this later on; let it suffice for the moment that 'time' is a meaningful concept only in the context of living things and the aforesaid notion of privilege, which among other criteria also entails that volitional behaviour and active participation forcibly imply the constant anticipation that is the hallmark of the living state. Eventually this privilege includes the transmission of characteristics (e.g. instincts) that have been acquired in the process of adaptation. If this could not be transmitted, it would scarcely be possible for any life form to sustain itself for longer than one generation.

Anticipation in turn presumes the existence of a form of memory to assist in the evaluation of any given situation. But memory is equally implicated in origins and self-reproduction. For it is one thing to speak of a phase change, but another to ask for its effect in the long run. Clearly a random attainment of animatedness would be wasted and dissipate instantaneously in the

environment.[18] But the transformation is embedded as a privilege in the newly-formed organism, so that life can sustain and reproduce itself. In a word: *organisms remember how they became organisms* and replay the scenario at every new birth. And now, *mutatis mutandis,* when mind appears on the scene, its causative agency is neither chemical nor neuronal wizardry, but the *heritable memory of phase change* that kindles the light in the infant brain as it did for the parent.

All these are issues far from the dominant speculative agenda of the philosophy of mind. They are conspicuously missing from theories of artificial intelligence, where the human designer himself constitutes the privilege. But when we reflect on the human self-reflexive capacity, we are acutely aware that it is something greater than the sum of its parts, as a sonata is an artefact that transcends the sum of its notes. With this comparison we touch indeed on the crux of the problem: for by what charm or magic the notes of the sonata 'add up' to a coherent form of intentional communication is a mystery as much as the activity of bundles of neurons being transformed into the coherent sense of a self-reflexive 'I'.

This brief exposition has drawn the gridlines of the theory. It is self-understood that the task of fleshing them out will require significant expenditures of ingenuity. A half millennium of ingenious philosophising stands behind it, and more than a century of intensive neurophysiological research. Somehow all this had to be fitted into the compass of one book. But I hope that the reader will eventually come to feel that enforced brevity has its virtues. In any case the main thrust of this book is philosophy, and speaking *pro domo* for one moment, it seems that this more than anything else is a virtue we must somehow rediscover for our own day.

18 Some researchers (e.g. Steven Jones, *The Language of the Genes*) propose that incipience occurred a million- or billionfold simultaneously, giving life to precipitates of moisture for a microsecond, analogous to a light show where lights come on and off seemingly irregularly all over the place. *But some of them must stay on:* the point on which my discussion hinges.

CHAPTER I

The Chameleon Molecule

Subject, Matter and the Subject Matter

1. *A question of perspectives*

As a child of the 20th century, I owe my intellectual nurture to its philosophical underpinnings. This means that unlike an author of earlier eras, I cannot begin my discourse with an explanation of *Genesis*. My source of reference has to be the *Periodic Table*.[1]

This being so to speak a fact of life for me as well as for my readers, makes it difficult to approach issues like life and mind without inviting contention. Nowhere else do we find so many disparate preconceptions proliferating. Millions of people cling to traditional ways of understanding those issues, persisting with inherited metaphysical beliefs, which the experts smile at and despise as hangovers of irrational predilections. A scientific culture should grow out of them and acknowledge that life and mind are founded in, and sourced from, material conditions, like everything else in the universe.

Yet these antagonistic positions are not quite as easily resolved. For on the one hand, there is the problem that *we ourselves* comprise the subject matter. It is at least counter-intuitive to imagine ourselves as a rock or a waterfall looking at human beings and growling, "they're just like us." A waterfall scientist could, at a pinch, give a comprehensive description of itself, down to the last atom and its last smidgin of energy; but this endeavour fails with a human being because lifting the skullcap where presumably all of that creature's perceptions, thoughts, ideas, imagination, poetic and musical dispositions are lodged, reveals nothing of the kind. Moreover, pulverising its body does not reveal the

1 The Bible presupposes of course that God is an intelligence; it therefore omits any mention of the exceptional mental endowment of humans in its account of creation.

element or feature or quality that conferred self-animation on it before it was killed. And these problems do not exhaust the list of disparities between waterfall and scientist, nor do they compellingly resolve the dispute between Everyman and the scientist. The worst of it is, that the scientist has no proof worth a pinch of salt for his suppositions on the material source of life and mind. It is all circumstantial, theoretical, forensic and metaphysical to a degree that the scientist would prefer to disavow. The witness in Court tells the prosecutor, "I saw him with a bloody knife in hand, bent over the bleeding corpse," and the accused is convicted for murder, whereas he just happened to pass by and picked up the knife from the street, shocked by the scene he saw. Such things can happen.

We have to bear this background in mind. In due course we will be obliged to apply a rational philosophical scalpel to claims and counterclaims of this sort in the sciences of life. For the moment, however, I must ask especially my scientifically trained readers to suspend judgement and to concede the possibility that in these departments, science is overreaching itself. It may not have the resources at its command to successfully conclude such a research undertaking; and it may not be in possession of a philosophy commensurate with the requirements of an appropriate theory. If the proof of the pudding is in the eating, then over 60 years of unremitting, yet unrewarded effort says a lot. Just what it says, however, is also under dispute.

2. *The matter of life*

It is of course entirely possible that these ambiguities are not merely human foibles, but inherent in the processes. Let us therefore take this remark as an invitation to make a first foray into the chemistry of life and acquaint ourselves with the chief actor of the 'Project Life'. At least we are all agreed on its identity: we all know that I am now speaking of the element known as 'carbon', whose name means the same in Latin as its common name in English: 'charcoal'.

However, before we proceed, and to ensure that we are all speaking the same language, a brief note on the concept of 'matter' needs to be inserted here.

Carbon is an atom. In common understanding atoms are pieces of matter. I must have heard it said thousands of times, as you will have, that "everything is made of atoms". Quite true, and yet misleading. Because, in fact, an atom is not matter in itself. For us to speak sensibly about matter it is indispensable to bear the qualities of matter in mind, and in this perspective it is clear that they manifest themselves in only very few atoms. It is not sensible to speak of such qualities as hardness, liquidity or gaseousness in terms of atoms, because they result from the aggregation of atoms in molecules. You might look at sodium and chloride, two of the most virulent chemical elements known to us, that become perfectly innocuous when combined in a molecule to form common table salt. Hence 'matter' is ineluctably plural, molecular. To avoid this not-so-harmless confusion, a resolution of the issue must acknowledge that while matter is made of atoms, atoms are not matter.

There is a simple, but important philosophical point behind this. The difference between life and non-life cannot be captured descriptively by recourse to the elements. *The qualities of matter are not on exhibit in a living biological fibre.* Accordingly we say, legitimately, that a biological fibre on the point of death *returns* its bodily substances to the status of matter.

The Chameleon Molecule

3. *Three anomalies*

All these issues reveal their importance when we inspect the qualities exhibited by living fibres as opposed to inanimate molecular structures. The latter are indubitably 'matter'; the former only by an impermissable widening of the notion. The plain truth is that they are *incompatible*. A piece of skin differs in its qualities in a living and a dead specimen; and in this dichotomy the flabbiness of all comparisons stands exposed.

And so the presence of life constitutes an *anomaly* to a materialistic conception of the world. 'Anomaly' is a word roughly synonymous with non-comformist, something that upsets common regularities. A solitary tree growing in the middle of the Pacific Ocean might be extremely difficult (if not impossible) to

explain. Our planet, a mere speck of dust amid the immensities of the universe, but full of throbbing earthlings, is like that.

We on this planet are surrounded by sensing, conscious creatures, yet *Homo sapiens*, endowed with the ability to self-reflect and philosophise, invent and create, is another tree in the ocean. It is said, I think truly, that all our knowledge put together, and all non-human creature life interrogated, cannot explain a line of poetry nor the invention of the calculus. Mind is an anomaly within the partition of existence that carries the prefix 'bio'.

Descending to the bottom layer of which the periodic table is the map, we find again an ocean of sameness, a well-regulated set of elements with a spartan endowment of properties and an easily enumerated output of products of their combinations.[2] The tree sticking out is the carbon atom. It poses such a challenge to science that an entire division of reseach, organic chemistry, has grown up around it. Carbon is the anomaly in the chemical realm, the maverick among the other law-abiding denizens of the periodic table.

4. *The Stranger in our Midst*

At first blush we may be surprised to hear that this element, central to all living organisms, also makes diamonds, graphite, coal, petroleum and plastics. But the explanation is simple enough: not all carbonaceous matter is alive; but all living matter is carbonaceous. For this reason the carbon atom merits our special attention.[3]

As it is, with this element we enter a realm that can seem to resemble a fairyland. For when you look at the periodic table with its neat and iterative assemblage, you get an impression of rigorous order and logic prevailing. A close up on any of those

2 One might expect the combinatorial possibilities of 92 elements to be productive of thousands, even millions of physical substances. Yet the total of all substances known to occur in the universe (without human aid!) only just exceeds 300 in number.

3 James Jeans, in a book that was once a great popular success (*The Mysterious Universe*), made the illuminating observation that one can think of the periodic table as a series of street numbers. Thus, if we wish to acquaint ourselves with magnetism, we should knock on the doors numbered 26-28. Life has its residence at No. 6. So easy to memorise!

addresses would only confirm it, admitting slight vagaries from one to another. But at No. 6 it might seem that indoors it is pandemonium.

Comparing carbon with the other chemical elements, it presents itself as an astounding cornucopia of divarications. The best way of drawing this into the light is to identify what may be called the norm in this realm and then proceed to showing how carbon turns much of this on its head.

Typically the assembly of matter is achieved by stacking atoms into a molecular lattice, e.g. a silicon molecule comprises five atoms. Inorganic molecules are therefore very small. They grow larger (=make matter) by repeated stacking up in so-called polymers.

Carbon is the exception to the rule. It constructs 'macromolecules', and the word *macro*, or 'big', is already an understatement—more aptly we should be speaking of gigantic molecules. Typically a carbon-based molecule strings together thousands of atoms, while even half a million is not an impossible task.

This is astonishing enough; and the reader might have guessed that such numbers could scarcely be piled up in a stack. So we are not yet done with the extraordinary. Indeed we shall see that the gamut of attributes emerging from carbon compounds represents a consummate expression of the multifariousness of chemical bonding—and it is nothing but the truth to state that without carbon, the whole concept of bonding would shrink to a cipher. With carbon, it is a spectacle and a wonder to behold.

A bond results when electrons of different atoms attract each other. There are stringent rules to this courtship, as one would expect where law and order prevails. The electrons encircling their nucleus form orbital tracks known as 'shells', in which several electrons may share an orbit. But for elements in the first two rows of the periodic table the outermost shell is subject to the strict regulation that it must accommodate either two or eight electrons, and it is at this perimeter where bonding occurs—where two or more atoms combine their retinue of electrons.[4]

4 The reader might need to be alerted to the fact that the descriptive language concerned with electrons, orbits etc. is somewhat decorative and analogical. My

Two types, respectively *covalent bonds* and *hydrogen bonds*, are essential to biological chemistry. Covalence means (as its etymology suggests) a co-operative attraction which occurs when atoms bring missing electrons into a partnership—a dowry to make their joint numerical complement conform to the regulations. Thus oxygen with a set of six electrons will happily consort with two hydrogen atoms, as each has just one electron. We happen to know this results in water, but it is not superfluous to mention here that the properties adopted by any such combo are rarely predictable. What we know, we nearly always know from experimental hindsight.

A hydrogen bond (technically 'coulombic bond') differs from the above mainly in that the enactment involves stripping another atom of its progeny, whereafter the victim is compelled to go looking for substitutes elsewhere.

But the plain description of covalence just given is complicated by another rule. Atoms need something more than comforming electrons to successfully conjugate. A picturesque description often used, the 'stud and socket model', illustrates it. It denotes that there are atoms with stud-like features and others with socket-like features. Evidently 'studs' must plug into 'sockets', which constitutes a further restriction on compounding and another explanation of the paucity of spontaneously occurring substances.

Once again carbon plays a trick on this rule. Its outer shell is haploid, just four instead of the normal eight electrons. But in compensation these electrons work like dual-purpose connectors: turned one way they are studs; turned another way they are sockets (a state of affairs termed 'tetravalence'). It stands to reason that in contrast to the normal curtailment of compounding possibilities, this feature facilitates a huge gamut of conjugations, including covalent bonds with its own kind. A moment's reflection will persuade you that these two features in combina-

definition of matter as molecular should be recalled, to avoid thinking of electrons as *things* (which the term 'particles' of course strongly insinuates). Rather, electrons in their orbital shells represent the energy levels of the atom, and it might be preferable to think of them as the various levels of amperage needed for lightbulbs, radios, heaters etc. in your household.

tion must be productive of an enormous plurality of compounding possibilities; and indeed it transpires that carbon atoms will conjugate quite freely with more than thirty other elements of the periodic table. At the basis of life we therefore encounter a chemical element capable of indulging in an altogether breathtaking display of concupiscence, adept at threading thousands of atoms into stable molecules. As one commentator pithily put it: "You do not have to be a fanatical reductionist to understand that the soul of life is carbonaceous."[5]

In addition carbon molecules are unusually stable. We all have first hand experience of it through such everyday problems as washing the grease off dishes with plain water. Without soap it is troublesome, because water dissolves fatty substances very slowly.[6] This afforded living things a safe haven by conveying to them the resource of manufacturing many types of grease, wax, jelly, resin etc. (which in old-fashioned terminology were grouped together as colloids), both as insulating materials and for the construction of organic fibres.

Finally carbon-based polymers exhibit a stupendous variety of forms, including spiralling or zigzagging chains, while internally they indulge in folding, flexing, zipping, curling and wrapping—the *sine qua non* of a self-propulsive dynamic from which the immense variety of living organisms sprang.

At this point a major conundrum leaps out of the picture. It is undoubtedly a help to know that carbonaceous products are profoundly involved with all forms of life, but the fact that exactly similar product are also found to constitute inanimate materials is discomfiting. Thus, we might inspect a lump of coal and an ear lobe, of which the first is dead while the second throbs with life. Immediately the question comes up: "What is *added* to the lobe to make it live?" But at this moment we should stop in our tracks and put a supplementary question: "Is this indeed the *right kind of question* to ask?"

5 Richard Fortey, *Life—An Unauthorised Biography*, p. 33.

6 Even better examples are furnished by old books, such as those preserved in monasteries. Their brilliantly coloured initials seem as fresh and untarnished to the eye as if they were executed yesterday. The secret is that medieval scribes mixed egg yolk into their paints—almost a guarantee for immortality!

We close on this predicament for now, without trying to preempt the central issue to be addressed in this book.

Our next section, longer and probably less entertaining, deals with certain 'metaphysical' issues; and I put the word in scarecrows to alert the reader to the extraordinary state of affairs that its authentic meaning is persistently falsified. But for this I ask you to consult the footnote and spare me the need to swell this text unduly.[7] They are necessary deliberations to our context, however, and carry forward the emphasis on unorthodoxy that has been sounded here.

7 *Meta*-physics deals with philosophical principles that have a bearing on physics, but do not deal with physics itself. A partial list of topics reads: Origin, Cause, Necessity, One, Substance, Identity, Relation, Limit, Part, Whole etc. Their propinquity to theoretical physics is obvious; and readers expecting to see God, devil, angels and soul will have to swallow their disappointment. The full list is found in Book Delta of Aristotle *Metaphysics*. But this is not the place to explain the causes of metaphysics being harnessed to theology; any reader curious about it, will find it explained in any of the larger philosophical dictionaries.