Dactylorhiza hatagirea (D. Don) Soo. A medicinal plant of temperate-alpine regions of western Himalaya distributed between 2800 and 4000 m above mean sea level.

the trade name *chirayita*, the most sought-after species of the genus. The species has been highly valued in the Tibetan system of medicine, and like other medicinal plants, was collected across the Himalaya by Lamas in earlier days. It is now said to be purchased in the open market at Amritsar.

Plant samples in the market are stored under undesirable conditions, over the years, and often contain multiple species mixture[10], thus adversely affecting their bioefficacies. It is generally felt by Lamas, practising medicine in the Tibetan School at Dharamshala in Himachal Pradesh, that the efficacy of many of their drugs, prepared on the same traditional formulation, is fading now, apparently because of the adulteration in the dried raw material purchased in the market. This may not be an exclusive case but holds true for several other formulations prepared in other indigenous system of medicine as well[11].

Adulteration seems, therefore, challenging not only the curative capacity, but the very faith in crude drug approach. The efficacy of schools of medicine, once built upon the tests and trials spanning hundreds of years, are being challenged, for reasons unrelated.

At a stage of uncertain raw material supply, and undefined limits of sustainability, while species continue to be extracted despite claims of cultivation, our joy of phytochemical discoveries is deeply shadowed by the fear of extinctions.

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How intangible is the outside world?

The recent article of Mukunda[1] based on his lecture 'Existence and reality in mathematics and natural science' gives an interesting account of the debate on the subject, and leaves no doubt that he prefers the company of believers though it ends on a somewhat ambiguous note. He states: 'Strange as it may initially seem and hard as it may be to accept, we seem driven to this conclusion – because mathematics is essential to describe nature, we have to adopt a more open view of existence and reality going beyond space, time and the tangible. The problem of existence and reality is much subtler than our naive expectations may have been. Mathematics then, like nature, has also an intangible level of existence.' The argument is far from persuasive and is in fact erroneous as I discuss in the following (see note 1).

The root of the error lies in using 'knowledge' and 'capacity for knowledge' as biologically equivalent when he states[1], 'And what is the result of slow learning through evolution for a species as a whole, lasting hundreds of thousands of years, seems to the individual member of the species as a priori, as *knowledge*, or better as *capacity for knowledge*, he is *born with* in advance of experience' (emphasis added). Delbruck's statement quoted in its support is valid strictly for 'the capacity for knowledge' which should be interpreted as the appropriate biological organ, the brain, and not the knowledge that is acquired by learning processes facilitated by this organ. Instincts, viewed as innate rational behaviours which are demonstrably genetically inherited, do not form a body of conscious knowledge of the category acquired by higher-order learning processes and embodied in symbolic knowledge such as mathematics implied in the article. No serious biologist today would dispute the impossibility of inheriting symbolic knowledge by encoding it in the DNA to be passed on to the next generation – that would tantamount to asserting Lamarckian evolution – though the evolution of the complexity of the brain by Darwinian selection would be considered feasible over a period of millions of years. Mathematical knowledge, as we know, is passed on to the next generation symbolically as written matter without coding it in DNA. The capacity of making sense of this symbolic matter is, however, passed on genetically as the brain with all its complexity whether or not the parents had acquired the knowledge. The psychological problem arises primarily from the complexity of the functions of the brain which is difficult to comprehend unless one looks deeply into the equally complex structure and the process of development of the brain. He is dissatisfied with the explanation based on the concept of 'emergent phenomenon' in the evolution and functioning of the human brain. Presumably, there would be no problem in accepting the emergent chemical properties of a benzene molecule from an aggregate of twelve atoms as quite natural. Francis Crick uses this example to deride the mystical meaning sometimes attached to the term *emergent* thus[2]:

'It is curious that nobody derives some kind of mystical satisfaction by saying "the benzene molecule is more than the sum of its parts," whereas too many people are happy to make such statements about the brain and nod their heads wisely as they do so. The brain is so complicated, and each brain is so individual, that we may never be able to obtain second-to-second detailed knowledge of how a particular brain works but we may hope at least to understand the general principles of how complex sensations and behaviors arise in the brain from the interactions of its many parts.'

It is important that we first understand the general principles of the working of the brain before asserting our confidence (using this ill-understood brain!) in the existence of reality in mathematics or, which is the same as, mystifying the outside world by attributing intangible properties to it as suggested by Mukunda quoted earlier. This itself may turn out to be an impossible task to accomplish. Penrose's argument implies that functioning of the brain may not itself be adequately understood by symbol manipulation which is the basis of computation, in howsoever powerful computers we may imagine that can ever be built[3]. For instance, while relating conscious understanding, especially mathematical, to the scientific world-view he concludes:

'... that it is essentially *impossible* that such a quality can have arisen as feature of mere computational activity nor can computation even properly simulate it – and I should emphasize that there is no suggestion here that there is any thing special about *mathematical* as opposed to any other kind of understanding. The conclusion is that whatever brain activity is responsible for consciousness (at least in this manifestation) it must depend upon a physics that lies beyond computational simulation' (emphasis original; ref. 3, p. 411).

Penrose is, however, optimistic that an intelligent device capable of displaying consciousness would be possible to build, 'so long as such a device were not a "machine" in the specific sense of being computationally controlled. Instead it would have to incorporate the same kind of physical action that is responsible for evoking our own awareness. Since we do not yet have any physical theory of that action, it is certainly premature to speculate on when or whether such a putative device might be constructed.' (ref. 3, p. 393).

A cautious approach suggested by Crick may be a more sober working hypothesis[2]: '... that there is indeed an outside world, and it is largely independent of our observing it. We can never fully know this outside world, but we can obtain *approximate* information about some aspects of its properties by using our senses and the operations of our brain. Nor, as we shall see, are we aware of everything that goes on in our brains, but only some aspect of this activity. Moreover, both these processes – *our interpretation* of the nature of the outside world and our own *introspections – are open to error.* We may think that we know our motives for a particular action, but it is easy to show that, in some cases at least, we are in fact deceiving ourselves.' (emphasis added).

Several instances of such deceptions in the well-studied phenomenon, simply one of several complex functions of the brain, visual perception, have been discussed in *The Astonishing Hypothesis*[2]. Additional to the above limitations, there is a real problem of understanding the evolution of the brain of the *Homo sapiens* by Darwinian selection which has eluded explanation so far. Knowing full well that we can only hope to get some approximate information of the outside world, is it reasonable to attribute reality to mathematics which is a product of complex brain functions, as Mukunda clearly advocates: 'granted that mathematics is of some use in formulation of natural laws, why does it turn out so fantastically accurate, so much more so than we could have reasonably expected?'? On precisely which fact(s) the reasonableness of the above expectation founded is not clear from the article. If it is based on the premise of implausibility of the 'fantastically accurate' symbolic representation of the outside world and its natural laws, then it is no sounder than attributing an objective reality to the accepted mathematical representation of the current concepts of physical theories. We, however, know that it is just as tentative a symbolic representation as any of the past, each discarded by the successive ones because of the very nature of acquiring symbolic knowledge by the methods of exact sciences[4] and certainly not by Darwinian selection of the brain structure from amongst genetic variants. A mathematical representation of a new physical theory that does not require matter to be viewed as something intangible at subatomic level could replace the quantum theory in future and yet it may have its own unsuspected defects which would surface later. Therefore, it would be incorrect to consider the mathematical knowledge as real as the one generated at the lowest level by the sensory stimuli from the outside world, which is in essence *independent of the mechanism* by which our brain encodes and interprets these stimuli for communication to another individual or for introspection by using symbols. The mathematical knowledge is a product of the processing functions of the brain at a higher level. The input information for this processing, which can hardly be described adequately, is surely going to be a complex mix of the output of physical stimuli both internal and external to the brain and its preprocessed information in the memory. We are totally unaware of what goes on during processing. Similar operations of the brain, presumably, have given rise to our linguistic capability. Therefore, the description of nature by mathematics is referential in the same sense as 'word' is in a language though it is more precise and possesses a more internally consistent logical structure that, presumably, is responsible for its high accuracy of representing the outside world. We cannot presently rule out with any degree of confidence, cosidering its complexity that the human brain may develop one or more symbolic languages in future which could describe nature more precisely than the existing mathematical language just as mathematics itself evolved long after the emergence and use of less precise numerous spoken languages. A classical essay on 'counting' first published sometime in 1906 by an eminent mathematician, Conant, describes several tribes in the modem world who use their spoken languages to communicate but some tribes do not have their own numerals and others who cannot count beyond three[5]. Apparently, the knowledge of positive integers is itself not as innate to a human child as assumed by Penrose (ref. 3, p. 54). Paradoxical and unrealistic solutions in descriptions of nature by mathematics are numerous and several are quite well known to be recounted here. The new ones bring in new paradoxes to be discovered after long use in newer situations though old paradoxes disappear. There are already some situations which seem to be demanding a shift of fundamental nature from the current description of the physical reality by quantum mechanics that has given mystic attributes to matter[6]. If it does change, as it surely must in the near future (compared to time necessary to fix a mutation for a more efficient brain function within a population), and if the reason behind the succession of ideas in the history of science is any guide, it will not be a consequence of evolution by natural selection of an improved brain anatomy. This is because the elimination of those ignorant of (or incapable of understanding) the new theories and geographical isolation of the group of newly born wiser individuals due to mutations affecting brain function, both of which are required by the mechanism of natural selection for the emergence of a new species, obviously, cannot occur in the modern world for many reasons. It is the realization of the existence of this block in possible evolution of higher species from human population that led Wallace, the co-discoverer of the theory of evolution by natural selection, to believe that it is now the spiritual (not biological) evolution that will take over and, therefore, parted company of Darwin much to Darwin's disappontment.

In view of our near-total ignorance of how the brain has evolved the capacity to use symbols such as 'words' as reference to the outside world and the mechanisms of coding and decoding the implied meanings for communication between individuals (using well-structured language) which exist only in the human brain, the suggestion of attributing a sense of reality to the mathematical symbols and their relationships seems extremely premature if not outright absurd at present. Mathematical knowledge may be considered a more sophisticated symbolic language compared to written linguistic knowledge developed by the *sapiens* in no more than a few thousand years – hardly adequate for emergence of new species with individual's life span of the order of fifty years. In a recent book[7], *The Symbolic Species*, neuroscientist Terrence Deacon persuasively argues that the uniqueness of human brain structure and function is a consequence of gradual co-evolution of spoken language and the brain for nearly two million years by Darwinian selection and adaptation from a rudimentary level because of the immense reproductive advantage bestowed by it on a socially interactive group over other similar but competing species lacking this facility. Basing his arguments on comparative anatomy of the brains and corresponding linguistic capabilities amongst the primates and human, he concludes that the restructuring of the brain has acted as a catalyst for our astonishing intellectual achievements which includes mathematical knowledge[7]:

'Brain-language co-evolution has significantly restructured cognition from the top-down, so to speak, when compared to other species. The prominent enlargement of prefrontal cortex and the correlated shifts in connection pattern that occurred during human brain evolution introduced strong biases into the learning process and gave human prefrontal circuits a greater role in many neural processes unrelated to language. Though intense selection was directed toward this aspect of mind and brain, its secondary effects have also ramified to influence the whole of human cognition. Human beings approach the world of sensory stimuli and motor demands differently from other species, particularly with respect to higher-order learning processes, and these differences are evident even when our symbolic linguistics abilities are uninvolved'.

A word of caution may be in place here. Since our interpretations and introspection are demonstrably subject to errors[2], the knowledge gathered even by the higher-learning processes will, in the ultimate analysis, remain vulnerable and to that extent tentative, fantastic accuracy of the knowledge notwithstanding. Could it be that this limitation, perhaps, is responsible for our attributing intangible qualities to matter and a sense of reality (i.e. intangible 'existence') to mathematical knowledge?

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Note 1.

In order to minimize likely semantic confusions which could obscure the discussion, I shall use the following words in the sense given in *The Pocket Oxford Dictionary*, fourth edition, 1960 print, and the relevant parts reproduced here for convenience:

tangible: (adverb) Perceptible by touch, of a material kind, palpable, not elusive or visionary.
knowledge: (noun) Knowing, what one knows.
know: (verb) Be aware of.
aware: (adjective, not placed before noun) Conscious, not ignorant.
instinct: (noun) Innate propensity, to seemingly rational act; intuition.

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