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Consciousness: A Natural History*

"[W]e always start at the sensory end and try to come out at the motor side. I very much agree with the late von Holst when he suggests that we start at the other end and work our why (sic) back toward sensation. … It requires some different way of looking."[1]

H. L. Teuber

"If any person thinks the examination of the rest of the animal kingdom an unworthy task, he must hold in like disesteem the study of man."[2]

Aristotle

Abstract

This article shows how the proper question to answer concerning consciousness is not 'how consciousness arises in matter', but how consciousness is part and parcel of the evolution of animate forms. The article traces out just such an evolution by consideration of real life forms including bacteria and invertebrates. It vindicates the evolutionary thesis that external proprioceptive organs, as evidenced in their own right, were modified and internalized over time into kinesthetic organs, sustaining, in effect, a directly movement-sensitive corporeal consciousness across virtually all forms of evolutionary life. The paper specifies significant consequences of the thesis having to do with the unconscious, with present-day focal studies of the brain that neglect a correlative natural history, and with the need to attend to corporeal matters of fact.

Keywords

animate forms, animation, responsivity, proprioceptive organs, kinesthesia, corporeal consciousness, surface recognition sensitivity, kinetic spontaneity, 'know thyself' as a biological built-in

Thomas Nagel, in a review of John Searle's book, *The Rediscovery of the Mind*, states that

"… we do not really understand the claim that mental states are states of the brain. … We are still unable to form a conception of how consciousness arises in matter."[3]

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1
H. L. Teuber in "Discussion" of D. M. MacKay's "Cerebral Organization and the Conscious Control of Action", in: John C. Eccles (ed.), *Brain and Conscious Experience*, Springer-Verlag, New York 1966, pp. 442–445; quote from pp. 440–441. The theme of MacKay's paper is "the controlling function of the brain in voluntary agency".

2
Aristotle, *Parts of Animals* 645a 26–27.

3
Thomas Nagel, "The Mind Wins!", *New York Review of Books* (March 4, 1993): 37–41, p. 40.

The missing conception is, of course, really a missing answer to the question: How *does* consciousness arise in matter? Nagel's agreement with Searle that "the subjective" is precisely the missing element is exemplified in his recognizably-worded statement that

"Facts about your external behavior or the electrical activity or functional organization of your brain may be closely connected with your conscious experiences, but they are not facts about *what it's like* for you to hear a police siren."[4]

The question of "*how* consciousness arises in matter" is thus clearly central to both Nagel and Searle.

What I want to do – in five parts – is outline basic reasons for thinking the question spurious, thereby demonstrating how genuine understandings of consciousness demand close and serious study of evolution as a history of animate form. The demonstration has sizable implications: (1) a re-thinking of the common assumption that unconsciousness historically preceded consciousness; (2) a recognition of the need to delve as deeply and seriously into natural history as into brains; (3) a critical stance toward arm-chair judgments about consciousness and a correlative turn toward corporeal matters of fact.

I

Philosophers of mind commonly pursue the same *how* question as Searle and Nagel, but many if not most take quite other paths. Daniel Dennett and Paul Churchland are notable in this respect. Both endeavor to offer a historical perspective by placing consciousness first of all in cosmic time. Their respective attempts are not protracted by any means and neither speaks explicitly of *the organic* and *the inorganic*. In what is nonetheless a clearly cosmological answer to the *how* question, both advert straightoff to the advent of replicators and the process of self-replication, thus attempting to distill inchoate life from the "purely chemical".[5]

Dennett's and Churchland's modest nod in the direction of a natural history is short-lived. Their respective "findings" from biological studies of the beginnings of life are neither carried forward in a consideration of the evolution of animate forms nor examined in the light of the diversity of actually living creatures. Their respective allusions to self-replication suffice for a historical answer to the question of "*how* consciousness arises in matter" because self-replication is where it all began and where it all began is where it still is: consciousness is a matter of matter. Their jump from the biology of self-replication to consciousness constitutes only an ostensibly reasonable move, however, because a major problem with a physicalist explanation of consciousness is clearly evident. It is succinctly if inadvertently exemplified in *Matter and Consciousness*. Whatever Churchland says of the self-replicating beginnings of life at the end of his book is predictably cued in advance by what he has stated at the beginning of his book about human life:

"[T]he important point about the standard evolutionary story is that the human species and all of its features are the wholly physical outcome of a purely physical process… . We are notable only in that our nervous system is more complex and powerful than those of our fellow creatures… . We are creatures of matter. And we should learn to live with that fact."[6]

The problem comes not in living with that fact but in living hermetically with that fact. Living hermetically with that fact comes at the expense of a viable natural history for the fact passes over fundamental understandings of animate life. These omissions in understanding emerge in a striking way in the metaphysical relationship Churchland proposes between the organic and inorganic. He insists that "living systems" differ from "nonliving systems" "only by degrees": "There is no metaphysical gap to be bridged" – or, as he later says, applying "the same lesson" – a difference "only by degrees" – to intelligence: "No metaphysical discontinuities emerge here".[7] Churchland does not *show* his "lesson in continuities" to be true, not even through his "lesson" in how to forge definitions of life that will be opaque to discontinuities, such as claiming that "the glowing teardrop of a candle flame… may just barely meet the conditions of the definition [of life] proposed", i.e., life is "any semiclosed physical system that exploits the order it already possesses, and the energy flux through it, in such a way as to maintain and/or increase its internal order".[8] In brief, Churchland's metaphysics is *of necessity* true in virtue of Churchland theory: if human consciousness is mere matter – relatively "more complex and powerful" matter,[9] but mere matter nevertheless through and through – then the organic can differ from the inorganic "only by degrees". Metaphysical distinctions are blurred by fiat as only they can be in such a theory.[10]

The consequences of holding a "no-gap-here" metaphysical theory aside, the major question is whether such a theory actually clarifies consciousness. In particular, however much information Churchland gives us about self-replication, "energy flux",[11] neurophysiology, or any other material aspects of living systems, and whatever the progressively refined definitions he gives us of

4
Th. Nagel, "The Mind Wins!", p. 39.

5
Paul Churchland, *Matter and Consciousness,* Bradford Books, Cambridge (MA) 1984. Churchland's opening sentence of the first section ("Neuroanatomy: The Evolutionary Background") of a chapter titled "Neuroscience" reads: "Near the surface of the earth's oceans, between three and four billion years ago, the sun-driven process of purely chemical evolution produced some *self-replicating* molecular structures" (p. 121; italics in original). Daniel Dennett, *Consciousness Explained*, Little, Brown and Company, Boston 1991. Dennett's opening sentences of the second section ("Early Days") of a chapter titled "The Evolution of Consciousness" reads: "In the beginning, there were no reasons; there were only causes… The explanation for this is simple. There was nothing that had interests. But after millennia there happened to emerge simple *replicators*" (p. 173; italics in original).

6
P. Churchland, *Matter and Consciousness*, p. 21.

7
Ibid., p. 153.

8
Ibid.

9
Ibid., p. 21.

10
At least one consequence of the blurring should be singled out in order to demonstrate the questionable propriety of claiming that "No metaphysical discontinuities emerge here". A continuous metaphysics creates a problem for distinguishing in traditional Western ways between life and death. However rationally doubtful, quasi-eternal life ('quasi' insofar as eternal life is punctuated from time to time but not wholly discontinued) suddenly emerges on the smudgy face of things as a viable metaphysical future possibility-if only materialist philosophers can deliver up their stone, aided, of course, by deliveries on promises by Western materialist science. Of course, the notion of cosmically differing "only by degrees" is in a metaphysically twisted and thoroughly ironic way also supportive of Eastern notions such as reincarnation and of so-called "primitive" notions of life after death, notions exemplified by non-Western burial practices in which dead persons are interred along with items they will need in their ongoing journeys. With respect to these notions, however, it is rather some form of the mental that is primary; matter is simply contingent stuff for the instantiation of spirit. What differs "only by degrees" is thus not fundamentally matter at all but a principle of life-*spiritus*, *pneuma*, or whatever else might be conceived to constitute invincible and inexhaustible animating vapors.

11
Ibid., p. 152–154.

life, we never seem to arrive at an elucidation of consciousness. The reductive equation of consciousness to matter is not *in fact* shown. The reductionist program is at best a matter of correlation: when there is consciousness, there is a certain kind of electrical activity ongoing in a brain; when there is not consciousness, there is not that certain kind of electrical activity ongoing in the brain, but electrical activity of another kind, or no electrical activity at all. As physiologist Benjamin Libet has observed:

> "One can only describe relationships between subjective phenomena and neural events, not how one gets from one to the other."[12]

We are in fact a long way from a natural history of consciousness. We are an equally long way in Dennett's account, particularly with his tethering of consciousness to a Center of Narrative Gravity. By radically privileging language, Dennett pulls the evolutionary rug out from under us. A consideration of language as he conceives it shows the slippage unequivocally. If human language explains consciousness, then consciousness arose in the form of human language. The question Dennett does not ask himself, but *should* ask himself, is how human language itself arose. Indeed, he should ask not only how human language could even have been conceived short of an already existing consciousness but how human language could even have been standardized short of already intact consciousnesses.[13] Dennett does not seem remotely aware of such questions, much less aware of their needing answers – which is why only linguistic creationism can explain a Dennettian consciousness.[14]

II

It is instructive at this point to look briefly at definitions of life both to bring to the fore the import of the animate and to highlight the troublesome textual use of quotation marks as a means of apportioning mental credit (e.g., the raven "knows", the baboon "recognizes"). Biological texts devote some pages to definitions of life. Among the constituents of those definitions is self-replication. Order and energy are also named. Responsivity is specified as a further prime constituent. As one text notes:

> "Plant seedlings bend toward the light; mealworms congregate in dampness; cats pounce on small moving objects; even certain bacteria move toward or away from particular chemicals… [T]he capacity to respond is a fundamental and almost universal characteristic of life."[15]

Oddly enough, this "fundamental and almost universal" dimension of life does not typically figure in definitions of life offered by philosophers of mind, especially those wedded to computational models. Yet responsivity – bending, congregating, pouncing, moving toward or away, in short, *animation* – commonly appears an integral part of cognition, hence part and parcel of consciousness. If queried on the matter, such philosophers might respond that it depends on what is doing the pouncing whether the terms 'cognitive' or 'conscious' apply. What basically matters, however, is not who is doing the pouncing but the ability to provide a wholly unprejudiced rationale for the common textual practice of making cognitive distinctions diacritically in order to separate real knowing from "knowing", real recognition from "recognition". Indeed, there is a mandate to specify the exact degree(s) at which quotation marks are appropriate. But there is also a problem: any specification is as arbitrary as it is mandatory. Whatever might be claimed to constitute a criterion is not a matter of fact but a matter of human judgment. While cranial capacities, neuron counts, and dendritic branchings certainly constitute matters of fact, these matters of fact do not *in themselves* specify anything whatsoever in the way of a standard. One might well recall what Darwin concluded in his study of Hymenoptera (insects such as ants and bees):

"It is certain that there may be extraordinary mental activity with an extremely small absolute mass of nervous matter."[16]

In short, specification – whatever its putative standard – turns out to be as completely arbitrary as it is mandatory. Indeed, in its arbitrariness, specification can only be labelled "subjective"; a standard completely impervious to human bias cannot possibly be identified. In consequence, a cancelling of all quotation marks appears warranted. The following description of a bacterium moving "toward or away from particular chemicals" is an especially interesting as well as exemplary candidate in this respect:

"Processing in a bacterium may be thought of as a sort of molecular polling: … the positive 'votes' cast by receptors in response, say, to increasing concentrations of a sugar are matched against the negative votes produced by increasing concentrations of noxious compounds. On the basis of this continuous voting process, the bacterium 'knows' whether the environment, on the whole, is getting better or worse. The results of this analysis appear to be communicated by electrical signals to the response centers. The final stage, the response, consists of a brief change in the direction of rotation of the several stiff, helical flagella that propel the bacterium. The

12
Benjamin Libet, "Subjective Antedating of a Sensory Experience and Mind-Brain Theories: Reply to Honderich (1984) ", *Journal of Theoretical Biology* 114 (1985): 563–570, p. 568.

13
For a discussion of these matters in detail, see author's book *The Roots of Thinking*, Temple University Press, Philadelphia 1990.

14
We should note that if the distinction between the organic and the inorganic is blurred, then of course distinctions among the organic are also blurred-just as Churchland in fact says they are blurred with respect to intelligence: there are differences "only by degrees". But the blurring between organic forms is necessarily finer than the blurring between the organic and the inorganic since organic forms are comparatively more closely related to each other than they are to the inorganic. In effect, to be consistent with Churchland's theory, common textual practice should be altered. Quotation marks typically surrounding cognitive functions as they are ascribed to what are termed "lower" forms should be erased. A difference "only by degrees" does not justify them. In a quite provocative sense, one might say that Churchland's overarching metaphysical blurring on behalf of an unrelenting materialism-whether one finds the latter credible or not-forces an examination and justification of common textual practice. It clearly calls our attention to a fundamental question about where and on what grounds cognitive lines are diacritically drawn in order to distinguish among capacities of various forms of organic life. All the same, it is important to emphasize that we are not charged with the task of making distinctions in material complexity, thus with the task of taking neuron counts and the like. On the contrary, we are charged with the task of *understanding the animate*. Accordingly, the quest begins from the other side. We take the phenomena themselves as a point of departure, not theory, and earnestly inquire into what we observe to be living realities. Denying distinctions thus becomes in this instance and in a heuristic sense epistemologically salutary rather than metaphysically corybantic.

15
Helena Curtis, *Biology*, Worth Publishers, NY 1976, p. 28. (Curtis's book is a standard text in biology.)

16
Charles Darwin, *The Descent of Man and Selection in Relation to Sex*, Princeton University Press, Princeton 1981 [1871], p. 145. Darwin goes on to say: "[T]hus the wonderfully diversified instincts, mental powers, and affections of ants are generally known, yet their cerebral ganglia are not so large as the quarter of a small pin's head. Under this latter point of view, the brain of an ant is one of the most marvellous atoms of matter in the world, perhaps more marvellous than the brain of man" (Ibid.). (Hymenoptera are an order of insects including bees, ants, and wasps.)

result is that the bacterium founders briefly and then strikes out in a new direction, once again sampling to see whether the environment is improving or deteriorating."[17]

In addition to being an exemplary candidate for diacritical erasure, the descriptive passage demonstrates in an intimately related way why responsivity – the "fundamental and almost universal characteristic of life" – is of critical import. Sampling, foundering, and striking out in a new direction are precisely a matter of animation and animation is precisely in some sense cognitive or mindful – as in assessing propitious and noxious aspects of the environment. Cognitive aspects of organic animation – in this instance, cognitive aspects of a bacterium's animation – cannot thus reasonably be considered mere figurative aspects. More generally, cognitive capacities cannot reasonably be reserved only for what are commonly termed "higher-order" organisms.

The unjustifiable use of diacritical markings to distinguish cognitively among organisms leads to a series of interlinked demands: a cessation of reliance on what is in fact a conceptually lazy, inapt, and/or obfuscating textual practice; a corollary recognition of the import of animation; a consequent investigation of the animate in terms of its natural history; a delineation of what it means cognitively to be animate. In a quite provocative sense, one might say that Churchland's blurring of metaphysical lines leads to such a series of interlinked demands. His overarching metaphysical blurring on behalf of an unrelenting materialism – whether one finds the latter credible or not – forces an examination and justification of common textual practice and typical Western thinking regarding so-called "higher" and "lower" forms of life. It clearly calls our attention to a fundamental question about where and on what grounds cognitive lines are diacritically drawn in order to distinguish among capacities of various forms of organic life. All the same, it is important to emphasize that in answering to the fourfold demand, we are not charged with the task of making distinctions in material complexity by taking neuron counts and the like. On the contrary, we are charged with the task of *understanding the animate*, precisely as the bacterium example demonstrates. Accordingly, the quest begins from the other side. We take the phenomena themselves as a point of departure, not theory, and earnestly inquire into what we observe to be living realities.

III

"Know thyself" is a Socratic imperative. It may also be said to be a built-in biological one. This imperative is most effectively elucidated by way of descriptive remarks Dennett makes about "The Reality of Selves" in the process of explaining consciousness.

Energetically affirming that "every agent has to know which thing in the world it is!",[18] Dennett begins by specifying what this knowing entails. He considers first "simpler organisms" for whom

"… there is really nothing much to self-knowledge beyond the rudimentary biological wisdom enshrined in such maxims as When Hungry, Don't Eat Yourself! and When There's a Pain, It's Yours!"[19]

In this context, he says of a lobster that "it might well eat another lobster's claws, but the prospect of eating one of its own claws is conveniently unthinkable to it". He goes on to say that

"Its options are limited, and when it 'thinks of' moving a claw, its 'thinker' is directly and appropriately wired to the very claw it thinks of moving."[20]

The situation is different, Dennett says, when it comes to controlling "the sorts of sophisticated activities human bodies engage in", because "there are more options, and hence more sources of confusion".[21] He states that

> "… the body's control system (housed in the brain) has to be able to recognize a wide variety of different sorts of inputs as informing it about itself, and when quandaries arise or skepticism sets in, the only reliable (but not foolproof) way of sorting out and properly assigning this information is to run little experiments: do something and look to see what moves".[22]

The experimental approach is the same, Dennett says, whether a matter of "external signs of our own bodily movement" or "internal states, tendencies, decisions, strengths and weaknesses": "Do something and 'look' to see what 'moves'."[23] With respect to internal knowledge, he adds that "An advanced agent must build up practices for keeping track of both its bodily an 'mental' circumstances."

Dennett's descriptive passages of course readily offer themselves as candidates for erasure no less than passages in biology. He marks mental phenomena diacritically both in order to make distinctions between higher and lower forms of life and in order to maintain a thoroughly materialized consciousness. What his diacritical markings actually allow is his having his material cake and eating it too. However loose his vocabulary – e.g., a *thinking* lobster – and however much it strays from purely materialist theory – *mental* as well as bodily circumstances – it is diacritically reined in to accord with the theoretical distinctions he wants to maintain and the materialist doctrine he wants to uphold.

What makes both the entailments and elaboration of Dennett's energetic affirmation such a compelling and richly informative point of departure for examining the bio-Socratic imperative is precisely what they overlook in theory, method, and fact. It is as if proprioception in general and kinesthesia in particular[24] did not exist; whatever the talk of movement, it is as if the *sense of movement* were nonexistent. Thus, one has to *look* and *see* what is moving. In such an account, the kinesthetic is more than overridden by the visual; it is not even on the books. Were one to examine Dennett's theory of human agency with respect to infants, one would straightaway discover its error.[25] We humans learn "which thing we are" by moving and attending to our own movement. Indeed, along with many other primates, we must *learn* to move ourselves. We do so not by *looking* and *seeing* what we're moving; we do so by attending to our bodily feelings of movement, which include *a bodily felt*

17
William T. Keeton and James L. Gould, *Biological Science*, W. W. Norton & Co., New York [4]1986, p. 452.

18
Daniel Dennett, *Consciousness Explained*, p. 427.

19
Ibid.

20
Ibid.

21
Ibid.

22
Ibid., pp. 427–28.

23
Ibid.

24
Proprioception refers generally to a sense of movement and position. It thus includes an awareness of movement and position through tactility as well as kinesthesia, that is, through external as well as internal sense organs, including also a sense of gravitational orientation through vestibular sensory organs. Kinesthesia refers specifically to a sense of movement through muscular effort.

25
Were one to examine it with respect to blind people, one would do the same.

sense of the *direction* of our movement, its *speed*, its *range*, its *tension*, and so on. In turn, we learn to distinguish certain kinesthetic bodily feelings from certain other kinesthetic bodily feelings. The putative agent who looks to see what moves could hardly be an effective agent. A bona fide agent is not only aware of initiating movement but aware of its spatio-temporal and energy dynamics.[26] An agent devoid of kinesthesia in fact belongs to no known natural species. Agents-those having the power to initiate movement and to direct it toward certain ends-necessarily have a kinesthetic sense of their own movement.

Kinesthesia is nowhere acknowledged by Dennett as a feature of "simpler" creatures any more than it is of "complex" ones. The idea that creatures have a sense of their own body and body movement is an alien thought in itself, not just a thought alien to the theory of a thoroughly materialized consciousness. Whoever "the thinker" might be in Dennett's zoology, it appears to get what it wants simply in virtue of its impeccable motor wiring. Yet we should ask what it means to say that a lobster will eat another's claw but that *conveniently*, as Dennett puts it, it finds eating one of its own claws unthinkable. Does it mean that there is actually a rule "Don't eat your own claw!" wired into the lobster's neurological circuitry? But it is patently unparsimonious to think that there is such a rule and patently absurd to think that every creature comes prepared with an owner's manual, as it were, a rulebook replete with what Dennett calls "maxims". Such a maxim, for example, would be only the beginning of an indefinitely great number of maxims that a lobster (or any other so-called "simpler organism") could be said to carry around in the neural machinery that counts as its "Headquarters":[27] "Don't try to go on land!" "Don't try to eat a squid!" "The large claw is for crushing! – the small claw is for seizing and tearing!" And so on. What makes eating its own claws "conveniently unthinkable" is clearly something other than a rule of conduct. Indeed, the putative evolutionary sense of convenience that Dennett invokes is misguided. "Convenience" is not a matter of an opportune adaptation but of an astoundingly varied and intricately detailed biological faculty that allows a creature to know its own body and its own body in movement.[28]

IV

Animate forms are built in ways that are sensitive to movement. They can be sensitive to dynamic modifications in the surrounding world and to dynamic modifications of their own body. A moment's serious reflection on the matter discloses a major reason why movement sensitivity is both basic and paramount: no matter what the particular world (*Umwelt*)[29] in which an animal lives, it is not an unchanging world. Hence, whatever the animal, its movement cannot be absolutely programmed such that at all times its particular speed and direction of movement, its every impulse and stirring, its every pause and stillness, run automatically on something akin to a lifetime tape. Consider, for example, an earthworm, its body pressed against the earth as it crawls along, or a beetle walking along the ground. In each case, the immediate environment is tangibly inconsistent; it has topological and textural irregularities-bumps here, smoothness there, moisture here, hardness there. Both earthworm and beetle must adjust kinetically to what they find in the immediate moment. A prominent invertebrate researcher makes this very point:

> "Information regarding the absolute disposition of the body is imperative in order that minor adjustments of muscular activity may be made to cope with irregularities in the surface."[30]

Clearly, the world is less than consistent in its conformations, and any animal that survives must literally or figuratively bend to its demands. Consider further that air and water move, and that movement in the form of currents or winds agitates, deforms, or otherwise impinges on animal bodies. In effect, such movement influences how an animal moves from moment to moment. A locust's face, for example, is covered with hairs that respond to the movement of air across their surface:

"Each hair responds maximally to wind from a specific direction, with the optimal direction being determined by the angle of curvature of the hair shaft."[31]

Sensitivity to its facial hair displacements facilitates the locust's control of lift during flight and is informative of orientation in flying. The intricateness of a spider's external proprioceptive system offers equally impressive testimony to the importance of proprioception. Hairs on its body, when bent, inform it of its orientation relative to its web, for example.[32] Far more numerous than its hairs, however, are other surface sensory organs called slit sensilla. A spider's slit sensilla are functionally analogous to an insect's campaniform sensilla;[33] both are sensitive to deformation. To give an idea of the singular importance of such proprioceptors, consider that the hunting spider (*Cupiennius salei*)

26
Were Dennett's injunctions taken literally at the letter, his agent-so-called-would have to have in sight at all times all parts of his/her body in order to see what they were doing. Such an agent could in no way build up practices in the manner Dennett suggests for the build up of such practices depends upon kinesthesia and kinesthetic memory.

27
D. Dennett, *Consciousness Explained*, e.g., p. 106: "The brain is Headquarters, the place where the ultimate observer is…"

28
Dennett is not alone either in his omission of the kinesthetic or in his privileging of the visual. Typically, kinesthesia never makes an appearance in discussions of "the senses" – the *five* senses. Any cursory glance at indices of relevant books in biology, psychology, and philosophy discloses either a radically abbreviated treatment of kinesthesia in comparison to vision (and audition), or a complete lack of treatment altogether. One might say with good reason that the mind/body problem is written into the very texts themselves. Moreover the topic of body movement, if making an appearance at all, typically comes on the scene only marginally in these books. The way it does so is through reduction to *the* brain and its efferent pathways. In both typical instances, we come up painfully short of a sense of movement. In one respect it is not surprising that kinesthesia is omitted or slighted and that we believe ourselves to have only five senses. As adults, we have long since forgotten how we learned to move ourselves-in a very real sense, how we learned our bodies. Moreover, kinesthesia is fundamental not only to our knowledge of "which thing in the world we are"; it is fundamental both to our ability to make our way in the world – to move knowledgeably in it – and to our knowledge of the world itself. Though we may have forgotten what we first learned of the world itself through movement and touch, there is no doubt but that we came to know it first by moving and touching our way through it, in a word, through our tactile – kinesthetic body.

29
Jakob von Uexküll, *Theoretische Biologie*, J. Springer, Berlin ^{2}1928. Cf. Ernst Cassirer's concise explanation of why there are *Umwelts*: "Every organism… has a world of its own because it has an experience of its own". Ernst Cassirer, *An Essay on Man*, Bantam Books, New York 1970, p. 25.

30
M. S. Laverack, "External Proprioceptors", in: P. J. Mill (ed.), *Structure and Function of Proprioceptors in the Invertebrates*, Chapman and Hall, London 1976, pp. 1–63, pp. 4–5.

31
Ibid., pp. 5–6.

32
Ibid., p. 27.

33
See, for example, B. R. Wright, "Limb and Wing Receptors in Insects, Chelicerates and Myriapods", in: P. J. Mill (ed.), *Structure and Function of Proprioceptors in the Invertebrates*, pp. 323–386; pp. 353–354.

has over 3000 slit organs on its walking legs.[34] Given the quantity of such organs, it is no wonder that, as one invertebrate researcher writes, "the quantity of proprioceptive information… from an appendage at a particular time (e.g., during walking) may be considerable".[35]

The astoundingly varied and intricately detailed biological faculty that allows knowing one's own body and body movement and that thereby allows knowing the world, is a dimension of consciousness. Inversely, consciousness is a dimension of living forms that move themselves, that are *animate*, and that, in their animation, are in multiple and complex ways engaged in the world. The earlier description of a bacterium's cognitive capacities is relevant precisely in this context. What the description indicates is a chemically-mediated *tactile* discrimination of bodies apart from, or outside of, its own body. Its discriminative ability might justifiably be termed a "meta-corporeal" consciousness, a consciousness of something beyond itself. Clearly, the essentialy tactile ability to disciminate bodies other than oneself is not the same as a proprioceptive ability to discriminate aspects of oneself as an animate form. Proprioceptively-endowed creatures are not only always in touch with something outside themselves; they tactilely deform and compress themselves bodily in the process of moving. When a creature bends its leg, for example, it brings two surfaces in contact with each other – in mutual deformation. Tactility thus enters into the essentially kinetic cognitional abilities by which a creature discriminates aspects of itself as an animate form. In the most fundamental sense, these kinetic cognitional abilities constitute a *corporeal consciousness*, a consciousness that, as I have suggested and as I will now illustrate in further if necessarily brief ways, is an astoundingly varied and intricately detailed biological faculty. The purpose of the further illustrations is again to link understandings of consciousness to corporeal matters of fact and thereby to an evolutionary history. In other words, with a recognition and understanding of the rootedness of consciousness in corporeal matters of fact, we can begin to grasp the possibility of a true evolutionary history of consciousness. It bears emphasizing that *we do this by direct consideration of the topic at issue: consciousness*, and not by appeal to constituents in definitions of life-to self-replication, organization, and so on. The notion of consciousness as fundamentally a corporeal phenomenon in fact already suggests a radical revision of the common evolutionary characterization of consciousness both as "a higher order" function, i.e., a function having nothing to do with bodies, and as a "higher order" function exclusive to "higher" forms of life, i.e., a preeminently human endowment. Similarly, it already suggests a radical revision of the materialist's characterization of consciousness as identical with neurological brain events. The key to this reconceptualization of consciousness and to its evolutionary import is the realization that bodies in the form of living creatures are not mere physical things but animate forms. Consciousness is thus not *in matter*; it is a dimension of living forms, in particular, a dimension of living forms that move themselves.

V

An invertebrate may be soft- or hard-bodied. Hard-bodied invertebrates are so called because they have articulable body parts attached to an exoskeleton. As suggested by the above examples, hard-bodied invertebrates have external sensilla of various kinds: hairs, exoskeletal plates, epidermal organs, cilia, spines, pegs, slits, and so on. It is these external sensory organs that make possible an awareness of surface events in the double sense noted above: an awareness of the terrain on which and/or the environment through which the animal is moving and an awareness of bodily deformations or stresses occurring coincident with moving on the terrain and/or through the environment. To appreciate in a beginning way the difference in proprioceptive sensitivity between hard- and soft-bodied invertebrates, compare, for example, a beetle and a polyp. A beetle that is walking on the ground has tactile contacts that allow an awareness of the ground's irregularities – bumps, stones, holes, and so on – and tactile contact with the air – breezes, vibrations, and so on – as well as an awareness of itself as topologically deformed or agitated by these contacts. Proprioception is thus distinctively informative of both body and surrounds. A sedentary hydrozoan polyp has tentacles bearing cilia that are sensitive to vibrations in the surrounding water. When vibrations occur, the polyp bends its tentacles toward their source, thus toward food particles such as larvae. English marine biologist, D. A. Dorsett states that the polyp's bending response is reflexive because the movement is neither generated by the polyp itself – it is generated by the vibrations – nor imposed upon the polyp – it is not the result of actual surface to surface contact, i.e., contact of animal body with solid object.[36] His point is more broadly made in the context of an analysis by M. S. Laverack, another English marine biologist, who distinguishes among four basic modes of external proprioception in invertebrates.[37] The simplest mode is through distortion of the body, whether through muscle contraction or passive deformation: external proprioceptors are in either case affected. The second mode is tethered to the fact that animals move relative to space; in effect, contact of the surface of an animal's moving body with a solid object results in proprioception concerning its movement and position relative to the object. The third mode is also tethered to the fact that animals move relative to space; it is a reiteration of the second mode of proprioceptive stimulation but with reference to a substrate rather than to a solid object. The fourth mode derives from the circumstance in which movement of one body part tactilely stimulates another body part through contact of external sensors of one kind or another, e.g., hairs, such contact providing information regarding movement and position of the two body parts. To say that the polyp's bending movement is reflexive is thus to say both that the polyp is not stimulated by bodily deformation or stress (the first mode)[38] nor is it stimulated because a surface of its body has come into contact with a solid object (the second mode). That the polyp is sedentary means, of course, that it does not budge from its base; hence, the third mode of stimulation is not a possibility. Neither is the fourth mode since the movement of the tentacles does not proprioceptively stimulate another body part.

34
Ibid., p. 351. See also: M. S. Laverack, "External Proprioceptors", pp. 24–25.

35
B. R. Wright, "Limb and Wing Receptors in Insects, Chelicerates and Myriapods", p. 354.

36
D. A. Dorsett, "The Structure and Function of Proprioceptors in Soft-Bodied Invertebrates", in: P. J. Mill (ed.), *Structure and Function of Proprioceptors in the Invertebrates*, pp. 443–483, p. 447.

37
M. S. Laverack, "External Proprioceptors", pp. 3–4.

38
If one considers that tentacle cilia are passively deformed by vibrations in the surrounding water, then of course a polyp's bending response *is* proprioceptive, not reflexive. See further in the text itself the discussion Laverack's remark about cilia as the beginning of specialized sense organ structure.

Polyps belong to a class of animals called coelenterates, "primitive aquatic animals".[39] It might be tempting to generalize about proprioception in coelenterates – and perhaps in other soft-bodied invertebrates such as annelids and molluscs as well – on the basis of the above example and discussion, but given the diversity of coelenterate forms of life, it would be a mistake to write off proprioception altogether in such creatures. Different proprioceptive capacities – or counterparts thereof – are highly suggested by the movement of creatures within the same class and even within the same phylum. For example, a somersaulting hydra is an exception to what might otherwise be considered "the sedentary hydrozoan polyp rule"; a fighting sea anemone similarly changes its contact with a substrate, thus, like a somersaulting hydra, it too is open to proprioception through its own movement in space; an anemone belonging to the genus *Actinostola*, though normally sessile, not only moves to distance itself from chemical substances emitted by starfish but writhes and somersaults in the process.[40] Clearly, there is a diversity of possible proprioceptive acuities commensurate with the diversity of life itself.

Now in spite of the fact that proprioception is less evident in soft-bodied invertebrates and is difficult to document,[41] marine biologists readily affirm a range of proprioceptive possibilities in these creatures. Laverack, for example, states that

> "Proprioceptive units in the flexible body wall of soft-bodied animals are probably legion, [although] … few have been shown either anatomically or physiologically";[42]

Dorsett states with respect to soft-bodied invertebrates generally that "abundant opportunities for true proprioception occur".[43] Dorsett's and Laverack's affirmation in the face of comparatively slim evidence warrants a moment's reflection as does the related conceptually challenging notion of "true proprioception".

The best evidence for proprioception in soft-bodied invertebrates comes from studies of gastropods (molluscs) whose complex feeding behavior is modulated by proprioception according to load. Given the difference in animate form between a gastropod and a sedentary polyp – which difference of course means a difference in movement possibilities and thus in behavioral possibilities[44] – it is not surprising to find proprioceptive capacities readily evident in the one and not in the other. It is precisely in this context of recognizing differences in animate form that the significance of both the affirmation of proprioception and the notion of "true proprioception" becomes apparent: What would dispose marine biologists to affirm "proprioceptive units" in the face of slim evidence if not an intuitive sense of the central importance of proprioception to animate life in general, and in particular, of its necessity in carrying through observed complex feeding behaviors such as those of certain gastropod species? What if not this intuitive sense generates the idea of "true proprioception", thus the idea that there are lesser forms of the same, forms one might historically call proto-proprioception? Consider the following remark that validates just such *evolutionary* notions:

> "[I]n passing from the coelenterates to the annelids and molluscs, we are looking at some of the earliest stages in the evolution and organization of the nervous system and must ask ourselves at what stage does a true proprioceptive sense arise."[45]

The question is indeed provocative: at what stage *does* "a true proprioceptive sense arise"? Does it arise with molluscs, for example? Or can it be said to have arisen with some of the presumably earlier evolving coelenterates? On the other hand, what is "true proprioception"? And can a "stage" be pinpointed as its inception?; that is, is it possible to say with respect to any particular group of creatures and with respect to any particular evolutionary period, "true proprioception starts here"? In view of the diversity of creaturely life, one might rather say that "true proprioception" arises for each creature according to the animate form it is, and that if "true proprioception" does not arise, the form does not arise either because it is not kinetically viable. In other words, one might want to say that the origin of proprioception is not an historical event as such; it is an event tied to the evolution of *animate* forms. Indeed, the evolution of formal diversity speaks to the evolution of a diversity of proprioceptive capacities because it speaks of the same phenomenon: the evolution of forms of life as forms of animation.

From the above corporeal matters of fact, we can in fact begin to distill a sense of the evolution of proprioception, from a meta-corporeal consciousness to a corporeal consciousness through the evolution of external sensors. As all of the above examples suggest, the undoubtedly multiple beginnings of proprioception are in each instance tied to *surface recognition sensitivity*, an original tactile faculty subserving movement and the recognition of something outside of one's own body. Laverack's remark about cilia-organelles that are present in groups of creatures from protozoa (unicellular eukaryotic organisms such as paramecia and amoebas) to mammals – is highly suggestive in this respect. He writes that

"If the cilium may be taken as at least a simple starting point for sense organ structure we may look for receptors even amongst the protozoa. Sensitivity towards physico-chemical events is well known, but specialized receptors much less so."[46]

His remark may be glossed in the following way: the evolution of sense organs at the most primitive eukaryotic level heralds a new kind of sensitivity, one mediated by specialized sense organs, i.e., cilia, rather than by physicochemical events, but still serving the same basic function: movement and the recognition of something outside one's own body. While this surface sensitivity is spoken of in terms of "mechanoreception",[47] it is clearly, and indeed,

39
W. T. Keeton and J. L. Gould, *Biological Science*, p. 161.

40
Bayard H. McConnaughey, *Introduction to Marine Biology*, C. V. Mosby, St. Louis 1978, pp. 270–272.

41
D. A. Dorsett, "The Structure and Function of Proprioceptors in Soft-Bodied Invertebrates", p. 479.

42
M. S. Laverack, "External Proprioceptors", p. 11.

43
D. A. Dorsett, "The Structure and Function of Proprioceptors in Soft-Bodied Invertebrates", p. 479.

44
For an excellent discussion of morphology in relation to movement and of the evolution of arthropods from annelids with respect to that relationship, see: S. M. Manton, "Locomotory Habits and the Evolution of the Larger Arthropodan Groups", in: *Evolution* (*Symposia of the Society for Experimental Biology, No. VII*), Academic Press, New York 1953, pp. 339–376. The eminent biologist J. B. S. Haldane spoke laudingly of Manton's work, saying "Manton has done for a phylum what comparative ethologists have done for small vertebrate groups such as the Anatidae" and described her as a "pioneer" (J. B. S. Haldane, "Foreword", *Evolution*, pp. xvi, xvii).

45
D. A. Dorsett, "The Structure and Function of Proprioceptors in Soft-Bodied Invertebrates", p. 443.

46
M. S. Laverack, "External Proprioceptors", p. 17.

47
Ibid.

from the viewpoint of living organisms, more appropriately specified as a form of *tactile*-reception. The protozoan ciliate species *Stentor*, for example, uses its cilia to sweep away noxious particles and the *Stentor* itself bends away from the tactile disturbance.[48] With the recognition of cilia as beginning specialized sense organs, the notion of "true proprioception" is definitively recast. It is not a historical attainment but a consistent function of animate form.

Specified in animate terms, animate forms disclose even broader evolutionary continuities. A bacterium that goes about sampling the environment is not sensitive to shape or to movement but to the chemical composition of its environment. Its sensitivity is all the same similarly mediated by touch, it similarly subserves movement, and it is similarly meta-corporeal. Hence, in both prokaryotic (single cell, no nucleus and no membrane-enclosed organelles) and early unicellular and multicellular eukaryotic forms of life, tactility is a way of knowing the world and making one's way within it, the source of both organismic movement and cognition. An evolutionary pattern thus begins to emerge with respect to *surface recognition sensitivity*. The pattern is evident in prokaryotic organisms, which are tactilely sensitive to their physico-chemical environment and which move dynamically commensurate with that sensitivity, i.e., sampling, foundering, changing direction; eukaryotic forms of life emerge, which are tactilely sensitive to the environment through specialized sense organs and which move in ways coincident with that sensitivity, protozoan ciliates responding to noxious elements in the environment by bending or sweeping movements, for example, the cilia of sedentary polyps responding to vibrations in the surrounding medium and exciting the polyp to bend a tentacle toward food, mobile forms such as annelids and molluscs moving in strikingly more intricate and varied ways on the basis of more complex external organs sensitive to deformation and stress. In sum, the pattern is a *dynamic* one. Whatever the form of surface sensitivity in prokaryotic and early eukaryotic forms of life, it is ultimately in the service of movement: toward or away from chemicals in the environment, toward sources of food, away from noxious elements or alien creatures, and so on.

A surface sensitivity subserving movement becomes apparent the moment one looks to corporeal matters of fact, analyzes them in sensory-kinetic terms, realizes the centrality and significance of movement to creaturely life, and begins thinking in terms of a natural history of *animate form*. It clearly suggests the basis on which proprioception arises and is clearly suggestive too of its crucial significance. A commonly cited definition of proprioceptors justly acknowledges a prime aspect of this significance, namely, continuous sensitivity.[49] Not only is a creature's surface in contact continuously with a medium or with other surfaces in the environment – whether it is moving or whether it is still – but its own conformations continuously change in the course of moving. Continuous sensitivity is thus doubly indicative of how a moving creature profits from such organs: it is sensitive both to the changing world in which it finds itself and to its own movement and changing bodily form. Moving creatures – animate forms – are, in fact, topological entities, changing shape as they move and moving as they change shape. Proprioception implicitly articulates this truth. Deeper and more detailed study shows it to articulate a further truth; namely, that animal movement, however centrally programmed, cannot be considered to be wholly devoid of proprioception.[50] However rote its basic behaviors might be with respect to its day to day living in the world, a creature is necessarily sensitive in a proprioceptive sense to the present moment; it begins crawling, undulating, flying, stepping, elongating, contracting, or whatever, in the context of a present circumstance. It is, in a word, *kinetically spontaneous*. When it does move, it breaks forth from whatever resting position it was in; it *initiates* movement and in ways appropriate to the situation at hand. The inherent spontaneity of animate forms lies fundamentally in this fact.

Kinetic spontaneity may be analyzed in terms of kinesthetic motivations, in terms of a species-specific range of movement possibilities, in terms of an individual repertoire of what might be termed "I can's", and in terms of a sense of agency. As might be apparent, these dimensions of spontaneity are keenly inter-related. A creature's initiation of movement is coincident with its kinesthetic motivations – its disposition to do this or that; its kinesthetic motivations fall within the range of its species-specific movement possibilities; these possibilities are the basis of its repertoire of "I can's"; as enacted, any item within its repertoire of "I can's" is undergirded proprioceptively by a sense of agency. A creature's corporeal consciousness is a composite of these four kinetic dimensions of spontaneity. In effect, creatures know themselves – "they know which thing in the world they are" – in ways that are fundamentally and quintessentially consistent with the bodies they are. They know themselves in these terms not by *looking*, i.e., not by way of what is visible to them of their visual bodies, but proprioceptively, or more finely, kinesthetically, i.e., in ways specific to movement alone, sensing their bodies as animate forms in movement and at rest.

As indicated, this form of creaturely knowing can be definitively spelled out along evolutionary lines, indeed, specifically along the lines of descent with modification. The evolutionary pattern sketched above emphasized the ba-

48
H. Curtis, *Biology*, p. 311: After bending away from a noxious stimulus, and if "the offensive stimulus persists, the Stentor will reverse its cilia and try to sweep the particles away. If bending and sweeping are not successful, it contracts and waits. Once it has contracted, it does not bend or sweep again, but it may reach out to sample the water several times before it finally swims away. The length of time it tolerates the noxious stimulus apparently depends on whether or not its site had previously proved a good feeding area. Thus, even ciliates show some flexibility in behavior."

49
H. W. Lissman, "Proprioceptors", in: *Physiological Mechanisms in Animal Behaviour (Symposia of the Society for Experimental Biology*), vol. IV, Academic Press, Inc., New York 1950, pp. 34–59, p. 35. – Quoted by P. J. Mill, "Preface", P. J. Mill (ed.), *Structure and Function of Proprioceptors in the Invertebrates*, pp. xvi-xviii, p. xvi. Lissman amends Sir Charles Sherrington's original 1906 coinage and definition of "proprioceptors" – sensory organs stimulated by "actions of the body itself" – in that, as Lissman states, Sherrington's definition "does not appear quite adequate, because, clearly, there are few types of sense organs which cannot be stimulated by actions of the body itself" (p. 35).

50
"[P]roprioceptive information plays a vital part in the control of movements and orientation." – It is of interest to note in this context the remarks of zoologist M. J. Wells with respect to the question of the relationship between proprioception and learning: "Because it is normally impossible to eliminate all the proprioceptors and never quite certain that one has succeeded in eliminating all other sensory cues, it is rarely possible to be certain that an animal is using proprioceptive information when it learns… One must examine cases where animals learn in circumstances that, *prima facie*, imply that they are taking into account information derived from within their own joints and/or muscles and/or organs of balance and explore these cases rather carefully to see what alternative explanations are possible. It should be emphasized that the object of this exercise is not to establish whether particular sorts of animal can possibly learn from proprioceptive inputs in *any* circumstances (since that question is unanswerable), but rather whether they normally appear to do so." – "Proprioception and Learning", in: *Structure and Function of Proprioceptors in the Invertebrates*, pp. 567–604, pp. 567–68.

sic phenomenon of surface recognition sensitivity – beginning with bacteria and proceeding to ciliated protozoa, to sedentary invertebrates, and to molluscs and annelids. This beginning sketch can be amplified. Creatures such as lobsters and spiders – arthropods – are creatures with an articulable skeleton, hence they have not only external sensors but internal ones as well, particularly around their jointed appendages. Generally termed chordotonal organs in invertebrates, these internal proprioceptors are sensitive directly to stresses within the body itself. On the basis of organic analogues and structural homologies, biologists believe these internal proprioceptors to have derived from external sensory organs, that is, to be the result of a migration of certain formerly external proprioceptive bodily structures. Thus, Laverack states that "Evolutionary trends in several groups [of invertebrates] show a gradual removal of proprioceptors from the surface to a deep or internal placement", and points out that this derivation, while apparent in some invertebrates, "is demonstrable in vertebrates", giving as example "the change in position of the acoustico-lateralis system in fish and amphibia".[51] He points out that internal proprioceptive organs are not directly vulnerable to environmental wear and tear and in this sense are protected. Creatures with internal proprioceptors are thus not at the direct mercy of the surrounding world. Arthropods and vertebrates are both notable in this respect. Though their evolutionary lineages are distinct, species within each phylum are similar in having a skeletal structure and in being extremely mobile forms. Although their respective skeletal structure is differently placed – invertebrate skeletons are outside, vertebrate skeletons are inside – the attaching muscular structure is in each case internal and functions in a similar manner; when a muscle contracts, skeletal joints close, pulling two body segments toward each other. A direct and continuous sensitivity to movement thus appears to have evolved in two distinct but highly mobile forms of life and with the same advantage: an internally-mediated corporeal consciousness of movement that is not dependent on external stimuli, hence on tactility, but that is internally mediated. This kind of corporeal consciousness is not only relatively protected as well as continuous in comparison to an externally-mediated corporeal consciousness. Being internal, its possibilities for elaboration are quite different. In particular, what is being sensed in the case of an internally-mediated corporeal consciousness has the possibility of opening up, of expanding into a richly variable and complex domain of awarenesses. The possibility of such a domain is adumbrated in the question "What is it like to be a bat?". Indeed, the question presumes the existence of an internally-mediated corporeal consciousness that has already opened up into a range of kinetically tied and internally felt phenomena and acts. In other words, it presupposes a range of experiences that a bat has both of itself as an animate form and of a particular world in which it moves. Proprioception is in this sense an *epistemological gateway*, one that, by descent with modification, may clearly be elaborated both affectively and cognitively. In just such ways, corporeal consciousness shows itself to have the possibility of expanding ultimately into a sense of self. Proprioceptive descent with modification foundationally explains this possible expansion. "The Reality of Selves" has its roots in corporeal consciousness.

In sum, if the evolutionary thesis is correct that external proprioceptors were modified and internalized over time, then a singularly significant consequence obtains: internally-mediated proprioception, however variously accomplished in terms of anatomical structures, remains nonetheless consistent in its results, *viz*, a directly movement-sensitive corporeal consciousness.[52] In effect, understandings of the evolution of proprioception lead precisely to understandings of the provenience of consciousness. Through all the intricate and changing pathways of descent with modification, *know thyself* has remained a consistent biological built-in; a kinetic corporeal consciousness informs a diversity of animate forms.

Maxine Sheets-Johnstone

Bewusstsein: Eine Naturgeschichte

Zusammenfassung

In diesem Artikel wird gezeigt, dass die angemessene Fragestellung bezüglich des Bewusstseins nicht darauf abzielt, wie sich Bewusstsein in der Materie niederschlägt, sondern auf die Art und Weise, in der das Bewusstsein als fester Bestandteil zur Evolution der Lebensformen gehört. Die Verfasserin zeichnet eine solche Evolution nach, indem sie reale Lebensformen einschließlich Bakterien und Wirbellose berücksichtigt, und vertritt die evolutionäre These, dass externe propriozeptive Organe – wie anhand ihrer selbst nachgewiesen wurde – sich im Laufe der Zeit modifiziert und zu inneren kinästhetischen Organen gewandelt und so das motorisch-sensorische Körperbewusstsein während des Bestehens aller möglichen evolutionären Lebensformen aufrechterhalten haben. Ferner spezifiziert die Autorin bedeutende Konsequenzen ihrer These, die sich zum einen auf das Unbewusste beziehen, des Weiteren auf aktuelle Brennpunktstudien über das Gehirn, bei der die korrelative Naturgeschichte in Abrede gestellt wird, sowie auf das Bedürfnis, sich mit körperbezogenen Tatsachen zu befassen.

Schlüsselbegriffe

Lebensformen, Leben (Animation), Responsivität (Ansprechvermögen), propriozeptive Organe, Kinästhesie, körperliches Bewusstsein, oberflächliche Rekognitionssensitivität, kinetische Spontanität, „Erkenne dich selbst" als biologisch eingebauter Prozess

Maxine Sheets-Johnstone

La conscience : une histoire naturelle

Résumé

L'article montre que la question appropriée en matière de conscience n'est pas « comment la conscience s'articule dans la matière » mais de quelle manière la conscience est-elle un élément de l'évolution des formes animées. L'article décrit justement cette évolution en examinant des formes de vie réelles, y compris des bactéries et des invertébrés. Il donne raison à la thèse évolutionnaire selon laquelle les organes proprioceptifs externes, en tant que tels, se sont transformés et intériorisés au fil du temps en organes kinesthésiques tout en maintenant de fait une conscience corporelle du mouvement sensible à travers quasiment toutes les formes de l'évolution de la vie. Le texte précise les conséquences significatives de la thèse concernant l'inconscient, sur des études actuelles centrées sur le cerveau qui négligent l'histoire naturelle corrélative, ainsi que sur le besoin de suivre les aspects corporels.

Mots-clés

formes animées, animation, responsivité, organes proprioceptifs, kinesthésie, conscience corporelle, reconnaissance superficielle de la sensibilité, spontanéité cinétique, « connaissance de soi » comme partie intégrante biologique

51
M. S. Laverack, "External Proprioceptors".

52
Cf. ibid., p. 48: "If the thesis that many internal receptors may derive from external receptors, (sic) is valid, then it would be anticipated that the properties of all mechanoreceptors will be similar. Variety may be expected as a result largely of anatomical rather than physiological attributes."