Real Mechanisms for Natural Thought? The History of an in-depth Analysis

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*Minor adjustments (19 May 2014): {1} new contact-details above, and {2} new PS to Preface below: — Others (10 Jan 2010): coloured "**Gray-80%**"

PREFACE

This project has tackled a problem for which lab-work (however desirable) can only scratch the surface. Meaningful progress has required an ambitious theoretical "jigsaw-puzzle" of apparently disconnected experimental findings and concepts from many disciplines — notably: Information Technology, Physics, Piagetian-psychology, Physiology, — and Epistemology (in its two guises of Learning-theory, and Scientific Method).

But apparently-significant progress in such ventures is just the beginning. The trouble comes from the very same diversity: Very few readers have the time and motivation to study the claims and findings in their original form, and *then take the trouble to appreciate the whole overall coherence* of those findings, seen collectively.

Thus the purpose of this paper is to attempt a fairly-short *readable-and-informative overview summary* of the project, with ample links and references to the original documents — which are now, conveniently, mostly online. That has mostly meant précis-writing, but in some places (e.g. regarding the "Quadrant enigma") it has seemed necessary to be *more* explicit-or-graphic than previously. New original material was *not* part of the brief, but there seems to be an incidental modicum of that — mainly in the footnotes.

For many readers, this will doubtless still be heavy going, so I intend to produce a future more-concise version,**†** though that will probably not be freely available online.

R. R. Traill,
Melbourne, 30 December 2009.

†
PS. [added May 2014]: A more concise version *has* emerged, as a PowerPoint conference paper, (and is freely available after all!): www.ondwelle.com/MolecularScheme.ppt (also provided in several other languages, see home page). This is accompanied by notes-and-references: www.ondwelle.com/MolecularSchemeNotes.pdf .
The notes give more recent references — especially the following, which demonstrates that axons *can* transmit infra-red, as predicted!
Yan Sun, Chao Wang, & Jiapei Dai (2010, Jan). "Biophotons as neural communication signals demonstrated by *in situ* biophoton autography". *Photochem. Photobiol. Sci.*, **9**, 315-322. —
http://static.shop033.com/resources/8B/13707/Other/Biophotons%20as%20neural%20communication%20signals.pdf *RRT*

CONTENTS

1. IS THERE A VIABLE METHOD FOR RESEARCHING UNOBSERVABLE COMPLEX MECHANISMS LIKE THE BRAIN?

Could anyone work out *the full operating details of how any piece of advanced modern electronics works* — starting from scratch, with no manuals, teachers, or special training? (We might allow a library of standard "basic science-theory" books, but nothing directly applicable). Well, it is a bit like that with the brain-problem addressed here. In both these "black-box" cases we do know that the brain-or-equipment system *can* work well, so *there must be some secret techniques to be discovered*, (even if we doubt that we could ever actually solve these technological enigmas on our own).

However the brain-problem is different in two overall respects apart from complexity: It is ***more difficult*** in that we don't really have any clear idea of what the most-basic components or internal "strategies" might be, so it is difficult to know where to start if we want to be thorough. (It is that "nettle" which the present project has been trying to grasp).

On the other hand, this brain-detective task is made ***easier*** when we accept that nature is uncaring and often unhelpful, so any surviving systems must be largely *self-organizing* — and that fact *considerably narrows the field* of feasible systems worth contemplating. Thus within the somewhat better-understood bio-studies of histology and embryology we are beginning to see • *that* micro-components move neatly into place — and to have some ideas about • *what drives* such movement and specificity. E.g. see examples of computer-modelling with histology-like outcomes (Goel, *et al*., 1970; Goel & Leith, 1970).

Here we see the influence of *energy-levels* inherent in various competing biochemical-and-microanatomical configurations, and (as in immunology) there is also *specificity* arising from "lock-and-key" codings at the molecular level. Many such details have yet to be uncovered, but they do tend to explain a trend toward whatever counts as "equilibrium" within the given temporary setting.

In life though, new equilibrium goals are always being re-set as part of the macro-activity of the creature concerned; so it becomes pertinent to ask: ♦ *"What set-of-micro-mechanisms will prompt the decision for such-and-such macro-effects?"* — ♦ *"How is it decided to send what coordinated-set of signals which reset those local goals (to achieve the macro-goal)?"* — ♦ *"How exactly are these signals delivered in a meaningful way?"* — and ♦ *"How are such abilities learnt in the first place anyhow?"*

Such questions suggest the need to pay particular attention to • **I**nformation **T**echnology (IT) if only to assess the signal-volume and carrying capacities needed; • the Physics of communication (more complex than usually supposed, due to inductance-and-wave effects); • Cybernetics (in its original meaning of *the study of self-organizing-or-stabilizing systems*); and • Epistemology (the study of knowledge — what it is, how it might be stored-and-retrieved, and how it might be acquired).

Yet hitherto the emphasis has been elsewhere, guided more by what was most easily **measured**, or **explained to funding bodies**; and while that has clearly led to some progress, it may now be timely to diversify our attack on such a demanding problem.

Let us start by considering the task afresh from two contrasting *general* approaches; — both seeking to model-or-understand the middle/central activity of dynamic reality, but tackling the task from two different directions: from *above* (concentrating on the whole system), or *below* (concentrating on the supposed basic components and how they interact):

1.1 The Bottom-up approach — for explaining mystery systems

One obvious technique is to take things apart to study them; (or, if possible, peer into them while they operate). For this we use microscopes, probes, and any other available instruments which seem helpful. *This supposedly leads us to a view of what the fundamental elementary-parts of the system might be*. (This is not always as obvious as it seems. E.g.

What are the *basic* units of a car? — Maybe (i) Its major subsystems such as "fuel-injection" and "steering"? — (ii) Its parts as listed in the catalogue? — or, if we also take *those* apart: (iii) All screws washers and wire-strips etc? — or (iv) All the molecules? — and so on!).[1] We next tend to form predictions of how these components might operate in ideal isolation-or-controlled-conditions, and then see if we can fit these "jigsaw pieces" together to reconstruct some collective dynamic systems — perhaps predicting that they will be relevant in such-and-such a way.

Meanwhile it is proper to test these various predictions EXPERIMENTALLY; and if they fail, it is rational to abandon at least some aspect of our model, and try again — as in Darwinian trial-and-error. It is less clear what to do if one's lab-work is mainly descriptive, and hence too vague about *real functions* for us to make any useful definite predictions! However, supposing that is not a problem, let us proceed:

It is perhaps significant that this procedure resembles the traditional deductive reasoning process of starting with certain axioms (seen as "rock-solid elements", at least for the time being); — and then hoping that some infallible line of reasoning will lead to a single clear solution. That might be fine for ideal cases of Aristotelian logic, but even a perfect mathematical formulation is likely to offer *multiple solutions* (as with the three solutions for "x^3-2x^2-5x+6=0") or indeed an infinite number of solution (as with "sin(x)=0.5") — and such multiplicity amounts to gross ambiguity if one is seeking some unique truth such as "how the brain would react in 'this' given situation".

In any case, whether we realize it or not, we will often have some trouble in identifying which "sub-items" should be considered as the "jigsaw pieces" that we should try to re-assemble, (supposing them to be structurally or causally relevant). As a medieval physician, I might have made much of the then-recognized "elements" such as bodily fluids and excretions — plus gross anatomical features — and the phase of the Moon! Some of these might even be vaguely relevant, but the unforeseen discovery of bacteria in the 1600s and viruses in about 1900, would later show any such medieval research to be largely ineffectual *even if it had observed impeccable modern test-procedures to analyse the available empirical concepts*. Of course the main difficulty was that the most crucial basic elements were quite undetectable in medieval times, and were only manifested by their perplexing *effects*. Eventually detection did become possible; but *could we today* cope with a similar situation where *such direct evidence* is forever beyond us, for whatever reason?

1.1(a) Or another way of viewing this *Bottom-Up* difficulty:

It is difficult to tell when our analysis has indeed reached "bottom" — where we have supposedly found items which are either indivisible (as atoms were supposed to be), or which can be treated that way for most practical purposes. (Such examples would be atoms as we know them today, or else molecules of a fairly stable compound such as a rock mineral). But then the breakdown in these approximations give us whole areas of study in their own right, so then "bottom" becomes ambiguous — and some might say forever beyond our reach. — An infinite regress[9] which carries our benchmark level with it into infinity!

Nevertheless, the approach does work reasonably well when we can find a situation with • reasonably stable items, • with not-too-many varieties (e.g. 100 chemical elements are manageable), • a moderate number of discoverable rules about how the items interact, and • a moderate number of solutions which are statistically probable (even if many others are mathematically possible). Clearly chemistry fits that description, and so does much of physics and engineering — but for the Social Sciences the situation is usually very different. (There even statistics has great problems due to local diversities). So what about Biology?

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[1] This is a weakness in the logic which often goes unrecognized. If we believe that "seeing is believing", and we *see* what *seem to be* the fundamental units (but fail to see other units because they are too small or otherwise invisible), then our "logical conclusions" could be unreliable.

Of course, provided that we recognize this ambiguity, we will organize our textbooks and manuals to deal with these stages in a separate-but-ordered way, consigning the molecule-level to books on chemistry and metallurgy etc., and writing quite different accounts for the workshop. Meanwhile the danger occurs wherever we fail to notice the possibility of other meaningful levels; — and the present project suggests that neurophysiology has indeed failed to consider alternative subunits.

That is arguably borderline, though it will depend on how micro one is prepared to go, and whether one then finds suitably semi-stable elements, etc.

$_{1.1}$(b) Prediction versus Explanation.

Before looking at the alternative (Top-Down) approach, let us take stock of one aspect of our analytic activity:

Precise prediction is impossible except in strictly-controlled digital systems; and the more complex and heterogeneous the system, the more it will be unpredictable. (Moreover even those ideal digital systems will still defeat our own powers of prediction unless we know every detail of their makeup and input patterns, *and* unless we have the independent ability to replicate all the system's activity ourselves, and do so faster than the system itself.)

Systems which are not ideally digital will always face "decision events" where they must choose between alternatives, and this choice will usually depend on some random element even if that effect is only indirect. That does not necessarily rule out prediction altogether, but such predictions should now include an overview "Meta-Level" comment (ML) on the probability of error — (and preferably also some MML indication on how reliable that ML error estimate might be!).[2]

That works admirably for systems which can be re-run multiple times, especially if we are really only interested in the *mean values* and their *standard deviations*. Likewise if we have a vast population of closely-similar elements acting largely independently — *e.g.* with gas molecules moving freely-and-randomly within a container, for which we can obtain an almost completely-exact *statistical* figure for the resultant pressure; (Maxwell, 1860, 1868).

In the social sciences, such precision is quite impossible (despite any delusions to the contrary); and we might have our doubts about it within biology, though we can find ourselves considering large populations whose members may be sufficiently similar.

Now, I mention "prediction" here mainly because its weaknesses have been used as a whip to chastise those who dared to dive deeply into possible submechanisms.[3] Despite the criticism, any reasonably-reliable prediction can obviously be useful *insofar as it is obtainable at all*; and to that extent I am sure most planners will continue to seek its meagre powers. However that is a matter of Technology or *Applied* Science — trying to *make use of* our *already-achieved* models of the world.

Instead of such formulaic application, my concern here is with the previous step of *seeking to construct those models* — to ***explain*** — to enable us to *understand* that world — and *maybe* that will indeed have no actual predictive use at all. Yet we may wish (e.g.) to know in retrospect where we went wrong in the past, or why Fred (or Joan-of-Arc) had hallucinations, or what exactly killed so many obstetric patients in the 1800s (see below). And who knows, maybe such explanations could *then* be applied to help prevent some mishaps in the future, even if we cannot predict much about what those advantages might be.

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[2] Here "Meta-" effectively means "overview of…". This overview concept is based on Ashby's (1960) book *"Design for a Brain"* in which a simple homeostat-or-thermostat mechanism "*L*" (with pre-set fixed parameters, and interacting with the outside world) can be turned into a device possessing a modicum of **intelligence**. This is done by firstly adding another such device ("*ML*") as a "supervisor" (which has no direct contact with the outside, but instead has the task of re-adjusting *L*'s parameters in the random "hope" of improving overall performance when needed).
Secondly, in a similar way, *ML*'s performance can also be monitored by some *"MML"* device; — *and so on!…*, provided that such extensions remain (i) feasible for that species-or-technology, and (ii) effective in improving performance. If Ashby was right, then this ability to keep adding Meta-Levels seems to be the fundamental basis for human intelligence — and much of the "Stream 1" of this project depends on that concept as complementing Piaget's theory of "stages".
Moreover, this approach has bearing on both *Brain Theory* (our subject of study), and also *Scientific Method* (a tool of study) — which is concerned with the intelligence of Society-as-Such. See Traill (2008a/2005b: www.ondwelle.com/OSM02.pdf , especially Table S on page 31).)

[3] I previously undertook to write a critique of this attack on such "reductionism". That task is still on my agenda, but it is not my top priority. The essay, *if-and-when it appears*, would be available as http://www.ondwelle.com/OSM07.pdf . See footnote 12 for further comment.

Then again, if nothing else, it is an aesthetic, pedagogical, and cultural advantage just to have a *coherent and reasonably complete account* of what makes the world tick! — and maybe that applies even if we have to admit that *Part X* of our model is only provisional.

1.2 The Top-down approach — for explaining mystery systems

If we are only interested in a single "Solution Z", then that cuts out much of the complication due to multiple possibilities. E.g. we might identify our sole concern as "brain-systems as they **actually are** (as best we know them, given all the evidence)", and not any "might-have-beens".[4] There is then no need for the hazards of general prediction — except as a means of *back-checking* the plausibility of various substructural explanations:

This time it is up to us to *invent-or-find* candidate components which might explain the macrophenomenon; — and these components might include: • solid "bricks", • influence-links between them, • continuous fields capable of generating digital effects such as threshold-boundaries; and • established global laws (of physics, etc.)…

Given these *hypothetical* "jigsaw pieces", it is then our task to try to fit them together into a workable facsimile system, but this time the testing happens away from the lab, THEORETICALLY, as a *test of coherence* which should include the *back-checking* considered two paragraphs ago.

This is "reverse engineering" — looking at the working system and trying to decode its underlying secrets via inventive re-design. (Unlike 100% invention, we do know in advance that there is a conceptual solution to every such problem, even if we lack the means to replicate it — and such reality-guarantees offer considerable encouragement to the researcher). But either way, the procedure does involve some significant "leaps of logic" which seem closer to a *Darwinian genetic-mutation-plus-selection* rather than the supposedly tidy philosopher's-logic of Bottom-Up.

1.3 The need for both "Top" and "Bottom"?

Do you walk with your right leg? — Or do you walk with your left?!

Without being quite so extreme, it does seem that we need both Top and Bottom principles to guide us in most real cases. If we start by modelling the supposed elements as a **Bottom-Up** exercise, we could arrive at a near-infinite number of conceivable outcomes (as we saw earlier). Of course we may be content just to accumulate data without managing to make much sense of it; (and that can unfortunately be our lot whether we like it or not!) But if we are to make any genuine progress, we have to consider the various *collective arrangements* of the elements and their established micro-properties, and pre-assess them for their macro properties of coherence and similarity to reality. — And that all looks rather like a series of belated Top-Down approaches tacked onto our supposed agenda. (If nothing else, it serves as a compass to guide us through the maze of possibilities).

Or suppose we start with a **Top-Down** question such as "What causes infectious disease?" — Dr. Ignaz Semmelweis made a good practical start in 1847 by showing *experimentally* that infection decreases when surgeons wash their hands properly; but this finding had little impact until Pasteur demonstrated that the basic elements were bacteria — and not the miasmas (foul odours) as had been generally assumed.[5] (Both hypotheses were worth considering when no-one really knew, and maybe other suggestions could also have been plausible. Indeed multiple-causation should have been taken seriously — but instead there was an arrogant pro-miasma certainty amongst the "experts" which was downright unhelpful).

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[4] or (say) the single ***x*=3** solution to our above equation x^3-2x^2-5x+6=0; (ignoring the other possibilities x=1, and -2).

[5] even though the existence of *micro-organisms* had been recognized since the 1600s! — (as noted above on page 4).

It might be an interesting exercise to see how far one might be able to argue for the bacterial model *if there were no way of detecting them directly*! Could one speculate credibly on such matters judging only from (i) careful observation of macro-phenomena, and (ii) background knowledges of various interdisciplinary types?
I shall leave that question open — though of course it closely parallels the title of this main section, viz. —— *"Is there a viable method for researching unobservable complex mechanisms like the brain?"*.

I will return to this parallel issue regarding the mind/brain, where the elements are still debatable at best. Indeed these Brain-Studies still lack the equivalent of a Pasteur who could directly demonstrate its fundamental secrets via laboratory-work — and thus, by default, the field is left open to the *theorists* (who we hope will be adequately informed!):

2. The Pre-existing Background

2.1 Psycho-Mechanism Theories in the early 1970s

● Within academic psychology, inflexible *positivistic* and *behaviouristic* doctrines still ruled supreme, tending to look askance at theories which lacked direct testability via approved experimental processes. ● Meanwhile there were certain "solid" ideas about neurophysiology (see below), still revelling in its achievements such as synaptic-mechanisms and therefore not keen to consider variant possibilities. ● Feeding off that was the growing interest in "Artificial Intelligence" — clearly of interest, but only dubiously related to real holistic bio-systems (our main concern here). ● The postmodern revolution had not yet hit Science, and some might claim this is still true; but *postmodernism* (revealing long-hidden shaky assumptions) was nevertheless "in the air" after the Paris student riots and the "Prague Spring" of 1968.

● In 1967/1971, Piaget's "*Biology and Knowledge*" had offered a more matter-based approach to brain theory (also well based in epistemology and other related philosophical issues), but it was somewhat vague and thus lacking in practical leads — perhaps partly in recognition of the prevailing unsympathetic climate. Piaget himself reached the age of 80 in 1975.

General readers (including most anglophone philosophers) knew very little about Piaget's most fundamental ideas on epistemology — those enigmas discussed above (asking "how is basic learning even possible?"). If the public was aware of his work at all, this was-and-is usually confined to his secondary analysis in terms of "Developmental Stages" and their likely unquestioned application to *practical teaching*.

● There had been considerable interest in experimental evidence that RNA-concentrations altered during learning (plus other variations on that theme), though there was no respectable information about *why* this occurred. At that time it was assumed (i) that any extra RNA like this could only be useful if it coded for protein-production. (ii) and that this could only contribute to memory if it somehow affected synaptic mechanisms). Evidently that total scenario of (i)+(ii) did not fit the facts, so the RNA idea was starting to fade away. Meanwhile no-one seemed to ask whether the two assumptions might be suspect — nor what the observed RNA changes could possibly tell us. Anomalies can be informative, but this opportunity was overlooked.

2.2 "The Schème" as the abstract candidate for "Basic Element of thought"

2.2(k) History of the "schème" concept.

I have discussed this history in detail elsewhere online (Traill, 2008a, Appendix to Part 1, pp.21-22: www.ondwelle.com/OSM02.pdf). Suffice it to say here that it may be traced to Kant, and was gradually introduced into psychology by Piaget, starting in about 1923. All such earlier treatments have taken the “schème” as an *abstraction*; but my concern has been to work out what *physical properties* it must have, and hence try to identify what it consists of in *material* terms. I believe each schème is, strictly speaking, *an orchestrated collection of (cloned?) coded-elements.*[6] Hence I have proposed the extra word “taton” for such individual elements (seen functionally), though we might also later identify them biochemically (e.g. as ncRNA molecules).

2.2(l) Hints at 1D (one-dimensional) importance.

It was *the apparent lack of reliable 1D memory-coding in the brain* which originally inspired this present investigation. That “minor anomaly” of the absent 1D string (taken alone), may seem a rather weak excuse for an investigation — though perhaps it is sufficient that *any* anomaly raises awkward questions, big or small, and that these questions sometimes lead to new candidate insights. Anyhow here the anomaly involved contradictions about whether the brain can-or-does organize activities into *tidily-ordered sequences*. — That probably requires the ability to organize event-codes into neatly-ordered *1D strings*, and to some considerable extent (even though it has long been know that there is *also* an inbuilt 2D mapping).

Both abilities are part of our everyday existence. 2D and 3D are obvious configurations (at least to us adults), but we just as constantly use 1D when we talk; — and as I write this text I am constantly plagued by the need to re-formulate multidimensional concepts into the standard 1D format of commonly understood speech. But *if indeed* the only coding units within the brain were those neurons and their synaptic connections, *then* the prospect for the 1D alternative would seem poor:

In principle, neurons *could be* organized into linear sequences, *but* (i) no-one seems to have observed such specialization; (ii) the usual abundance of their dendrites seems to run counter to this requirement; (iii) so does their apparently floppy organization; and (iv) it looks wildly inefficient to be using such complicated structures to embody much simpler digitally-functioning base-units. The only known plausible alternative seemed to be linear *molecular* strings — “RNA-like”[7] (especially considering the independent evidence supporting RNA-involvement, see *page 7* above).

2.2(m) A similar-but-independent concept within philosophy — Fodor’s “LOT”

The philosopher Jerry Fodor (1975) argued strongly that there must be some internal brain-language or “**L**anguage **O**f **T**hought” — distinct from any learnt social language like English. That offers an interesting semi-corroboration to the Piagetian idea of 1D scheme-encodings, but without any of the biological accoutrements.[8] Thus he has no clear answer as to how such abilities might evolve or be embodied, nor does he have any convincing solution to the problem of infinite regress[9]. Within philosophy though, it does

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[6] Why this orchestrated *ensemble*? Well, any single encoding would be much too vulnerable to corruption, and anyway that seems to be the way that nature does things at chemical/molecular level — with crossfeed signals to ensure sufficient unanimity when appropriate; (Monod & Jacob, 1961), and as depicted in BruMon#15 (1976b/2007: www.ondwelle.com/OSM05.pdf), *fig.(v)b*.

[7] Other stringlike “RNA-like” candidates have been considered; viz. DNA, PNA, and protein — (Traill, 1999, §2.1[c], p.12).

[8] This serves as another example of the unfortunate failure for some disciplines to intercommunicate. Philosophers never seem to mention Piaget’s deep-epistemological agenda, indeed they rarely even mention him at all; while scientists are often unaware of developments within areas like philosophy.

[9] The “infinite regress” problem runs roughly like this (using *size*, though one might well use other criteria):
I can understand things on a ***1Km*** scale due to my knowledge of ***1m*** systems and how to deal with them;
I can understand things on a ***1 m*** scale due to my knowledge of ***1mm*** systems and how to deal with them;
I can understand things on a ***1mm*** scale due to my knowledge of ***1μm*** systems and how to deal with them;
I can understand things on a ***1 μm*** scale due to my knowledge of ***1nm*** systems and how to deal with them;
I can understand things on a ***1 nm*** scale due to my knowledge of ***Åu*** systems and how to deal with them;
I *will* understand things on an ***Åu*** scale when … … … and so on — ***without end!***
As they are seeking (unattainable) perfect foolproof logic, philosophers can find no acceptable escape from this paradox. However if we are prepared to take a small leap of faith by using coherence-testing to close residual logic gaps, that will often

mark a significant development over previous tendencies to claim that thought was only possible once one had acquired a social-language (despite the fact that dogs and one-year-old infants show distinct evidence of thought).

He has recently published another book on the same topic, (Fodor, 2008), popularly known as "LOT2". Judging by the online reviews it may be more readable, but it seems to have nothing new to say on biological matters.

2.3 Middleground — Taking Stock before proceeding

2.3(n) Psychology-centred works within the present project

As already noted, it was such cognitive mind/brain-problems which inspired the project, so here is a summary of how the direct investigation progressed. Note that the original *essential arguments* are mostly contained in four in-house departmental publications in the "Brunel University Cybernetics-Monographs"[10] series, though these same themes are elaborated in much more detail in the other works.

Note too, that there was also an early "fork in the road" to follow *parallel-but-different problems of intercommunication*. That unforeseen side-issue turned out to be of considerable interest in its own right, so it will be dealt with separately in the "Stream 2" section, starting on page 14.

bypass this obstacle. Of course we will occasionally be wrong, so we should avoid any arrogant certainty; but such human-like fallibility is arguably better than unproductive rainbow-chasing. (We can't always have a firm authoritative reference-point, as Newton showed us, and yet the Solar system does seem to function as a coherent ensemble.)

[10] here identified by the abbreviations "BruMon#15" *etc.* (Other contributors to this series included: F.H.George (#1, *etc.*), — A.G.S.Pask, — and Patricia Kelly-Botting (#19).)

3. A BRIEF HISTORY OF THE ONGOING BRAIN-MECHANISM PROJECT

3.1 The Present Project, before dividing into two streams

BruMon#12 *Thinking as mental model-building* — (April 1975a, Nottingham conference)

This work (www.ondwelle.com/OSM04.pdf) proposed that:

(1) Within the Scientific community, language has only a limited rigour, which lacks any infallible base — citing Gödel and Popper. (Today we can see that this is in line with the "infinite regress" problem,[9] though without using that term). Hence we need some way to "bootstrap"[11] our stock of knowledge, starting from next-to-nothing.

(2) By invoking Piaget, we can make a similar case regarding the individual, but meanwhile augment Popper's (1972) "three worlds" concept, adding (*in italics*) a transition step thus: $_1$Outside-world ‖ *input/output* ‖ $_2$Active mental attention ‖ $_3$"Models" (or "stable products of thought").

(3) Consider preset "sealed units" (schemes, structure unspecified) which • Determine Motor-activity, or • Modify sensory paths; — or, citing Hubel and Wiesel, • Recognize standard *sensory* patterns.

(4) Schemes inhabit the $_2$world , encoding activity (or perhaps "being" activity). There they tend to be destroyed-or-mutated if the effects associated with them seem noxious or unhelpful for knowledge-growth.

(5) The degree of success in knowledge-growth is gauged by how much their ensembles show "consistency or coherence or closure" during dynamic checking (perhaps during sleep[16]). Success here probably bestows inherent stability, so such concepts would become established as "Long Term Memory".

BruMon#15 *The gulf between behavioural psychology and fundamental physiology* — (1976b, York conference)

The strategy here (www.ondwelle.com/OSM05.pdf) was: — (i) not to be overly-impressed by such current fashions as computer-theory, holograms, cells-as-elements, behaviourism, or excess-empiricism; (ii) to seek relevant concepts from diverse interdisciplinary sources (to assist coherence-testing), including: physiology, physics and ultramicro-anatomy; and (iii) to propose a "mechanistic" (self-organizing) account, based if possible on discrete "reductionist"[12] elements which might enable explanations to escape from the usual fuzziness of psychological accounts.

Hence consider three interrelated types of activity (and the very different scope for testing them):
‖ (1) Behaviour (testable but…) ‖ (2) Schemes (untestable?) ‖ (3) Signal transmission, IR? (testable) ‖.
— all being on a scale from *Vague-macro* down to *Well-defined-micro*.

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[11] Computer jargon, referring to the seemingly impossible analogous task of "lifting oneself up by one's own bootstraps".

[12] Unfortunately such concepts are anathema to some biologists such as my former mentor Professor Stephen Rose (1970, 1971, 1976, 1981, 1992; Rose & Haywood, 1977). As mentioned in footnote 3, I had intended to discuss this issue in depth, but I have had great difficulty finding any *coherent explicit* statement of what the objections are (though there is plenty of rhetoric). In principle I was prepared to play devil's advocate and second-guess at the objection-details (probably based on legitimate concerns within the *Social Sciences*), but that extra burden meant that I have given the task a low priority over very many months. I have since found a new approach which might offer a framework to deal with that extra burden, so I *may* come back to the task within the coming year.
If I do, the work will appear as www.ondwelle.com/OSM07.pdf .

"(3)" takes advantage of its physics-basis to conclude: • That the most plausible signal mode between any *molecular* encodings would be via predictable types of infra-red (**IR**)[13] rather than the millisecond action-potentials suited to the much larger whole-neurons. • If so, then it just so happens that myelinated nerve-fibres could be ideal for carrying these signals (since they have just the right size and co-axial geometry) — as shown in the simplified diagram. • That could also solve several issues: 1.Giving much higher information-carrying capacity; 2.More stable signal-sources (needed for holograms to be even feasible); 3.Offering a hidden signal-pathway for any glial participation; and 4.Maybe helping to explain the mechanisms of chemical transmitters like 5HT and ACh, (offering them a possible optical stimulus component).

One objection is suggested by the existence of rival action-potentials (but these are seen as compatible). A more serious objection is the very high absorbance-rate for IR within water. There are some suggestions as to how the IR could be held within the safety of the lipid myelin, including Cope's (1973) interesting hypothesis that cytochrome oxidase could be highly reflective for IR. Then again, the high absorbance outside the myelin could be seen as a blessing in disguise — damping out interference and cross-talk.

"(2)" looks into the likely "untestable" mechanics of any macromolecule strings which might serve for Piagetian schemes, offering two diagrams on how they might function as Hebb's "formal neurons" (writ small); plus one diagram on how multiple replications could be orchestrated to perform in unison; and one on possible "mutations" by crossover, to produce new codes.

As already noted, this paper marks a split in the project-treatment, with the "(2)"-line continuing on the **original psychology path** (Stream 1), while the "(3)"-line branches off into **neurophysiological novelty**, (Stream 2, p.14 *ff*).

3.2 STREAM 1: Further work on the Brain-Coding Question

The two papers in Kybernetes (1976a and 1978a)

These also re-appeared as "Part A" (www.ondwelle.com/Mol-Intel-A.pdf) of the subsequent thesis (pp.22-47), and they are summarized on page 3 of www.ondwelle.com/MolecMemIR.pdf, the online version of "Part B".

Together they constitute a much more thorough account of the above-mentioned issues regarding • Scientific Method and • relating to the "Linear Micro-element" theory of how memory-for-intelligence might be encoded (as in the preliminary concise monographs BruMon#12 and BruMon#15) — with the extended collective references now in www.ondwelle.com/Mol-Intel-Refs.pdf . (However those earlier monographs tend to be more comprehensively illustrated, and they are perhaps more readable).

BruMon#18 "*Short papers and letters*" — (1976e)

This www.ondwelle.com/OSM06.pdf is a compendium of minor works from the mid 1970s, mostly illustrated, expanding on the **1D-coding** theme. Thus: —
(Chapters **I** and **VI)**: The *development of OBJECT concepts* using 1D elements, suggesting and illustrating the likely mechanics of a Piagetian approach to this enigma, based on schemes associated with physically tracing the geometry of objects. **(II)**: Extending this to "*Self-construction of PERSONAL IDENTITY*". **(III)**: A letter definitively assessing the arguments *for-and-against the "linear micro-element" model* for memory (and now in 2009, updated with preface-notes on the then-unforeseen Darwinian implications).

There are also chapters on Scientific Method: (V) Distinguishing between *mere passive* reception of data (camera-like, and unproductive cognitively), versus *active involvement* similar to Piaget's formulation[17] for individuals. (IV and VII): Post-conference correspondence on peripheral issues. An ordered list might be convenient:

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[13] The IR issue is discussed in more detail in the parallel longer version in *Kybernetes* **7** (§A3.3), see the next section here below; — and in much greater detail in later works, q.v.

Chapter I: The development of object concepts [using 1D elements], (La Trobe Conference August 1975); pp5-10.
Chapter II: Extending this to "Self-construction of personal identity", (same Conference); pp.11-13.
Chapter III: "A defence of the linear micro-element"; (Letter September 1975); pp.14-17.
Chapter VI: [further development of *Chapter I*'s theme], (York Conference April 1976); pp.25-32.
Chapters V. Scientific Method — the 'camera fallacy' [vs. *active* perception], (York Conference); pp.21-24.
Chapters IV and VII: Other issues in Scientific Method, (post-conference correspondence).

Part C of Thesis: Application to Psychological reality

Chapters[14] **C1-C2** recapitulate issues already raised here: coherence, Piaget, 1D coding — plus hierarchies of control (as in §(h) (3) above), for which the M^0L, M^1L, M^2L,… notation is now applied.[15]

C3 considers schemes which supposedly act internally on other schemes, offering *introspection and hierarchical control*, thus enhancing adaptability and hence intelligence. That then raises the question of *recursion*: — whether essentially the same mechanism can be re-applied repeatedly for each level of the hierarchy, with *no need to redesign each* new level — and how many hierarchical levels this might support.

C4 outlines Ashby's (1960) application of this idea to simple homeostats, leading to simple-design robots with uncanny abilities. (Yet these did not satisfy Ashby himself because they were not sufficiently self-organizing: *He himself* had done the basic design, and adjusted the parameters until the systems worked).

C5 sets out to integrate the two approaches: the Piagetian 1D schemes yielding "developmental stages", plus Ashby's hierarchies — the one starting with manifest behaviour, and the other with basic elements. After some detailed discussions, it ends with suggested resolutions to Ashby's self-criticism, thus offering a plausible blueprint for a biologically viable "human" system which seems compatible with Piaget's formulations.

C6 sets out to consolidate these ideas in broader terms, such as seeking to make some sense of well-known-but-vague psychological concepts such as "attention" and various Freudian terms. It likewise considers non-obvious concept-organization tasks we need to master for normal social life, and the danger of psychosis etc. if we fail. The significance and nature of *sleep* is also discussed.[16]

C7 interprets *neuroses* on this basis, while **C8** seeks to explain *psychoses* using the same model.

"Thinking by Molecule, Synapse, or both? From Piaget…to…ncRNA" (2008a/2005b)

This paper (www.ondwelle.com/OSM02.pdf) is the most recent exposition on the topic to date. Sections **(1)-(8)** cover territory now familiar perhaps to the currently-attentive reader, but with updated references and frequently in greater depth. (A major task here was to marshal and tidy Piaget's insightful-but-disorganized ideas about the schème and its applications — as set out in his epistemologially-directed book *"Biology and Knowledge"* 1967/1971[17]). The remaining sections enter new territory:

[14] These five chapters are all available within www.ondwelle.com/Mol-Intel-C1-5.pdf (with the references in www.ondwelle.com/Mol-Intel-Refs.pdf), — or via http://hdl.handle.net/2438/729 for the whole thesis. The later chapters are at …/Mol-Intel-C6.pdf, …/Mol-Intel-C7.pdf, …/Mol-Intel-C8.pdf — respectively.

[15] This is expanded upon in what follows, but a preliminary explanation (based on *footnote 2, p.5*) might be of some help. Thus: —— *L*="$\mathbf{M^0L}$" (the base-level, dealing with real world), — while the Meta-Level is labelled by *ML*="$\mathbf{M^1L}$", —— then *MML*="$\mathbf{M^2L}$", —— *MMMMML*="$\mathbf{M^5L}$"…, etc.

[16] Sleep — a topic which was later elaborated further along with the nature of humour, (1999), §8.6 — both being seen as an integral part of coherence-seeking.

[17] In fact there was also a sequel-book: (Piaget and Inhelder, 1968/1978: "*Memory and Intelligence*"). Until recently I was unaware of its relevance (augmenting the case for Piagetian views on knowledge-acquisition) — though the book does not seem to offer any radically new ideas. However the following extract from the conclusion adds force to his acknowledged viewpoint about the need for **active** perception:

§**(9)** • reviews the 1960-1980 rise-and-fall of the notion of RNA-as-a-memory-base (then assumed to be synapse-related); • speculates on the reasons for that decline; and • indicates why that dismissal may have been premature — given the possibility that RNA might encode *in its own right*, (independent from any direct involvement with synapses).

§**(10)** points out the need for •*"**Verbs**"* (as well as "nouns") — i.e. • ***Action codes** implying a 1D time base*, (versus "building plans" implying static structures in 3D space) — or put differently: • *Effect via an **intangible** "telephone message"* (versus a sometimes cumbersome "bricks and mortar" process requiring a ribosomal "factory" and possible delays pending the arrival of raw materials).

This distinction then offers COMPLEMENTARY ROLES for • "junk" **ncRNA** which does **n**ot **c**ode for protein production, *but may be able to gate quantum-signal-traffic* in real time, (versus **mRNA** which *is known to* relay blueprints for lumpy protein structures in 3D space, which then often use their 3D shape for selective quasi-static identification as "lock-and-key" coding). Thus we have "*verbs*" of fleeting **t**ime-codes, and "nouns writ as **xyz** sculpture".

§**(11)** Astoundingly it now turns out that some **97%** of the RNA produced is actually ncRNA! (Mattick, 2001, 2003, 2004; Mattick & Gagen, 2001). — That raises the question of what tasks this great abundance of ncRNA might be serving; and given the fact that the above theorizing had predicted "linear micro-elements" for memory back in the 1970s, there is one very obvious answer for at least some of that 97%. (Not quite a fulfilled *Popperian* prediction, but almost, and at least another significant move in that direction).[21]

Meanwhile it also transpired that some of the RNA codes only work properly when they are "*edited*" (Levanon *et al*., 2004) — altering some nucleotides within RNA (typically **A**denine-to-**I**nosine) — and that some of these changes have psychological implications, e.g. relating to autism or schizophrenia; (Mattick, 2004). (Not quite the "mutation by crossover" predicted in the *BruMon#15* (Traill, 1976b/2007) discussed above on page 10 — but something offering a similar effect).

There have been at least seven suggestions on how these ncRNAs might be serving as regulators, including control of: •mRNA, •mitosis/meiosis, •precise-structure,[18] and now (as "tatons" underlying Piagetian schèmes) •memory, and indeed the spontaneous actions which precede memory.

§(**13**) Points out that such regulation could be useful in adjusting the stability of schemata as candidates for "Long Term Memory" status; and §(**12**) briefly argues the case that IR communication will be necessary (see above, and below in "Stream 2"). — §(**14**) suggests the value of the postulated double-system of *two* memory-types, especially *where small brains are needed* due to other constraints, e.g. in birds and in insects; and §(**15**) digresses into a side-issue.

The Supplement (pp.27-34) starts by listing "eight key defining-notions associated with the Piaget-orientated view of how the mind/brain operates" — of which only the last one need concern us here: — *"(H) The brain is one 'epistemological system', but there are others…"*. In fact there seem to be four different types of system capable of self-assembling and remembering "knowledge" (broady defined): •Brain-of-the-individual, •Society-as-such (including "Science"), •Immune system, and •DNA-of-the-species (the classical Darwinian case).

But this leads to the key epistemological question: *"Do they all use the same basic strategy?"* Well, probably *"yes!"*, despite their often very different embodiments and time-scales. The case had previously been argued in Traill (1999, Chap.4) and Popper (1975) after suggestions from Jerne and other immunologists, and is now represented as "Table S" within this supplement (p.31).

> "…most psychologists *believe* … that most reality is … organized in a form *directly accessible to the subject, who has only to open his eyes…* to grasp that organization and become moulded by it… " (p.400; *my italics*).

I would like to think that *psychologists* now know better; but clearly other people do not.

[18] Also this structure-control might be assisted by optical interference (Traill, 2005a: www.ondwelle.com/OSM01.pdf , and 1999: "*Book A*", chapter 7); — and see below.

If they *do* all use the same basic strategy, then that has the important implication that, whenever we manage to explain an enigma in one of these domains, that same explanation has a good chance of applying to the others unless there are specific local obstacles. E.g.(i), it is now well known that the DNA genetic-code of a species "learns" about how to deal with its environment through a Darwinian Trial&Error process — therefore it is likely that each one of the other three domains uses this same strategy, at least during its start-up phases; (see row 6).

E.g.(ii) is central to Piagetian "scheme" theory: For all the domains *except the brain*, we now know that they depend heavily on string-like 1D coding (see row 2) even if they also use other modes such as 2D, so that is a strong hint *that the brain would also* be dependent on 1D coding. Moreover other advantages are also pointed out on page 34: *"…1D codings have some intrinsic advantages when it comes to: storage, simplicity, duplicating, active 'read-out', adaptability-as-substructures, and as a means of coping with sequencing and exhaustive-searches."* (Also see "1D" in index of Traill (2000)).

A less obvious issue is how one can sometimes transcend the crude Darwinian strategy, by having one domain interfere with the operation of another. Thus we humans (column (a)-or-(d)) can-and-do intervene in the genetic code (column (c)) yielding those controversial "genetically-modified" agricultural products — deliberately designed and arguably part of a *Lamarckian* process.

A more subtle variation of this is to consider the various mental levels in the Ashby/Piaget hierarchy as being separate epistemological domains (like the four separate columns in Table S). Thus if level M^2L resets the parameters of M^1L, then it is (at least in some respects) interfering in a different domain — hence offering a measure of *"Lamarckianism"*, or *"deliberate design"*, or indeed *"intelligence"* (and after all, that explication was Ashby's goal). In short, there is a case for subdividing the *column (a) domain* up into *(a_0), (a_1), (a_2), (a_3),* …etc. to account for human intelligence.[19]

Such subdivision scarcely seems possible for *the immune system (b)*, nor *the genetic code (c)*; and it is debatable just how far this intelligence-strategy has really penetrated into *(d): Society-as-such*. — Indeed the oft-recurring "stupid" disasters in world affairs might make us wonder.

Let us now go back to the "fork-in-the-road", and look at that *other* parallel investigation:

3.3 STREAM 2: Unforeseen Co-developments in Electro-neural explanation and IR

Much of this half of the project is quite technical, so one really needs to follow the links-and-references *for any full account*. Hence the exposition presented here will be somewhat brief, and it might be convenient simply to take the claims on trust until after the first reading.

BruMon#15 — (again)***: The gulf between psychology and physiology* — (1976b/2006)**

This work www.ondwelle.com/OSM05.pdf (already discussed on page 10) marked the parting of the ways into two sub-projects: STREAM 1: Psychology and Epistemology, dealt with above; and now STREAM 2: the surprising proposal that the nervous system effectively has a second extra mode of operation (in addition to the accepted synaptic world of action-potentials). — So here we change course, and *NOW* focus on the latter:— the

[19] Incidentally (though this is not our current brief): Any theorists seeking to use science &/or philosophy to support-or-attack theological postulates of ***"intelligent design"*** *of creation by some supernatural power*, might consider adding a column (e) to Table S, and thereby treat the hypothesized supernatural power as yet another epistemological domain — considered provisionally at least. If this domain were to exist, it would presumably be capable of interfering with the operation of the others — but also be subject to scrutiny regarding the rationale of its own operation as the (multi-levelled?) designer it is claimed to be.

proposed *molecular-memory with IR links*, and its likely advantages in channel-capacity, stability, and co-opting glia.

BruMon#24 — Toward…explanation of electro-chemical interaction in memory-use: …infra-red components and molecular evolution — (1977)

This key work (www.ondwelle.com/MolecMemIR.pdf) also served as "Thesis Part **B**". There are two other summaries for this work,[20] but this one may be more appropriate here. **Chapters B1 and B2** concentrate (i) on the likely basic physical-elements of memory-and-thought, postulated as being *"RNA-like" molecules* of 1D coding; and (ii) the internal *infra-red (IR) signals* likely (due to quantum considerations) to be linking these molecular sites. **Chapters B3 and B4** re-appraise the situation from a different angle:– going back to the text-book account of saltatory conduction, but suggesting that the accompanying circuit theory is obsolete, omitting some crucial features accepted by electrical-engineers ever since the 1890s. Moreover it was shown that circuit-theory was ultimately equivalent to optics if one generalizes to all frequencies, (Maxwell, 1865, 1873; Hertz, 1887, 1888); and that such optics is often the best means of approach. That clearly makes IR seem much more reasonable.

Chapter B1 looks more thoroughly at basic molecular-coding issues.

It may help here to précis the relevant paragraphs — slightly re-ordered:

(Para.2): The **physiology of psychological mechanisms** is impossible to observe simultaneously in sufficient detail. Our only hope is a *top-down AND bottom-up* approach: accept the macro-reality *AND* the available building-blocks, and thus seek to re-design realistic models ourselves:

(Para.3) invokes the above case that *the basic-elements* are 1D-codings for actions, codings which are probably molecular — hence very small, and thus allowing for massive-populations and Darwinian-Trial&Error. — (That had been *an unforeseen bonus* — an *"unexpected"*[21]).

(Para.4): However it was next necessary to check the logistical plausibility by offering technically-feasible explanations for • signal-links[22], • signal-selectivity-and-meaning; — and • code-control-and-manipulation (which is dealt with elsewhere)[23].

(Para.1): **Electrical signal-links?** Bio-electromagnetic emissions, (including IR), have been observed from a variety of sources: neural, mitochondria, mitosis, and learning.

(Para.5): Given the Para.1 account, there is now an *apparent-rivalry* between the traditional millisecond *"voltage-spike" complex*, and the *postulated IR* — though the two are actually seen as compatible, and probably interdependent.

(Para.6): The traditional millisecond "spike" seems *inefficient* for *routine* communication

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[20] Two summaries: (i) For the more relevant chapters (1-3), as pp.3-4 in the new online introduction; and (ii) briefly for all chapters at the close of Part A (www.ondwelle.com/Mol-Intel-A.pdf), p.47.

[21] Such unexpected answers have some features in common with the Popperian ideal of making a bold prediction on the basis of one's hypothesis of what is to be "expected", and then "testing" it.
Both cases make a leap into the unknown, and both are subject to some sort of "test".
There is, of course, a subjective difference involving surprise, which renders the "*unexpecteds*" somewhat less convincing at first, (though maybe they might rate at a 50% discount-of-credibility compared with the "bold-predictions").
The interesting question then is *"How should we assess the situation when new unexpecteds (each plausible-and-mutually-consistent) keep turning up within the same project?"*

[22] Here tacitly assumed to be electrical. The alternative of chemical communication would here suffer from (i) not being able to be transmitted neurally for the longer distances, and (ii) logistical problems of how sites which are (supposedly) themselves molecular, could marshal other molecules to do their bidding (and do so with enough efficiency).

[23] Thesis, Part C: (Traill, 1978) — http://hdl.handle.net/2438/729 (2 files) — *or* www.ondwelle.com (7 files).

of *coded* information with sites of sub-micron size.[24]
(Para.7): Close examination of the physics and maths of saltatory conduction[25] showed that physiologists were using only one class of solutions to the basic equations, whereas there was also another valid set of solutions which they had overlooked. This actually repeated a very-contentious debate of the 1880s regarding trans-Atlantic telegraph cables — and the double-solution finally won!

(Paras.8–11a): A look at some previous **synapse-based** attempts at solving this problem of the interface between memory and orderly transmission. At best, their results seem vague and in need of specific-or-digital guiding mechanisms *as an extra feature*.

(½Para.11b): Local **optical effects could provide such extra guidance**, and also offer a hugely enhanced information-carrying **capacity**.[26] (Here then is a second example of a bonus "unexpected"[21] — offering a bit more corroboration to the current approach.)
(½Para.12a): This "optical effects" hint (suggesting IR) is then seen to be in accord with biochemical quantum jumps associated with normal metabolism, and hence likely to be both relevant and readily available. — (Meanwhile ½Para.12b discusses *lower frequency* "microwaves", which are less relevant here.)

(Paras.13–14): preview the next chapter.

Chapter B2 : *Writing, storing, and retrieving 1D-codes on molecules?*

Still discussing "BruMon#24"

§ B2.1 a special role for IR?

(Para.1): Brains process information, some of it sophisticated, but how? All types of memory and information processing will need some form of coding, and some way of matching codes (like a lock-and-key) for selective identification.
In biological brains, selective interaction requires some matching-skill between *1D-chemical* and *electrical* activities. If this is at the molecular level, it probably implicates absorption bands or molecular bio-resonance frequencies. And —
(Para.2): it just so happens that such molecular frequencies are in the IR range ($\approx 10^{14}$ Hz).

(Para.3): So any •*1D-chemical* activity seems scarcely related to the •*traditional synaptic* system with its action-potentials; — and yet there seems no good reason why the two cannot co-exist as moderately independent systems.
(Paras.5–6): (Indeed it is possible that there may be a *symbiotic* IR component underlying the textbook "Hodgkin-Huxley" account of the chain-reaction of ion-flows; — the

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[24] That could still leave room for inefficient-but-necessary exceptions; e.g. when the two systems need to cooperate, bearing in mind that the "spike" system has a monopoly of communication with the outside world, whereas the IR system is postulated largely to explain higher thought processes.

[25] i.e. conduction of signals via myelinated (lipid-coated) segments of nerve-fibre.

[26] By now (in 2009) the power-and-efficiency of such optic signalling has become very obvious. E.g., this also offers a candidate-answer to the riddle of how the optic nerve could have enough "channel capacity" to cope with the vast amount of signal traffic from the eye which has about 100 million photoreceptors — roughly *80 times more* than the 1.2 million fibres linked to the visual cortex; (Jonas *et al.*, 1992). Certainly there will have been some pre-processing of the retinal signals, but it seems a bit incredible that this could compact the information flow eightyfold, assuming that the new output is just another stream of action-potentials. Admittedly it is now well known that there is substantial reorganization of the image-data (concentrating on outlines and contrasts etc.) and this probably starts immediately before transmission, but could that really condense the flow sufficiently? (Note especially that "reorganization" does not necessarily reduce actual "bit-flow" content: E.g. if I change my graph-plottings from cartesian to polar coordinates, I will have "reorganized" my data, but I will still have the same number of actual readings.)
Anyhow no such mystery would remain if the reorganized signals were to be newly encoded as infrared messages, which the current theory suggests as a plausible possibility. (Indeed if the wavelengths were even shorter, venturing into the visible or even UV range, the signal capacity would be even greater. I mention that because, surprisingly, recent examination of the facts makes UV etc. reasonably likely. I should spell out that there is no suggestion that any such light would be a direct re-transmission of the light originally received by the retina).

chain-reaction which explains the action-potential. That would further diminish any "rivalry".)

(Para.7): Moreover Cope (1973) pointed out that ATP metabolism involves quantum jumps of *±9 Kcal/mole*, (i.e. *0.39 eV/molecule*), corresponding to a wavelength of 3.24μm — and that is squarely within the IR range.

Still discussing "BruMon#24"

§ B2.2 Specific patterns-and-events as stimulus triggers

(Paras.1–3, +Table): IR bands likely to be associated with meaningful chemical-configuration changes) are: 1.7-2.5μm — 2.6-3.6μm — 3.4-3.5μm — 5.7-5.78μm — 6.7-7.15μm — and 10-13.9μm. Meanwhile we may need to consider the impact of disruptive "noise" from thermal radiation, peaking at about 9μm,[27] (though conceivably such noise could actually be *co-opted* by "gating" its flow, as occurs for electrons in a triode).[28]

(Para.4): More worryingly, IR suffers *drastic absorption* in watery media. See § B3.4.

(Para.5): If chemical memory is to be accessed by "label", then signal-specificity seems essential. A mere matching of frequencies would be too crude and ambiguous, so we should expect *key-like patterns* of sequenced codes in time or space, (seeking to find their matching "*locks*"). But how should these be processed, obeyed, or stored?

§ B2.3 Emission and reception of selective IR signals

SIGNAL EMISSION, (Paras.1–2, +Figure 1): Two probably-compatible mechanisms were postulated: (i) The conduction of some stimulus (such as an exciton) along the linear molecule, thereby translating the *1D-spatial* code into a *1D-temporal* signal[29] — probably orchestrated to be in unison with other such molecules, (Fig.2.3/1).
(ii) The emission of some specially shaped pulse (from whatever source) — with a characteristic fourier spectrum which might later be analysed via an optically-dispersive medium such as an optic fibre in an "inefficient" vibrational-mode, or else a rainbow-like spectrum. This "(ii)" case would probably be less adaptable, but that might make it more useful in relation to 2D activities such as those related to the traditional action-potentials — or indeed [added 2009] some of the required interaction between any IR system and the traditional action-potentials.

SIGNAL RECEPTION, (Paras.3–4): Recalling the §**B**2.2 need for "key-like" coding for selectively activating *destination 1D codings* structurally-similar to the emitters:
(Paras.5–7, +Figure 2): Two types of mechanism are offered: (a) If the correct sequence of tuned-frequencies arrives at the receptor, it will build up its successive excitation states until some threshold is reached, causing it to act. (b) If the correct *pattern* (in time *and* space) falls upon associated sites along the label-part of the destination-molecule, it would then act. This molecule would thus behave as if it were an "and-gate" in a Hebbian *formal neuron*, but now on a vastly smaller scale than any true neuron, with important implications discussed below in §**B**2.4. This 1D system would also obviously solve problems of precision and reproducibility.[21]
(Para.9): Note that the pattern which actually arrives at this destination could well be quite different from its configuration when it started, due to optical dispersion. That would usually distort-or-"translate" this "key" in transit — but in a reproducible way which could retain its specificity, whilst increasing the chance of finding a compatible random "lock" at some range or other (if that is a problem).[30]

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[27] Later discussed in detail in *Book B* (Traill, 2000, Chapter 14).

[28] However there was no suggestion as to how that might be done in this case.

[29] Note that this is analogous to mRNA translating its code (in a ribosome "factory") into a protein molecule which is a *3D spatial structure*. Here instead we have the probably *simpler task* of merely generating a 1D electromagnetic emission in *time* — with no need for any cumbersome factory.

[30] See • *BruMon#24*, (2006 *pdf* edition: footnote 4, on its page 18); — also • the present discussion of its Chapter B4, (p.1, below); and • §C6.7 of thesis (1978b: www.ondwelle.com/Mol-Intel-C6.pdf).

(Para.8) notes that the traditional action-potential system may be able to do some of these things *sometimes*. In any case, any such partnership could-and-should be mutually compatible and co-operative. In particular, the quasi-static voltages from action-potentials are likely to *temporarily affect thresholds* for mechanisms like those just discussed.

§ B2.4 The "code-writing" enigma — and its likely Darwinian solution

Still discussing "BruMon#24"

(Paras.1–2) How could new memories be written down in any meaningful way which could also be meaningfully retrieved? There seems to be no credible natural answer to the question in its present form. Thus:
(Paras.3–5) explore the logistical requirements for such real-time "transcription" (as if one were designing a tape-recorder), and conclude that these lack any credibility without active continuing intervention by deliberate designers or repairers.
(Para.6): "The alternative adopted here instead, is the **radical postulate** that incoming impressions are *not* strictly-speaking recorded at all; — they must rather operate on arbitrarily generated code-sequences, and 'accept-or-reject' these as being a proper or valuable record of the on-going situation (including both perceptions and actions)."
(Para.7): "If this proposal seems too drastic, it should be recalled that this idea has long been implicit in the Piagetian concept that all learning requires initial *action* on the part of the learner — even for such apparently passive activities as visual or auditory perception, and such initial action must presumably be arbitrary (or genetically pre-determined). (Furth, 1969)."

(Paras.8–9): Such Darwinian processes require huge populations of basic elements — probably even much more than the 10^{13} or 10^{14} which available synapses could offer, given the probable need for reliability, redundancy and precision, plus the need for "housekeeping" activities — and then the scope for massive Trial&Error on top of that. However if the basic coding is indeed mostly at the molecular level, that increases the memory capacity by many orders of magnitude, making the whole selection-arrangement feasible.
(Paras.10–11): "Thus most of the difficulties seem to disappear under the 'neo-Darwinian' postulate", with: *specific-label-code*, *retrievability*, and *action-code* all preprogrammed — and selected only if they *all* happen to be appropriate. Also, as in Darwinian evolution, it removes the need for teleological concepts, and the puzzle of how the body might have *gradualistically* evolved "high-tech" mechanisms like tape-recording.

One might now add in retrospect that this convergence of solutions was not a part of the original brief, so it is yet another "unexpected"[21] — offering more internal coherence for the whole approach.

Still discussing "BruMon#24"

Chapter B3 : Electro-transmission properties at various frequencies

§ B3.1/.2/.4 A Seeking an independent view on what signals a nerve-fibre can carry

As a cross-check, the account now starts again but this time argues *from circuit theory* relating to nerve fibres, especially the non-trivial question of *saltatory conduction*. (That is the normal mammalian procedure whereby electrical nerve-signals jump somewhat mysteriously along 2*mm* segments of myelin-insulation between "Nodes of Ranvier" gaps, instead of the primitive *chemical* chain-reaction along the surface of unmyelinated nerve-fibres.) The standard explanation is in terms of the *capacitance* of the myelin sheath conveying Morse-like blips within a DC circuit, and that is mathematically correct enough for most "reasonable" frequencies on this sort of "cable". Or so it was assumed in those days before *broadband* became commonplace in the commercial world!

The Historical Problem over High Frequencies

In the period from 1855 to about 1880, most telecom theorists took it as obvious that there were serious problems over trying to signal using high frequencies. In this, they took their lead from the influential consultant to Trans-Atlantic-Cable projects, William Thomson, who later became Lord Kelvin; (see e.g., Thomson (1855*a*, *b*)).

The difficulty was that the capacitance (*C*) between the out-and-return wires enabled the signal to leak away too much; and the closer the wires, the higher the capacitance. One obvious consequence was *attenuation*, but a more important problem lay in *distortion of the signal* eventually making it unintelligible (a "re-shaping" which one can now explain in terms of different dynamics for the different frequencies for the various Fourier components of that signal).

However that account turned out to be simplistic (even if it was an appropriate approximation for the specific commercial task of transmitting simple Morse-code signals): After a bitter controversy during the 1880s, it became generally accepted that self-inductance (*L*) was just as important at high frequencies, and tended to neutralize the *C*-problem — and of course that opened up the possibilities for those high frequencies in cables, (*and* the invention of radio as a bonus by-product! — (Hertz, 1887, 1888)).

The Same Apparent Problem within Neurophysiology

Myelinated axons seem to be coaxial cables, essentially similar to the trans-Atlanic coaxial cables. However I do not recall ever having seen a reference to self-inductance (*L*) in any relevant account written by any neurophysiologist — and (*e.g.*) that is certainly true for Rushton (1951) and Katz (1966).

Of course their concern has been with the millisecond pulses of the action-potential (and their saltatory transmission along 2mm "cables"), which have a lot in common with the *"dots"* of Morse-code (Katz, p91). So physiologists have tacitly adopted the pre-1880 Kelvin theory about cables, presumably without even considering the possibility of high-frequency signals, or what would be involved in detecting them if they were there. After all, just as Kelvin's formulation seemed fine for simple *dots* in big cables, it has also seemed appropriate for simple *action-potental-spikes* for the microscopic nerve-fibre cables — until one starts considering *other signalling possibilities* to co-exist with those dots and spikes. The question then becomes:

Is High-frequency legitimate in Neuro-theory?

I.e.: "Is it reasonable to take seriously the possibility that high-frequency (IR) signalling is transmitted along myelinated segments of axons, even though there is not yet any systematic experimental evidence for it?"

There are perhaps four ways of promoting this legitimacy idea, apart from the direct experimental evidence which might follow in due course:
(A) Appeal to *historical precedent* at a more macro scale, as just sketched above.
(B) Point to the huge contemporary advances in high-frequency (broad-band) technology, and appeal to the concept that *nature herself would not have been shy about finding-and-exploiting such technical possibilities eventually*, whether or not we were aware of those possibilities.
(C) Formal *circuit-theory calculation* of the transmission-properties of such micro-cables (and any significant difference from the macro cables which might modify the comparison); and (D) Formal investigation of the *fibre-optic possibilities* of such axons — probably viewing this as an alternative perspective on circuit-theory, case "(C)".

Of these four, case "(**B**)", (today's flood of broadband and IR-signalling) is now so salient that it hardly needs me to emphasize it further, so I will leave it at that. (Bear it in mind though, that IR-and-broadband were by no means so omnipresent back in the 1970s when this topic was being argued in the 1977/1980 paper under study here.)

Case "(**D**)" (the optic-fibre argument) emerges in the following "chapter 4" of the 1977/1980 paper, and in other works from time to time; so I will not elaborate on it here. On the other hand: Case "(**C**)" (circuit-theory) ***is*** expounded in some detail in the 1977/1980 paper's "chapter 3", so it calls for some discussion here:

Justification via Advanced Circuit-Theory (Case "C")?

The Kelvin/Physiologist circuit theory is simplistic; so my 1977 version sought to add the effect of self-inductance (L), which is vital for considering high frequencies. The trouble is that this is still simplistic in at least two respects. Crucially it overlooked the so-called "skin-effect" which alters the dynamics of current-flow at high frequencies (which alters the *effective resistance* (*R*), as well as the effects of *C* and *L*); and the 1980 edition offered a *qualitative* correction for this oversight, and this revision made much better sense!

With the benefit of hindsight, one can now *also* see: (i) That the AC theory employed was dependent on the assumption that signals were basically *sinusoidal* — something which is probably true for quantum-based IR photons, but could perhaps be questioned. (ii) Given that half-wavelength loops can-and-do come to be comparable to cable-diameters, new geometry-based effects become important (as is evident within Radio-Frequency circuit theory — a discipline which is not for the faint-hearted! — but it is applicable here if we scale the concepts down to micron levels). (iii) Some of this geometry is catered for by switching to an optics interpretation, as in "chapter 4", but the complexity remains. (iv) The history of circuit-theory development does not inspire confidence that the subject is immune from some new elaboration due to a hidden factor which everyone has overlooked so far. (In that, it begins to look almost like one of the Social Sciences, where we should *never* expect a completely reliable theoretical model, though we may have to make do in a tentative way.)

In short, any formulation we might produce here could well be accurate and legitimate, but it is difficult to know for sure until one tests it in practice. Hence its power as a tool of persuasion-from-first-principles is rather circumscribed; — useful perhaps, but in need of corroboration.

And so:

Accordingly I have now drafted a short separate paper[31] which goes more deeply into the arguments, though mostly regarding the *historical precedent*, "(A)".

However it might be seen as sufficient merely to point to the Broadband/IR/Wireless revolution, Case "(B)", as evidence for the power of IR and high frequencies in general.

§ B3.3, B3.4b: Possible "mirror" conductive-layers: their nature and implications

Still discussing "BruMon#24"

(Paras 1–2) discuss various molecular effects which might enhance reflectivity at such boundaries by locally increasing the motility of electrons. In particular:

(Para.3): Cope (1973) suggested that cytochrome oxidase might fill this reflective role — maybe even offering *superconduction* in certain circumstances! (His concern was actually with *mitochondrial* membranes, but the effect might also occur elsewhere if it exists at all).

§ B3.3b: Saltatory Conduction experiments which quite overlooked IR possibilities

(Paras 4 *ff*) — A critique of the experimental work (reviewed by Stämpfli, 1954) which had set out to show how saltatory conduction can be blocked. This had supposedly identified the *one-and-only method* for signal-transmission in-or-on myelin segments[32] but of course such experiments took no account of IR possibilities, or how to control for them.

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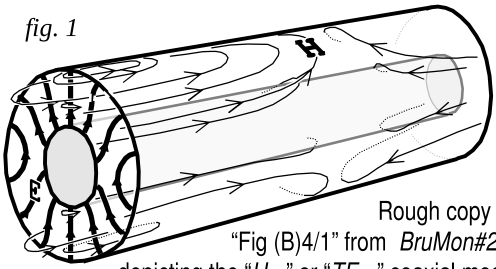
[31] When released, it will be accessible as http://ondwelle.com/OSM13.pdf

[32] Within the then-existing terms of reference, this work-agenda did evidently show that the Morse-like action-potential signals were stopped by greatly increasing the resistance of the external electrolyte. However in our new context, it is obvious that those experiments made absolutely no provision for high-frequency signals and their likely effects — especially not for frequencies in the IR range or higher. Their results are therefore of only limited validity, so the experiments should probably be radically re-thought and re-done.
In any case, they concentrated on the Peripheral Nervous System (PNS), whereas our present concern is mainly with the Central Nervous System (CNS) — and it is well known that there are important neurological differences between them. Moreover there was the criticism by Ranck (1975) that exposure to air may make important changes to the electrical properties of brain tissue within a few minutes.

Chapter B4 : *The second-lowest mode of transmission in co-axial myelin ($H_{1,0}$): optical dispersion of infra-red*

Translation through dispersion — an arcane side-issue.
Engineers usually plan signal media so that all Fourier frequency-components travel at the same speed, and so stay together in the same pattern. However it is here suggested that nature might plan things differently — allowing some pre-set patterns to alter in a predictable way during their travel. This ephemeral "translation into different languages" might give a better chance that the signal-"key" (in one of its guises) might find a suitable arbitrary "lock" *somewhere* for selective reception.

fig. 1



Rough copy of "Fig (B)4/1" from *BruMon#24*, depicting the "$H_{1,0}$" or "$TE_{1,0}$" coaxial mode

If that is viable, it might aid in solving the enigma of code-writing: —— § B2.4 within *BruMon#24*, and discussed here on page 1 above; — (a solution invoking a pseudo-Darwinian process).

In that case, it might be an advantage if conditions could allow various untidy vibration-modes within the myelin, thus producing dispersion and "signal translation" as just discussed. One such mode is analysed here with this in mind.

Chapter B5 : *Evolution of communication methods: suggested extensions to Bishop's two stages*

Bishop (1956) had argued that the much-discussed "action potentials" evolved later than "graded potentials". The new suggestion was made here, that IR signalling may well have preceded them both.

Indeed, in retrospect, we might now (in 2009) argue that this must be true for single-celled animals — if only just by default.

Chapter B6 : *Other related architecture in brief: glia, paranodal regions, and cell-body interior*

Given the possibility of IR signalling — which would presumably focus in *previously-unsuspected directions* before-and-after its travel within the myelin "optic fibre" — there is now a better case for envisaging *glial-cells* as being more actively involved in mental processes! That could help explain[21] the surprisingly high abundance of these cells.

SS&T — The case that intelligence depends on molecular codes, IR links, and myelin as optic fibre — (1988)

This was largely a re-telling of *BruMon#24* (which we have just examined), but written this time for an official journal. It recently re-appeared online (by permission) in mid-2009, as www.ondwelle.com/OSM10en.pdf . The main **new points of interest** are
• its concise listing of five clues[33] — and especially
•"C": (the literature-reports of bio-emissions) which included, not only IR, but other frequencies as well. In particular, this included **ultra-violet (UV)** whose quanta require significantly more energy — well beyond Cope's figure of ±9 *Kcal/mole* (λ=3.24*μm*) for ATP! (cited above on page 1, §B2.1). Anyhow the relevant "SS&T" comment here was:

> "Later work, [Popp et al. (1979, 1984)] has shown that coherent photon emission, from the infrared to ultraviolet, is common in active tissue of many sorts, including cucumber! So there is ample scope for such emissions to be used constructively by any species that can effectively detect them. Indeed, Konev reported that yeast cells were able to synchronize their mitosis by means of ultraviolet photons. [Konev et al (1966), and Ruth (1979)] "
>
> (Page 7 in the online version (2009/1988))

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33 Clues to the IR interpretation: A: Waveguide considerations; B: Quantum considerations…; C: Direct detection of IR…; D. "Insulation" of signal-channels; E. Size of waveguide cross-section.

At the time I was unaware of the USSR politics surrounding the UV emissions; nor did I dwell on their surprising implications regarding metabolic energy. It did seem to imply "if emissions are well documented *even for UV*, then who can quibble over such evidence for the IR?" and that was adequate incentive to re-report it. However, later we shall see that this was a bit of a missed opportunity,[34] and that there may be more to the UV than at first appears (indeed that should have been obvious, as with most anomalies).

Book A — *Mind and Micro-mechanism* (1999)
— Chapters 7 & 6: Control of Axon-geometry

From this work (www.ondwelle.com/BK0_MU6.PDF), let us focus here on just two chapters, (though others may be cited elsewhere in the present text) :

6. The Dilemma over Striking-but-Elusive Data
7. What Controls the Shape of Cells which have Impermeable Barriers?

Chapter 6 reports a chance-observation — one which triggered a whole new line of enquiry about IR and myelin. Now triggers-for-enquiry do not need to be reliable evidence — maybe just an irregularity noticed by a detective, or a dream about molecular-structure by Kekulé — and such was the case here; though it was based on lab-work which *could* be repeated and elaborated upon.

This arose from noticing the same faint non-orthodox *trend-pattern* in two published scattergrams plotting myelin thickness against axon-diameter. This suggested that both graph-plots were conflations of ***two-or-more straight lines*** *going through the origin*, rather than just the assumed poorly correlated effect around *one line* going nowhere-in-particular. Next, the "two-or-more" suggested a quantized effect of some sort, giving *multiple solutions to its equations* (like the spectral data which guided Bohr's theorizing). …

Such multiple solutions are often associated with the wave-effects of optical interference, and since the postulate of IR within myelin was already being considered, this looked like being an associated side-effect. Thus we might suppose that pre-existing local IR emissions might come to reverberate across any bounded "cavities" such as *not-yet-myelinated axons*. In cylindrical cases like this, (apart from any *transmission* parallel to the axis), there is scope for *standing-wave* components in the transverse radial directions — like those on a circular drum-skin (in 2D) — and such standing-waves can exist is several alternative patterns. E.g. seen in cross-section through the centre of the drum-skin, we could have: • the "$\mathbf{TM_{0,1}}$" mode[35] (with a single cosine-like loop between the boundaries: ▌∩▌) or • the "$\mathbf{TM_{1,1}}$" mode (with two smaller sine-like loops: ▌∪∩▌).

In either case we might expect some leakage which in favourable circumstances[36] could generate an extension of this pattern *around* the source, approximately thus: …∪|∩|∪… and …∩|∪∩|∪… — with the wave perhaps continuing (with diminished amplitude) in both directions in both cases. However the point is, that each first outside loop (as shown) may have the power to *act as a template* to define the region in which myelin may develop, and that this growth might well stop when it reaches the "moat" at the end of that first outside loop. —— (Another unexpected[21] but plausible solution).

We might reasonably suppose that it is *the energy-field within the loop* which prompts or energizes the growth until this energy falls to zero (or some other threshold minimum) as the "moat" is approached. — See pp.52-53 especially.

Note firstly that the axon itself can meanwhile be increasing its diameter as ***it*** grows in its own right. Despite this expansion, it may still find suitable (longer) ambient wavelengths at every stage to maintain the reverberation; so that the actual *shape-and-proportions* of the wave-template can be conserved, despite the ever-changing size overall! Thus the ratio:

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[34] Let us refer to this as "the neural high-frequency anomaly" — to be discussed in future publications, and having potentially important implications.[21]

[35] See almost any standard engineering textbook on cylindrical waveguides; e.g. Skilling, p.216. (Note that there are alternative names for these two modes; viz.: $E_{0,1}$ and $E_{1,1}$ respectively).

[36] These circumstances could be quite weak, and they could also be *only intermittent*. (After all, such growth could readily be *interrupted frequently* without serious disadvantage)

(myelin thickness) / (axon diameter) will tend to remain constant — hence accounting for those apparent straight lines through the origin of the scattergrams.
But secondly note that this ratio will be different for the two modes, thus yielding *two different* straight lines, each with its own gradient[37] — thus tentatively explaining the suspected new two-line pattern in the Boyd-&-Kalu scattergrams, (1973), (and replotted in this Book A: pp.40-41 — in chapter 6).

Replication of this study would obviously be highly desirable; but I was in no position to do that myself, and other similar studies unfortunately used an automated technique which lacked the necessary resolution (though of course it was adequate for their own objectives). There was however an encouraging-but-suboptimal *post-hoc verification* using *other data* (previously unpublished it seems) from Boyd-&-Kalu themselves: See Fig. 6:3 on page 42 — where the postulated multi-line trend is arguably a bit *more* pronounced!

The next step in this theoretical investigation was:–

OSM#1 (2005a) — *"Strange regularities in the geometry of myelin nerve-insulation"*

Here in www.ondwelle.com/OSM01.pdf , this *"IR as architect"* argument is taken further, applying the *interference-pattern* theory to other mysterious experimental anomalies:

Critical diameter for the start of myelination

§B5.1 starts: *"As often discussed since Duncan (1934), there seems to be a minimum critical diameter of about 1µm below which PNS*[38] *myelination cannot usually occur. For the CNS, the figure is more like 0.2µm."* Clearly, if the above wave-template theory is correct, then we could not expect myelination to start until the diameter was big enough to allow some relevant half-wavelength "∩" loop to fit into its space. For the **PNS**, the common cutoff diameter of about 1*µm* implied a wavelength of roughly 2*µm* (IR),[39] and of course that fits in with our earlier theorizing.

However the **CNS** tells a somewhat different story. Reported values for d_{crit} include 0.25*µm*, 0.245*µm*, 0.2*µm*, 0.18*µm* — and these imply $\lambda_{c,(vacuum)}$ values of 0.567, 0.556, 0.454, and 0.408*µm* — (*green, green, blue,* and *violet* wavelengths, respectively). The electro-micrographs published by Peters *et al*, (pp.279[40], 301) also reveal corroborative cases with $d_{crit}\approx$½*µm*. These observations suggest that the CNS may be doing something special[41] which involves higher-energy quanta; and perhaps that is not too surprising in view of the extra "skills" expected of the CNS.

Here then is another "unexpected[21] bonus-finding" (or perhaps two, if we consider the CNS case separately) — again offering increased coherence and intelligibility to the whole picture, even if that is not actual proof.

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37 Indeed other modes are also possible, so we might theoretically expect *a few more such lines*. However these will tend to "compete" in two ways: (i) the relevant "∩" loops need to be *short* enough (having quanta with high enough energy) so that they can fit within the current axon-diameter; and yet (ii) there will be a bias against the higher energies — for obvious logistical reasons.

38 **PNS** = Peripheral Nervous System; and **CNS** = Central Nervous System (of brain, optic nerve, and spinal column).

39 The actual formula for cutoff wavelength (in ideal $TE_{1,1}$ mode conditions), is $\lambda_c = (1.706)\cdot d\cdot(\textit{refractive index})$.

40 This photo (Fig.7-1) also shows mitochondria with diameters of about 0.1*µm*, (100*nm*). If we now extend Cope's "trapped photon" interpretation to these "non standard" mitochondria, then this might suggest captive waves of λ ˜ 200*nm* — clearly in the UV range! More on this later.

41 In fact this **CNS** situation gives us another suggestive glimpse at *"the neural high-frequency anomaly"* (as mentioned on page 22).[34]

The "Quadrant" enigma

§1 discusses a strange finding (Peters, 1964; Webster, 1971, pp353-357) — concerning the myelin-layers which are wound onto the axon (like a bandage) until the myelin reaches the appropriate thickness; (see figs.3–5). The finding was that statistically, the "bandaging" tended to start and finish within 90º of each other — for no apparent reason, and no obvious means for the outer growth-region to "know" where the beginning was now situated.

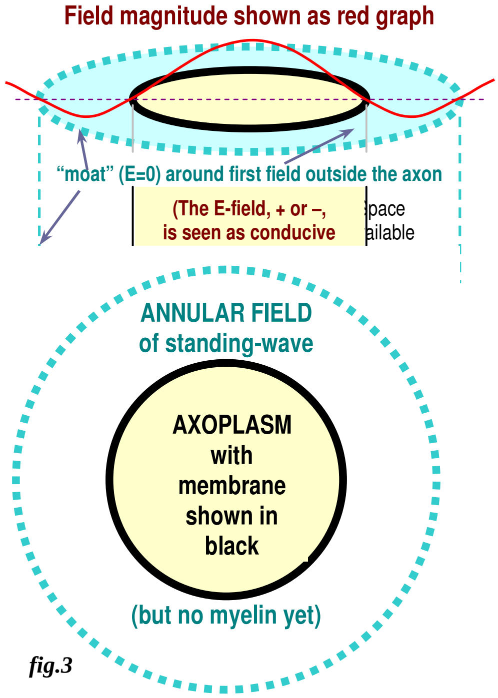


fig.3

The only plausible type of solution would seem to depend somehow on those intangible "force-fields" of physics — unhampered by most biochemical barriers or insulators — and of course that suggests the "∪|∩|∪" standing wave as a plausible framework. The diagrams show a virtual annular "∪" space (defined by the standing-wave as the growth-area around the axon, bounded by the "moat". — See *Book A* (1999, chapter 7: www.ondwelle.com/BK0_MU6.PDF).

Then the "bandaging" takes place within this space; but after 4 turns (in this simplified example), there will be no gap left — so growth will cease at about the angle where the pre-existing myelin-thickness steps-up from 3 to 4 layers deep.

Ideally that will always be at about the same angle as where the "bandaging" looks as though it began, and hence "within the same quadrant". (Actually the "start-point" usually moves, but we are concerned about *where it is when growth stops*).

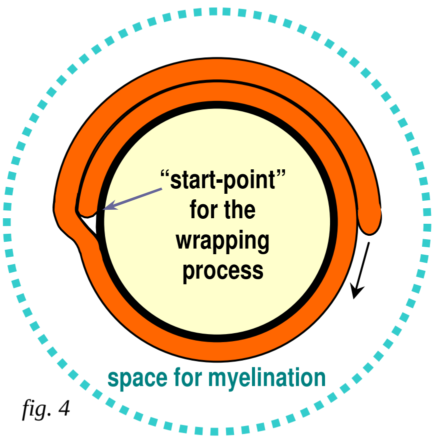
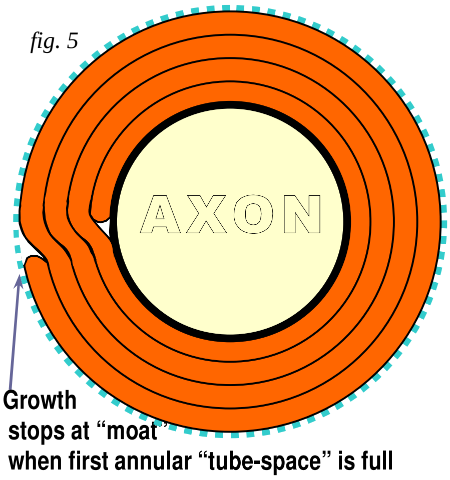


fig. 4

fig. 5


Of course that is not a proof; but by offering a serendipitous solution[21] where none other seems credible, it does perhaps serve as further informal support for the "∪|∩|∪" notion and the ensemble of other ideas and solutions which are associated with it.

Book B — Physics and Philosophy of the Mind; (Part II) — (2000)

An online version of this book is currently at www.ondwelle.com/BK1_V28.PDF .

Chapters 11 and 14 scrutinize possible objections to the IR theory

The most obvious apparent-objection is that *"black-body radiation"* will drown out any dedicated IR signals. The main counter is that it should not be difficult to employ "signal-labels" (like phone-numbers) which are *specific enough* to bypass any likely level of *random* background noise; and in any case, that noise would not even exist for wavelengths shorter than 4μm. Instead though, the real threat would come from *"cross-talk"* (messages leaking into the wrong channel). Here water's high IR-absorbance should actually help — scrambling the leaked messages, thus turning them into the comparatively harmless background noise.

Chapters 12 and 13 — Signal-control via "Labels" and "Fences"

Issues like *cross-talk* raise the question: "By what principles can the system *decide the relevance* of new-or-old data for the task in hand?" Part of the answer seems to lie in understanding two types of categorization — **intensive** (noting *its attributes-or-labels*: "Is it blue? or abstract?" etc.), or **extensive** ("Which *box* is it in?" — "What network is it 'tethered' onto?" or "Where is its name *list*ed?"). Indeed much of our mental activity actually consists of "re-filing" information on this basis — e.g. using *intensive definitions* ("checking **'labels'**") to service some *extensive definition* ("herding selected items into a '**fenced** paddock', ready for easy access").

Both labels and fences have their uses, but they also exhibit their own logistical peculiarities. *Fencing-or-tethering* can be provided (e.g.) by confining certain signals to a particular nerve-fibre or bundle, and protecting them from outside interference; but *labelling* has rather different requirements: On page 13 (above), the *complementary roles* discussion reminded us of the "lock-and-key" 3D-shape mechanisms of immunology and embryology. But it also developed arguments for similar *time*-based key-combinations or "phone-numbers" and their likely molecular coding via 1D sequences — strings which would send a similar *type* of coding to their recipients (even though the code itself might have been "translated" in a pre-set way by the time it arrives).[29] Also see Traill (1978b: www.ondwelle.com/Mol-Intel-C6.pdf, §C6.7).

In fact these differences are also suggestive of different roles, (see Table 13, p.67). Or, as summarized on the next page: ———

> "**(1)**…there are important roles for both *fence* and *label* …; **(2)**…the postulated IR-system (like computers and telephones) would tend to be best at the label role, *while:* **(3)** the traditional synapse-and-action-potential system would be best at the *direct delivery* of standard message-patterns — (and in this, it would be like lens systems, and other sorts of "neural net"). **(4)** There is probably ample scope for a symbiotic cooperation between the two neural systems, if they both exist. And note that if they *don't* both exist, there will remain many questions left unanswered until someone suggests a better explanation."

This two-chapter account was not a rigorous argument, but it does perhaps offer some useful circumstantial evidence and help paint an overall picture of how mind/brain organization might be operating.

OSM09 and 03. IR for long-distance insect communication — and maybe internally

Laithwaite (1960: www.ondwelle.com/Laithw.pdf — after Fabre) had described the astonishing ability of some male moths to locate unmated females over long distances (> 91 metres) even when the wind was ensuring that none of the pheromone emissions were reaching the males — and he argued that this had to be via IR or some other electromagnetic signal. Meanwhile the entomologist (but non-physicist) P.S.Callahan, noticing a remarkable similarity between war-time Radar-aerials and various spines and structures on the cuticles of insects, had come to similar conclusions. He also noticed short-range effects (especially around UV sources) indicating the likely involvement of fluorescence, and developed his theories accordingly — invoking ambient radiation (e.g. blue light) as driving the fluorescence. However his argument was led astray by mixing it with issues of short-range olfaction — and on that basis he was "shot down" in a *rhetorical* contest in 1977.

This issue was brought to my attention in 1988 by the editor of the SS&T paper (see above), as being an interesting parallel to my own work. Much later I reviewed the "debate" in some detail — deciding that (on the published evidence) *both Laithwaite and Callahan were correct in their chief conclusions*, but that there were serious shortcomings on both sides of the rhetorical contest. See Traill (2005c: www.ondwelle.com/OSM03.pdf), but the more concise and better-illustrated *conference version* might be more helpful: (Traill, 2008b: www.ondwelle.com/OSM09.pdf).

Of more interest here though: One anomaly left over after the debate, was that although Callahan had shown experimentally that moths responded *behaviourally* to IR stimuli, he could not detect any intervening action potentials! (He had no such problem with visible-light stimulae). However, given the postulated IR neural-solution in mammals (using myelin as a dielectric), it seemed feasible that insects might also use IR internally (perhaps using chitin as the dielectric somehow, whatever its shape). In that case, with internal IR facilities, *and* when the input happened to be IR, why bother with the cumbersome action-potential "mediator"? (See the conference-version, or pp.13-14 of the 2005c paper). ——— *Closer investigation is surely called for here!* — but meanwhile it seems to constitute yet another serendipitous *"unexpected"*[21] which might fit into our overall jigsaw-puzzle about the mind/brain and its mechanisms.

CONCLUSION

"There are often TWO-OR-MORE WAYS *of doing things, or interpreting the evidence".* That has been a recurring theme throughout this project. If that was a surprise, it should not have been: E.g we saw (on page 18) that in 1855, the famous Lord Kelvin made the mistake of only considering low-frequency transmission; and yet radio and our current broadband explosion both depend crucially on *high* frequency. (Also he made another similar mistake later through overlooking the *yet-to-be-discovered extra effect* of internal radioactivity in heating the Earth; (Nahin, 1988)). — So there were effectively **two modes** for sending telegraph signals, ***and*** **two explanations** for why the interior of the Earth is hot.

In the present project, the main driving force was a similar dissatisfaction with a single *"obviously correct" account which nevertheless totally failed to explain part of reality* — and this was the orthodox synaptic/action-potential "Hebbian" account of the nervous system. No-one could doubt its importance and its power, especially in certain specific tasks; — and yet it simply did not offer (*on its own*) any credible info-tech means for explaining holistic human intelligence, especially given the extra bio-constraints of inheritance, development and maintenance.

One clue to the way out of this impasse came from Hebb himself (1949) since he insisted that his *"formal neuron" with logic-like properties* need not necessarily correspond to an actual neuron. Another clue was the apparent need for memory codes to be easily capable of being linked into *one-dimensional chains*. This led to a search for something *material* which could offer logic-like switches usually organized in a 1D string. — That naturally suggested a short-list of those long bio-molecules: DNA, RNA, PNA, and protein, (even though these then raised new questions — new anomalies which, as it turned out, also served as useful clues since they seemed to require short-range infra-red signals *in addition to* those action-potentials; see below).

The point here is that there is now a case for believing in ***two memory-coding modes*** for the brain to use in *coding* its memory, plus the ***two fast intercommunication methods*** which that implies. So (like Kelvin) we may have unwittingly handicapped ourselves by complacently accepting *only the most obvious mode* in each case.

Moreover we can now see the same narrow vision in our "SCIENTIFIC METHOD". Ever since Popper's (1934) book, there have been powerful public forces for scientists to follow the Popperian prescription (or more often, its popularized version, a doctrinaire derivative). I think the essence of Popper's idea was (i) To force hypotheses about reality to enter a logical loop which brought them back to face reality itself; and (ii) To try to ensure that personal motives did not distort this process in favour of "pet theories". That seems commendable, but was there really *only one valid way forward from there?*

The doctrinaire Popperian loop includes using one's hypothesis to make some crucial prediction — and then conducting an experiment to see whether that prediction comes true. Well, that may be fine for some situations, especially in some more-structured sciences like some branches of physics. But on the one hand, a single loop of this type seems a bit flimsy (if we accept its analogy to a physical structure); and, on the other hand, some details of this idealist-recipe are unmanageable within many disciplines such as History, plus many aspects of Sociology and Biology — and indeed the Metaphysics-of-Physics-itself (with such questions as "Are the fundamental constants different in other parts of the Universe?").

Furthermore we might now see that the popular-Popperian formulation looks very like a form of Darwinian Trial&Error within the "Society Domain" (Traill, 2008a, espec.p31). The Darwinian-selection process is very robust (*if* there is a large population!); but it is excruciatingly slow and often painful, so we might ask ourselves just how long we want to dither around, and whether we might be able to improve on this crude Darwinian process, whose rules we may already be clandestinely flouting for just that reason.

Note that Darwinian selection brutally kills off whole phenotypes, regardless of any merits they may have as *part* of their makeup. It *"throws out the baby with the bathwater"*, in an often-very-wasteful way. Popperian examples discovered within this project include: **(a)** The 1977 rejection of Callahan's theory about pheromone operation via infra-red, (Traill, 2005c, 2008b), which also led to amnesia about Laithwaite's important paper (1960). **(b)** The premature abandonment of 1960s' ideas that RNA might be crucially involved in memory-acquisition, despite clear evidence that *something interesting* was going on, even though the contemporary interpretation had gone awry. Also there were two striking hypothetical examples from Ashby (1960, §11/5) and Thagard (1992, pp95-96).

How do we rise above Darwinian techniques? In brief, that requires *"intelligence"* of some sort — and that can now be given a more precise meaning in terms of the Piagetian concept of *schème* and the Ashby/Piaget concept of *hierarchy-within-the-individual-brain* which allows for Meta-Level intervention in the crude Darwinian activity of the base level. The trouble is that Society-as-Such does not have any systematic provision for its own coherent Meta-Levels (*ML*), never mind the further sophistication of *MML*, *MMML*, *M^4L,…etc.!* Of course we tend to rely on supposedly-wise leaders to offer some meta-structure, but the results can be haphazard due to political and other systemic reasons, including the personal bias implicit in Popper's "(ii)" concern (see above). This is not a trivial problem, but I suggest that it needs urgent attention.

Meanwhile we might note that the work of these meta-levels evidently centres on *"coherence-seeking"* regarding whatever information is available, or *"equilibration"* to put it in Piagetian terms — and that is much discussed within the project.

(In fact I even interpret Darwinian testing of the outside world as yet another form of coherence-seeking, though I choose to label it as "*external* coherence-seeking" — the job of the basic "L" level. Given that generalization, one can then argue that all successful learning processes *BEGIN* as Darwinian Trial&Error, using some coherence-seeking criterion to evolve their concept-repertoire — and then maybe a meta-structure which enables them to move on to greater efficiency, given the environment as they now know it. Such specializations may *then* be seen as Lamarckian "ready-made short-cuts", and such short-cuts are fine • ***if*** you can develop-or-import them, and • ***if*** the tacit assumptions they were built upon remain valid.

The prime hidden example of that is our ability to make sense of our visual world. We adults obviously can usually do it, but it depends on massive learning tasks, both through the DNA-selection amongst our evolutionary ancestors, and our own "casual play" during infancy. See the quote from Piaget on page 12 above; — footnote 17.)

But, getting back to Scientific Method as the tool for learning by "Society-as-Such": The Popperian formulation might now be seen as one of those Lamarckian short-cuts, which seems to work well in certain circumstances, and is therefore applied carelessly to *all* scientific problems on the public agenda. (And if they cannot be fitted into that mould, then they will probably be left in the "too hard" basket, and never reach the public agenda).

We saw the Popperian paradigm as attempting to complete a **logical-circle** (with an extra specification to include the outside world — and yet this was still just a circle — though of course that is much better than the *uncorroborated straight-line-logic* of pre-science!). An alternative formula was offered by Thagard (1992, and his "ECHO" website) — a search for a **whole ensemble of loops** as a way of assessing overall coherence, envisaged in a 2D diagram (or equivalently as matrix tables in my discussion of his approach, 2005c). Note that, unlike Popper, he did not insist on direct tests against the outside world. — (That was prudent since, as the above Piaget quote reminds us, there is no genuine way we can ever *directly* *experience the environment conceptually* — even if it destroys us! This is a paradox which has worried philosophers at least since Hume, as it seems to require an infinite regress[9] in the argument. However biologists may be better positioned to see that coherence-testing could offer a way out of the paradox.)

My own model, (*e.g.* in "BruMon#18" (Traill, 1976b)), is based on Piagetian equilibration ideas. It also amounts to an ensemble of loops, but these are envisaged in 3D (or maybe 4D+) like the faces of a cube or octagon etc., rather than on a 2D page. Thus it is almost equivalent to Thagard's except that mine makes tacit provision for *proximity* between the nodes, and it could sometimes be easier to understand.

Anyhow here then is another overlooked case of TWO SOLUTIONS: • The still dominant Popperian formula based on a *single loop which has "one foot on the ground (assuming that the ground actually exists)"*, so to speak; and • the hidden alternative of *many-interlinked-loops* judged by their collective coherence.

Clearly the Scientific Method for the present project has been of the multi-loop type. The reasons are fairly obvious. (A) Firstly, *I had no choice once I had settled on the task*: There was no way *anyone* could fully observe all the probably-relevant happenings within the brain while the subject performed Piagetian tasks. Common sense told me that. Heisenberg's indeterminacy principle told me that. Elsasser's paper in vol.1 of the *Journal of Theoretical Biology*, also told me that. Recent lab-work, useful though it may be, is still far from what would suffice. (And as it became apparent that molecular activity was probably crucial, the possibility of a realistic-and-proper Popperian approach to the problem diminished even further.) No doubt that is why no one had seriously tackled the task previously: It was seemingly impossible, and just languished in the "too hard" basket.

On the other hand, with the *unexpected* splitting of the project into two, the new "STREAM 2" (postulating an increasing number of infra-red effects in-and-around axons), lab-measurement did eventually become a real possibility. However I have not hitherto been in a position to initiate such Popperian research; though I would like to think that this summary might encourage some interest in work of this sort — e.g. the comparatively simple extension of the findings regarding insects, see page 25.

(B) Secondly as I became increasingly familiar with the merits of the Piagetian approach for analysing the intelligence of individual humans, it was also increasingly clear that the same principles were likely to apply to Science-as-Such — regardless of what Popper or anyone else may have said. Accordingly *I took my own medicine*, (despite having been first drilled in the supposedly inviolate status of Popperian procedures when I studied physics, and then *again* when I later studied psychology! — and despite my own respect for Popper's work, in its proper context).

So then: — Can I identify those "multiple loops" which are in my supposedly coherent account? I have not yet done that systematically; but in going through the present text, I have labelled (in red) apparent candidates for *"emerging novel solution status"* as being associated with footnote [21] (whose text is on page 15). Those thus identified[42] seem to be:

(1) The almost-Popperian fulfilment of my prediction of RNA importance when it emerged that only 3% of RNA codes for protein in humans! (Mattick, 2001—2004). (§**(11),** p.13).

(2) The massive population-increase (from Neuron to Molecule) makes radical Darwinian-selection mechanisms feasible ("Chapter B1", p.15).

(3) Optical effects could give better explanations for mental precision (when applicable), rather than those effects vaguely attributed to synapses. (Page 12).

(4) Molecules as a better fit for the Hebbian model, with much more coding-capacity, greater precision (again), and readily reproducible. (§ B2.3, page 17).

(5) The massive population-increase (see "(2)" above) makes radical Darwin-like mechanisms feasible as *substitutes for memory "writing"!!* (§ B2.4, p.18).

(6) A possible explanation for the superabundance of glia. ("Chapter B6", page 21).

[42] Not counting the "missed opportunity" (to date) discussed in footnote 34. Also see overleaf:

(7) An explanation for myelin geometry: What makes *(myelin thickness) / (axon diameter)* tend to be constant, even if the axon is growing meanwhile? (Pages 22–23)

(8) "Critical diameter": In the PNS, what stops myelination from starting until the axon diameter reaches to about 1μm? (Pages 23+)

(9) The "Quadrant enigma": myelin-wrap often ends near where it began! (Page 24)

(10) Apparent resolution of the 1977 debate about long-distance pheromone-detection by insects (applying the pre-existing published evidence) (Page 25+).

And I note that this list is mainly for STREAM 2 (the IR/technology part of the project). I may have overlooked some innovations within STREAM 1 (the direct application of the Ashby/Piaget concepts which is where the project started). Some such (e.g. explaining *Sleep*, and *Humour*) may be found within "Book A" (Traill, 1999) and "BruMon#18" (Traill, 1976c), *etc*.; also (more speculatively?) *Neurosis* and *Psychosis.*[23] — But then, as this was the focal part of the project, many of the concepts were simply borrowed (in their vague abstract form) from Piaget; and any new "progress-loops" would have been in devising feasible material mechanisms to bring those concepts to life.

So could this ensemble of loops fit into Thagard's ECHO analysis (1992, and website)? Maybe. But I shall leave that for others to attempt if they wish to do so, though I would be interested in the results, if any.

Be that as it may, with so many apparently-coherent and mutually-supportive theoretical findings, I feel that there must be *something* right about this project! I would be surprised if all the suggestions turned out correct, but I *would expect some* of them to be right, no matter how bizarre they may have seemed initially. In any case, the project has raised some tricky questions — and if the answers offered here happen to be wrong, then someone still has the task of making sense of many of these puzzles. Or else, of course, they could just be put back into the "too hard" basket.

Meanwhile some useful experimentation does now seem to be possible and desirable, even if that only applies to the infra-red / myelin side of things (STREAM 2). So I look forward to some activity on that front. Then again, there are more *theoretical* "loops" on the horizon, and they too will need attention.

REFERENCES

Ashby, W. R. (1956/1964). *An Introduction to Cybernetics*. Methuen: London.
Ashby, W. R. (1960: Second Edition). *Design for a Brain*. Chapman & Hall: London.
Bacon, F. (1620/1960). *The New Organon*. Bobbs-Merrill: Indianapolis. [Aphorism XCV]
Bishop, G.H. (1956). "Natural history of the nerve impulse". *Physiol. Rev.*, **36**, 376-399.
Boyd, I.A. and K.U.Kalu. (1973). "The relation between axon size and number of lamellae in the myelin sheath for afferent fibres in groups I, II, and III in the cat". *J. Physiol., London*, **232**, 31P-33P.
Brachman, R.J., and H.J.Levesque, (2004). *Knowledge Representation and Reasoning*. Morgan Kaufman/Elsevier: San Francisco.
Cope, F.W. (1973). "Electron-phonon (trapped photon) coupling and infrared coaxial transmission line theory of energy transport in mitochondria and nerve". *Bull. Math. Biol.*, **35**, 627-644.
Duncan, D., (1934). "A relation between axone diameter and myelination determined by measurement of myelinated spinal root fibers". *J.Comp. Neur*. **60**, 437-471.
Eccles, J.C. (1986). "Do mental events cause neural events analogously to the probability fields of quantum mechanics". *Proc. Roy. Soc. Lond.,B*, **227**, 411-428.
Eccles, J.C. (1990). "A unitary hypothesis of mind-brain interaction in the cerebral cortex". *Proc. Roy. Soc. Lond.,B*, **240**, 433-451.
Fodor, J.A. (1975). *The Language of Thought*. Crowell: New York. ISBN 0-690-00802-3
Fodor, J.A. (2008). *The Language of Thought Revisited*. Oxford University Press. ISBN 0199548773 (hbk) 228 pp.
Furth, H.G. (1969). Piaget and Knowledge. Prentice-Hall: New Jersey.
Goel, N.S., R.D.Campbell, R.Gordon, R.Rosen, H.Martinez, and M.Ycas (1970). "Self-sorting of isotropic cells". *Journal of Theoretical Biology*, **28**, 423-468.
Goel, N.S., and A.G.Leith (1970). "Self-sorting of anisotropic cells". *Journal of Theoretical Biology*, **28**, 469-482.
Hebb, D.O. (1949/1964). *The Organization of Behaviour*. Wiley: New York and London.
Hertz, H.R. (1887 May). "Ueber sehr schnelle electrische Schwingungen", *Annalen der Physik,* **267** (7), 421-448.
Hertz, H.R. (1888 March). "Ueber die Einwirkung einer geradlinigen electrischen Schwingung auf eine benachbarte Strombahn", *Annalen der Physik*, **270** (5), 155-170.

Hertz, H.R. (1888 May). "Ueber die Ausbreitungsgeschwindigkeit der electrodynamischen Wirkungen", *Annalen der Physik*, **270** (7), 551-569.

Jonas, J.B., Schneider, U., and Naumann, G.O.H. (1992) "Count and density of human retinal photoreceptors". *Graefe's Arch. Clin. Exp. Ophthalmol.* **230**, 505-510.

Jordan, D.W. (1982) "The adoption of self-induction by telephony". *Annals of Science.* **39**, 433-461.

Konev, S.V., Lyskova, T.I. and Nisenbaum, G.D. "Very weak bioluminescence of cells in the ultraviolet region of the spectrum and its biological role", *Biophys.*, **11**, 410 (1966).

Laithwaite, E.R. (1960) "Radiation Theory for the Assembling of Moths". *The Entomologist*. **93**(1165 June), 113-7, and **93**(1166 July), 133-7, +plate. http://www.ondwelle.com/Laithw.pdf

Levanon, E.Y., E.Eisenberg, R.Yelin, S.Nemzer, M.Hallegger, R.Shemesh, Z.Y.Fligelman, A.Shoshan, S.R.Pollock, D.Szybel, M.Ilshansky, G.Rechavi, & M.F.Jantsch (2004). "Systematic identification of abundant A-to-I editing sites in the human transcriptome" *Nature Biotechnology*. **22**, 1001-1005. http://star.tau.ac.il/~eli/PDFs/p39.pdf

Mattick, J.S. (2001). "Noncoding RNAs: the architects of eukaryotic complexity". *EMBO Reports* **2**(11), 986-991. http://emboreports.npgjournals.com/cgi/content/full/2/11/986

Mattick, J.S. (2003). "Challenging the dogma: The hidden layer of non-protein-coding RNAs on complex organisms" *Bioessays*. **25**, 930-939. www.imb-jena.de/jcb/journal_club/mattick2003.pdf

Mattick, J.S. (2004). "The hidden genetic program of complex organisms" *Scientific American*. **291**(4), 30-37. www.sciam.com/article.cfm?articleID=00045BB6-5D49-1150-902F83414B7F4945

Mattick, J.S., & M.J.Gagen (2001). "The Evolution of controlled multitask gene networks: The role of introns and other noncoding RNAs in the development of complex organisms". *Mol. Biol. Evol.* **18**(9), 1611-1630. **[Review]** http://mbe.oupjournals.org/cgi/content/full/18/9/1611

Maxwell, J.C. (1860 Jan) "Illustrations of the dynamical theory of gases". — Part I. "On the motions and collisions of perfectly elastic spheres". *Phil.Mag*.(series 4), **19** (129),19-32

Maxwell, J.C. (1860 Jul) "Illustrations of the dynamical theory of gases". — Part II. "On the process of diffusion of two or more kinds of moving particles among one another". *Phil.Mag*.(series 4), **20** (130),21-37

Maxwell, J.C. (1865). "A dynamical theory of the electromagnetic field". *Phil. Trans Roy Soc London*, **155**, 459-512.

Maxwell, J.C. (1868 Feb) "On the dynamical theory of gases". [Part 1]. *Phil.Mag*.(series 4), **35** (235),129-145

Maxwell, J.C. (1868 Mar) "On the dynamical theory of gases". [Part 2: "On the final distribution of velocity among the molecules of two systems acting on one another according to any law of force"]. *Phil.Mag*.(series 4), **35** (236),185-217

Maxwell, J.C. (1873). *A Treatise on Electricity and Magnetism*. Clarendon Press: Oxford.

Monod, J. & Jacob, F. (1961). "General conclusions: telenomic mechanisms in cellular metabolism, growth, and differentiation." *Cold Spring Harbor symposia on quantitative biology*, **26**, 389-401.

Nahin, P.J. (1988). *Oliver Heaviside: sage in solitude*. IEEE: New York.

Packard, K.S. (1984). "The origin of waveguides: a case of multiple rediscovery" *IEEE Transactions on Microwave Theory and Techniques*, **MTT-32** (9), 168-173.

Patel, S.N, Steven P.R.Rose and M.G.Stewart (1988). "Training induced dendritic spine density changes specifically related to memory formation processes in the chick, *Gallus domesticus*" *Brain Research*, **463**, 168-173.

Pauling, L. (1935/1960). *The Nature of the Chemical Bond and the structure of molecules and crystals*. Cornell University Press: Ithaca, NY.

Pauling, L., and E.B.Wilson. (1935). *Introduction to Quantum Mechanics*. McGraw-Hill: New York.

Peters, A. (1964). "Further observations on the structure of myelin sheaths in the central nervous system". *J.Cell Biol.*, **20**, 281-296.

Peters, A., Palay, S.L. and Webster, H.deF. (1991: 3rd Edn). *The Fine Structure of the Nervous System: Neurons and their supporting cells*. Oxford University Press: NY.

Piaget, J. (1967/1971). *Biologie et connaissance: Essai sur les relations entre les régulations organiques et les processus cognitifs*. Gallimard: Paris — *Biology and Knowledge*. Chicago University Press; and Edinburgh University Press.

Piaget, J., and B.Inhelder (1968/1978). *Memory and Intelligence*. Routledge.

Popp, F.A. Becker, G., König, H.l. and Peschka, W. (Editors), *Electromagnetic Bio-Information*, Urban & Schwarzenberg: München (1979).

Popp, F.A. Nagl, W., Li, K.H., Scholz, W., Weingärtner, O. and Wolf, R. "Biophoton Emission: New evidence for Coherence and DNA as Source", *Cell Biophys.*, **6**, 33-52 (1984).

Popper, K.R. (1934/1959/1972). *Logik der Forschung. / The Logic of Scientific Discovery*. Hutchinson: London.

Popper, K.R. (1972). *Objective Knowledge: An evolutionary approach*. Oxford University Press.

Popper, K.R. (1975). "The rationality of scientific revolutions"; in Rom Harré (ed.), *Problems of Scientific Revolution: Scientific Progress and Obstacles to Progress in the Sciences, The Herbert Spencer Lectures 1973*.. Clarendon Press: Oxford. — Also in (ii) M.A.Notturno (ed.) (1994) *The Myth of the Framework: In defence of science and rationality*. Routledge: London.

Preece, W.H. (1887). "On the limiting distance of speech by telephone" *Proceedings of the Royal Society*, **42**, 152-158.
Ranck, J.B., jr. (1975). "Which elements are excited in electrical stimulation of mammalian central nervous system: a review". *Brain Research*, **98**(3), 417-440.
Rose, S.P.R. (1970/71). "The environmental determinants of brain function". In Chalmers *et al*.(1971), *loc.cit*.; pp.246-248.
Rose, S.P.R. (1971). "The biochemical approach to memory". In Chalmers *et al*., *loc.cit*.; pp.232-238.
Rose, Steven (1976/1973). *The Conscious Brain*. Penguin: Harmondsworth.
Rose, Steven P.R. and J.Haywood (1977). "Experience, Learning and Brain Metabolism" — In: A.N.Davison, *Biochemical Correlates of Brain Structure and Function*. Academic Press: London; Ch.8, pp.249-292.
Rose, S.P.R. (1981). "What should a biochemistry of learning and memory be about?" *Neuroscience*, **6**(5), 811-821.
Rose, Steven (1992). *The Making of Memory*. Transworld: London. — ISBN:0593-021800
Rushton, W.A.H. (1951). "A theory of the effects of fibre size in medullated nerve". *J.Physiol.*, **115**, 101-122. — http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1392008/pdf/jphysiol01449-0115.pdf
Ruth, B. (1979) "Experimental investigations on ultraweak photon emission", in Popp, F.A. et al. (Editors), *Electromagnetic Bio-Information*, pp.107-121. Urban & Schwarzenberg: München.
Skilling, H.H. (1948). Chap.13: *Fundamentals of Electric Waves*. Wiley. — [especially pp.198-217].
Stämpfli, R. (1954). "Saltatory conduction in nerve". *Physiol. Rev*., **34**, 101-112.
Thomson, W. [Kelvin] (1855a). "On the electro-statical capacity of a Leyden phial and of a telegraph wire insulated in the axis of a cylindrical conducting sheath". *Phil. Mag. (series 4)*, **9**, 531-535.
Thomson, W. [Kelvin] [& G.G.Stokes] (1855b). "On the theory of the electric telegraph". *Proceedings of the Royal Society*, **7**, 382-399.
Traill, R.R. (1975a). *Thinking as mental model-building: a Piagetian-cum-mechanistic explanation of the 'engram'*. Monograph **12**, Institute of Cybernetics, Brunel University. www.ondwelle.com/OSM04.pdf
Traill, R.R. (1975b). "Sensori-motor development of object concepts: a mechanistic hypothesis". Paper presented at the tenth annual conference of the Australian Psychological Society, La Trobe University, August 1975. In Traill (1976e), pages 5-10.
Traill, R.R. (1975c). "Self-construction of personal identity: an extension of the mechanistic mental object hypothesis". Paper presented at the tenth annual conference of the Australian Psychological Society, La Trobe University, August 1975. In Traill (1976e), pages 11-13.
Traill, R.R. (1976a). "Acquisition of knowledge without transcendental assistance: an extended Piagetian approach". *Kybernetes*, **5**(2), 73-82. [also Chapters A1 and A2 of *thesis* (1978b, Part A): www.ondwelle.com/Mol-Intel-A.pdf , see below].
Traill, R.R. (1976b/2007). *The gulf between behavioural psychology and fundamental physiology: a systematic attempt to bridge the gap*. Monograph **15**, Institute of Cybernetics, Brunel University. (Paper presented at the workshop on Memory during the annual conference of the British Psychological Society, York, April 1976).(www.ondwelle.com/OSM05.pdf)
Traill, R.R. (1976c/2007). *On modelling reality: the 'camera fallacy' in our approach to scientific method, and sometimes to mental functioning*. Paper presented at the annual conference of the British Psychological Society, York, April 1976. [Abstract in *Bull. Brit. Psychol. Soc.*, **29**, 222-223].
Traill, R.R. (1976d). "Mechanistic modelling: of consciousness?" In Traill (1976e), pages 25-30.
Traill, R.R. (1976e/2007). *Short papers and letters on the 'linear micro-element' theory of mental mechanism and related questions of Scientific Method*. Monograph **18**, Institute of Cybernetics, Brunel University / Ondwelle: Melbourne. www.ondwelle.com/OSM06.pdf
Traill, R.R. (1977/2006). *Toward a Theoretical Explanation of electro-chemical interaction in memory-use: the postulated role of infra-red components and molecular evolution*. Monograph **24**, Institute of Cybernetics, Brunel University. : [www.wbabin.net/physics/traill8.pdf *or* www.ondwelle.com/MolecMemIR.pdf] — [also *Part B* of *thesis* (Traill, 1978b/2006), opp.cit.]
Traill, R.R. (1978a). "Analytical theory of sensori-motor spatial development". *Kybernetes*, **7**, 61-71. [— also Chapter A3 of 1978b].
Traill, R.R. (1978b/2006). *Molecular explanation for intelligence…*, Thesis, Brunel University: http://hdl.handle.net/2438/729 (2 files) — or Ondwelle Publications: www.ondwelle.com (7 files). — Including *Part C*: "Development and Application".
Traill, R.R. (1988). "The case that mammalian intelligence is based on sub-molecular memory coding and fibre-optic capabilities of myelinated nerve axons". *Speculations in Science and Technology*. **11**(3), 173-181. (www.ondwelle.com/OSM10en.pdf).
Traill, R.R. (1999). *Mind and Micro-Mechanism: a hunt for the missing theory*. Ondwelle: Melbourne. http://www.ondwelle.com ISBN: 0-9577737-0-6
Traill, R.R. (2000). *Physics and Philosophy of the Mind*. Ondwelle: Melbourne. http://www.ondwelle.com ISBN: 0-9577737-1-4
Traill, R.R. (2005a). *Strange regularities in the geometry of myelin nerve-insulation — A possible single cause*. Ondwelle: Melbourne. http://www.ondwelle.com/OSM01.pdf
Traill. R.R. (2005c). *How Popperian positivism killed a good-but-poorly-presented theory — Insect Communication by Infrared*. Ondwelle: Melbourne. www.ondwelle.com/OSM03.pdf — Also in *Gen.Sci.J.* www.wbabin.net/physics/traill7
Traill. R.R. (2008a/2005b). *Thinking by Molecule, Synapse, or both? — From Piaget's Schema, to the Selecting/Editing of ncRNA*. Ondwelle: Melbourne. www.ondwelle.com/OSM02.pdf [French version: www.ondwelle.com/FrSM02.pdf] — Also in *Gen.Sci.J.* www.wbabin.net/physics/traill2.pdf
Traill. R.R., (2008b). *Critique of the 1977 debate on infra-red 'olfaction' in insects — (Diesendorf vs. P.S.Callahan)*. Ondwelle: Melbourne. [http://www.ondwelle.com/OSM09.pdf — Conference of the Australian Entomological Society, at Orange, NSW, Australia: 30 September 2008]
Webster, H.deF. (1971). "The geometry of peripheral myelin sheaths during their formation and growth in rat sciatic nerves". *J.Cell Biol*., **48**, 348-367.

