

The Outline of Systems Engineering for Developing a Conscious Ware

A.K. Mukhopadhyay, MD.
All India Institute of Medical Sciences, New Delhi
Email: mukhoak1953@gmail.com

Abstract: Adequate knowledge of operations of mind, self, life and consciousness obtained from the study of human psyche and the brain can bring a foundational change in the field of Artificial Intelligence. The paper analyzes the hierarchy of the operations, as part of systems science of consciousness and extracts realistic clues from functioning of the human psyche and the brain. It outlines the logical steps and prepares question-weaponry for moving forward from the present state of software engineering to systems engineering of a conscious ware with incorporation of operations of mind, self, life and consciousness as its ingredients in decision making.

Key words: Systems Consciousness, Systems Engineering, Nested hierarchy, Conscious ware

I. INTRODUCTION

In systems science, all operations observed in a system are considered to be consistent with the goal of the whole. In nature's model there are systems nested within the systems. Their communications, gated or free, are important for coherence and to bring uniform order in the dynamicity of the whole. The systems within the systems are interconnected and respond to any stimulus as a whole. If ever an autonomous subsystem is found to respond, it does so always in concurrence with the whole. In the management of such systems, during top-down communication the systems at the higher level are found to have large-scale regulatory networks and more freedom for itself. Looking bottom-up in the organization, it could be found that the systems at the lower level communicate with systems at higher level with small-scale connectivity [1]. Freedom is restricted more and more down the ladder.

Since systems science of consciousness is inclusive of almost all systems and excludes probably nothing. The systems psychology, systems biophysics and informatics, systems biology, systems sociology, systems neuroscience and behavior are integral parts of it. How can we translate this knowledge in systems engineering to develop a live conscious ware from a signal processing soft ware is the issue under discussion in this paper.

II. UNDERSTANDING THE SYSTEMS OF CONSCIOUSNESS: TOP-DOWN APPROACH

Behavioral expressions of consciousness are cognition, will and emotion (feelings). All of the three are capable of sending regulatory signal for the systems operating within its premise. The ultimate channeling is through will. The next layer down the ladder is the system that designs the purpose of the will as desired by consciousness. System next works out on phenomenology for execution of the will. Phenomenology is centered round the self. In the systems next to it all is in third person's perspectives. One could see the events first happening at microscopic quantum level and then surfacing at macroscopic classical level. Therefore, the systems science of consciousness consists of five principal nests [2] as shown in the Figure 1.

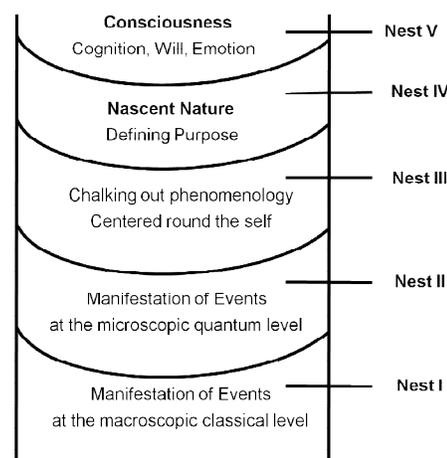


Figure 1. Nested Hierarchy of Systems Consciousness

The operator in the nest V is consciousness itself. To put this in epistemological perspectives, the operations identified in the nest V are operations of consciousness. In the nest IV, operator is consciousness's nature, the nature that is most close to consciousness, nascent as nascent this could be, and by nature is the "Mother" of all natures. The operations could be designated as operations of

Mother Nature, which defines the purpose of the will of consciousness. Principal target in this operation is 'life'. The purpose, which does not suit 'life', is deleted from the broad agenda of the will. Or else, the defined purpose compels 'life' to change accordingly. Mother Nature thus customizes the will of consciousness for the purpose of life and the other way round as well. In the nest III, the self working with mind, memory and intellect determines the phenomenology necessary in the execution of will. The currency of business transaction in this nest is information. In the nest II, none or nothing other than the nature's quantum principles, the principles of quantum physics are responsible for the event management. Inside the nest I, the events are managed by the principles of classical physics.

III. BOTTOM-UP APPROACH IN REASONING OUT SUCH NESTING IN SYSTEMS CONSCIOUSNESS

Uncertainty limits our cognitive ability and imposes epistemological constraints in observation. That nature observes a stratified nested hierarchy in organization could be logically constructed on the basis of an extended uncertainty principle [3]. Perceived uncertainty in describing simultaneously and precisely the paired properties, which are canonically conjugate to each other in Hamiltonian sense (e.g. position and velocity, angular momentum and angular position of the particle in perpendicular plane, or the energy of a particle and the time of its measurement), is the characteristic of quantum nature (nest II). In classical nature (nest I) no such uncertainty is encountered. The nature subtler than what is measured within Planck's scale could be reached by penetrating through 'quantum discontinuity' or 'quantum void'. This is sub-quantum (nest III) nest of nature that deals with existential phenomena (e.g., in cosmological context, black hole) that are most 'elementary' in character. The perceived uncertainty within this nest for describing observer-dependent reality is come across between *properties* of the object and its very *existence!* The ability to distinguish properties from the existence requires a sharper cognitive function. With further sharpening of cognitive faculty this principle of uncertainty could be extended into sub-sub-quantum nature (nest IV) where in the description of the observer-dependent reality uncertainty is encountered between *existence* and *non-existence* (e.g., in cosmological context, emerging from black hole to white hole). Properties become irrelevant here. In the deepest recess, the recess of consciousness (nest V), perceived uncertainty in observer-dependent reality is seen to play between *non-existence* and a *new existence* (e.g.,

in cosmological context, multiple new universe)! Unconditional consciousness as a perceived reality *either* does not exist *or* it exists as a reality that is new, novel and was hither-to-unknown. It appears in a new 'form', every time one tries to observe and describe it. Four levels of perceived uncertainty, therefore, determine four different depths of nature beyond the classical nature. Uncertainty is measurable and, therefore, could be an issue for science. The stumbling block for many of us in science is the use of word 'existence' in this extended principle. However, there is no other option available immediately to circumvent this obstacle.

IV. THE REAL ISSUE IN TRANSLATING SUCH HOLISTIC CONCEPTS INTO ARTIFICIAL CONSCIOUS WARE

How this idea could be brought to reality and made sensible? Our limitation is that we work with mind and intellect and perceive with senses. Unless these non-observable operations are brought into scaffolding of sensible intellect, unless we produce such information which mind can seriously conceive and deliver appropriate 'form' or energy (recognized as movement) that senses can perceive as footprints or signature of life or of consciousness, there is no hope! Therefore the whole idea remains nonsensical.

The issue could be presented in an alternative way. How do the top-down management by consciousness through operations of self and life, which although understandable but non-observable having large scale ramification in material world and the bottom-up communication with small scale climbing, for example from signal to information (nest II to nest III), can meet and work together? Can we make a tentative model to build up such artificial ware, taking cue from the model existing in nature? Top down, is it possible to present all these ontological operators or their epistemological operations as signal, which is sensible? To be more candid, how the will of consciousness could be understood as signal? Bottom up, can we make an intellectual travel from this sensible signal high up to the level of consciousness, from software to softer mind-ware, to intelligent ware, live-ware and finally to conscious ware?

V. BOTTOM-UP APPROACH IN BUILDING UP THE WARE

Ordinary software processes signals. With signal processing by the software we have done reasonably well by probabilistic reasoning in the field of Artificial Intelligence in terms of machine learning, robotics, computer vision and even natural language processing. However, to scale further, understanding

the difference between signal and information should be made clear.

	Signal	Information
1.	Physical. Independent of Mind. Mind makes signal out of Information	Organic. Requires mental processes, mind or mind-like structure and process in nature. Mind converts signal into information
2.	Bereft of any meaning	Meaningful
3.	Bereft of intention	Intentional
4.	Signal is symbolized by frequency, space/unit of time	Information is a reconstructed 'form' or image out of space and time
5.	Localized. Obeys laws of 'local' Physics. Requires media for transmission.	Because of association with mind or mind-like structure and process, information acquires the property of being nonlocal! Does not require physical media for transmission.
6.	Works with one or two logic gates	Works with a number of logic gates

Table 1. Difference between Signal and Information

Bottom up, the first small step is to transform a signal into information. This small step, once taken carefully, can revolutionize by its translational potential the systems engineering in particular and the systems science in general. Transformation of signal to information or information to signal requires operation of mind or mind-like structure and process in nature.

$$\text{Signal} \leftrightarrow [\text{Mind}] \leftrightarrow \text{Information}$$

There is a far difficult problem in explaining this conversion. Signal can be converted into information by a living entity only. While ordinary software works with signals and its computation, the ware in living entities operates with information and mind. Mind is a softer ware than signal processing software. In live situation, mind does not operate alone. Its operations are connected with those of self and life.

Mind-like properties as recently incorporated in ordinary software differ from the properties of mind itself. The former cannot extract meaning out a signal. Mind can extract meaning out of signal. Software in non-living entity (e.g. silicon chip) is a finite entity. It works with finite energy and does not evolve. Mind, because of its connection with 'life' is not finite, almost endless, operates practically without any constrain of energy and has capacity to evolve!

When signal has been working with mind, the self takes the decision to convert this signal into information by an outside-in phenomenon of the space-time geometry (for example frequency pattern) of the signal. Requisite energy, which is invisible, and is suggested by the author to be dark energy, comes from 'life' (Fig.2).

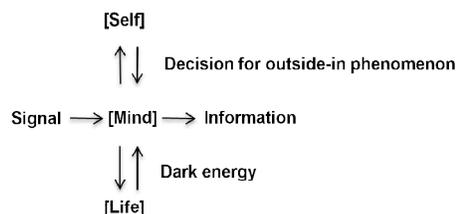


Fig.2. Transformation of Signal into Information

The proposition is a response to a question, what is present within information structurally but is missing in the signal? Non-living entities carry business transaction with physical energy, which is visible and measurable. Living entity can carry business-transaction, in addition, with dark energy. Management of dark energy is one of the properties of 'life'. Addition by 'life' of dark energy as scaffolding into the structure of signal is an essential step while mind converts signal into information. On the reverse, when information is split by operation of mind there is release of this dark energy [3], [4], which is managed by 'life' (Fig.3).

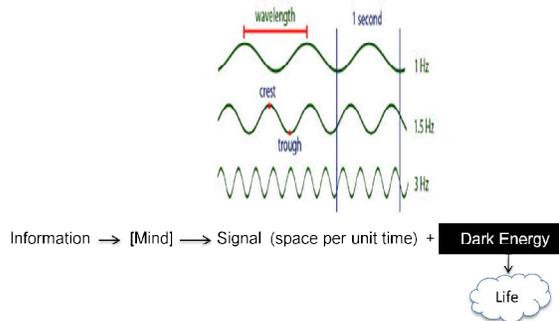


Fig.3. Transformation of Information into Signal

Ideologically, although, appears sound, for inclusion of this relationship into science one requires objective evidence which could be recognized as signature of 'life' or of consciousness. The problem with this proposition is how to engineer this 'dark energy'? The solution could be found in understanding how operations of life manage it. In an earlier publication of author [5] the possible relationship has been envisaged as shown in Fig.4.

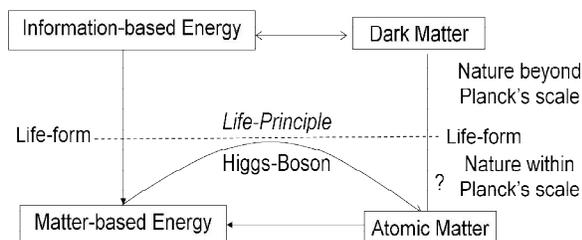


Fig.4. The proposed role of life-form in management of Dark Energy

In figure 4, life-form stands at the borderline between nature within Planck's scale and nature beyond Planck's scale. Higgs-Boson and life-principle (subtlest representative of 'life') touches either side of the border. Dark energy to dark matter conversion has been happening beyond Planck's scale while atomic matter to visible energy conversion happens within Planck's scale. This area could be harnessed for any future utility.

Signal could also be considered as photon wave curved out for a frequency and amplitude by arrangement of phonon waves. What 'life' adds during transformation of signal into information by mind are conformity to the whole (conformon) and flexibility (neutrinos) within the ambit of the self of the system. Keeping the self at the center, photon, phonon, conformon and neutrino are suggested to form the structure of information [6]. Therefore, neutrino and conformon are assumed to have relationship with dark energy.

Our Success and failure:

The human mind is allured for invention of *intentional expert system*, which can negotiate and at opportune moment executes a befitting decision [7], [8]. Partial success has compelled the hardcore material scientists to use the term like 'machine consciousness'. Many inventions have blurred the distinction between human machines and machine humane, the '*Homo siliciens*' of Rodney Cotterill [9]. Surgeon-robots and sex-robot are two of such examples. Many expert systems now show the

function of Access consciousness (consciousness-A) and Monitoring consciousness (consciousness-M), the terms used by N. Block [10]. Operations of self, to some extent, has already been incorporated in robotics, for example in self-assembling computer, in the self-replicating robots working in both structured and semi-structured environment and in robot, which can structures its own environment. Such properties like access consciousness and monitoring consciousness have been mechanized in the expert system to a very limited degree in contrast to the what is in possession of 'being' consciousness, which operates in an unlimited extent and in multiple domains as judged by the being's ability of unbounded imagination and speculation. However it is very difficult to make an expert system, which possesses and expresses self-consciousness, phenomenal consciousness (Consciousness-P of Block) and reflexive consciousness for which the being can outwit various circumstantial pressures with his ability to decide by reflex or intuition. The above reasons make Bringsjord [11] to argue why an honest scientist should decline a billion dollar offer for making a conscious robot!

Harnessing operations of life in robotics:

To harness operations of life in robotics, there are now efforts to make biological chips (for example, DNA chips) instead of silicon chips. Hybrid chips are also under consideration. Microbial robot has been engineered for drug delivery etc.

VI. TENTATIVE GOALS

To create a humanoid robot is our initial goal. However it should not degenerate into sex toy or into war-weaponry. In human-robot interface our goal is to reduce human effort in laborious mental task, to have robot, which can take decision in a very complex situation. Further, we like to have robot that can manage the dark energy, which constitutes 70% of the universe and a robot, which can harness information-based pollution-free energy for daily use.

VII. UNDERSTANDING THE LAYERS FROM FUNCTIONING OF THE HUMAN PSYCHE AND THE BRAIN

We would discuss the issue in the context of the nervous system, nature's live model for consciousness. Nervous system processes both signal and information. Signals are for reflexes, which have been automated since a desirable level of perfection has been achieved in the systems. The brain is also an information hub and is home for the processes and operations of mind, self and life. Naturally within the brain, especially within the cerebral cortex, there is conversion of *information* into form (space-time

structure of image) and release of dark energy. This dark energy can ruin the sensitive neurons. Therefore, the neurons are guarded, and the dark energy is managed by a number of live astrocytes working round the neuron. They ‘absorb’ this invisible dark energy and convert this into visible energy (Fig.5). Circumstantial evidence for such proposition comes from a well-established fact. Astrocyte is the only cell in the body so far recognized which in healthy condition releases its “cash” energy, ATP, in substantial amount for the utility of other cells such as neurons (ATP: A ubiquitous gliotransmitter integrating neuron-glia networks [12]). The cell which has been dealing with dark energy (unaccountable cash) can afford to donate cash substantially to the nearby needy in accountable form, in form of ATP.

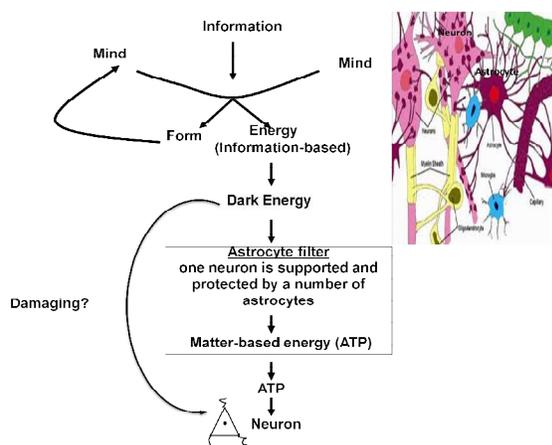


Fig. 5. Astrocyte-filter for dark energy

The lesson to be learnt from this is as follows. For automated reflex actions where there is no role of information, signal transmission is sufficient for communication of the message. However, where there is a need for activity of mind, for example in the cerebral cortex, which is the factory for the production of dark energy, one requires many life-forms such as astrocytes around. In the artificial neural network model therefore, we require to put astrocyte-like structure and process to proceed further in creating consciousness.

Inside the psyche, who the mind reports to? To self! Self takes decision for the system. In the human psyche it is difficult to see mind operating in isolation from self. Self and mind jointly operate on the background of memory and experience to create what is called intelligence. Inclusion of self, which is categorically identical with consciousness and is customized, to operate on behalf of consciousness within the system brings the ability to take decision.

The self is responsible for self-organization of the natural system. Further, in the ordinary software, signal processing is done through algorithmic pre-specifications, which is not the case with the brain. During self-organization in the case of a non-living entity (e.g., in a fractal), the number of logic gate remains limited and therefore the pattern remains constant although it may be endless in number. However in the living state, where mind-ware is not isolated from the operations of life, the systems are open to several logic gates and therefore retain possibility of creation of multiple patterns with endless potential. In a non-living ware information is static. In a live-ware as in neuron-neuron-astrocyte-neuron network, information is dynamic and constantly changing. It is because the source of any new information is ‘life’ itself. Life creates new information. Integration of different information in various ‘connectomes’ of the brain is the step following communication through in neuron-neuron-astrocyte-neuron network. At this point, the author likes to point out the distinction between the terms ‘integration’ and ‘integral’. The distinction apparently appears as philosophical but the author feels it real. The process of integration is the result of arithmetical, algebraic or geometric aggregation of several inputs and is a bit ‘masculine’ in nature. In contrast, the process integral results in creation of something new out of several known and given inputs and is feminine in reality. The very feminine nature of the integral process unfolds its productive potential for creation of something new! Involvement of operations of ‘life’ in the neuron-neuron-astrocyte-neuron network brings this feminine aesthetics and creative properties in the whole ware. Therefore, arithmetical, algebraic or geometrical ‘integration’ of information achieved by operations of mind, self and intelligence becomes ‘integral’ component of the ware systems in presence of this ‘life’.

The most difficult part in the artificial ware engineering seems incorporation of this ‘life’ in it. On the reverse, it is equally difficult to use any life-form in systems engineering for developing in it consciousness of such enormous magnitude. The problem in handling ‘life’ in the ware is that it cannot be digitized. What are the lessons from the brain? Life inside the natural brain ware remains in its subtlest form, as *life-principle*. In the context of artificial ware, one might call this the “processes of life” or the “principles of life”. The brain from which the operations of ‘life’ have disappeared, network hardware within it becomes useless even for simple communication! The brain in this state to be able to support consciousness is a far-reaching dream! Consciousness supports ‘life’ to manifest itself.

Without adequate support from consciousness, self can continue its operation within the brain, although unwillingly, till 'life' remains fully functional. Inclusion of 'life' in the brain ware opens up logic gate of mind theoretically to infinite number and allows self to decide from options without any algorithmic pre-specifications. That means self can work by choice. The lesion stands as follows. The phase of nature that is supportive and active inside the brain is required to be nurtured for making the artificial conscious ware.

How do we explore the possibility of incorporation of consciousness as the participating ground in the artificial ware? Again here, we are to take lessons from the systems neuroscience and systems cell. In the context of the brain, it is suggested that the self, 'life' and consciousness triangulates to keep the system awake. All information is not necessarily brought to the conscious level. When intentional-threshold of any information fails to conform to the perfection-threshold as decided by consciousness of the system and the concern-threshold of self, information is brought to the conscious level for scrutiny. Otherwise, information operates at subconscious level (Fig. 6). When intentional threshold of information is not intense enough, it is left to operate below conscious level.

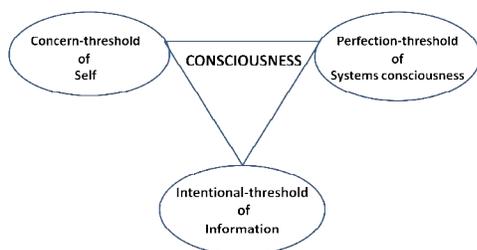


Fig. 6. Three thresholds guard information from entering the level of consciousness

In perfectly functioning systems, physical signaling or cell signaling pathways are automated, and there is no need of any consciousness as long as those are perfectly in harmony with the whole. Metabolome-proteome-genome signaling pathways are the best examples of such automation in systems cell. As soon as the perfection in communication is lost, there is noise in the systems and when the self is called upon for application of mind. Following a conscious decision on the remedial measures for the cell systems, the proposed change in life-style works through the epigenetic mechanism to restore the perfection in genome-proteome-metabolome signaling. Further, the capability of willing and the power of will in the biological live-ware of the brain come from participating ground consciousness.

Consciousness, in an overarching position, looks after and in-charge of what all is going on in the mind, self and life of the systems. Operations of consciousness assure support to the operations of self, life and mind and in the process ensure coherence, order and its own supremacy. When consciousness takes a decision, it takes all stakeholders on board.

How do we harness such capabilities of consciousness in the artificial ware? To be inclusive of operations of consciousness, the ware need to be elevated to that state where it is conducive for consciousness, when it can express the will and emotion (feelings) of consciousness.

The decision-making apparatus in any conscious system, brain or non-brain, in micro-, and macro-scale has five apparently non-observable but understandable operations (of information, mind, self, life and consciousness), which make the process really labyrinthine, multilayered and hierarchically nested. The operations are systems-based and are accomplished through different kinds of cognitive networks. This systems labyrinth of this decision-making ware of consciousness requires to be deciphered in systems engineering. The model of this systems labyrinth is shown in Fig. 7.

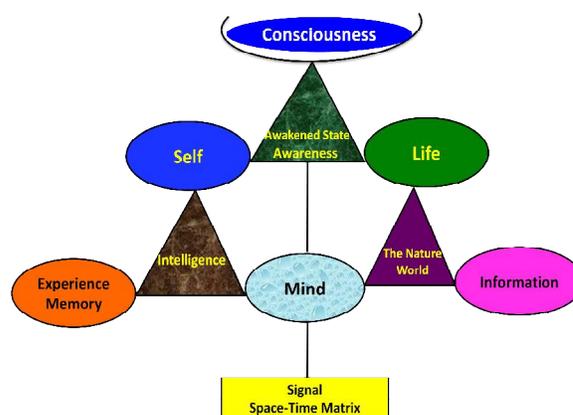


Fig. 7. Systems Labyrinth of a conscious-ware

The operations, although, have been shown encircled in the Fig. 7, operations in reality have been happening in nature in different phases and the phases are in communication. The proposition eliminates old medieval concept of 'ghost' or 'invisible' hands in operation of the psyche and brings objectivity in the approach.

VIII. THE SOURCES OF INGREDIENTS REQUIRED FOR THE WARE

Matter and energy including dark energy are ubiquitous in nature. The source of 'life' is life only.

'Life' comes from life ("*Omne vivum e vivo.*" - Louis Pasteur). Consciousness begets consciousness and consciousness too comes from consciousness only. Human being could be the source of consciousness for a conscious humanoid robot.

IX. VERIFICATION OF THE ARTIFICIAL WARE

The steps for making a conscious ware have been identified: soft ware, mind-ware, intelligent ware, live-ware and conscious ware. In every step while engineering the ware, we are to examine the capability, logic gates and sensitivity of the ware. Following three tables categorize the questions for such verification. The question-weaponry makes us able to label the ware as it stands for. Table 2 begins with five questions.

Questions	Response	Characteristics
Does the ware work according to algorithmic pre-specifications?	No	Not even a software
	Yes	Software
Can it extract meaning out of signal?	No	Software
	Yes	Mind-ware
Can it take a decision on either way, working through a number of options?	No	Software/Mind-ware
	Yes	Intelligent ware. Properties of both mind and self are there.
Can it choose from options available outside algorithmic pre-specifications?	No	Software/Mind-ware/Intelligent ware
	Yes	Live-ware
Can it have its own will?	No	Unconscious ware
	Yes	Conscious ware

Table 2. Questions on the capability of the ware

Any artificial signal or information-processing ware functions on the basis of its logic gate, their number, their mode of functioning. Recently in the controlled laboratory environment, it has been shown how an organic jelly can make fractal logic gate with an infinite truth table [13]! Following is the table (Table 3) with questions weaponry in the context of logic gate of the ware.

Questions	Response	Characteristics
How many logic gates are there?	One, two or a few	Software
Can any of the logic gate be made to function endlessly?	No	Software
	Yes	Self and Mind are in the ware! Example: self-organizing fractal.
Can the number of logic gates be more than a few?	No	Non-living ware
	Yes	Live-ware
Is new logic gate appearing spontaneously in the ware?	No	Unconscious ware
	Yes	Conscious ware

Table 3. Questions on its Logic gates

In systems engineering, one designates 'Controller' and the 'Plant'. The former monitors the 'regulated variables', in reference to 'set point' and generates signal to correct the 'error-value' by stimulating the 'flow' from the 'Plant' [14]. Every nest of the systems will have designated controller and the plant and their regulated variables. Therefore we also need to know the sensitivity of each operator and its operations (Table 4).

Questions	Response	Characteristics
Is the ware sensitive to only signals?	Yes	Software
Is the ware sensitive to information too?	No	Software
	Yes	Mind-ware
Is the ware sensitive to phenomenon as well?	No	Mind-ware
	Yes	Intelligent ware
Is the ware sensitive to change of symmetry around it?	No	Nonliving ware
	Yes	Live-ware
Is the ware sensitive to environmental surrender of properties?	No	Unconscious ware
	Yes	Conscious ware

Table 4. Questions on the Sensitivity of the ware

X. THE TESTABLE MODELS FOR UNDERSTANDING THE OPERATIONS

Do we have any model where all the statements on the operations could be verified? Yes, at present, there are two live-models, which can be used to understand these hitherto unobservable operations and their possible applications in development of this conscious ware. Eddy and Funk advocate for fostering synergy between cell biology and systems biology [15]. The author has recently published how the systems cell could be used as a testable model for the holism described above [16]. The molecular signatures of different operations could be obtained from experiments in cell biology such as live cell imaging and nano-tracing of molecular traffic. This will allow us to understand further the nature of different operations hitherto non-observable. In the nervous system, there is glia-neuron model through which one can verify and acquire knowledge how systems biology of neurons are mosaiced with those of astrocytes, how cognitive networks of systems biology of two kinds of cells is embedded in systems biophysics and informatics in the nervous system.

XI. CONCLUDING REMARKS AND PERSPECTIVES

Science progresses when imagination is based on existing knowledge [17]. On the background of knowledge existing in psychology, cell biology and neuroscience, imagination of the author has acquired a shape in form of models as shown in Figs 1, 2, 4, 5, 6 and 7 and resulted in a question-weaponry with which progress can be made in systems engineering for developing a conscious ware. The matters of immediate concern are how to engineer the dark energy, what is its relation to visible energy and how operations of 'life' come in between. One can expect a fusion of biotechnology, nanotechnology and information technology while nurturing the nature of the brain in the artificial ware. What is yet to be decided is the basic nature of the matter for developing such ware, a chemical jelly, or a mass of protoplasm with DNA, or glia-neuron culture, and how to go about it step by step.

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REFERENCES

- [1] H. C. Mak, and Q. Justman, "How to understand Systems," Cell Systems, vol. 1, pp. 99, 2015. doi.org/10.1016/j.cels.2015.08.009
- [2] A. K. Mukhopadhyay, The Millennium Bridge. New Delhi: Conscious Publications, 2000.
- [3] A. K. Mukhopadhyay, "A Radical view of Information. On its nature and Science," Frontier Perspectives, vol. 16, no. 2, pp. 19-29, 2008. <http://akmukhopadhyayconsciousness.com/pdf/LINK6.pdf>
- [4] A. K. Mukhopadhyay, Setting the Agenda for a Science of Information, 2013. <http://akmukhopadhyayconsciousness.com/pdf/LINK14.pdf>
- [5] A. K. Mukhopadhyay, "God Particle to Consciousness. Life-science, Neuroscience and Nonlocal Science hold the Key," Science and Spiritual Quest, pp. 108-123, 2012. <http://akmukhopadhyayconsciousness.com/pdf/LINK12.pdf>

[6] A. K. Mukhopadhyay, "Information Holograph. The Structure, the Source and its Operation," *International Journal of BioEngineering, NeuroSciences and Technology*, vol. 2, no.2, pp. 12-32, 2012.

<http://akmukhopadhyayconsciousness.com/pdf/LINK13.pdf>

[7] J. Moore, "Participating in Explanatory Dialogues: Interpreting and Responding to Questions in Context." Cambridge: MIT Press, 1994.

[8] J. Rasmussen, A. M. Pejtersen, and L. P. Goodstein, "Cognitive System Engineering." New York: John Wiley & Sons, 1994.

[9] R. M. J. Cotterill, "CyberChild A Simulation Test-Bed for Consciousness Studies," *Journal of Consciousness Studies*, vol. 10, no. 4-5, pp. 31-45, 2003.

[10] N. Block, "On a confusion about function of consciousness," *Behavioural and Brain Sciences*, vol. 18, pp. 227-247, 1995

[11] S. Bringsjord, "Offer: One billion dollars for a Conscious Robot; If you are honest you must decline," *Journal of Consciousness Studies*, vol. 14, no.7, pp. 28-43, 2007.

[12] A. M. Butt, "ATP: A ubiquitous gliotransmitter integrating neuron-glia networks," *Seminars in Cell and Developmental Biology*, vol. 22, no. 2, pp. 205-213, 2011. [doi:10.1016/j.semdb.2011.02.023](https://doi.org/10.1016/j.semdb.2011.02.023)

[13] S. Ghosh, D. Fujita, and A. Bandyopadhyay, "An Organic jelly made fractal logic gate with an infinite truth table," *Sci. Rep.*, vol. 5, p. 11265, 2015. [doi:10.1038/srep11265](https://doi.org/10.1038/srep11265)

[14] M. Kotas, and R. Medzhitov, "Homeostasis, Inflammation, and Disease Susceptibility," *Cell*, vol. 160, pp. 816-827, 2015. [doi: 10.1016/j.cell.2015.02.010](https://doi.org/10.1016/j.cell.2015.02.010)

[15] J. A. Eddy, C. C. Funk, and N. D. Price, "Fostering synergy between cell biology and systems biology" *Trend. Cell Biol.*, vol. 25, no. 8, pp. 440-445, 2015. doi.org/10.1016/j.tcb.2015.04.005

[16] A. K. Mukhopadhyay, "Systems Cell: a Testable Model for Systems Holism," *International Archives of Medicine*, vol. 8, no. 104, pp. 1-10, 2015. doi.org/10.3823/1703

[17] J. Goldstein, "A Well-Hung Horse: Sired by Knowledge and Imagination," *Cell*, vol. 162, pp.1179-1182, 2015. doi.org/10.1016/j.cell.2015.08.03



About the Author

Dr. A.K. Mukhopadhyay is a medical graduate from the University of Calcutta (1977), a postgraduate (MD) from All India Institute of Medical Sciences (1981), joined the Faculty of AIIMS in 1985. At present he is Professor & Head, Department of Laboratory Medicine at AIIMS, New Delhi. He is Member of the National Academy of Medical Sciences (India), New York Academy of Sciences, USA, Society for Scientific Exploration USA, Scientific and Medical Network, UK, a Fellow of International Society for Philosophical Enquiry, USA. From India he was an invitee of Pontifical Academy of Sciences, Vatican, during Academy's meeting of Science for Man and Man for Science in November, 1999. He coined the term and concept of supracortical consciousness in 1985 and developed further this idea integrating Science, Humanity and Spirit. His keen desire to develop a Science for Consciousness has given birth to four worthy documents; (i) *Frontiers of Research for Human Biologists* (1985), (ii) *The Dynamic Web of Supracortical Consciousness* (1987), (iii) *Conquering the Brain* (1995) and (iv) *The Millennium Bridge* (2000).

Website:

<http://www.akmukhopadhyayconsciousness.com>

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