The Simulation Model of a complex System: the neural System

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Abstract

The object of this study was to create an elementary electronic circuit which can produce signals that are similar to those produced by intracellular and extra-cellular circuits, a hardware that works autonomously with no need of an external software because it self-creates it. In this paper I describe an artificial, and/or bionic, neural structure formed by the simulation of modular similar-analogic electronic elements for generating and/or re-establishing correct communication between components of a biological structure, in particular a nervous System. I present a series of data, which derive from a simulation of what becomes a very simple electronic and informational elementary circuit. This circuit is extrapolated from many other circuits which are supported by a universal model and, working together, give coherent answers and are able to help or replace a neuron or a group of neurons. The simulated structure includes a plurality of modular electronic devices interconnected together to form at least one pair of meshes and is able to generate analogic electrical signals of various waveforms and various electric powers. I have so realized an simulator System as a quasi-Boolean net, but functional only, because the omni-directional reaction to an operative, at a perturbation level action, gives origin to different functionalities in a similar structure, which exists in a non-digital way, or, it might be better to say, which lives in an analogical quasi-digital way, with molecular code and decode factors, to which, at present, I approximate in an quasi-complete way. I have obtained an almost perfect correlation between those signals that are generated in nature and those that we have artificially produced. I have demonstrated that, to build a real and working artificial intelligence, or a particular part of it, we must preliminarily plan an "opposite-engineering" System that, starting from the biological and not "vice/versa", can, in the meantime, define the "how", hoping it becomes even the "why". The fundamentals ideas that lead to the new electro-informatics model construction are examined either from a theoretical point of view (that is the basis for my researches and which describes the production and the direction bus of the informative signals) and from the point of view of the structure realization.

Keywords (in alphabetical order)
Automata; Chaos; Complexity; Cyborg; Models; Neurons; Robotics; Systems; Uncertainty.

The Author's Research Path

From the social System, which is one of the many sub-Systems of the System-universe, I have extrapolated one only Individual, which is one of the social sub-Systems and I have analyzed one of his many sub-sub-Systems, namely the nervous System. *Fig. 1*.
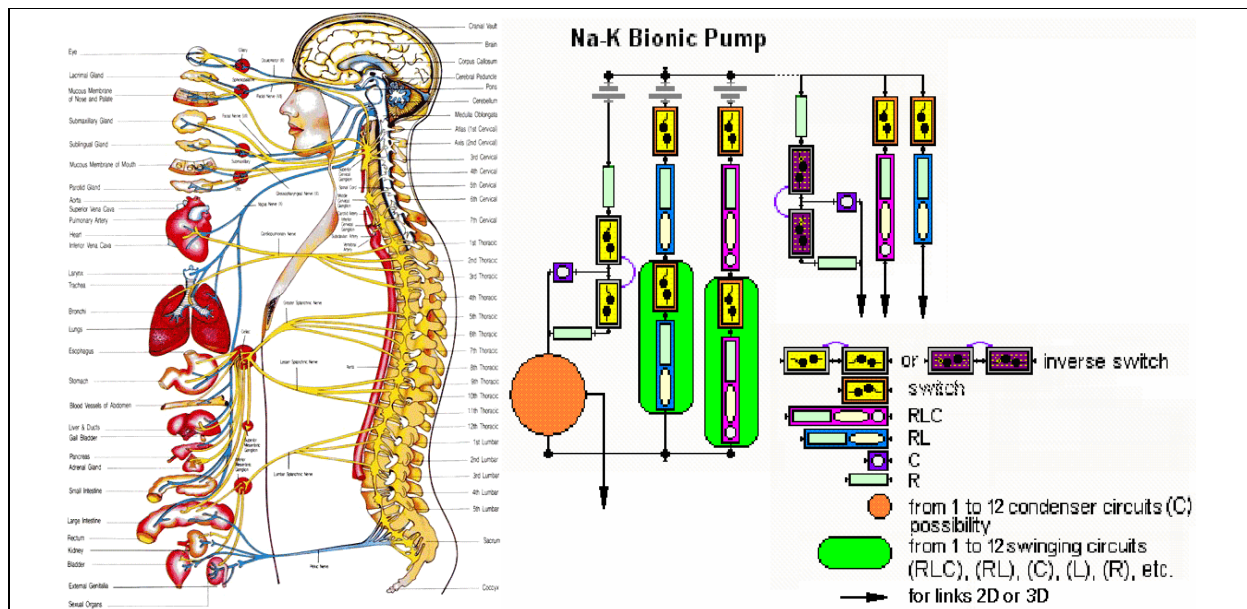
Fig. 1

What I have done is not restrictive as we can assume that the other sub-sub-Systems behave in the same way, now that we know, basing on the **P-N-E-I** theory (*Fig. 2*), that they are all inter-connected, so they must use the same communication codes. And therefore, analogous behavioural keys.
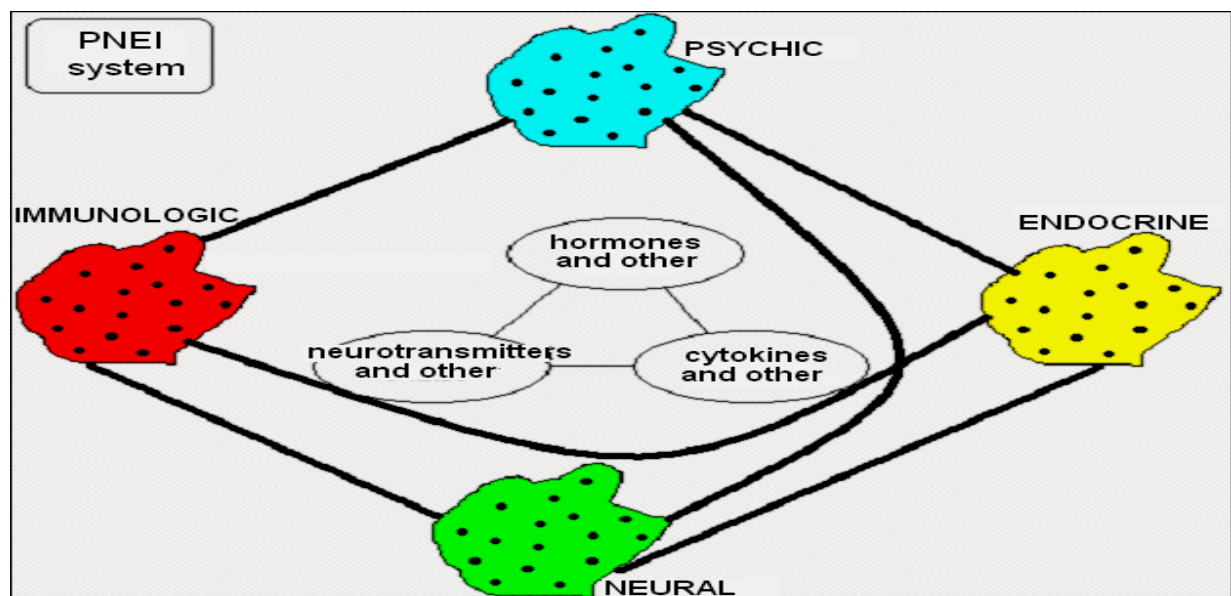

Fig. 2

In *Fig. 3* we represent the hypothesis:

- of the neural segmentation;
- of the operative frequencies set choice.

The Figure above follows the actual traditional approach.
The set of octaves keys on a piano's keyboard is the set of frequency intervals of the waves used, obviously with the appropriate associations, combinations, permutations and dispositions.
Either for assonances and for dissonances.
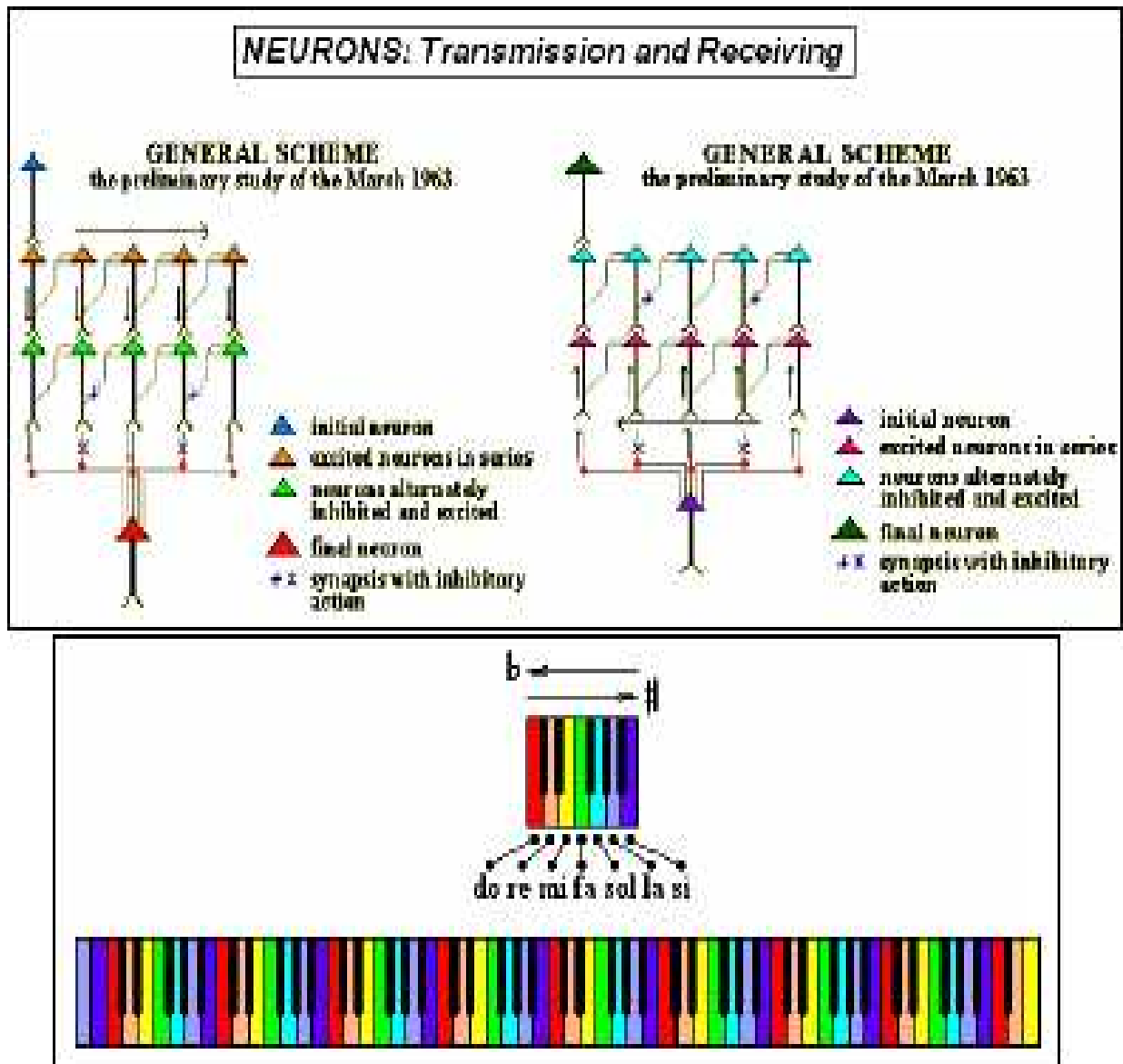
Fig. 3

This *Fig. 4* represents the fortuitous intuition that allowed me to build the new model of neural transmission: the sax-neural coupling analogy.
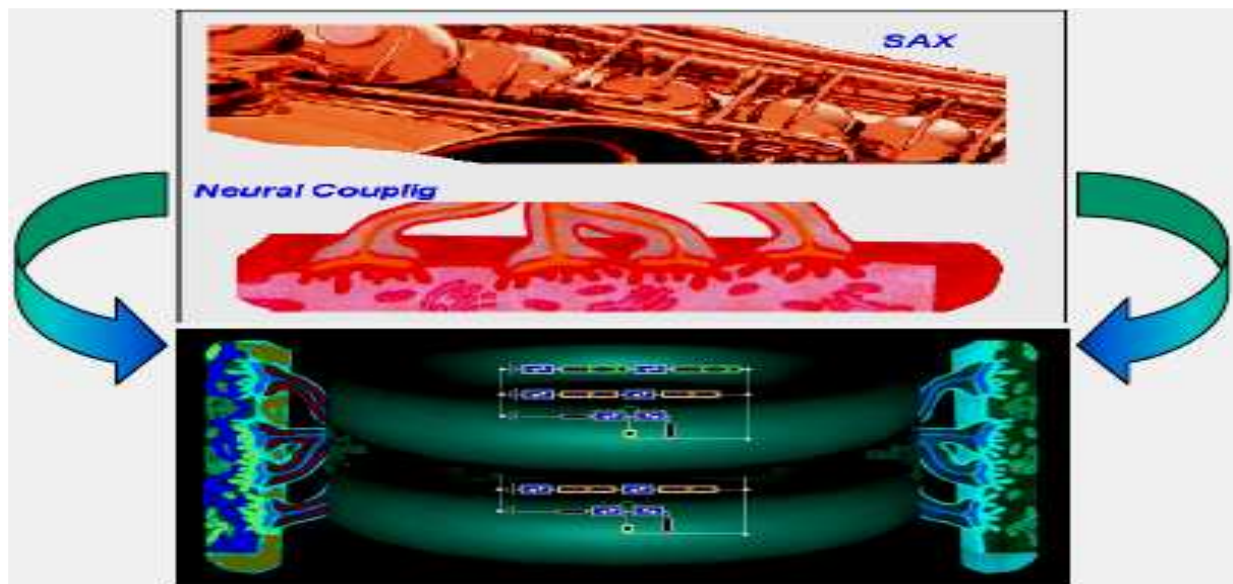
Fig. 4

And this is the new neural transmission's model. *Tab. 1*.

As you can notice it is much more extended than the current in use, because it considers the inertia in reception and in transmission of what is natural versus the artificial.

If you want to simulate reality, which is analogical, and not digital, we must adapt to its needs.

HOPFIELD'S MODEL	NEW MODEL
1. The time and neural activity are non-continuous.	*1. The time and neural activity are non-continuous.*
2. The neurons are geometrically arranged in a reticule form and are connected to each other.	*2. The set of 2n neurons is subdivided into two subsets: n transmission (j neurons), n reception (m neurons). Both neuron subsets are connected between them by unidirectional reticule connections.*
3. To the m^{-th} neuron a variable $\sigma_m = +1$ is assigned if the neuron is active or $\sigma_m = -1$ if it is passive.	*3. To each neuron a variable $\sigma_j = +1$ is assigned if the neuron (of subset j) is active (in transmission) and $\varepsilon_m = +1$ if the neuron (of the subset m) is active (in reception). To each neuron a variable $\sigma_j = -1$ is assigned if the neuron (of subset j) is passive and $\varepsilon_m = -1$ if the neuron (of subset m) is passive (in reception). The reception frequency is determined by induction from the transmission frequency.*

Tab. 1 - NEURAL TRANSMISSION
(see Fig. 6)

In *Fig. 5* I have represented the key tools to perform the simulation:

- the Cubic Matrix algebra [for zero (only one element) -one-two-three dimensions];
- the "De Morgan Plus"' Theorem (for circuits' simplifications);
- the Plasma-Jet Cone flux.

I had to formulate the Cubic Matrix algebra for solving Systems of Systems of equations.
It shows an interesting characteristic about the Heisenberg's uncertainty Principle.
This may also allow in general to deal with undetermined problems in the macro.
The "De Morgan Plus" Theorem is my implementation of the main theorem.
The Plasma-Jet Cone flux comes from my studies on magneto-fluid-dynamics.
As you can notice, the construction of a model is always math.

Fig. 5

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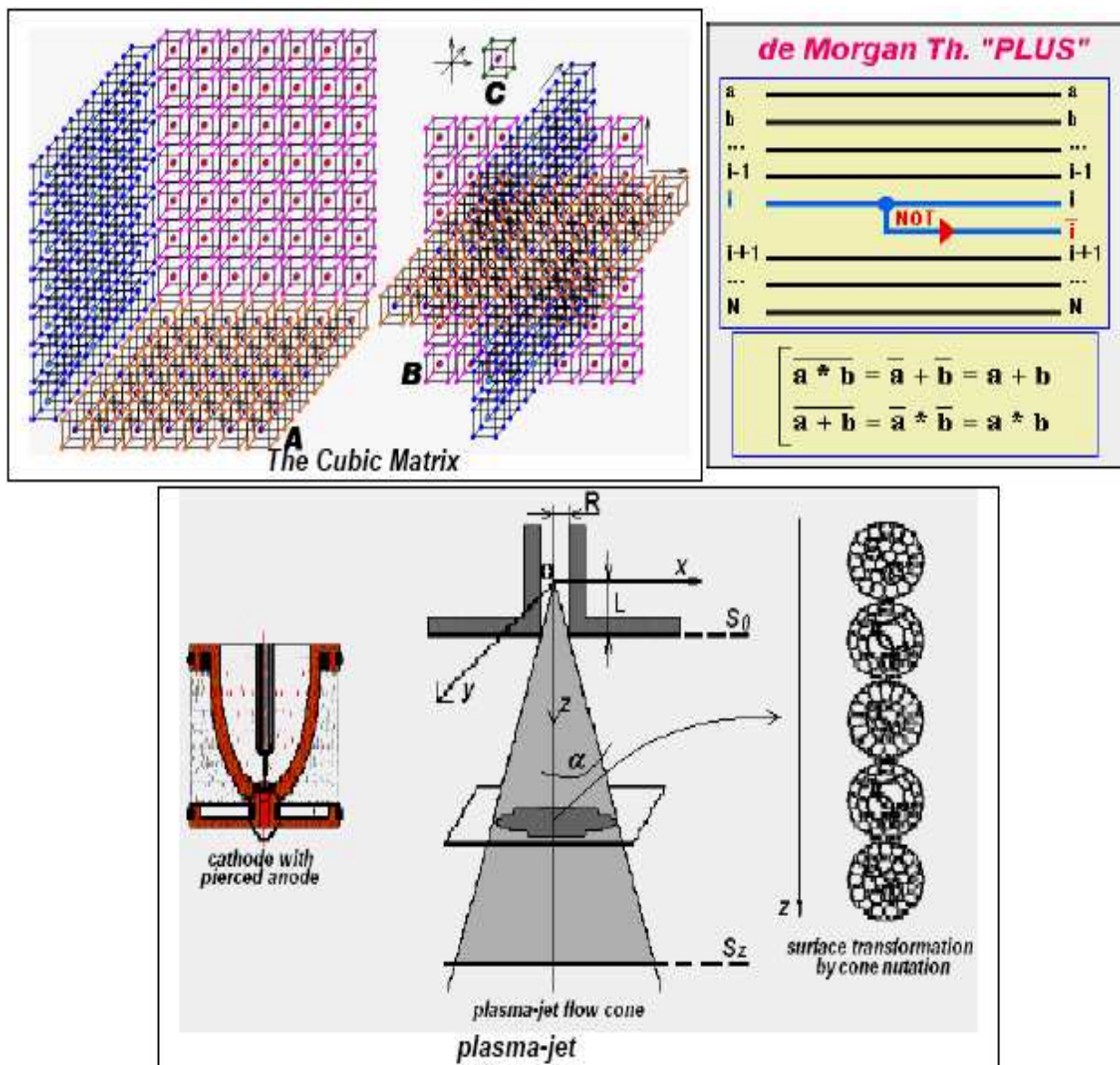
The simulation (*Fig. 6*) was achieved following the hypothesis of an in-put/out-put model among sets of neurons in communication.
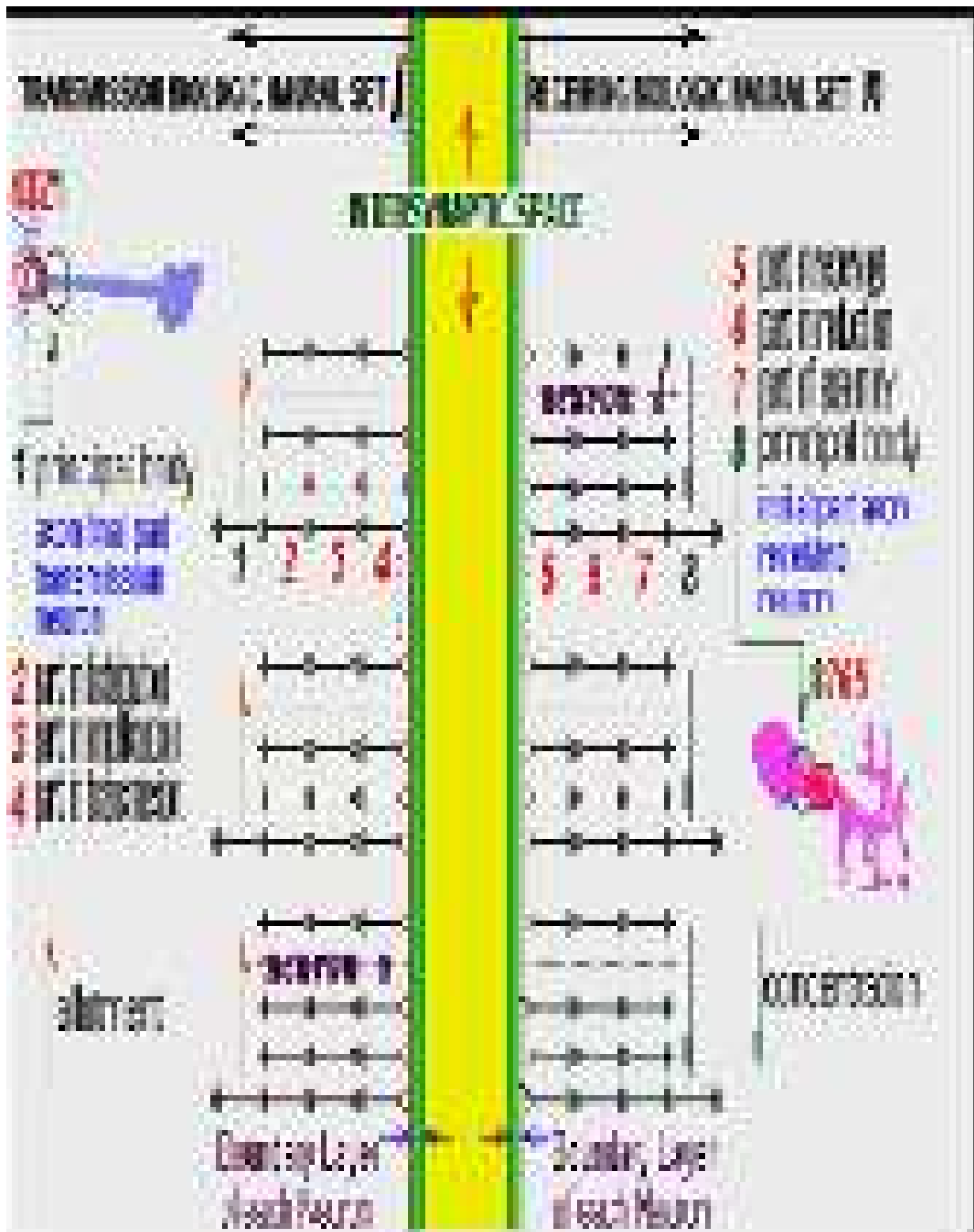

Fig. 6

The intersynaptic space (*Fig. 7*) is here very simplified and doesn't show the presence of mediators of communication, such as the astrocytes, glial cells.
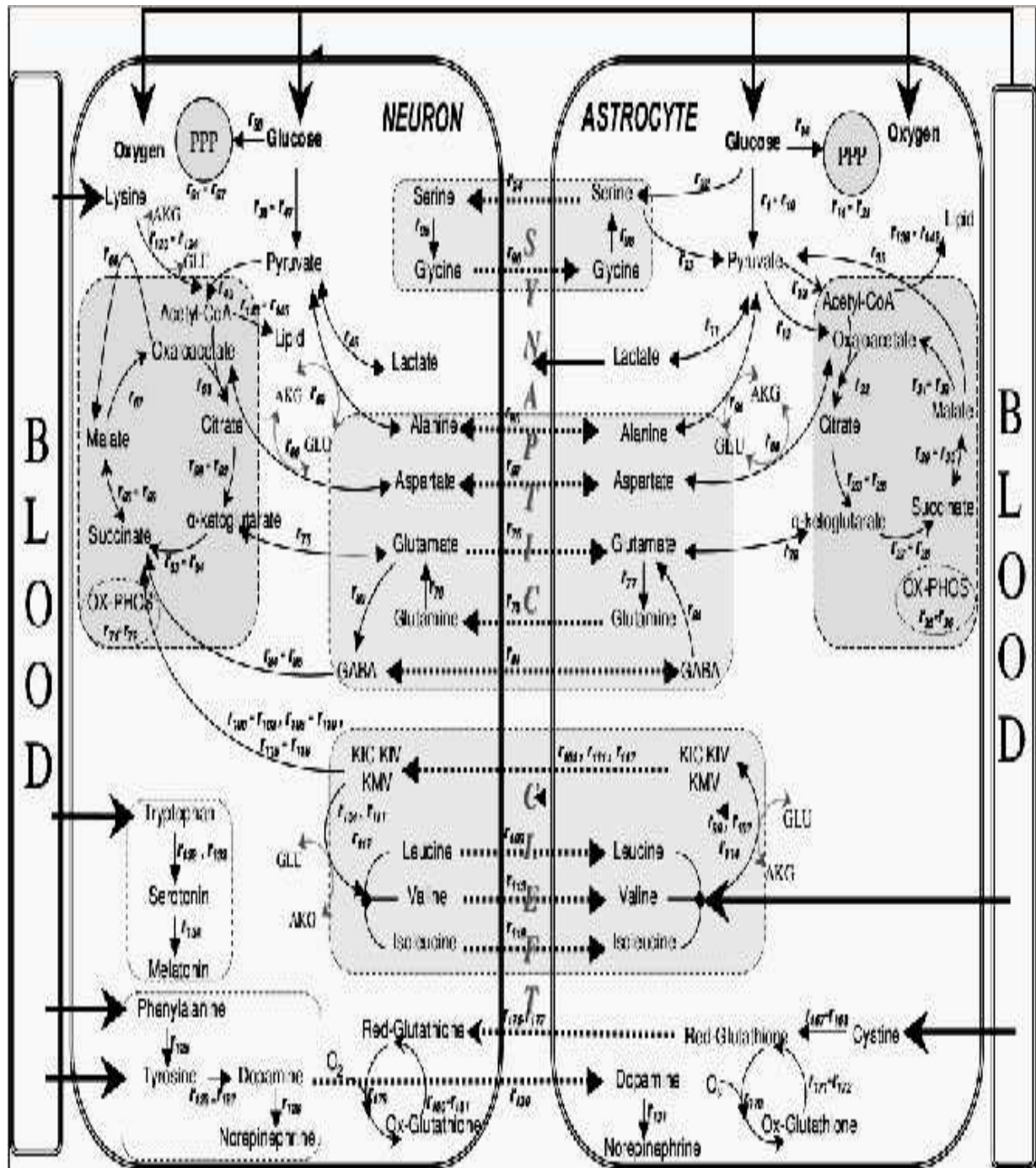

Fig. 7

These cells are schematized in their behaviour by a mathematical simulation in the space-time. The space-time choice was made because in this research we can't pass over neither the theory of relativity nor (above all) the quantum mechanics. *Fig. 8*.
The ball that you can see on the right is the astrocyte.
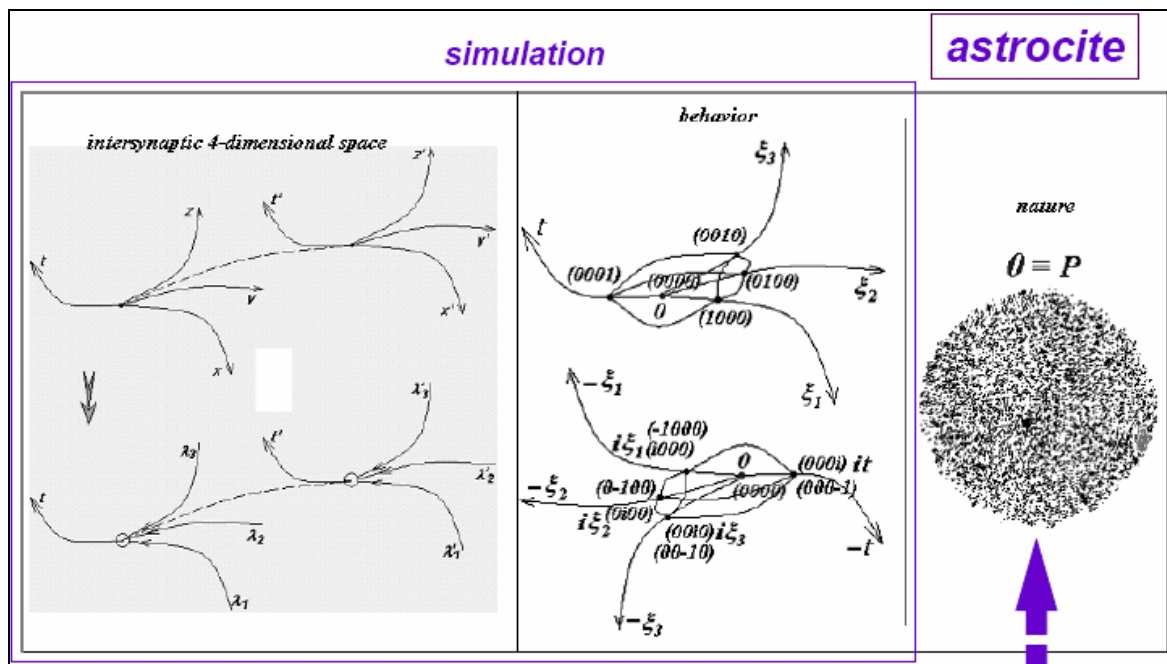
Fig. 8

The new explanatory model (*Fig. 9*) for the neural communication is the one represented in this Figure n°, in which I show the various levels of physical-mathematical study.
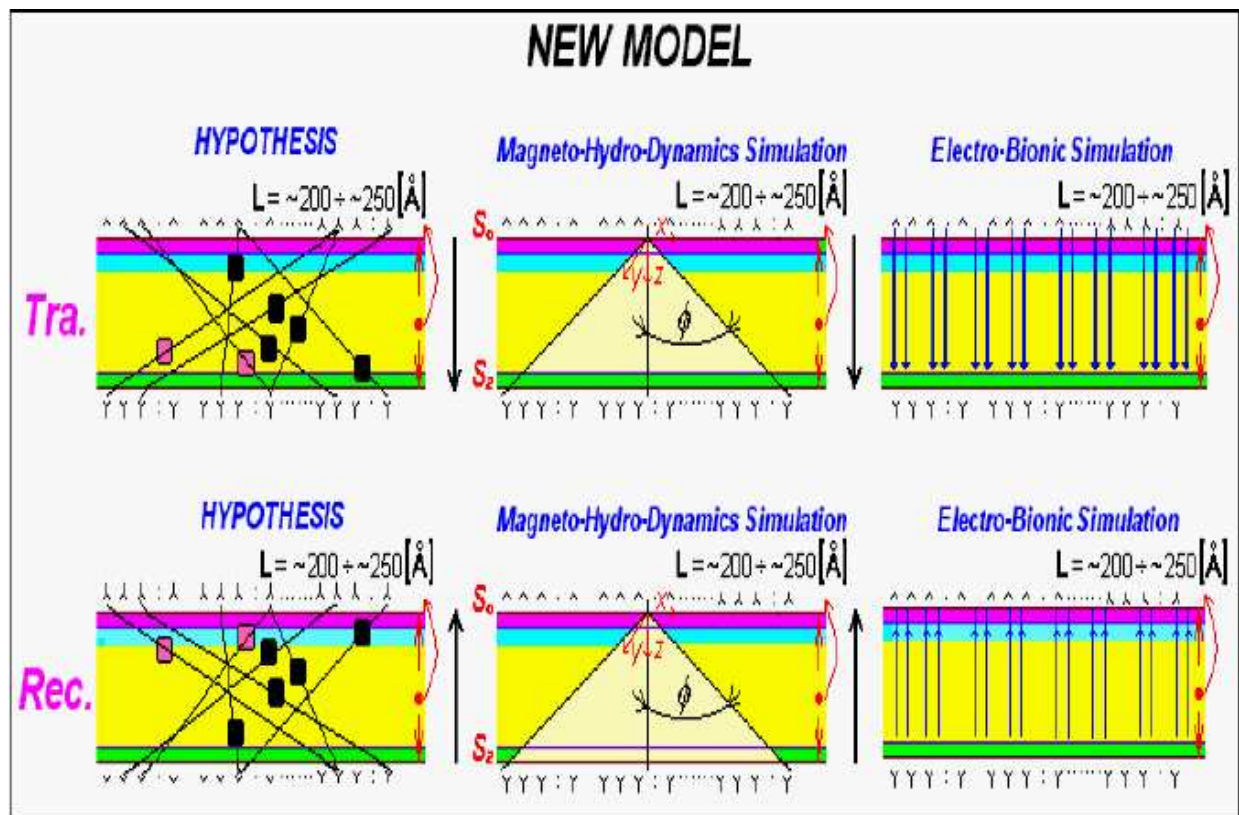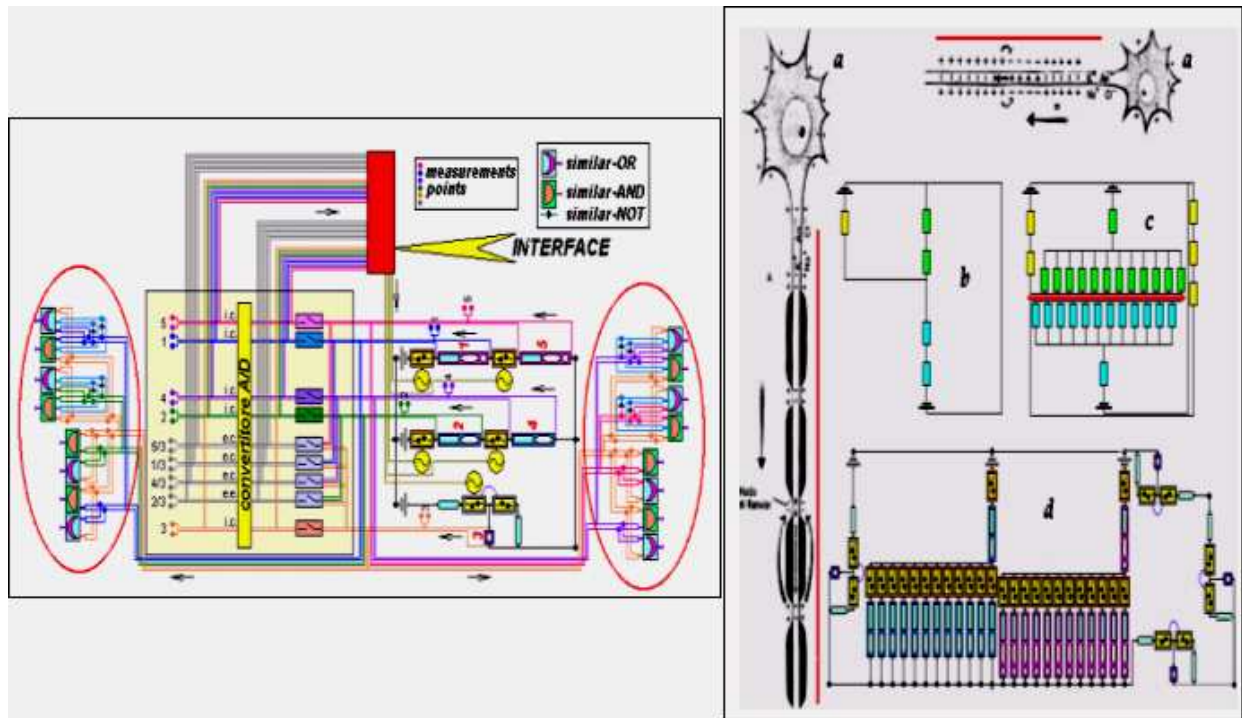

Fig. 9

In *Fig. 10* I show what I have obtained, that is the elementary circuit and the structural-functional neural analogy.

Fig. 10

Whose heart is represented here. *Fig. 11*.
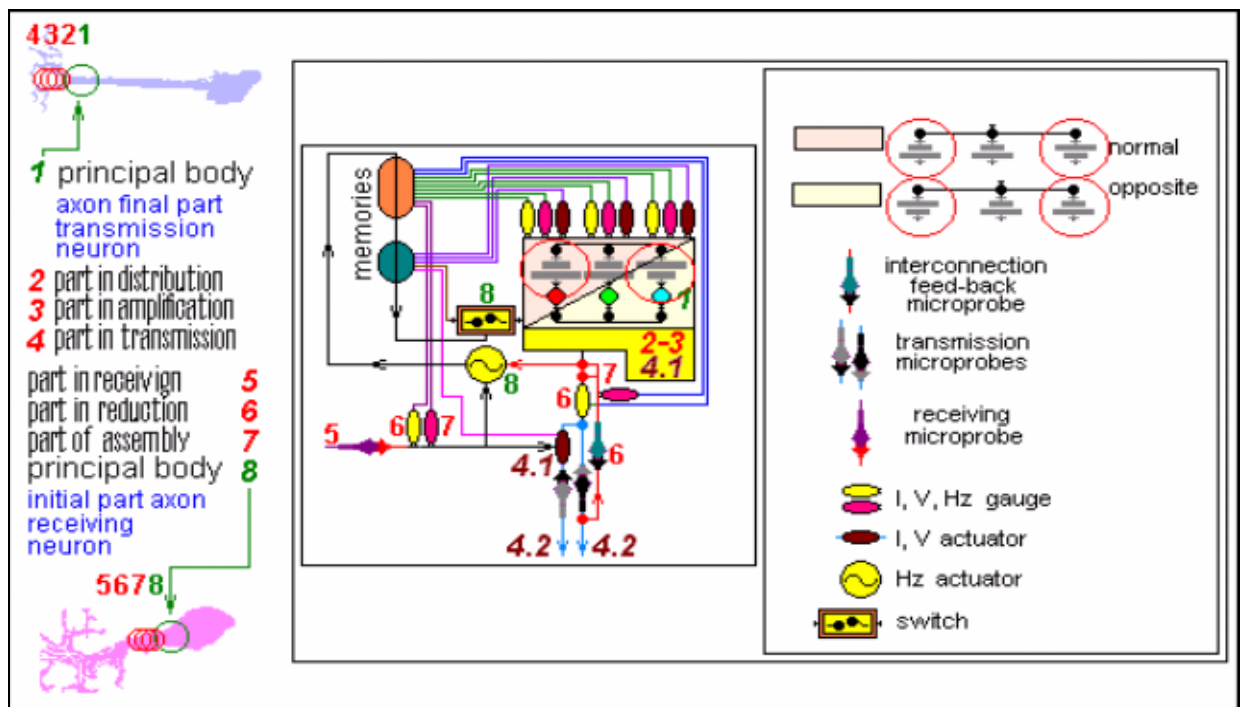
Fig. 11

Another step was to obtain this other analogy: the Axon-Linear Accelerator analogy (non-relativistic case). We can see in the Figure the strict analogy either as a structure and as a function between the **L-I-N-A-C** and a neuron. *Fig. 12*.
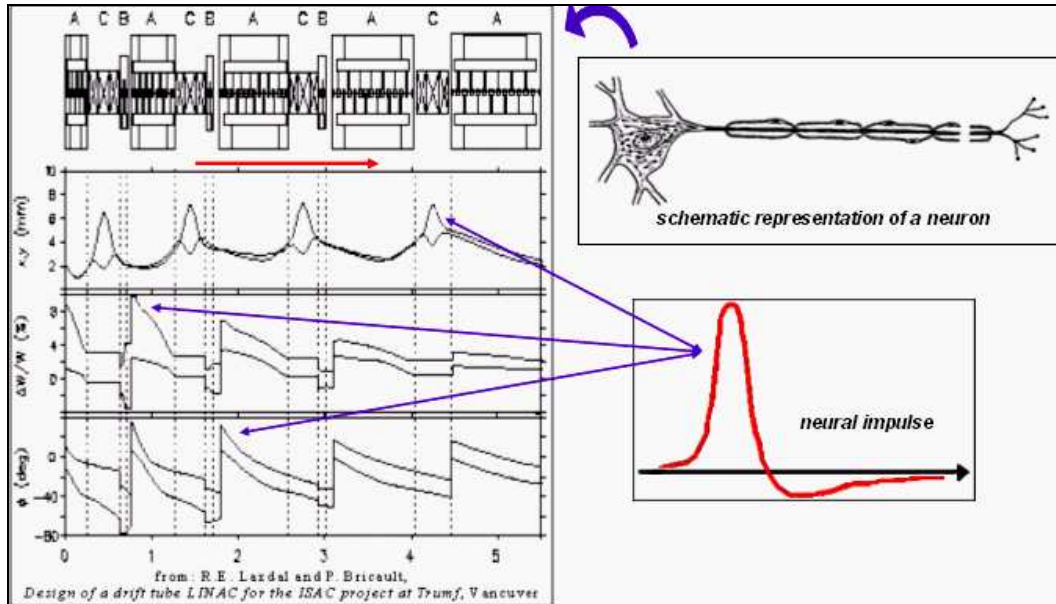
Fig. 12

A further step was to make a geometric simulation and a hypothesis of a brain's behaviour following an internal or an external stimulus: the brain-ellipsoid of rotation analogy. *Fig. 13*.
In the central Figure deriving from my simulations, we can see the ellipse that is run through by a stimulus involving a range of areas of the brain. We have to notice that the ellipse is the projection, in the three-dimensional space, of a straight line in the space-time, which is run over in a not-uniform way.
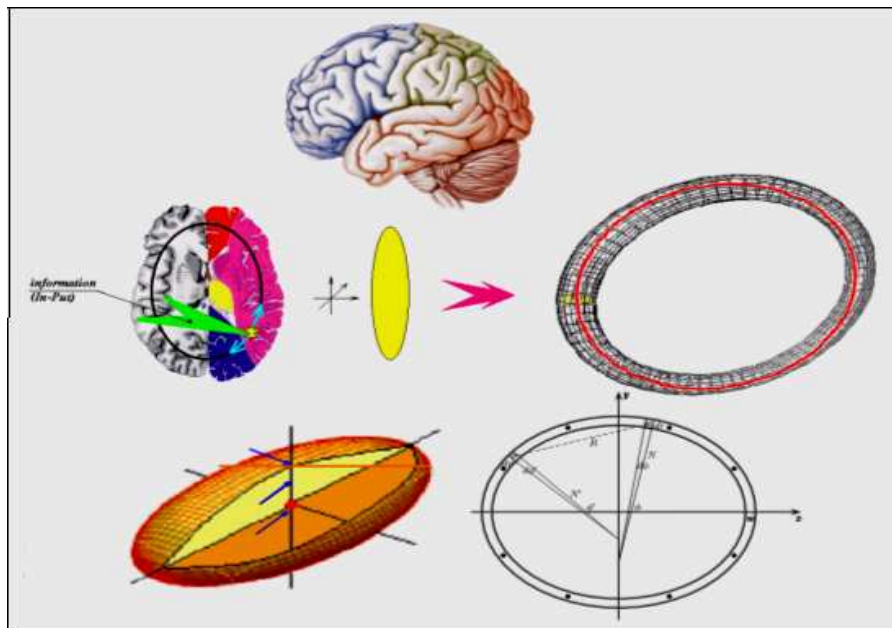
Fig. 13

This shows how the various areas of the brain can receive an informative communication in relatively different times and so also assimilating and reacting in different times. *Fig. 14*.
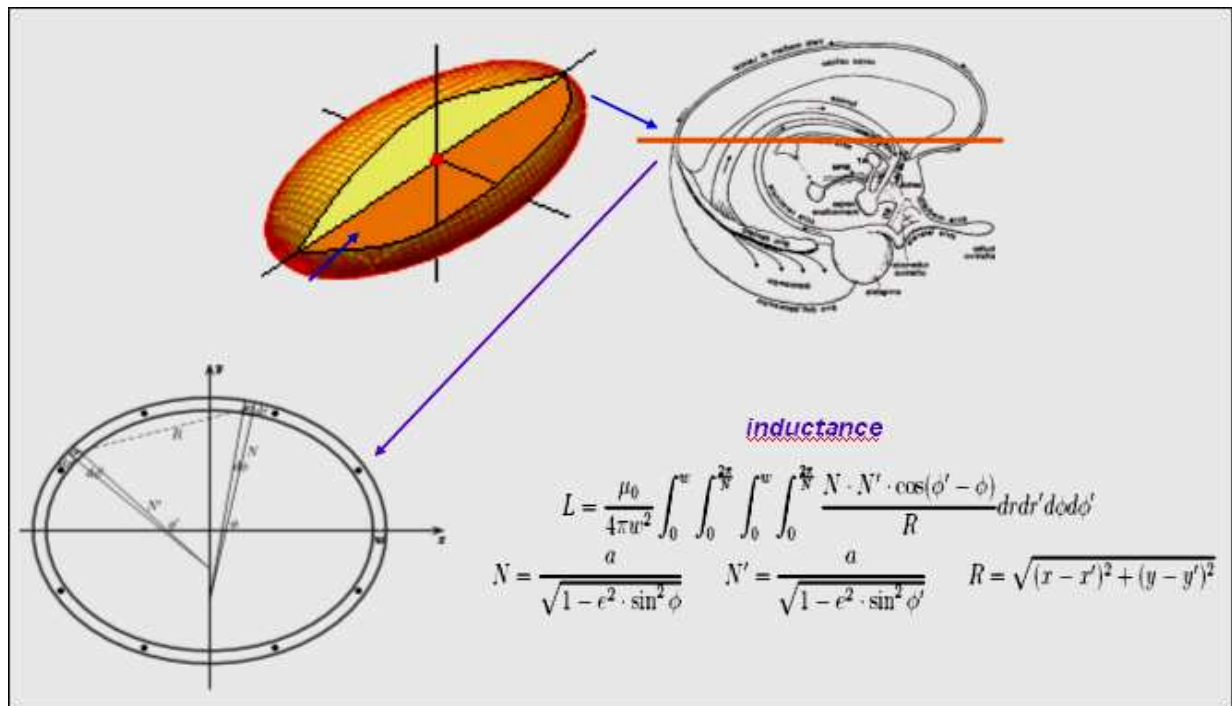
Fig. 14

We can consequently think valid, in particular human body's areas, the non-local principle and not the possibility of entanglement (but not the certainty of this *non-possibility*). This may be because Life works at negative entropy (or negentropy), just as an adrift of Schrödinger's statistic thermodynamics. *Fig. 15*.
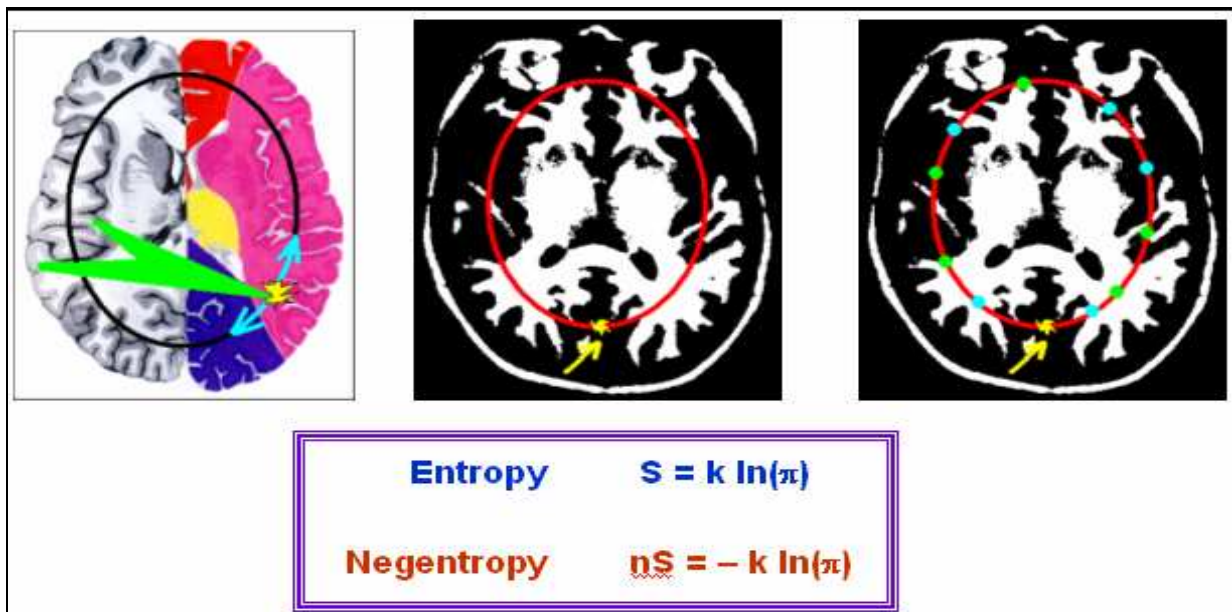
Fig. 15

And this is the first mathematical model obtained for the study of the whole neural communicative behaviour. *Fig. 16*.
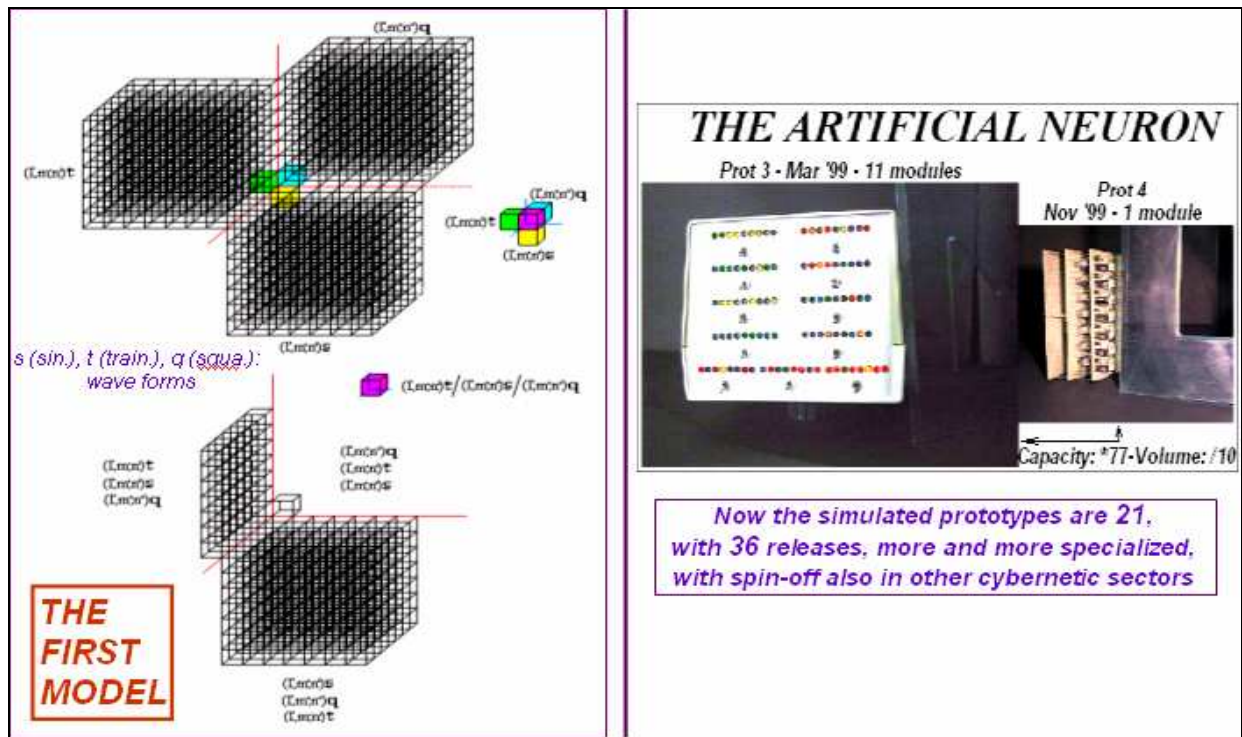
Fig. 16

Thanks to all this, I built this final model that is really complicated which has to be solved with a System of differential equations at partial derivatives. *Fig. 17*.

I tried to overcome this difficulty including a semi-empirical formula that I had made for other.

$$v_i = [1 \pm 1/a_i]^+ b_i^{1/5} \cdot n_i^2$$

n and *b* natural, and *a* natural ≥ 2
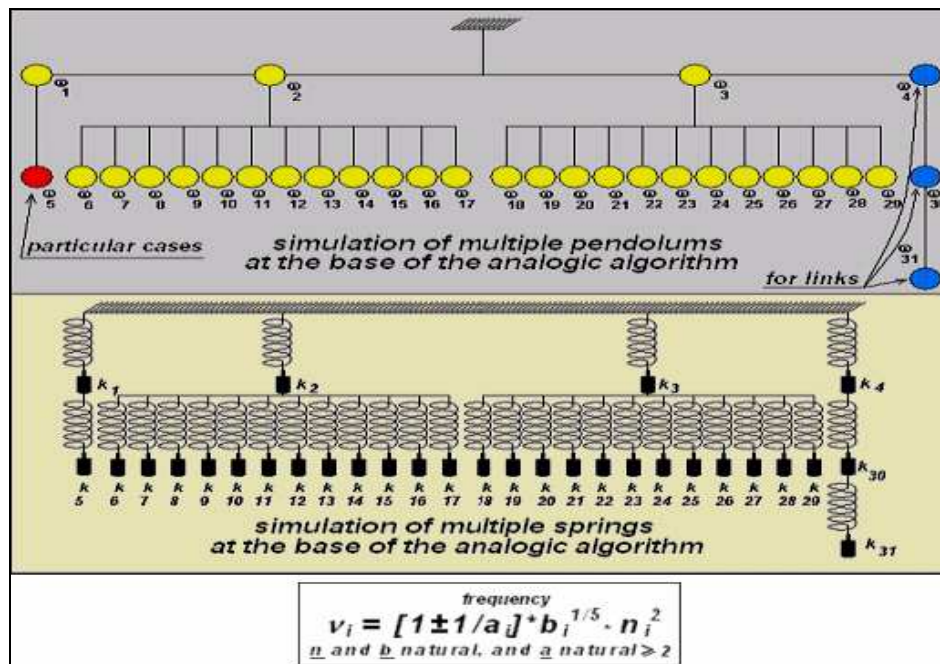
Fig. 17

This final model, as I found out later, in its preliminary hypotheses, can also make possible the study of the performances of the Power Management in social Systems. *Fig. 18*.
In fact, the interiority of each individual influences and is influenced by its external environment.
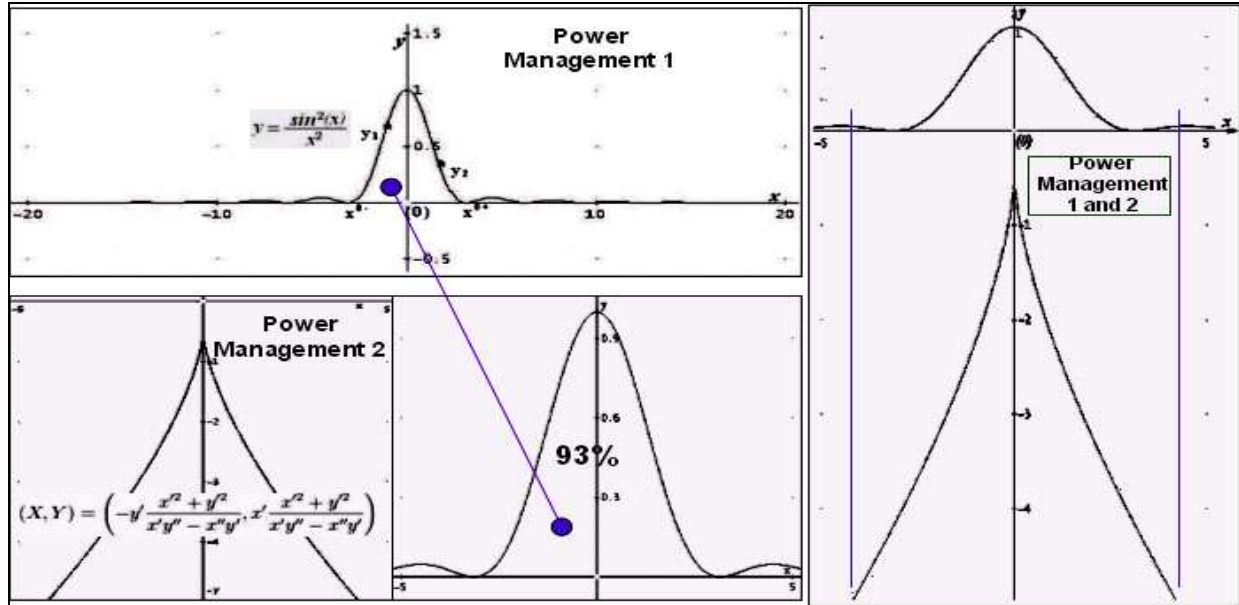
Fig. 18

In the end, this neural study is focused on the first outcomes presented, on the distribution of circuits to be analyzed and on this summary card (on the left), with the goal of a bionic simulation. *Fig. 19*.

Fig. 19

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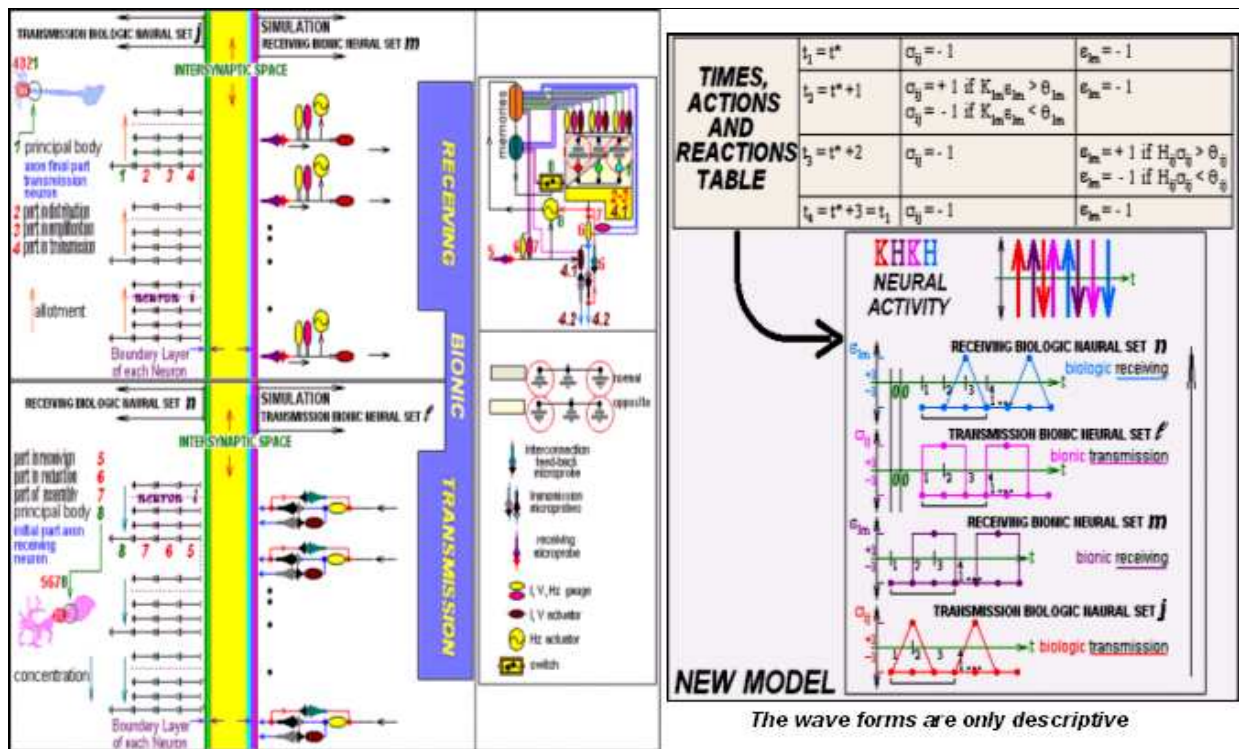
The outcomes can be easily seen.
Here I show the striking coincidences among the intra-cellular signals (*Fig. 20*).
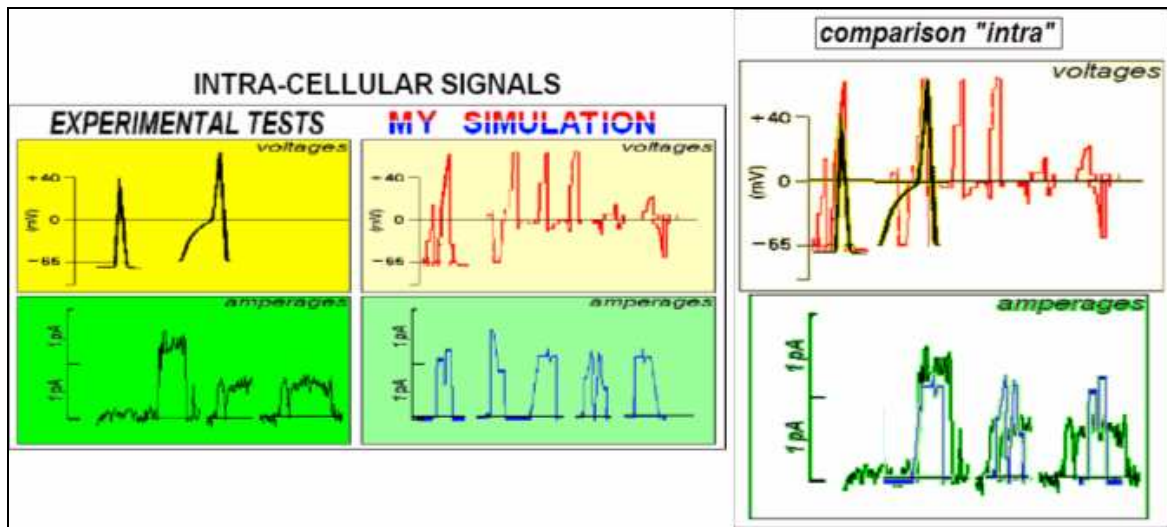
Fig. 20

And in this *Fig. 21*, those among the extra-cellular signals.
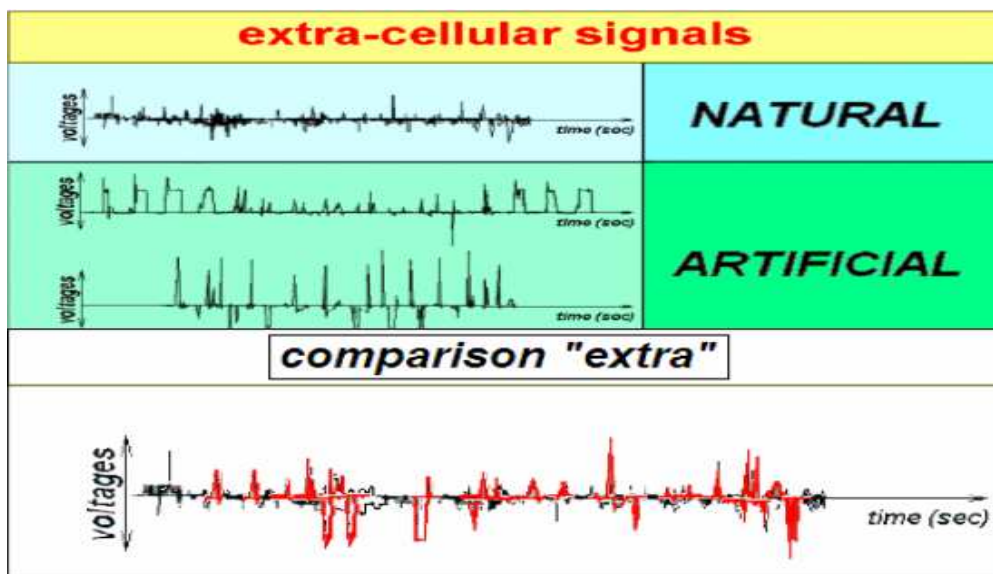
Fig. 21

Ultimately, I simulated a series of prototypes, and in all the previous models, the essential work is in accordance with these assumptions:

- we have the configuration of balance for the Na-K pump;
- we can insert in it switches and replace the generic resistances with appropriate resistors, which run in fixed frequency-fields;
- opening and closing the circuits, we can create the conditions of dis-equilibrium, that give different productions of currents, which, each in turn, generates various signals in transmission.

The various signals must then be put together, placed, enlarged and transmitted. *Fig. 22*.
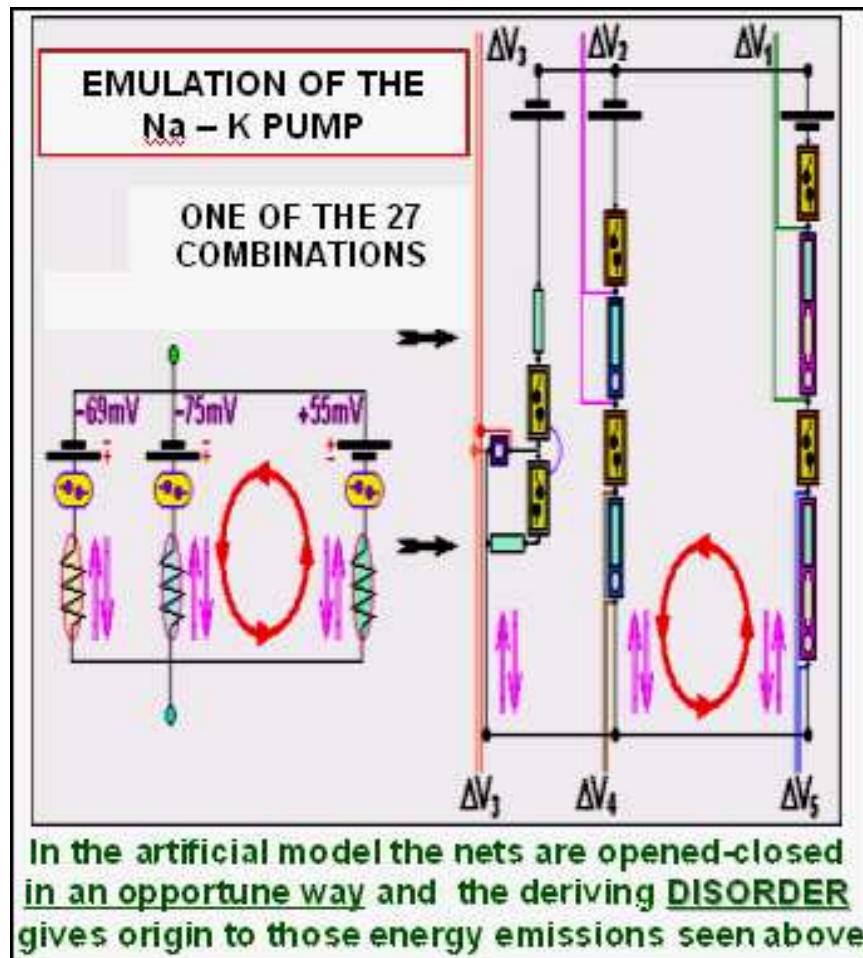
Fig. 22

I can describe this very simplified prototype model which consists of a single sub-stratum among 80 (40 + 40) sub-strata, that at its turn becomes a single element of an hexagonal. *Fig. 23*.

group, and this single element has 5 signals instead of 27.

I have obtained an almost perfect correlation between the signals that are generated in nature and those that I have artificially produced. Analyzing the data, I have noticed that equal signals obtained among the signals generated in nature and those that I have artificially produced can be compared, either for values and for development, to the pre and post-synaptic ones.

In fact, the presented bionic simulated structure proves to be analogous to a set of staminal cells, and moreover, with the opportune modifications of the resistance elements, it is even analogous to a set of glial cells.
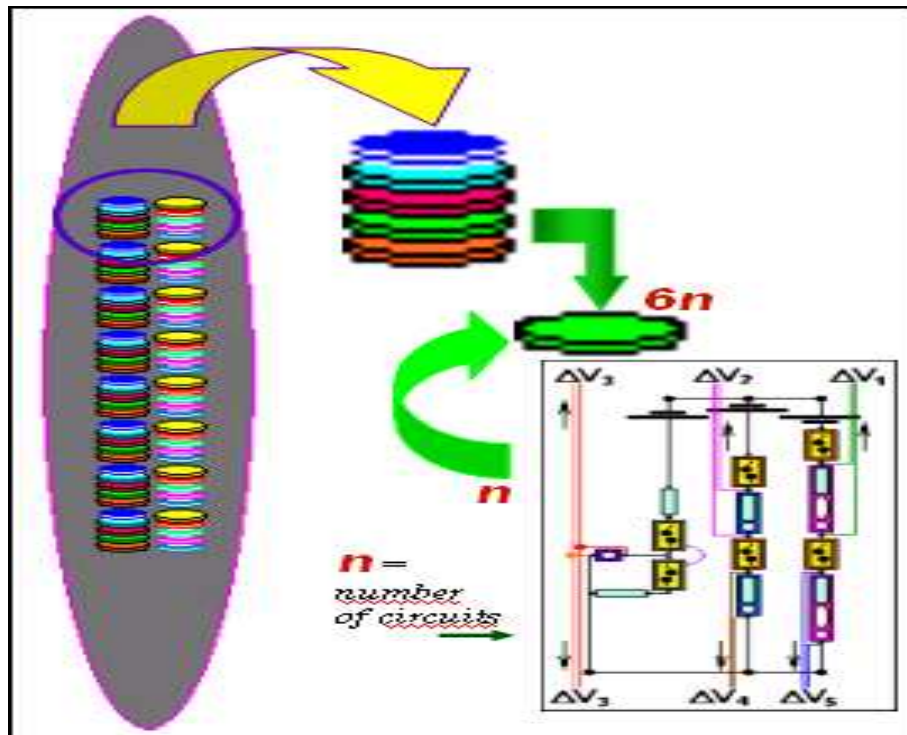
Fig. 23

An example of simulated artificially analogical signals. *Fig. 24*.

Using the Fourier's analysis, in series, we can demonstrate that, for every sequence of bionic emission, there are various harmonics which are similar to those from natural neurons.

My results concerning the third component (the condenser):

This third component is a particular component in which all the other simple intracellular signals, defined by their resemblance to physiologic intracellular signals, are combined in order to produce extra-cellular signals.
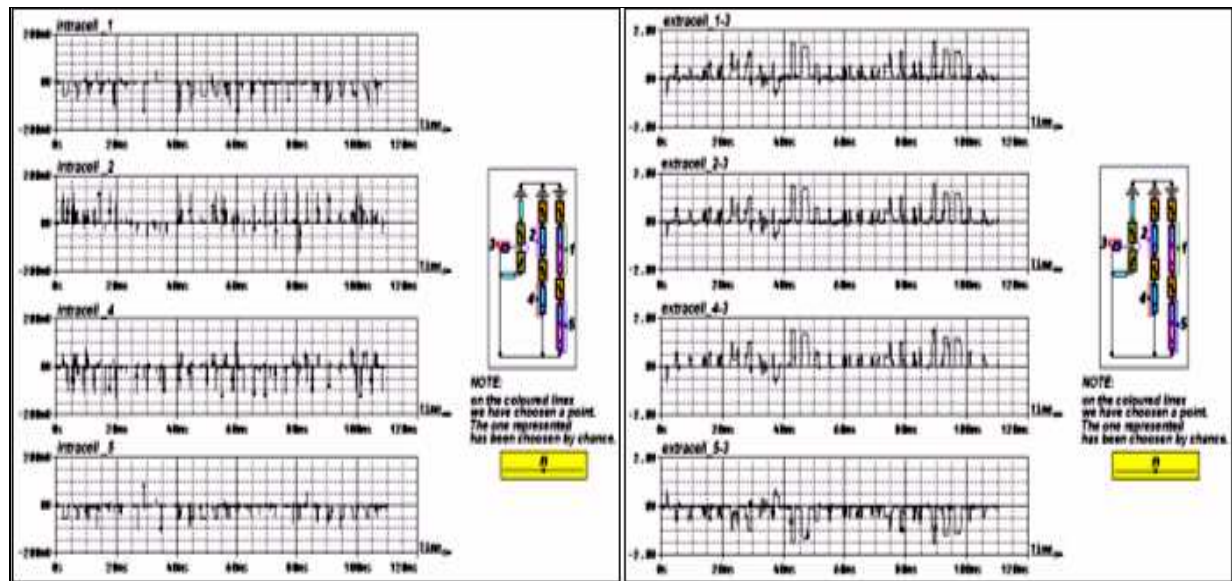
Fig. 24

In *Fig. 25* we can see the potential and intensity current development and the development of the Fourier series, of the same component. The frequency distribution is clearly optimal for the bionic dialogue among, not only the neuron (the signal target), but also among all the other cells nearby, creating, in this way, synchronicity among the interconnections.

If up to some years ago we believed that the neural information transmission occurred through the pre-post-synaptic connection between two neurons and that nothing was interposed, we have later noticed that in reality it seems to occur in presence of glial cells that not only incorporate the "*pre*" of a specific neuron considering the "*post*" of the following neuron, but also they are interconnected with many others that surround them.
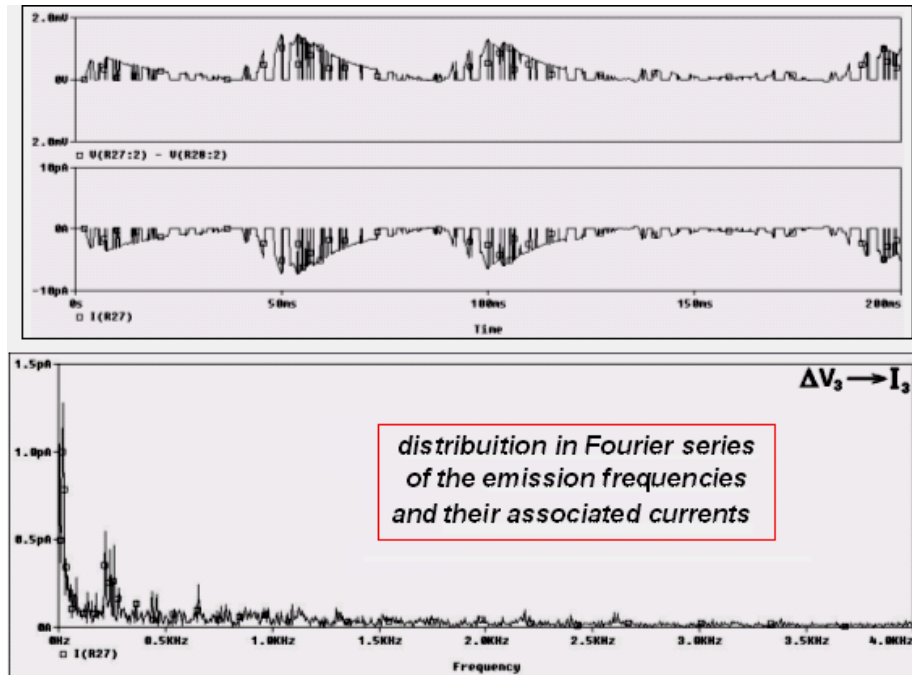
Fig. 25

I had to notice this when in my simulations I evaluated the upper harmonicas of a transmission, and I could calculate the quantitative of energy that was apparently dispersing, looking redundant considering a single neuron-target.

It was then that I understood that the apparent dispersion was like a cloud, that I simulated like the cone of a plasma-jet, which collides with a neural surround, and in this way all what was considered the boundary was informed of what happened on and about the fundamental neuron-target.

I can demonstrate that, at present, I am able to:

- build signals similar to physiological ones;
- have a bionic dialogue;
- build "**three-D**" structures, ever more and more complex. *Fig. 26*.

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Fig. 26

Concluding Considerations

As we can see the object of this study has a highly complex Systemic content and contributes to Systemics in general and, in particular, to the following sectors:

- Cybernetics, Automata, Robotics;
- Systemics and Medicine.

The object of this study was to simulate an elementary electronic circuit which could produce signals that were similar to those produced
by intracellular and extra-cellular circuits.

I planned and simulated a new type of neural transmission model that considers every single neuron as the receiver of _n signals_ and as the generator (in answer) of $\underline{n^k \ signals}$ partly in traditional logic and partly in fuzzy logic.

The results, obtained in the course of several experiments of computerized circuit simulations, are comparable to those produced by neural circuits that are described in the literature.

Based on these results I think that we can create bionic (artificial) cells which can functionally act like stem, glial, or other kinds of biologic cells.

I have at last obtained a fusion between Neurosciences and Robotics that lead to C*yberneurophysiology* and from this to *Bionethics (i.e. Bionics and Ethics)*.

Stated the outcome of this work, even if with an extremely simplified model of a single circuit of a single form-circuit, the theoretic bases are, at the moment, the most completely possibly configured. I'm also convinced that today the technological research can easily supply the instruments to assemble and use it.

We know that the mass is one of the ways to be of the energy that is constantly connected to those processes that, at a microscopic level, occurs among abstract -at a dual character- separated entities that show a "*tendency to find themselves*" in a determined place with a certain "*tendency to happening*".

This occurs with the "waves of probabilities" which represent the possibility of interconnections. There are no separate nor even separable "fundamental bricks", but there is "only" a complex net of relations among the different parts. We are moving within the world of the relational complexity.

But we have also the problem of the non-linearity which is a characteristic of the chaotic world. It often happens that deterministic simple equations can produce unexpected behaviours. And also that a complex and apparently chaotic behaviour can give origin to ordered structures.

In an unstable System, little changes can produce "strange" effects for feedback, self-reinforcement and self-powering processes.

The non-linear equations do not allow making exact predictions, but not even linear equations can give exact result and the measurements that need for the conditions at the limits, are subject to measurement or reading errors.

From the quantitative analysis and from the measure, we have to move to the qualitative analysis and to the topologic characteristics. Resolving all the problems in a structural analogy with the space or the space-time is for sure a good measure of the knowledge of the relationship with the truth.

Just in the sense that a unitary research in the world of the physics must start from chaos and complexity to go back (in a narrower range) to the quantum and relativistic "classic" conceptions till analytical mechanics.

With the simulations described in this Paper, I give a plain or at least partial answer to some of these questions.

The *human* System is an autopoietic highly complex System. It is self organized in a way that the

totality is more of the sum of the parts as it provides a myriad of potentialities offered by the different relations and, at the same time, the totality is also less of the sum of the parts, as it concretizes only one of the potentialities offered by the different relations.

Probably it partially activates them serially, i.e. modifying itself temporarily in parallel. It is a System whose study needs three epistemological connotations: an absolute time doesn't exist, an absolute space doesn't exist nor an absolute centre which can be the *source* (that irradiates) or the *sink* (that absorbs).

A System in which everything is interconnected, interrelated, depending from (i.e. perturbed), and influential on (perturbing). A System rich in several different complex and chaotic sub-Systems. It is the System of our life that continuously *moves towards* and *into* the chaos just to order it.

The future consists of probabilities and only the present choice carry out a specific one and the scenario is purely dynamic. In this myriad of opportunities and solutions, Chaos is no more that a summary of dynamic equilibriums sequences.

When a System lacks of balance, tends to get a new configuration at a different energetic value. We can notice this in the self-regulating "biological" System.

The organism, just for its structure, is a self-regulating System. It has a feed-back control System at least of the second order. In my researches I assumed the human body as a geometric structure with the same morphology of the universe. The communicative biological signals move inside it essentially like the photons outside. We know for example that the intersynaptic exchange occurs through matter, energy and information.

My neurons set neither can create matter nor can receive or transmit it, and so it by-passes this type of exchange, i.e. it is planned for immediately clutching informations and energy just before the source of the transmitter-neuron and for giving informations and energy just after the reception-sink of the receiver-neuron.

Biologically the neuron [whose axon works in an analogous way to the LINAC (linear accelerator)] is characterized by an enormous surface in order to facilitate the exchanges.

Artificially this can be carried out only increasing the number of the probes in reception or in transmission, articulating their mutual relationships and the most possible facilitating the coding.

The cards, that I planned, completely simulate the different types of circuit (i.e. from the divergent to the convergent, from the recurrent to the parallel).

They can also be connected with other similar cards, forming regular polygonal groupings (from 3 till 8 sides) which can be combined linearly, planarly and spatially.

In this paper, the physical objects, like the biological ones, are substituted in the simulation with other physical (specifically artificial) devices.

As we can easily notice, there is a remarkable coincidence with the real situation if we consider the paths that link the nervous centres. Obviously we can't yet transform the different neuro-states (which are still increasing and the more and more specific) in psycho-states. *That is why we aren't able to generating, as an example, the conscience.*

Personally and for the moment, I have only obtained the possibility to create an inter-connectible hardware with similar elements, *that works without any software introduced from the outside but that is self-controlling and self organizing.*

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