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Biodynamics, Illness and Similarity

Part One: The Vital Force (Homeodynamics of Complex Systems)

SUMMARY

Biodynamics, disease and the similia principle. The medi-cal tradition of homeopathy has been separated from that of conventional science for a long time. One area of dialogue and of common progress is that of biodynamics of living systems, probably because these topics are closely related to the traditional "vital force" of the body's self-healing power. This review will show that the "simi-le" - brought back to its biological meaning of the inverted, or paradoxical, effects of the same or similar com-pounds – is compatible with the most advanced concepts emerging from the dynamic systems theory and its applications to medicine. Within the framework of our current knowledge of homeostasis (here properly referred as homeodynamics) in living systems and of modern inve-stigational techniques, we here propose a scientific reformulation of the principle with the aim of constructing reasonable models that can be tested at different biological levels, from cells to human beings. We also discuss the specific characteristics of the homeopathic approach, which places great emphasis on identifying a cure for the whole organism, and the effects of very low doses or high dilutions. The work will be published in three parts, the first one (which is here presented) deals with "homeo-dynamics", that is the main rules by which biological information is transmitted and exchanged to maintain and recover the body-mind health. The second part will deal with *"homeo-pathology",* that is with the general causes and mechanisms of diseases and especially of the chronicization processes. In the third part *("homeo-thera-peutics")* we will see how and when these advanced scientific concepts, whose acceptance is widely increa-sing, may rationally justify the classical homeopathic approach to pharmacological regulation.

The work of my research group 1 is based on current scientific knowledge (cellular biology, inflammation and physio-pathology) and seeks connections with the traditional knowledge of homeopathy or with its empirical evidence. As often happens in the history of science, the moments of synthesis help clarify some problems which, if viewed unilaterally, were previously incomprehensible. At the same time, new ideas are born, fertile for the different fields that establish communications. Thus, through an operational dialogue between advanced biomedical science and homeopathy, new possibilities for understanding and advancing pathology and pharmacology are opening up.

A summary and update of the ideas developed by us (1-6) are here reported for *The Homeopathic Doctor,* giving following the conference and related discussions held on the occasion of the con-FIAMO national congress of 2003 [2]. The publication of the work is divided into three parts, which will be reported in three numbers consecutive of the Magazine: the first part (this) deals *with homeodynamics,* that is, to talk about the main rules of information in biological systems that maintain the state of health; the second part deals with of *homeopathology,* that is, of the causes and of the general mechanisms by which they arise and those homeodynamic disorders that we call (often inappropriately) diseases have become chronic; in the third part (which we will call, in analogy to the previous ones, *homeotherapy)* we will illustrate the reasons why the homeopathic approach classic, which follows the rule of similarity, is consistent with the current and updated knowledge of biology and pathophysiology.

Homeopathy and science It exists, both in academic and among homeopaths, a tendency to regard science and homeopathy as two almost incompatible "worlds". On the one hand one wonders what contribution it can provide a "nineteenth-century" discipline such as homeopathy to the progress of medicine. Such skepticism often comes to generate attacks and ostracisms against this therapeutic method, which does not have nothing scientific but they rather seem aimed at preventing their development and diffusion. One of the (many) objections that are moved against homeopathy is its alleged inconsistency with scientific theories current. In response to this objection, today we can state with sufficient reason-

1. Other colleagues who have provided significant contributions to the research activities are Giuseppe Andrioli, Simone Bertani, Sara Castellani, Salvatore Chirumbolo, Anita Comforts, Sabrina Lussignoli, Graciela Martinez, Gennaro Muscari Tomaioli, Riccardo Ortolani, Valeria Piasere, Raffaella Pomposelli, Francesco Pontarrolo, Marialucia Semizzi, Andrea Signorini, Rosy Tommasoli. The development of this work, for its originality and its apparently "against the grain" direction current", it was not and is not easy both in terms of commitment scientific than academic difficulties (substantially due to the prejudice that still hovers over the subject in many so-called scientific environments).

2. Some of the author's publications are available in the its web pages (http://chimclin.univr.it/bellavite).

fearfully solid that, at least for what concerns the principle of similarity and the reassessment of the totality of symptoms, Homeopathy is not only perfectly scientific but it constitutes a proposal cutting edge, which would deserve well greater attention from the medical-scientific community.

In this regard, there are many problems posed by homeopathy to the investigation medical-scientific, which can be addressed according to different theoretical and experimental approaches (Figure 1). Clinical research of experimental and observational type, essentially answers the question on the effectiveness and efficiency of the method and/or of the drug, while the clarification of the mode of action requires other types of studies, which develop in different disciplines (as with every branch of medicine). The biology, pharmacology, toxicology, immunology, etc., are useful approaches to clarify both the homeopathic "similar" and the question of the action of microdoses of drugs. The physics of water, bioelectro-magnetism, etc., are necessary approaches to investigate the issue of high dilutions and "dynamization". In this location, there being no space for a comprehensive review of all points, we deal with the question of the mode of action according to a perspective that seems to us great importance and relevance: that provided by the theory of complexity and dynamic systems (Figure 1, bottom left). This type of approach has the merit to help understand the issue of the globality and individuality of care, but also the principle of similar, which is the basis of homeopathy.

On the other hand, some wonder what can give a scientific rationalization to the homeopathic "art of healing", which, in fact, has largely developed independently of biomedicine and from clinical epidemiology techniques with which they are normally evaluated drugs. Sometimes it is even suggested that, in comparison with science, homeopathy may "lose" something of its originality. One answer to these questions is that the science is incompetent on the "artistic" aspect of homeopathy (a dimension which is however present in all branches of medicine) [3], while it could rather contribute to homeopathic theory precisely where it "claims" (rightly) of *also* being a science. This applies, for example, for example, for explanations of the mechanisms of pathology, or for methods of evaluating the outcome of therapy (8). more up-to-date knowledge and methods of research developed for biomedicine could contribute to consolidate homeopathy as a medical science, proposing new research hypotheses and new methods of analysis of the clinical case. For example, in the third part we will see how from a a certain conception of the process of chronicity could derive from a certain evaluation of the dynamics of the symptoms, an aspect of primary importance in homeopathy, which has often been discussed starting from ideological or "school" beliefs rather than referring to arguments rational and based on scientific evidence.

Complexity and dynamic systems

The complexity of the human organism, of biological healing mechanisms and of diseases seems evident. The argument of complexity in medicine and specifically in homeopathy has been recently taken up again in numerous articles appearing in the international literature, summarized in our review (9). In particular, it is worth It is worth quoting what Hyland and GT Lewith, authors of an article in which they demonstrated with a double study blind the appearance of oscillations in allergy symptoms after the intake of a diluted and dynamized iso-pathic (10): *"These data suggest that the remedy induces a self-organized oscillation whereby the symptoms, rather than being constant, oscillate above and under the state of health. This oscillation is consistent with an interpretation based on the complexity of the organism's networks seen as a single entity."* The conclusion *significant of this reasoning is: "Homeopathy should be seen as a complex intervention and therefore should request a clinical methodology and a research method different from the one currently employed".*

3. The "art of medicine", which is as necessary as it has a solid scientific basis, it has been defined as "The combination of knowledge, intuition and judgment" (7)

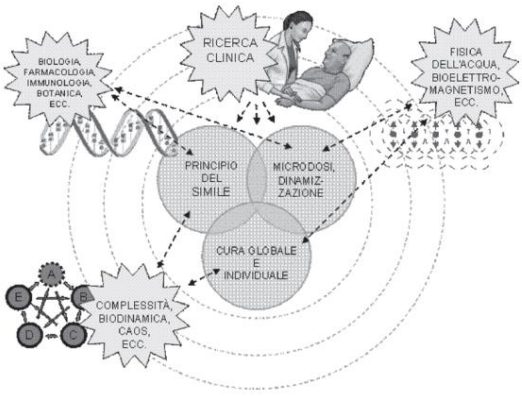

Figure 1. Different lines of research on three fundamental principles of homeopathy. Clinical research says whether the homeopathic method, in its entirety and generality, "works" and can also signal the reality of the phenomenon of dynamization, but not allows you to understand the mechanism of action. For this basic, laboratory and theoretical research is also needed, according to the three approaches represented here.

The enormous increase in knowledge provided by the diffusion of the techniques of analysis and particularly of biology molecular does not seem sufficient to "dominate" the complexity of the problems underlying many pathologies, even the most currents, often due to multiple factors individual and environmental. The more you investigates the living system, the more profound and subtle regulatory mechanisms they come to light, without it being possible then build a definitive model, totally deterministic in the classical mechanical sense. In the 1950s, people began to to think about biology according to a systemic approach, indeed it was identified in notion of system almost the point of convergence of all sciences. In fact there are biological systems, physical systems, systems social, economic systems, systems of equations and so on; systems can be themselves composed of other systems. The recent development of artificial intelligence and computational mathematics has renewed interest in the systemic approach and the ancient concept of system has been generalized in that of "dynamic network", which allows to represent situations extremely complex (11).

Essentially, complexity is could define that feature, typical but not exclusive to living beings, according to which a certain system contains information of a higher degree than sum of its parts: *"A complex and adaptive system is a set of individual agents free to act in ways that are not totally predictable and whose modifi-*

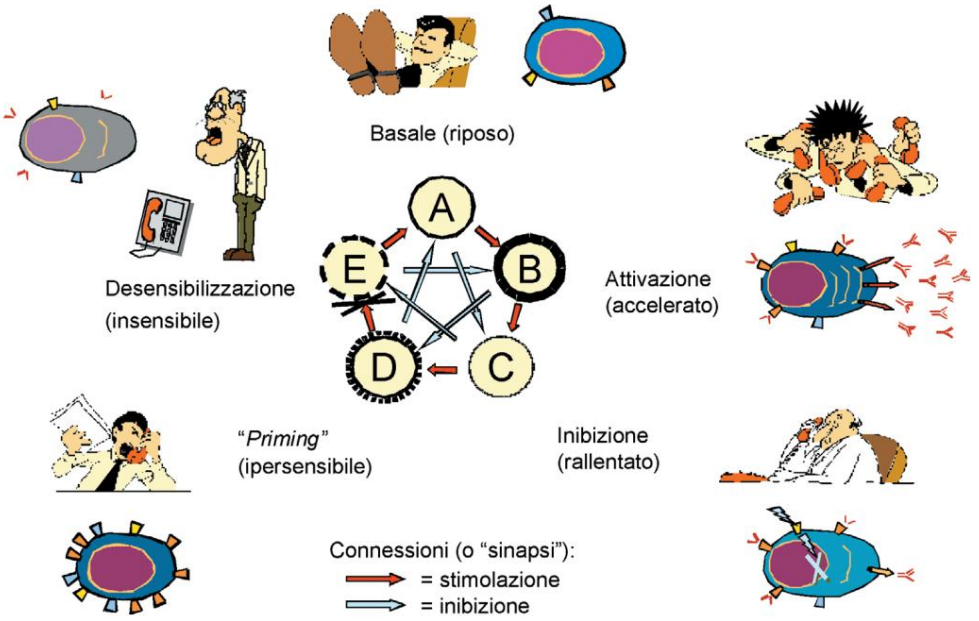

Figure 2. Schematic of a dynamic network with five nodes and two connections for each node, used as a conceptual model for illustrate the possible states of the nodes and the various connections. The model can be applied on many scales of complexity, from the cell to the society. Here, for example, the possible states of different individuals (or of the same individual at different times) are represented in the course of of work activity and the possible functional states of B lymphocytes during the immune response. It should be noted that the state of "rest" does not mean "inactivity", but rather it represents the state of normal physiological (or biochemical or metabolic) activity, in the absence of external stimuli to the system itself.

the dynamics are so interconnected that the action of one factor changes the context for other factors" (12).

The essential properties of such systems are the *non-linearity* (the intensity of the response is often not proportional to the stimulus, up to and including chaotic behaviors), *self-organization* (emergence of new properties from interaction of the parts and following environmental stimuli) and *dynamism* (evolution, change of sensitivity, adaptation) (4, 9).

This last aspect cannot be underestimated, representing an element essential for the understanding of biology and pathology. Hahnemann has intuited and well expressed the concept of *"dynamis"* with its constant reference to "vital force". *Dynamis* emphasizes not only the energy necessary for life, but also that influence which generates the change in health over time and the possibility that it is precisely in and on these changes that establish pathological processes: *"The disease and healing only develop through dynamic influences"* (13); *"The medicines act non-anatomically but dynamically"* (14). Up to now the dynamic aspects of the pathology have been so neglected by academic medicine that the contribution of has not been fully understood this author. On the other hand, the lack of a plausible scientific interpretation has sometimes led to transforming the Hahnemannian concept of *dynamis* into spiritualistic or even magical visions (15), which leave little space for rational criticism and, therefore, for progress.

Neural Networks

Maintaining Health of the organism (in other words, the "vital force") depends on the structural integrity of the individual components at all levels (from the molecule to the environment) and from functional validity of communications between the different levels and between the different components (the one defined above self-organization of complex systems). The capacity for self-organization, therefore also of learning, evolution and adaptation, is based on the existence of an enormous number of possible states (configurations), in turn dependent on the number, type (and defects) of interconnections between the constituents of the system.

feedback loops they are the "bricks" that constitute the emerging order, being both of a positive type (amplification) is negative (control).

The most obvious example of complexity in our organism it is the nervous system, but the idea of togetherness, interweaving, network *(web* or *network* in Anglo-Saxon terminology) characterizes every biological system (e.g.: immune network of idiots, network of cytokines, endocrine system, systems intracellular signal transduction, control of gene expression, etc.) and social (economy, communication systems, etc.). Since the network prototype physiological is constituted by the nervous system, on this model the study of the so-called neural networks has been developed, which tend to simulate some behaviors of the nerve centers, but also of the system immune and all biological systems complex. In these network models it is the property that these networks have is underlined of "learning" and "memory". Such properties are due to the fact that information is encoded as patterns *("pattern")* of different states of individual nodes and in the "strength" of the synapses, that is, of the informational relationships between nodes.

In the history of medical thought we find the same concept of network expressed, of a scheme of different nodes that influence each other- no mutually, from ancient medicine Chinese with the famous law of the five elements or the five movements. It regulates the relationships between wood *(Mu),* fire *(Huo),* earth *(Tu),* metal *(Jin)* and water *(Shui)* and between the corresponding organs in the body human (liver, heart, spleen/pancreas, lung and kidney respectively). Also Ayurveda considers five fundamental elements or *pancha* (five) *mahabhuta* (basic elements) which, combining in different proportions structure the different material realities: space *(akasha),* air *(vayu),* fire *(tejas),* water *(jala),* earth *(prithivi).* It may be added that, even in West, the Pentagon has fascinated the mathematicians, from the Pythagorean School to Leonardo da Vinci, for the harmony and incommensurability of the proportions: in fact the relationship between the diagonal and the side is equal to the ratio of the golden section and is an irrational number (diagonal:side=dia- gonal+side:diagonal=1.6180339887…).

Network models could be infinite, but due to the historical roots mentioned above, we have chosen to use this classical scheme to represent the basic model of network structures and some

in the typical dynamics of complex systems. The first version of this model (1, 16) was used to demonstrate its cybernetic operation: the dynamics of the network can be simulated with iterative algorithms, executable with a simple program computer scientist (Model Maker for Windows). Subsequently, the model was implemented with further definitions so to make it more flexible and responsive to well-known properties of complex biological systems, including that of the reversal of effects, typical of the homeopathic "similar" (ref. 3 and this work).

Figure 2 shows this scheme, which allows to illustrate various properties of the neural network, made up of five nodes, between connected to them by stimulating influences or inhibitors. The network scheme is freely taken from specialist texts (17, 18) and reworked on the basis of the law of five elements as in previous works (1, 3). The concept of "pri-ming" and "desensitization" has been added to it. will be illustrated here.

This model has many implications, useful for understanding the logic of the systemic and dynamic approach to the regulation of biological systems through small perturbations, a fundamental line of thought of traditional medicines. Clearly, it does not provide quantitative demonstrations or explanations on the action of these forms of therapy but, rather, it can be an opportunity for to rethink, in analogical form, the ends rules of self-organization of systems biological in terms of cybernetically regulated networks. The model has the considerable advantages of being able to apply on various scales of complexity (from the single cell to the human-system and even to the rules of the companies) and to be valid independently from the physical-chemical nature of the signal informative that the nodes exchange, the what is particularly important when one considers that the nature of the information, hypothetically "contained" in highly diluted homeopathic medicines, it is physical as well as chemical (more precisely, it depends on the dilution and the sensitivity of receptors).

Like the dynamic properties of living cells and tissues, each node (or neuron) of this network can be represented in various "functional states" or "activity", which the node can assume in different times: a normal or "basal" activity, also called rest *(A);* an increased activity (the one you have at following a stimulating impulse that prevails over the possibly inhibitory one) (B); a decreased, slowed down activity, up to complete block (when the inhibitory influence prevails) (C); a state of hypersensitivity called *"priming",* which remains after that the node has come into action and therefore represents a sort of "imprint" of the previous activation 4 (D); finally there it is another important state, called desensitization, of failure to respond to input regulations 5 (E). These notions on the behavior of biological systems

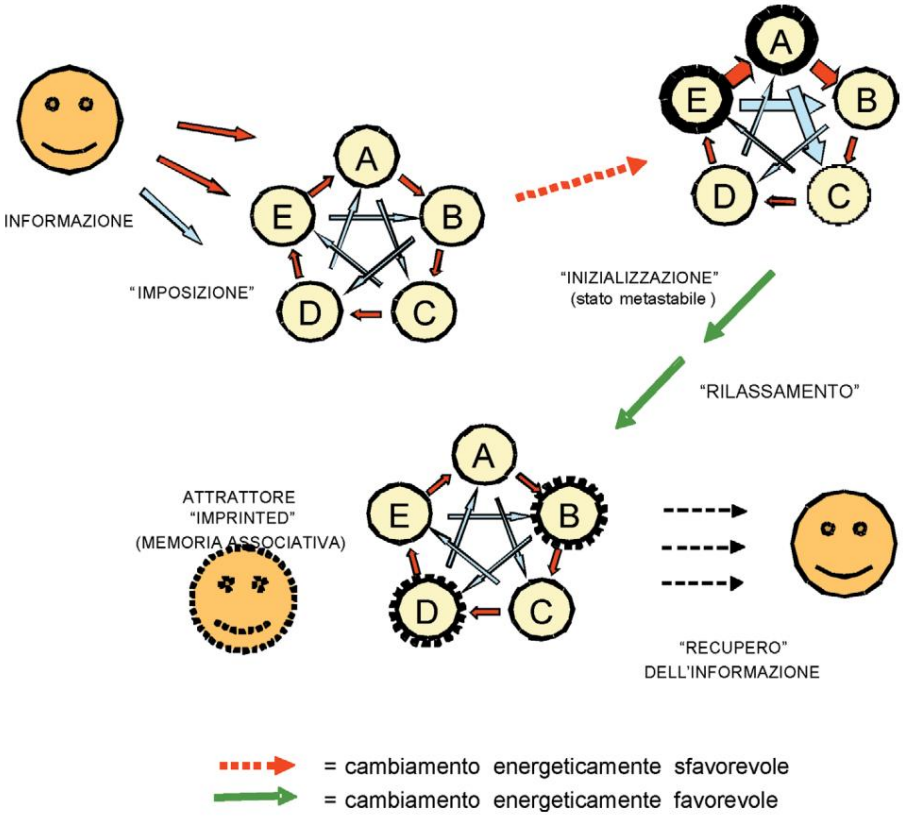

Figure 3. Typical network modifications and consequent formation of associative memory

4. We define as *"priming"* (or "hypersensitivity", "positive conditioning", "increased susceptibility") a condition of increased sensitivity and/or response of a biological system (cell or tissue) to a second stimulus (secondary stimulus) that is established following a previous treatment (primary stimulus). In summary, the general characteristics of this phenomenon are the following: 1. It is obtained with treatment primary with small doses or small stimuli, mostly sub-activators; 2. priming is usually both homologous (towards the same primary and secondary stimulant), both heterologous (towards various other secondary stimulants, which use different receptors); 3. a primary treatment with high doses (full activation of the system) causes only heterologous priming, because the homologous one is overcome by homologous desensitization. On a cellular scale the phenomenon may involve the level of receptors (number, affinity), and/or transduction systems, and/or effector systems. re. Priming is not "activity" expressed in a specific moment, but is it greater sensitivity or greater responsiveness to a possible second stimulus. This last aspect of biological regulation often involves changes in the level receptor and takes different forms according to the system derato. To give just one example, interleukin-2 stimulates the lymphocytes to express multiple receptors for the same interleukin (homologous priming) but also for other cytokines, chemotactic factors, anchoring proteins, HLA molecules (heterologous priming), precisely in order to predispose the cells to a better integration in the complex systems/signals that regulate the immune responses. In addition, the entire protein synthesis machinery is turned on again.

5. We define as "desensitization" (or "tolerance", "negative adaptation", "loss of connectivity", "block", etc.) a condition of reduced or absent sensitivity and/or response is of a biological system (cell or tissue) to a second stimulus (secondary stimulus) that is established following a previous treatment (primary stimulus). Schematically, the general characteristics of this phenomenon are the following: 1. It is obtained with primary treatment with high doses or strong stimuli, especially if maintained or repeated, 2. desensitization is usually homologous (i.e. it involves the response to the same primary stimulant), with some possibility, in particular cases, of being heterologous (cross-desensitization); 3. a primary treatment with high doses (full activation of the system) causes homologous desensitization, but priming remains heterologous, however induced by the primary treatment. On At the cellular scale, desensitization may involve the level of receptors (number, affinity), and/or intracellular signal transduction systems, and/or effector systems (enzymes, gene expression, movement, etc.).

we have undergone various treatments were originally brought to our attention from experimental research on regulation of leukocytes and experimental inflammation by small doses of bacterial and pharmacological agents (19-22). However, these are behaviors widely demonstrated in many models experimental and universally applicable in biology and pharmacology (23-25).

The state of receptor or synaptic desensitization often arises following of prolonged stimulation and involves, as a rule (with many exceptions) the same receptors that have been over-used (or rather we are talking about desensitization homologous). On the other hand, the *priming* state It usually arises following a mild or physiological stimulation and involves both the receptors primarily implicated, both many different receptor sensitivities (i.e. we speak of both homologous and heterologous *priming).* This aspect of regulation biological is of great importance in pathology and pharmacology and will be taken up again in next chapters of this treatise, for illustrate the phenomena of chronic pathology, following repeated biological stress, and the mechanism of action of the drug homeopathic, which due to its low concentration/ energy can only affect the increased sensitivities.

It must be pointed out that in biology each network is connected to other networks (that is, it is informationally and energetically "open") and belongs to a hierarchy of networks on different scales of complexity. In other words, the nodes of a network (e.g. organ system) are made up of other networks of smaller elements (e.g. cells), within which they sometimes networks are found on a molecular scale, and so on. The "logic" of fractals (self-similarity at different scales, or "the whole in the fragment") is typical of any complex system.

Learning, adaptation and memory

Understanding network dynamics, their general rules of operation, is how to understand some "secrets" of the life and, as we will see later, even of the pathology.

Figure 3 illustrates the basic scheme with which a network can "learn" information (17). This is based, essentially, on the fact that such systems intertwined multicomponents are dynamic and "plastic". In fact, in every biological network the configuration of the nodes at the same time "n" determines the generation of information regulations which will modify the others connected nodes, so that at the time "n+1" will have a different configuration. The series of changes, however, is not infinite, but rather ends in a configuration preferential, or in a limited cycle of configurations, such that that configuration or that cycle (attractor) represents the state of least energy expenditure of the system as a whole.

The neural network model predicts that the various nodes can be influenced not only from internal exchanges of information, but even from signals coming from outside, for which adequate systems of reception (e.g. sight, hearing, smell, protein molecules for lymphocyte receptors, etc.). Using a graphic information as an ideal scheme, we have that the "form" consisting of light pulses goes to influence a number of visual receptors which, in turn, are connected to a series of neurons in the network. These neurons are modified by electrical impulses, which "impose" a pattern of activations (e.g. bright light) or reductions in activity (e.g. dark areas). The neural network changes consistent with the image, but not remains "fixed" like a photographic plate, but rather undertakes a series of adjustments due to the reciprocal stimulating and inhibiting influences that are triggered from from the imposition of the external form.

As shown in figure 3, the first mobilization is called *"initialization",* which is followed very quickly (more slowly in the immune system) by a series of subsequent changes, until the network is *"relax",* when it finds the configuration more stable, schematically constituted by the one that is most convenient because in it the the greatest number of neurons is found in the state of rest or *"resting"* (lower expenditure global energetics). In the relaxation phase, however, not everything switches off completely, but the "sign" of the event remains. new activation experience (and also of inhibition, but for simplicity it is not here considered) as a *priming* state (usually attributed to synaptic strength or to the connection) of some node. This preferential *"imprinted"* state is also definable as an *"attractor"* and is "associated" with the specific image that initially generated (or images similar, as we will see). For this reason the new network configuration, featuring its energy stability, is called *"associative memory".* If necessary, such information can be "recovered" and used by the living system, of which the network is part of, for certain purposes. The system nervous system is able, for example, to use this "virtual image" to compare it to a real or current image and establish any similarities or differences. The immune system encodes the memory in the idiotypical network and can use this memory to evaluate the nature, more or less dangerous, of a new biochemical information that the organism comes into contact with.

The information is encoded in a certain structure of the attractor following of the "experience" gained in previous cycles of stimulation and activity induced by *inputs* external. The same information (called (also associative memory) can be then recovered and used during the subsequent cycles of network activity. In this way, networks can also "correct" the defects of an external information input (which may possibly contain errors), generating correct information as output, comparing the input with its own associative memory.

Any experience creates new associative memory. Memory is in the plasticity of connections ("synapses") and of the sensitivity of the nodes *("priming",* desensitization). Not only the end point is stored, but also the experience, the dynamics of the behavior, that is, the entire path that is taken from initialization to relaxation *to imprinting.* This is very important for the experience of "illness": healing is a way of behaving of networks who have "learned" the best setup and the best response to disturbances.

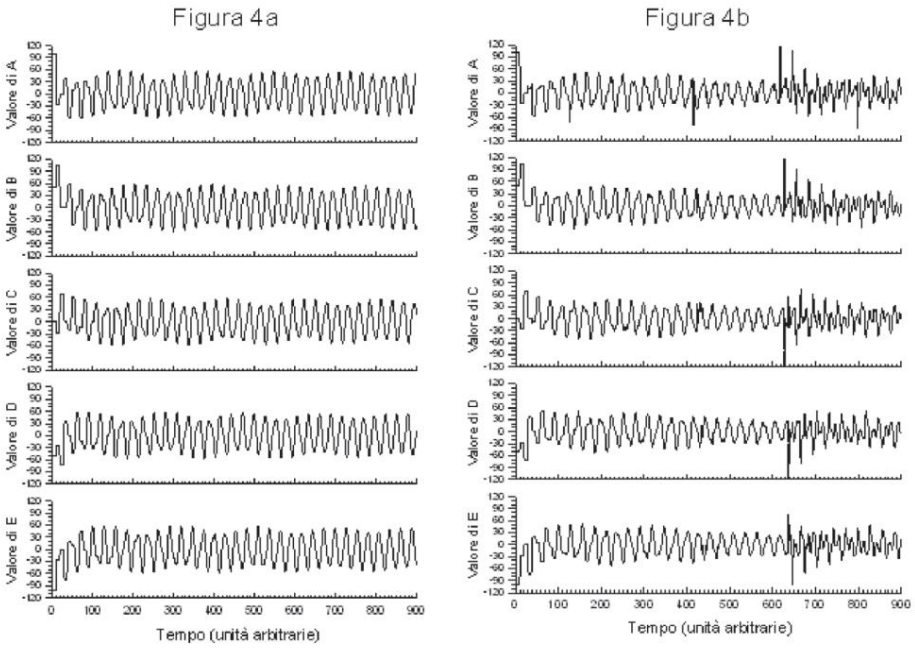

Figure 4. Results of the "activity" values of the five nodes of a continuous variable network, described in the text. In this simulation it was established that the initial value of the nodes was the following: A=100, B=50, C=0, D=-50, E=-100. The value of k was set to k=0.53. 4a: network with periodic and harmonic trend; 4b: network with periodic and chaotic trend. In both cases coordination is observed of the different nodes. The algorithms of the two networks are described in the text.

The accuracy and complexity of the image obviously depends on the number of nodes and connections in the network. The same network can encode several images, which partly overlap. Each scheme It constitutes a repository of information. Different networks can partly use the same cells (nodes). Evolution consists in the self-organization of ever-changing networks more complex, pressure-driven environmental. The structure of the networks is given genetically, learning is given as a history of the individual.

Of course, in nature networks are much more complex than the one ideally represented here. It has been calculated by S. Kauffman that a network that simulates the genetic heritage (made up of dozens of thousands of nodes) theoretically has millions of different possibilities of expression, but in in practice the attractors are reduced to some hundred (a figure that roughly corresponds to the number of systems organized (cells) that the heritage genetic is capable of generating.

Networks with continuous variables

If the network model is executed using continuous variables (i.e. allowing numeric values instead of states different and limited), the model shows that a homeodynamic system generates normal-mind of the oscillations of the variables same. The details of this model are have been presented previously (1) and are summarized here.

Figure 4 shows the results of simulations with a network model five variables similar to the one illustrated in precedence, but with the modification that here relationships between elements vary according to a continuous ladder. Each node X (A,B,C,D,E) of the network responds to the influences (stimulatory and inhibitory) of the other nodes, increasing or decreasing the its activity proportionally to the activity of the two nodes with which it is connected. In short, the model is summarized in the following algorithm:

X(A,B,C,D,E)tn+1=kNStn-kNItn

Where the value of node X at time tn+1 depends positively on the value it has at the previous time (tn) the stimulating node (NS) and in negative from the value of the inhibitor node (NI), multiplied by a parameter k, which indicates how much influence (in stimulation or inhibition) has the value of a variable on the node with which it is connessa. In this model, the initial value of the five nodes must be predetermined and the k value, which indicates the "intensity" of the signal.

In figure 4a it is observed that the game of crossed activations and inhibitions produces oscillating changes in the five variables, which gradually synchronize perfectly and dampen the instabilities observed at the beginning. From a a messy situation turns into a more orderly and harmonious thanks to the coherent behaviour of all the components of the network that influence each other.

Such an ordered homeodynamic network and harmonic simulates only some aspects of the behavior of real physiological systems which, as is known, present characteristics of chaos and variability. In order to I am trying to mathematically illustrate this property, it was thought to include in the same system a non-linear element.

A node of the network (A) was "conditioned" by a control factor, represented by the ratio between an arbitrary value of Amax (maximum allowed) and the value of A at the previous time (Atn). Precisely, the algorithm of the function, with reference only to node A, it is the following:

Atn+1=kEtn-kDtn+(Amax /Atn)

Where Amax is a value set at the beginning, which can be changed at will (in this case=20). The other nodes follow the algorithm already presented for figure 4a. Figure 4b shows that the network starts exactly as we saw before, having the tendency to produce rhythmic oscillations with the frequency equal to the one seen above. However, there are some peculiar characteristics of these tracks: the presence of marked discontinuities in the amplitude of the peaks (some of which are smaller, while many present a wide excursion) and the appearance of additional peaks, of apparent irregularities in the interval between a normal peak and the other. In some places you can notice multiple small oscillations of the track (for example example around the time 400-450), in At other points, marked doubling of the peak is noted (for example around time 700-800). However, there is a notable coordination of the entire network, such that the discontinuities of a node communicate each other quickly to other nodes. This behavior is characteristic of a system in which the tendency towards self-organization and a factor of non-linearity coexist.

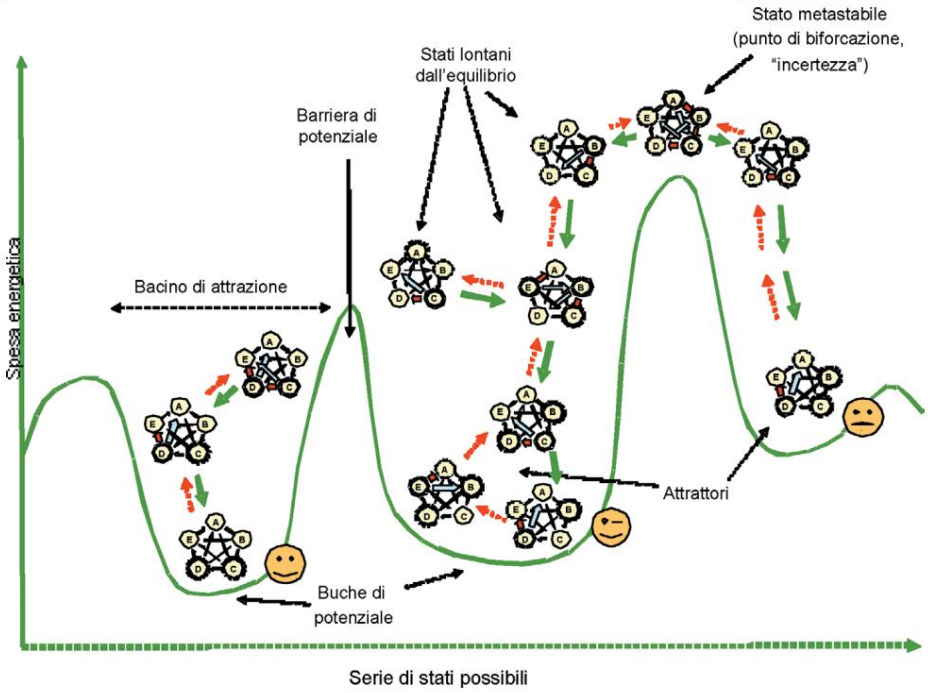

Figure 5. Example of a phase space (or "energy landscape") of a dynamic network. The symbols are the same as those used and described in figures 2 and 3.

rity, which generates deterministic chaos.

The transition from order to deterministic chaos can occur through minimal variations in the control parameters of the function. The theory of dynamic systems has shown, with evidence of this kind and others even more elaborate, that chaos is not "disorder", but it implies as characters distinctive features are the great sensitivity to initial conditions (or to perturbations) and a certain degree of unpredictability of the evolution of the system in subsequent times (1, 4, 9, 26). By amplifying small fluctuations, it can provide a natural system access to novelty and to flexibility with respect to the changing environment. The "Achilles heel" of this property of dynamic systems lies in the fact that they are also susceptible to disturbances in a pathological sense, if they occur certain conditions.

In biological systems there is a wide series of phenomena that show dynamics of oscillation, with periods varying from a few milliseconds (enzyme oscillations, neuronal activity) to seconds (breathing), minutes (cell division), hours (circadian rhythms, glandular activities, sleep-wake rhythm), days (ovarian cycle), months and years (population variations). In short, almost all phenomena interesting for life are rhythmic. The oscillations have their own peculiarity importance, as they help coordinate and stabilize the functioning of different organs and systems. The oscillations discharges of the cerebral cortex are probably very important for ensure the coordination of different groups of cells and nerve centers. The secretion of many hormones has a pulsating, non-constant pattern. Likewise important in biology are the phenomena of molecular oscillations coupled to oscillations of the electromagnetic field: fields electromagnetic intensity and frequency extremely low can modulate hormones, antibodies, neurotransmitters and cellular proliferative activity.

It is emerging from the frontiers of science, especially from quantum physics and from the science of complexity and chaos, a new vision of matter and of life, in which organisms are seen as highly regulated dynamic systems and complexes, which show a characteristic meta-stability around certain homeostatic levels (better called, as has been said, homeodynamics). This meta-stability is made from continuous oscillations, rhythms, networks, amplifications and feedback loops. The systems living beings are "suspended" between order and chaos, participate in these two fundamental characteristics of the matter and exploit them in a purposefully oriented manner survival. Now we begin to enter-

see that even medicine "at the bedside" patient" may undergo a development on the basis of these new dynamic and integrated perspectives that are being developed.

One of the major acquisitions of the dynamical systems theory is that their behavior is often unpredictable and that such unpredictability is not due to the lack of information about the system itself, cannot be filled by the acquisition of new information, but is rather a intrinsic property of physical systems, which It manifests itself more or less evidently according to internal or external conditions to the system itself. From this evidence it is chaos theory was born, which tries to frame the variability and apparent disorder of forms and behaviors within the laws of nature.

We have focused on this aspect also for the reason that the consideration of the sensitivity of complex systems and chaotic to disturbances represents a of the cornerstones of any theory that claims to explain how such information "subtle" as that possibly conveyed by the homeopathic medicine can have a decisive influence on the evolution solution of health and disease.

Attractors, freedom and information

Returning to the network described at the beginning, we observe that, from the combination of the states of each single node at different times, the network can take on a considerable number of different schemes. To put it simply, the the number of possibilities of different shapes allowed to the network is called the "degrees of freedom" of the network. The degrees of freedom of such a network (i.e. of possible combinations of the states of the different nodes) is precisely Nk where N is the number of states granted to each single node and the exponent k is the number of nodes. For example, if there are 5 nodes and there are 5 possible states (as in this case (basal, active, inactivated, primed, desensitized) there will be 55 = 3,125 different possible network patterns. For simplicity, we do not let's consider the number of connections (here placed as two for each node), which would introduce further complications in the rules of operation of the system, not necessary for the reasoning we are following here.

Despite the theoretically large number of different possibilities, the dynamics of the learning described above makes it possible that the various configurations are consequential (one follows the other, describing of trajectories until they end up in an attractor). Therefore, the preferred states ("attractors") of a network are fewer in number than the number of degrees of freedom. In fact, most of the schemes are usually represented by transitory configurations, energetically "inconvenient", or "far from equilibrium", which They are constantly "looking" for their own attractor.

This characteristic of complex systems is usually represented in a graph called *phase space* or *space of the states,* a graph that is used conceptually to describe the trajectories of network behavior, in our case the dynamics of health and then of diseases (Figure 5). In this space you observe a "landscape" made up of different dimensions, according to the variables that are can consider. In the simplest case two dimensions are used, in our in vertical case we put the energy expenditure of the system, in horizontal we put the evolution of the system over time, or even more simply the different possible attractors. If the parameter considered is mainly the energy expenditure (deriving, ultimately and in extreme simplification, from all the phenomena of activation that gradually affects the individual nodes), the state space is aptly defined as the "energy landscape" of a system.

This diagram is useful for describing the dynamics of health, disease and the effect of therapy. The system considered is followed with its trajectory in the energy landscape, a trajectory that follows both the intrinsic dynamics of the network, both the external disturbances that can be imagine.

In figure 5 it can be seen that the same network system can be in various positions in the energy landscape, according to the state of activation of the different nodes. In an energy landscape there can be different "basins of attraction", at the bottom of which they are called "potential holes" where we find the dynamic attractors of the network. The system can be found "stable" in different positions, or potential holes, or energy minima. Some attractors are stable or semi-stable configurations of the same network, where the nodes are at rest or *"primed",* similarly to what was seen in figure 3: in this situation the system considered is "fixed" in its best energy situation and thus remains in the absence of external stimuli. For example, the functional state of the stomach or gallbladder during fasting they are situations of stability which, to simplify, remain so until until you take food. Others attractors are made of multiple configurations, which describe a cycle of modifications consequential, closed in itself; also in this case there is a constancy of behavior of the network (attractor), but of a type dynamic. For example, in the heart there is alternately systole-diastole, in the lung inspiration-expiration: these situations change spontaneously, even if the speed of change is certainly influenced by factors external to the system physiological considered.

The energy landscape therefore describes the various "possibilities" of movement, the various states of equilibrium and disequilibrium, of a certain system. The encounter with external disturbances and the availability of energy determine the actual movements that occur in the landscape. The same system can occupy different spaces and find oneself in different attractors at different times. For example, the brain in the state of sleep and wakefulness found in two semi-stable situations, in which It persists and self-organizes functionally and biochemically for several hours. The transition from one state to another occurs rather abruptly, to determine itself of (internal) conditions of removal from balance and external stimuli. Also the abrupt transitions from intrauterine life to independent life (birth) and from childhood in youth (puberty) changes in attractor are to be considered. All this is perfectly physiological, but it will be seen in followed by the concept of attractor also applies in pathology (especially for chronicity).

Inside a basin of attraction the network enjoys "conditional freedom". The network may be temporarily down configurations far from equilibrium, especially if there is a "push" from a factor which "initializes" it (see above), but tends always in the position where its energy free is smaller, so it tends to reach the "potential well". For example during the waking state we can have moments of clouding of consciousness and During sleep we can have moments of greater or lesser excitation and mobilization of some nervous centers (distance from equilibrium); however, usually the attractor prevails and one remains in the homeodynamic situation achieved, at least until the departure from equilibrium is so marked as to bring the system into the basin of attraction of another physiological state.

In the energy landscape you can describe (in this case ideally, but (many physiological examples can also be given) of the "potential barriers" that clearly separate the attractors, that is situations where a barrier exists very high energy, which makes it difficult to transition from one configuration to another. The configurations belonging to two basins of attraction, even though they are energetically equiprobable (or even a configuration could be more more convenient than another one which is however further the barrier) are not interchangeable because this would require modifications too expensive network intermediaries or too complex, at least in conditions physiological.

The configurations that came to be to find (for a particular energetic or informational push) on the "top" of a potential barrier would be in a situation of metastability, that is, extreme indecision about the next one "move" that would bring them into an attractor rather than in another. At that point, also called bifurcation point, a minimal shift of the system in the energy landscape can change for a long time term its position (change of attractor). The higher the uncertainty, the more the less energy is needed to cause the movement to one side or the other.

In biological systems there are always

positions of disequilibrium and are those that represent the greatest sensitivity to disturbances and therefore also a greater susceptibility to phase changes (both in the sense of the onset of chronic pathology, and in the sense of a possible return to health if one starts from a pathological situation).

Here the information that can reach the system from the outside (that is, from other systems in which the network operates) has a key, absolutely determining role with respect to subsequent dynamics and with respect to a *choice of direction* that could represent a watershed between normality and pathology. On top of a barrier of potential, the network enjoys an "unconditional freedom" (or almost), but for this freedom to be played in a productive way, it must be an "informed freedom". In this position of uncertainty, the teleonomically useful ("healthy") information is that which comes from the rest of the organism (from other networks in turn informed by the experience gained and by the genetic information of the individual), information on the basis of which the network in question can make an effective rather than destructive choice.

: Every change that occurs in a dynamic system is associated with an increase in entropy (second law of thermodynamics). If the change is not spontaneous, it is also associated with energy consumption and this state therefore requires a greater effort from the biochemical systems involved in its production. Furthermore, during the changes in state of the different nodes of the network, there is also an increase in the possibility of errors (for example, a cell undergoes mutations more frequently during mitosis rather than during the inter-mitotic resting state). Consequently, if we consider in a very general way the meaning of a different position in the economy of the organism, the position at the top, with respect to the vertical axis (energy consumption) can be considered in some way as less stable, therefore less "physiological" (or more "pathological" at least in the sense that it could be a source of symptoms) than the lower one, in which less energy is consumed.

energy, in which fewer changes occur. From a certain point of view (which will be better specified in the next chapter), the highest position will be, in this perspective, also less desirable, especially when it is defined by a "potential well", therefore a stably higher position (attractor). For this reason and with the necessary clarifications, we can use the same conceptual scheme - which

despite its abstract nature, it describes real properties and some fundamental rules of living systems - also to follow the changes of the network system during the illnesses.

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