BIOLOGICAL AND EXTRABIOLOGICAL MEMORY

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Lettera scripta manent, verba volent.
Latin proverb

Over the past few years there has been a growing understanding of living systems' thermodynamics. Living systems do not defy the central laws of thermodynamics; they behave in an antientropic fashion during the time they remain alive, as Schrödinger originally stated. In order to do this, they must acquire free energy from the environment and use it for purposes of reproduction and in order to acquire new free energy. Certain features of living systems have emerged; these include: self- organization, memory, autopoiesis, self-reproduction, self-repair and antientropic capacity. Living systems are open systems that interchange energy and information with their surroundings. Prigogine has referred to living structures as "dissipative structures in non-equilibrium with their surroundings." Memory is an outstanding feature of living systems; they have vast memories stored in their DNA. Even the most humble procaryiotic cell has an enormous amount of information kept in its DNA molecules. Animals who have brains also have a capacity to store vast amounts of information in their central nervous system. Mammals probably have the largest capacity to keep information into their brains. The biological information stored in the DNA is mainly information of the species; the information stored in the brain is individual information. Nevertheless both types of information are of a biological type.

The human heart and all living systems also have the capacity to store energy in the ATP molecule and use it for purposes of contractions or mechanical displacement. This alternation between storage and usage of energy (diastole and systole) has been suggested by Eduardo Césarman

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to be one of the fundamental properties of living systems. Without the ability to store energy in a molecule, life would not exist. We suggest there is a profound relationship between the ability to store and use free energy, and the ability to store and use information. Claude Shannon, years ago, saw a relationship between energy and information. This seems to hold in living systems.

Our basic tenet is that human beings are the only animals that have achieved the ability to store extrabiological information, that is, to have memory outside their bodies. The development of extrabiological information is one of the most important events that has made humans different from the rest of the animals. The capacity to store energy outside the body is also related to the storage of extrabiological information. ¿How has the human animal achieved this? The history is fascinating and is related in one way to the ability to produce and store food, and in another to the ability to store information through the writing system.

In the Pleistocene, the animal who ulteriorly gave himself the name of *Homo sapiens*, roamed the prairies and other lands for several thousand years seeking food. Sometimes, he was on the verge of dying of hunger. He was heavily dependent on weather changes and in times of climatic irregularities many members would inevitably die. Then, about ten thousands years ago, humans discovered or invented agriculture. The domination of planting cannot be underestimated. It gave humans the possibility to store grains and thereby, by reducing the risk of famine, increased their chance of surviving. It also made possible for human beings to stay in one place for prolonged periods of times. The possibility of building-up sustenance reserves was a crucial turning point in the history of mankind. It gave humans the possibility of growth in terms of number and thus quicken the cultural evolution's pace. As a consequence of a sedentary life, made possible by the provision of food, humans diversified their activities. Humans would no longer devote a considerable amount of their time in search of sustenance; thus, they had more time to build houses, make dresses, shoes, furniture and utensils of all sorts. Bread, in all its forms, was the most important nutriment as it could be baked at any time due to the availability of grain and other storagable carbohydrates. This kind of food has been present in all farming cultures in Europe, Africa, Asia and the Americas. Then, a "miracle" occurred. Humans invented a way to keep record in a material sustrate of their symbolic patrimony. Before the invention of writing, almost all the information had to be stored in the individual brains; fathers and mothers taught daughters and sons, and the elders of the tribes (aged 40 years or less) transmited information to their youngsters. Biological information stored in the individual brains was fragile; a lot of information would disappear with the death of an individual. With the advent of writing,

extrabiological information was created. Before that time, some extrabiological information was already present in certain forms: signs, buildings, artifacts and other utensils created by man. But it was not until the discovery of writing that extrabiological information came into being with instrumental capacity. Extrabiological information allowed humans to efficiently store information for the use of future generations. Man became a fully symbolic animal. We can almost say that books in any of its forms became the essence of human beings. With the invention of the press and the making of books, the extrabiological information became available to many human beings. Sciences and arts flourished during the Renaissance and continued to grow ever since. At the present time, extrabiological information is so vast that no single human being can master but a small fraction of it. This is the real reason for specialization. Humans have become dependent on extrabiological information as much as in food. In the Bible is stated that "man cannot live on bread alone." It is certainly one of the most important truths of man as a symbolic animal, but it is based on the real capacity of making such bread.