NEGATIVE ENTROPY: ANOTHER APPROACH

Carlos Pedro Lantos
Laboratorio de Esteroides, Departamento de Química Biológica, Facultad de Ciencias Exactas y Naturales and PRHOM-CONICET, Ciudad Universitaria, Pabellón 2, (1428) Buenos Aires, Argentina

PIERRE LECOMTE DU NOÜY AND BIOLOGICAL TIME

Pierre Lecomte du Noüy was born in Paris in 1883, the heir of a family of writers and artists. His mother, Hermine, acquired certain fame as a novelist and his father, an architect, became known as a designer of modern cathedrals. His grandfather, Eugene Oudinot, the last of a dynasty of sacred painters, restored among others the vitraux of the Chartres Cathedral. Among his early ancestors was Corneille. Pierre was the only scientist of his family.

Even for his time, Lecomte du Noüy's educational background was astonishingly encyclopedic. He earned degrees of *Licencié en droit*, a Ph.D. and a D.Sc. from the Sorbonne but became best known for his work in a highly experimental discipline that would now be included in several branches of biophysics. As an officer of the French army during the first world war, he was the first scientist to correlate the temporal process of wound healing with the patient's age, leading to predictions in this critical field of war medicine. Beyond its military applications, however, his formulae were - perhaps exaggeratedly - hailed as the first contributions of mathematics to modern problems of biology and as a proof of the duality of time: '*biological time*' *vs.* the physical time of inert matter [1]. From 1920 to 1927 he was an associate of the Rockefeller Institute in New York and from 1922 until his death in 1947, head of the division of biophysics at the Insitut Pasteur in Paris. In 1937 he was named director of the *École des Hautes Études* of the Sorbonne.

Within - and in spite of - this diversity, his life was a methodic sequence of experiments followed by critical conclusions, working hypotheses and - finally - theories. Only at the end, Lecomte du Noüy indulged in epistemology and philosophical reasoning, often based on conclusions from his own experimental findings.

Best known for his experiments on the surface-equilibria of colloidal solutions, he developed in 1919 a tensiometer for the exact measurement of surface tensions, allowing him to carry out original three-dimensional measurements on molecules and the determination of the Avogadro number.

COLLOIDAL SOLUTIONS AND THE GIBBS ENERGY OF LIVING CELLS

The first thermodynamic considerations of Lecomte du Noüy I am aware of can be found in his *Équilibres Superficiels des Solutions Colloïdales* [1]. They deal with the Gibbs energy of living cells. He hypothesizes on the tendency of macromolecules to concentrate on limiting surfaces, co-transporting (*dragging with them*) electrolytes that would otherwise be distributed randomly in the bulk of solutions. He postulates that the thermodynamic equilibrium of the cellular components imposes the actual cellular shape and size and that from its starting point on, the isolated cell becomes thermodynamically not only understandable but

also necessary. Cell size, in particular,

would be a function of the time elapsed between nuclear division and the attainment of thermodynamic equilibrium.

ORDER AND TIME SCALES IN THE APPROACH TO EQUILIBRIUM

This multiplicity of *times* reappears continuously as an almost obsessive constant throughout du Noüy's work. From wound-healing (see above) to the relatively prompt, gradual or extremely slow decrease of surface tensions in colloidal solutions - including living cells - the understanding of differences between the periods physical phenomena take to reach Gibbs equilibria is essential to understand the universe - including life - and its evolution. Millikan, who wrote one of two forewords to [1] - the other one was written by Alexis Carrel -, said the following on this insistence: '*... For the physicist, Dr. du Noüy's manuscript is remarkable: ...it shows that the establishment of an equilibrium in solutions - the only valid condition for the Gibbs equation - is a slow process which can be followed step by step. This compels us to think before drawing hasty conclusions from that law...*".

However, this inert system still lacks '*the vital element, the nucleus. It is only the casing of a watch, without movements in its interior*'. The latter observation may have been du Noüy's starting point for '*negative entropy*'. In an effort not to betray the original thoughts of the author, I translate literally from *L'Avenir de l'Ésprit* [2]: '*... It is evident that the evolution of living beings discloses an increasing complexity of coordination. Whether we like it or not, if we accept this theory we must admit life to have begun under very simple forms which then differentiated progressively. From the beginning on, therefore, there was an increase of asymmetries. From complication to complication, from one asymmetry to a bigger one, and from a small probability to an immense improbability, the scale of beings was finally crowned by man, his brain and psychological life; while entropy levels off inequalities and makes values disappear, life seems to have a tendency to create both*'.

'*Things occur as if energetic order, the decline of which can be demonstrated statistically by the increase of entropy, were replaced by the evolution of organized beings, by an increasingly complex organization in a domain escaping statistical laws, the field of individual actions that do not depend on the principles we announced. The march of the material universe towards an inherent chaos, towards nothing, would therefore be compensated by the simultaneous progression of an imponderable universe, that of the spirit, whose order and perfection would stem from the ashes of the unorganized world' (Note: "Order" is here to be understood as the antithesis of "disorder" and has not to be taken in a symmetric sense. Perfect "disorder" is that corresponding to the homogeneous solution. In it, at average and within the limitations of our scale of observations, no asymmetry that might generate forces can be found)*'.

To understand Lecomte du Noüy's ideas on evolution and entropy, we have to consider various facts and circumstances: First, that he was a precursor: although a contemporary of Schrödinger and the jesuit anthropologist Teilhard de Chardin, his *Équilibres Superficiels des Solutions Colloïdales* was written when Prigogine was in his childhood. *L'Homme devant la Science* [3] as well as *Human Destiny* [4] were written before and during the second world war. Second, the author's exposure to three equally strong, concurrent influences: the heritage of his forefathers, his humanistic, interdisciplinary education (see above for both) and -

perhaps most important of all - the particular circumstances during the German occupation of France, during which [2] and [4] were written.

His epistemological work puts therefore an unusual emphasis on ethics and even morale but avoids undue generalizations and dogmatism. As if to excuse himself for an incursion into this field unfamiliar to experimental investigators, he assures that his theories, like all theories '*might be false even if serving to a beneficial purpose*' and that his ideas on entropy might be '*long-term extrapolations deserving the credit of all extrapolations*' [2].

Most of the ideas and quotations of his note were translated from Spanish or French editions, or (even worse) back-translated from publications originally written in English, then translated into these languages. These are part of the limitations of the biography of a mostly forgotten precursor whose life and work deserve a thorough analysis.

REFERENCES

1 Lecomte du Noüy P (1929) *Équilibres Superficiels des Solutions Coloïdales Études de Biophysique Moléculaire*. Masson et Cie, Paris

2 Lecomte du Noüy P (1949) *L'Avenir de l'Esprit*. Spanish Translation (El Porvenir del Espíritu) Editorial Sudamericana, Buenos Aires

3 Lecomte du Noüy P (1939) *L'Homme devant la Science*. Flamarion, Paris

4 Lecomte du Noüy P (1948) *Human Destiny*. Spanish Translation (*El Destino Humano*) Rueda, Buenos Aires