Zeitschrift: Archives des sciences et compte rendu des séances de la Société
Herausgeber: Société de Physique et d'Histoire Naturelle de Genève
Band: 42 (1989)
Heft: 1: Archives des Sciences

Artikel: Polarity : from dipoles to biopolarization
Autor: Turian, Gilbert
Nachwort: Epilogue
DOI: https://doi.org/10.5169/seals-740080

EPILOGUE

However attractive in its aesthetic simplicity, the principle of electric charge symmetry, first suggested by the Yin-Yang of the oriental philosophies, and confirmed by the discovery of the primordial couple electron-positron of the nuclear physics, it could not have provided the fundament for the expansion of the inert matter of the universe and its evolution into living matter requiring differential growth along polar axes.

Polar expansion of any structure, inert (crystals, etc.) or living (cytoplasm, etc.), into an organized pattern necessarily had to involve *separation* of the two opposite electric charges. This could only be achieved by the secondary couple *electron-proton,* still charge-symmetrical but mass-asymmetrical, thereby leading to orbital spinning of the light electron around the much heavier proton; both were associated into the primeval, dipolar atom of hydrogen which can thus be considered as the basic "brick" (protium) of inert as well as living matter. The probabilistic spatial asymmetry of its electric charges was further amplified by excited ionization of H to $H^+ + e^-$. Charge asymmetry of H and of its evolving, heavier atoms (He — Be — Li — ... C — N — O — ... Fe — ...) eventually led to their association into dipolar molecules such as the life-sustainer H_2O or the NH_3, and then to the polarized biogenic macromolecules needed to orient growth of the living matter. This necessary rooting of biomolecules in the fundamental electric bipolarity could be a utilitarian answer to the statement enunciated in 1969 by the philosophically-minded nuclear physicist A. Weisskopf that "we cannot really claim an understanding of molecular processes before we know why the world consists of positively (nucleons) and negatively (electrons)-charged particles".

All cells can be considered as endowed with an intrinsic polarity. Thus there should be no fully *a*polar cells; even resting, relatively isometric cells present some degree of polarity along all their radial axes of peripheral growth. Isometrically-expanding cells present a *radial* polarity which is the sum of all bipolarizing events along bipolar (center to periphery) cell axes. This radial polarity is first expressed by the more or less central location of the nucleus and the polarity of its surrounding cytoplasm reenforced by the array of microtubules centrifugally oriented toward the cell periphery.

Polarity is most conspicuous in *mono*polarly, anisometrically growing structures such as hyphae or neurites which require processes of monopolar dominance paradoxally insured by maximally efficient, self-sustained processes of apical internal bipolarization. Any impediment of these processes by deficient energy replenishment of the electric loops or disturbed cytoskeletal integrity, etc. will damp this monopolar dominance and, consequently, allow uncontrolled *bi-* or *multi*polar growth. In agree-

ment with Bünning's axiom (1952) "Keine Differenzierung ohne Polarität", cell differentiation also depends upon internal bipolarization of an apparently homogeneous cytoplasm. It is *mono*polar when bipolarization results in only the apical pole being differentiated while it is *bi*polar when the process separates, by unequal division, two reciprocally differentiated poles. The nature of primary events is particularly critical in such stages of development, where only one or a few cell divisions must determine multiple binary choices from a single pool of genes and cytoplasm. The structure of the DNA molecule might provide a mean for distinguishing progeny cells because each daughter cell appears to receive a different complementary strand of parental DNA in each chromosome (Klar, 1987). This achievement would thus answer Sinnott's (1960) question "how far is polar behaviour an inherited character, potentially present from the beginning of development, and how far induced by the actions of various environmental factors?", a question which has also received another promising answer with the recent discovery of the selective localization of maternal messenger RNAs related to the axial polarity of animal oocytes. Remains, however, the central question of "what is the nature of the primary asymmetrical event?" *Can it simply be a sophisticated molecular extrapolation of the original charge separation proton/electron?*

At another question raised by Sinnott about polar behaviour "is polarity an aspect of the whole organism or do individual cells possess it?", it could be answered that the overall polarity of developmental patterns simply results from the superposition of their individual cell polarities. However, at the highest level of intercellular polarity, morphogenesis, the intrinsic polarity of individual cells appears to be superceded by gradients of morphogenetic substances or morphogens, generated by either simple diffusion or by polarized transport — back diffusion mechanisms, imprinting a general polarity over the field of cells (Meinhardt, 1982). The question remains, however, whether polarity and the field properties of living organisms are reductible to those of physics, or whether they are irreductible and exhibit their own distinctive phenomenology. In 1976, B. C. Goodwin's belief was that "one must remain agnostic on this until there is sufficient evidence to provide an informed conjecture". Since that epistemological statement, there is no doubt that the conceptual barrier between the living and the non-living world has continually eroded. The penetration of the concepts of physics in biology has been facilitated by the introduction of new, sophisticated instruments and techniques which have allowed a deeper study of the several functions of cell, now ultimately understood by means of simple physical concepts such as diffusion, electrical conduction, tunnelling through a potential barrier, and ... electric dipolar moments of biomolecules. The increasing success of this mechanistic world view, in which fundamental electric biopolarity, thermodynamics and quantum mechanics play a central role was already well recorded, in 1970, by Jacques Monod in his both highly rational and intuitive overview of biology "le Hasard et la Nécessité".

It is to provide the incentive for further answering these fundamental questions that we have polarized our interest on an integration of all possible knowledge about general polarity, from its physico-chemical fundaments to its multifaceted biological expression. To effect this long intellectual travel strongly appealed to us when reaching ourselves the so-called reflective stage of life. Now that it is completed, it does not leave us with the feeling that "finishing the book does mean the life" and, "in cha' Allah", we therefore expect to continue for a time to keep up with the rapidly advancing front of biopolarity, to further convince newcomers in Biology to climb the evolutive ladder from its primeval dipoles to that most thinking "vertical dipole", the human being. As "thinking head", we hope to have captured at least a spark out of the dynamic spirit of Polarity which pervades all aspects of Nature and lies at the origins of Life.