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Evolution and conservation of immunological activity

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Abstract

Paraphrasing what Gregory Bateson says on evolution, we might say that: "Immunology has long been badly taught. In particular, students - and even professional immunologists - acquire theories of immunological activity without any deep understanding of what problems these theories attempt to solve."

Key words
- Theory
- Immune system
- Evolution
- Conservation
- Bateson
- Maturana

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"Steps to an Ecology of Mind" (1) is an outstanding collection of essays and lectures by Gregory Bateson on a wide array of subjects, gathered by his students and associates. The book is divided into six sections and section IV, which is devoted to "Biology and Evolution", starts with a remarkable little text in which Bateson uses his wide culture to mock the anti-evolutionary ruling of the State Board of Education in California that, in 1970, demanded religion to be taught together with evolutionary principles. In this short paper, Bateson stated that:

"My father, the geneticist William Bateson, used to read to us passages of the Bible at breakfast - lest we grow up to be *empty-headed* atheists; so I find it natural to wonder what broadening of the mind may come from the strange anti-evolutionary ruling of the State Board of Education in California." He also stated that: "Evolution has long been badly taught. In particular, students - and even professional biologists - acquire theories of evolution without any deep understanding of what problems these theories attempt to solve. They learn but little of the evolution of evolutionary theory."

He then suggests, ironically, that the State Board of Education may be right in forcing the students to study (Christian) religion because: "The extraordinary achievement of the writers of the first chapter of Genesis was their perception of the problem: *Where does order come from?* They observed that the land and the water were, in fact, separate and that the species were separate; they saw that such separation and sorting in the universe presented a fundamental problem. In modern terms we may say that this is the problem implicit in the Second Law of Thermodynamics: If random events lead things to getting mixed up, by what non-random events did things come to be sorted? And what is a "random" event?"

Bateson insists that the problem of order, which is not trivial, has been central to Biology and to many other sciences for the last 5000 years, and asks: "With what word should we designate the principle of order which seems to be immanent in the Universe?" In his irony, Bateson says that the California ruling might get students to consider differ-

ent answers to this ancient problem: "Our students might have their minds broadened somewhat if they would look at other theories of evolution and consider how a man's spirit must take a different shape if he believes that all sorting in the universe is due to an external agent, or if, like the Iatmul and modern scientists, he sees that the potentiality for order and pattern is immanent throughout this world."

The Iatmul are a tribe of Stone Age head hunters from a swampy region in New Guinea who believe that land was separated from water when a vast crocodile, Kavwokmali, that paddled his back legs and maintained the mud in suspension, was killed by the culture hero, Kevembuangga (1).

The contrast between transcendent and immanent solutions to the origin of order should be perceived as the main issue in Evolution, but this is certainly not the general trend, and Wilkins (2) may be correct when stating that: "The subject of evolution occupies a special, and paradoxical, place within biology as a whole. While the great majority of biologists would probably agree with Theodosius Dobzhansky's dictum that "nothing in biology makes sense except in the light of evolution", most can conduct their work quite happily without particular reference to evolutionary ideas. "Evolution" would appear to be the indispensable unifying idea and, at the same time, a highly superfluous one."

To which Conway Morris (3) might have added: "When discussing organic evolution the only point of agreement seems to be: "It happened." Thereafter, there is little consensus, which at first sight must seem rather odd."

Maturana and Mpodozis (4) are two other biologists who claim that the main issue in Evolution is not generally acknowledged, but they add an important second twist. They claim to be proposing a basic conceptual change in dealing with the same fundamental questions that led Darwin to the theory of evolution by means of natural selection, because:

"...change occurs continuously as a spontaneous feature of the molecular existence of living systems (and of all molecular systems), and that as an intrinsic condition of the existence of living systems it must not be explained. What must be explained is the course that change follows in the ontogeny and phylogeny of living systems."

They say that the most important concept in the evolutionary process is *not* to know how living beings are diversified or conserve their characteristics of their adaptation to their circumstances, because: "this is already understood, at least in general lines". What must be understood is how this variation and this conservation followed the particular trend they followed. How did living beings vary the way they did, and how did they conserve invariant certain aspects of living and not others (4)?

Conservation and variation of form was the major concern of Gregory Bateson's father, William Bateson, who published a remarkable collection of observations on the subject (Bateson, 1894), recently reprinted by the John Hopkins University Press (5). In the introduction to this book, Webster (6) quotes: "In a summary of his conclusions, (William) Bateson rejects "the crude belief that living systems are plastic conglomerates of miscellaneous attributes and that order or form or Symmetry have been impressed upon this medley by Selection alone" (p. 80, of Variation). Rather, he suggests, we have to recognize that "the system of an organized being is such that the result of its disturbance may be *specific*" (p. 74). "This remarkable conclusion implies that the response, in terms of the form produced, of a biological system to perturbation - the action of a causal agent - is determined by its intrinsic repertoire of possibilities, that is, the inherent nature of the particular causal mechanism implicated."

Thus, here is a clear statement by Gre-

gory Bateson's father and predecessor declaring his faith in *immanent* mechanisms in the generation of biological form. Webster (6) proceeds to mention the phenomenon of *phenocopying* in support of William Bateson's idea: "Perhaps the most striking support for Bateson's conclusion is provided by the phenomenon of *phenocopying* investigated by Goldschmidt (7) who claims that practically any kind of environmental perturbation of developing wild-type *Drosophila*, applied at the appropriate time, will result in a specific morphology which is normally associated with the presence of a mutant allele." Goldschmidt also discusses these phenomena in terms of the range of forms, which is inherently possible for the organism and which "determines the possibility of appearance of both mutational and environmental effects."

Change and conservation in immunology

Recently (8-10) and also not so recently (11), I have insisted that, to be treated genuinely as *a system*, the immune system must be endowed with a defined *organization*, i.e., an *invariant* set of relations among some of its components (12). There is abundant evidence for the generation of (clonal) diversity (GOD) during lymphopoiesis (13,14). In contrast, the still scarce evidence for *conserved patterns* of operation in immunological activities has remained unacknowledged.

Nevertheless, a significant number of observations on the production of natural plasma immunoglobulins, i.e., those appearing in healthy organisms without artificial immunization, has shown that, early in ontogeny, their reactivity is spontaneously organized in patterns (15) that are influenced by genes important for immunological activity (16) but, surprisingly, not by contact with environmental antigens, such as those derived from food and flora (17), and are robustly conserved throughout healthy living (18). In other words, these observations point to mechanisms of organization in the immune system which are *immanent* to its operation. Immunoglobulins formed by newborn mice are known to favor an internal interconnectivity (19) and interference with their formation is known to cause severe abnormalities in the adult animal (20). Furthermore, the several aspects of processes leading to lymphocyte activation have been shown to be conducive to the generation of lymphocyte interconnections (21).

There is a large disproportion between the immense amount of information available on the nature and operation of genetic/cellular/molecular components of the immune system and the possibility to extract from it practical, clinical, diagnostic, and preventive applications. The impediments to this development are conceptual rather than technological and lie in the way of seeing immunological activity as a form of response to foreign materials.

Since the variety of foreign materials which may eventually invade the organism is virtually unlimited, a corresponding unlimited variety of lymphocytes would be necessary to cope with the need to respond specifically to each one of them. The solution to this riddle was the adoption of a NeoDarwinian solution, i.e., coupling a random source of variants (lymphocyte clones) with a selective mechanism (competition among existing clones for binding of foreign materials) - which is the essence of the dominant immunological theories, all based on stimulus/response/regulation models (13,14).

The observation of robustly conserved patterns of reactivity, as well as several other lines of evidence, rule out the possibility that immunological activity is generated at random and calls for historic/systemic descriptions. Paraphrasing Maturana and Mpodozis (4), the main issue to be explained in the ontogeny of immunological activity is not how lymphocyte diversity is generated, because this is already known, at least in gen-

eral lines and, as they say, change is an intrinsic condition of existence in living systems and this does not need to be explained. "What must be explained is the course that change follows in the ontogeny and phylogeny of living systems" (4). Therefore, the deep issues in Immunology are: "How did the combinatorial immune system arise in phylogeny the way it did?" and "How does the immune system organize itself in ontogeny the way it does, and from then on, conserves its pattern of reactivity?"

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