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BIOLOGICAL INDUCTIONS FROM THE EVOLUTION OF THE PROBOSCIDEA[1]

By Dr. HENRY FAIRFIELD OSBORN

MEMBER OF THE NATIONAL ACADEMY OF SCIENCES

THE extinct and living Proboscideans, including mastodonts and elephants of all the continents except Australia, of the 50,000,000 year period since Oligocene time in North Africa, have been intensively studied since the year 1907 or for the past quarter century for a monograph which will afford biological inductions even more significant than those set forth in Chapter X of the author's Titanothere Monograph of 1929.[2] Whereas the Titanotheres are geologically short-lived and variants of two chief types of adaptation, the Proboscideans are geologically long-lived, 55,000,000 to 65,000,000 years, and represent no less than fourteen widely distinct types of biomechanical adaptation to an environmental range from the equator through the north and south tropics to the southern and northern continental extremities, guided by a surpassing intelligence, and guarded by tusk-like weapons equal or superior to any of those invented by man up to the introduction of firearms.

In brief, Proboscideans rank next to man in biological interest and far surpass man in confirmation of the principles of biomechanical evolution first set forth (December, 1931) in my seventh contribution to this series.[3] These six principles are: biomechanical

[1] Read by title before the National Academy of Sciences, Ann Arbor, Michigan, on November 15, 1932. This is the eighth contribution on the Origin of Species, and the principles of biomechanical evolution, as demonstrated in vertebrate paleontology.

[2] "The Titanotheres of Ancient Wyoming, Dakota and Nebraska," Monograph 55, U. S. Geological Survey. Washington, 1929.

[3] "New Concept of Evolution Based upon Researches on the Titanotheres and the Proboscideans," SCIENCE, December 4, 1931, Vol. 74, No. 1927, pp. 557–559.

evolution is (1) continuous or uniformitarian rather than mutational or cataclysmic, (2) germinal or centrifugal rather than somatic or centripetal, (3) creational in the Osborn sense rather than variational in the Darwin sense, (4) in geologic time adaptively reactional rather than adaptively vitalistic or entelechistic, (5) syn-energistic and anti-energistic, that is, gathering energy to resist and overcome energy, (6) prior to somatic experience or prot-empirical, rather than after somatic experience or met-empirical.

The six principles above have slowly emerged during forty years of research and are now confirmed by the Proboscidea. They act like lethal enzymes on the four chief historic hypotheses of the causes of biomechanical adaptation put forth in the twenty-five centuries since evolution was first conceived by the Greeks. These four hypotheses are: (1) Adaptational use and disuse inheritance, as formulated by Lamarck. Lamarckism is moribund and unconfirmed (Osborn, 1929) by recent paleontology. (2) As formulated by Buffon and St. Hilaire, environmental, physico-chemical inheritance, through action on the germ, has been confirmed by field zoologists and recently by experimentalists as a cause of germinal mutation and evolution in color and form. (3) Darwin's selection of favorable germinal variations camouflaged under a variety of terms now prevails among the zoologists and the leading geneticists (*e.g.*, Haldane, Morgan, Huxley) as the only indirect cause of adaptation which has been discovered. (4) Entelechy or internal perfecting tendency is not an explanation; it is a *petitio principi.*

Recent authorities (Haldane,[4] Morgan,[5] Huxley[6]) offer no new hypotheses or explanations, only variations of the four old ones, enumerated above.

The twenty-five century problem of the origin of biomechanical adaptations remains unsolved by any of these four historic explanations. None of their modern substitutes conforms to the actual order or modes of evolution, derivable solely from paleontology, while wholly beyond the ken of zoology or experimentalism. When I say that there is not a scintilla of evidence for the adequacy of any of these four historic explanations as applied to biomechanical evolution, I weigh my words carefully because I realize that I must be prepared not only to defend this statement but to substitute an entirely new concept of the complex of evolution phenomena which we sum up (Osborn, 1931) in the single word, *aristogenesis.*

[4] J. B. S. Haldane, "The Causes of Evolution." New York and London, 1932.

[5] Thomas Hunt Morgan, "The Scientific Basis of Evolution." New York, 1932.

[6] Julian S. Huxley, "Problems of Relative Growth." New York, 1932.

The evolution of the Proboscidea undermines the inductions of the experimentalists and geneticists by demonstrating the non-significance of the larger portion of modern genetic discoveries. Only Bateson, founder of modern genetics, had the courage to frankly throw up his hands in despair of obtaining really significant results as to the origin of species. The larger number of modern zoologists are committing suicide by adopting a modified Darwinian creed, to use the elder Huxley's significant phrase. The attempt to trace the temporal origin of biomechanical adaptations, which paleontology demonstrates are *determinate, orthogenetic, secular germinal-reactional processes,* involving enormous periods of time, shows that the mutationists and selectionists are traversing a swamp of useless inquiry led by the will-of-the-wisp of expectation.

Offsetting the temporary specific instability and inconstancy of the heredity-germ under physical and chemical experiment, paleontology demonstrates that the most fundamental principle is germinal stability; adaptive biomechanical change or variation of the germ-plasm is only secular. *Absolutely inevitable and germinally predetermined evolution, distinguished as aristogenic or always tending toward improvement, takes place in widely separated geographic areas, at the same or different evolutionary rates. The term aristogenesis applies to this germinal-reactional creative potentiality.*

Referring to my previous communications for details, I now present to the academy two concrete examples among many which are now demonstrable in the evolution of the Proboscideans. They especially demonstrate three of the six principles above, namely: (1) *aristogenesis, the orderly creation of something better or more adaptive,* (2) *secular genetic reaction, i.e., creative origin from the germ plasm of entirely new germinal characters in the grinding teeth;* (3) *potential homogeny, the potentiality of the creative origin of new adaptive characters which distinguish certain lines of descent, the potentiality lying in a common germinal ancestry.*

The scene of the first example of proboscidean aristogenesis is from a descent line of mastodonts living in the Siwalik Hills of northern India during the flood plain deposition of 13,000 feet of Miocene sediment (Chinji, 2,300 feet; Kamlial, 1,700 feet; Murree, 8,000 feet; Gaj (Bugti), 1,000 feet). The percentage of these Miocene strata to the whole Siwalik series of 16,000 feet is 81 per cent. The time estimate of the Miocene period (Barrell, 1916) is from 12,000,000 to 14,000,000 years. We witness here the creative origin from the germ plasm in a definitely known period of geologic time, which may be tabulated as follows:

NEW ELEMENTS ADDED TO THE THIRD INFERIOR MOLARS IN THE PERIOD ESTIMATED AT 14,000,000 YEARS

		Ridge crests	Cones	Conelets	Conules	Trefoils	Total conical elements	Total new elements
Upper Miocene	*Trilophodon macrognathus*	$5\frac{1}{2}$	12	19	4	8	26	34
Middle Miocene	*Trilophodon chinjiensis*	$5\frac{1}{2}$	12	21	4	14	27	35
Lower Miocene	*Trilophodon palæindicus* ...	$4\frac{1}{3}$	10	17	3	6–7	20	27
Basal Miocene	*Trilophodon cooperi*	$4\frac{1}{5}$	10	17	2	0	19	19
Lower Oligocene	*Phiomia osborni*	$3\frac{1}{3}$	8	10	2	0	10	10

In the lower Oligocene *Phiomia osborni,* the third inferior grinders, with the corresponding grinders above, condition the daily needs of crushing the requisite amount of herbage and are prophetic of the fact that in all Proboscideans it is the back molars on which biomechanical adaptation concentrates. Nine new elements are added in the Basal Miocene *Trilophodon cooperi;* seventeen new elements in *Trilophodon palæindicus;* twenty-five new elements in *Trilophodon chinjiensis;* twenty-four in *Trilophodon macrognathus.* Each of these elements rises from the creative potency of the germ, first as an inconspicuous rudiment, finally as a functional and useful cone or enamel folding. This phyletic series accordingly is a true picture of the evolution of the aristogenesis latent in the germ plasm.

The three principles of potential homogeny, of secular adaptive reaction, of the creation of something more adaptive or aristogenesis, are absolutely and irrefutably demonstrated in these third inferior molars of a single line of descent. They conform with what has been repeatedly observed in other lines of descent. The fact that this creative aristogenesis is a totally unexplainable and mysterious process in no way invalidates or undermines this absolutely concrete and irrefutable evidence of the actual modes of the origin of new characters in species, genera and higher divisions. These three principles are totally at variance with the working hypotheses of Darwin's variational-natural-selection, or of Lamarck's inheritance of acquired characters.

My second illustration is from the superior and inferior grinding teeth of the higher elephantoid division of the Proboscideans; it affords us a still more brilliant and convincing demonstration of the absence in biomechanical adaptation of anything in the nature of chance or experiment or trial and error. In the reciprocal mechanism of the grinders for the finer comminution of the food every mechanical adaptation of the upper grinders is reversed by an energetically counteracting adaptation in the lower grinders; the rates of these reciprocal upper and lower mechanical adjustments are precisely coordinated.

The enamel foldings by which the adaptive ridge crests rise from three in Oligocene time to thirty-seven in Pleistocene time constitute a potential characteristic of the Proboscideans. They begin with a low transverse ridge crest seen in a previous Miocene mastodont molar with a ganometric enamel length of 470 mm. (*Pentalophodon sivalensis*), which by multiplication of ridge crests and elevation of the enamel foldings rises to 6,800 mm. in the highly complex mammoth stage of *Mammonteus primigenius compressus.* These are the extremes. In this closing Pliocene and entire Pleistocene of 1,250,000 years we are enabled by the new ganometric system[7] to demonstrate that each of the six great phyla or genera of elephants—*Archidiskodon, Parelephas, Mammonteus, Paleoloxodon, Loxodonta, Elephas*—has an independent line of grinding tooth evolution, progressive at distinct rates, slow, medium and rapid, parallel and similar but wholly independent. In fact, the end terms of this independent evolution produce grinding teeth so closely resembling each other that only recently has it been possible for Osborn to demonstrate that each of the six generic lines may be clearly distinguished when closely analyzed.

While fatal to Lamarckism in the temporary sense that all that is acquired is inherited, there is a vestige of the Lamarckian idea in the secular 14,000,000 year experience of the mastodont and elephantoid grinding teeth, in that these new germinal characters and new germinal foldings do not rise spontaneously as they would on an entelechistic or vitalistic hypothesis, but the twenty-six new conical elements or thirty-four total new elements observed in the mastodontoid series appear in secular response to the demands made on the feeding mechanism by different kinds of food. They are closely proportioned to the whole amount of feeding energy which is thrown upon the grinding teeth. Where other feeding organs, such as the incisive tusks, share the problem of the feeding animal as a whole, the grinding tooth mechanism is much simplified. The same principle is observed in the contrast between the conservative grinding teeth of the modern African elephant which have remained in an upper Pliocene stage of evolution with a ganometric scale of 2,300 mm., while the grinders of the modern Indian elephant attain a length of 7,850 mm.

Fatal as biomechanical evolution is to Lamarckism,

[7] Henry Fairfield Osborn and Edwin H. Colbert, "The Elephant Enamel Method of Measuring Pleistocene Time. Also Stages in the Succession of Fossil Man and Stone Age Industries," *Proc. Amer. Phil. Soc.,* Vol. lxx, No. 2, 1931, pp. 187–191.

it is still more fatal to Darwin's working hypothesis of adaptation through survival of variations in any degree subject to chance. First, chance is absolutely eliminated, both theoretically and actually, by Proboscidean evolution; second, the rapidity of evolution is now known to be entirely independent of the rapidity of selection. In the Pleistocene million year period extremely slow-breeding elephantoids evolve their grinding teeth with amazing rapidity, far outstripping any of their rapidly breeding mammalian contemporaries in which it is difficult to distinguish a Lower Pleistocene specific stage from a modern specific stage.

We must confess that Biology is at present a totally uncoordinated science still in its infancy. It is not a science in the sense of astronomy or physics or chemistry. As compared with astronomy, it is what astronomy would be if, after the discovery of the spectroscope, the whole structural astronomy had been abandoned. In other words, when we biologists abandon morphology, as a great majority are doing, we are leaving out of consideration the phenotypic aspects of heredity. Certainly no one could dream of the creative evolution of the germ plasm without the aid of the penetrating secular vision of modern vertebrate paleontology.

SPACE STRUCTURE AND MOTION. II

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If we carry out the dynamic description of motion to its logical end, we arrive at rather puzzling conclusions. Let us use a reference system fixed to the earth.

MACH'S PRINCIPLE

The celestial bodies cause a turning of the plane of motion of Foucault's pendulum. *When a street car stops and I feel a jerk, I conclude that there would be no jerk at all, or only a small jerk, if the distant galaxies were not there.* This is a consequence of our dynamic conception that all motion is relative to matter. This principle was first enunciated by Ernst Mach.

Is there anything wrong in our deductions? Some authorities think that matter may perhaps only be responsible for the distortions in space-time and not for its fundamental properties. Weyl[4] has written an interesting dialogue about this subject. But most authorities defend Mach's principle and maintain that the stars are responsible for all the metrical properties of space-time, including inertia.

To understand this action at inconceivable distances we must greatly extend our study. We have, in the writer's opinion, to go deep down into the dark corridors of the foundation of matter. We must also include a new, but not unfamiliar, element in our study.

INTRODUCTION OF THE OBSERVER

In the introduction I enumerated the elements which enter into our description of motion, but I omitted one very important factor. There is also the human observer with his peculiar habit of describing, analyzing and interpreting his sensations and measurements, not as complexes, but in terms of simple, not further reducible elements.

Most human observers have an inherent love for simplicity, uniformity and permanence, and express these concepts in terms of unchanging physical laws of the simplest possible kind valid for the whole universe. If he finds that he can "explain" nature in such a way he prefers this explanation and disregards more complex conceptions, or at least suspects them of being artificial, only usable for giving numerical relations. For this reason he has some preference for inertial reference frames and Euclidean geometry. That is the reason he thinks the earth moves around its axis and not the stellar frame around the earth; the earth moves about the sun and not the sun about the earth. He is influenced by the smallness of the earth as compared with the immensity of the system of galaxies, and ascribes more reality and importance to a frame where the sum total of energy and momenta in the observable universe is comparatively small than to one in which it is tremendously much greater.

Back of the human observer's analysis lies also a peculiar characteristic of his consciousness, which makes him single out one particular axis in space-time, which he calls the time-axis. He regards this as being built up of small elements, which he calls moments of time. His memory enables him, to a certain extent, to combine these moments into a longer time interval, within which he has a definite feeling of retaining his identity, even if his material structure has been entirely renewed. The extension of the time-axis in one direction, the past, seems also to be of a different nature than the extension in the opposite direction, the future.

[4] Massenträgheit und Kosmos, *Die Naturwissenschaften*, 12: 197, 1924.