of the open ocean as the source of the material as in the case of the Sargasso-sea faunas. Such is the Genessee shale which like the Genundewa limestone contains a typical planktonic element, the Genundewa limestone representing a Devonian pteropod-ooze. The widely extending Chattanooga shale is characterized by the conodonts, now recognized as the teeth of cyclostomes. It was formed in near-shore and lagoonal areas where the cyclostomes died after the spawning season but which were not open to Sargasso-sea invasions from the ocean. The same is true of the Carboniferous and Permian shales.

It is probable that when attention is directed to the possible planktonic elements of the Paleozoic marine faunas, more forms will be recognized as being of that nature.

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BIOLOGICAL INDUCTIONS FROM THE EVOLUTION OF THE PROBOSCIDEA

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AMERICAN MUSEUM OF NATURAL HISTORY

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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 Titanotheres Monograph of 1929. 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 (Dec., 1931) in my seventh contribution to this series. These six principles are: biomechanical 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 Huxley6) offer no new explanations, only variations of the 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.

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 creative potentiality.

Referring to my previous communications for details I now present to the Academy two concrete examples among many which are now demon-
strable 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 homogeneity, 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 2300 feet; Kamlial 1700 feet; Murree 8000 feet; Gaj (Bugti) 1000 feet). The percentage of these Miocene strata to the whole Siwalik series of 16,000 feet is eighty-one. 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 of 24 new characters which may be tabulated as follows:

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

<table>
<thead>
<tr>
<th>Period</th>
<th>Species</th>
<th>HIGH</th>
<th>CONES</th>
<th>CONVOLVES</th>
<th>TUBES</th>
<th>TOTAL CONVOLVES</th>
<th>TOTAL ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Miocene</td>
<td><em>Triophodon macrognathus</em></td>
<td>5 1/2</td>
<td>12</td>
<td>19</td>
<td>4</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>Middle Miocene</td>
<td><em>Triophodon chinjiensis</em></td>
<td>5 1/2</td>
<td>12</td>
<td>21</td>
<td>4</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>Lower Miocene</td>
<td><em>Triophodon palaeindicus</em></td>
<td>4 1/2</td>
<td>10</td>
<td>17</td>
<td>3</td>
<td>6-7</td>
<td>20</td>
</tr>
<tr>
<td>Basal Miocene</td>
<td><em>Triophodon cooperi</em></td>
<td>4 1/2</td>
<td>10</td>
<td>17</td>
<td>2</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Lower Oligocene</td>
<td><em>Phiomia osborni</em></td>
<td>3 1/2</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>10</td>
</tr>
</tbody>
</table>

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 *Triophodon cooperi*; seventeen new elements in *Triophodon palaeindicus*; twenty-five new elements in *Triophodon chinjiensis*; twenty-four in *Triophodon 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 homogeneity, 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 Proboscidians; it affords us a still more brilliant and convincing demonstration of the absence in biochemical 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 Proboscidians. 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 6800 mm. in the highly complex mammoth stage of *Mammonteus primigenius compressus*. These are the extremes. In the closing Pliocene and entire Pleistocene of 1,250,000 years we are enabled by the new ganometric system 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 any entelechistic or vitalistic hypothesis. 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 2300 mm. while the grinders of the modern Indian elephant attain a length of 7850 mm.

Fatal as biomechanical evolution is to Lamarckism 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.

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 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 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.

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 the 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.

1 This is the eighth contribution on the Origin of Species, and the principles of biomechanical evolution as demonstrated in vertebrate paleontology.