mechanical adaptation organs arise out of the germ-plasm without the antecedent action of self-adaptation. (*a*) While in all parts of the skeleton the principle of mechanical self-adaptation prevails and new proportions, new characters, new adaptations, new functions, new modes of locomotion may be created in the lifetime of a single individual, all that is transmissible in heredity is the germinal variation to plasticity or adaptability in the desired direction, which may be accumulated through coincident selection as applied by Osborn, Baldwin, and Morgan. (*b*) Even more perfect mechanical adaptations arise in the grinding teeth which are not perfected during lifetime.

8. *As against mutational or saltatory hypotheses of evolution* hitherto held by Bateson and his school, the principle of bio-mechanical continuity is so firmly established that we may attribute all discontinuity in bio-mechanical evolution to abnormal, unnatural, pathogenic causes or, through recent discovery, to endocrinal disturbance. Whatever may be true in bio-chemical evolution, in colour, in immunity, in metabolism and phenomena of that order, we may be certain that the bio-mechanical evolution of the skeleton and teeth as observed in palæontology assumes and follows its firm and undeviating order.

9. *Bio-mechanical evolution as observed in full palæontological series*, whether vertebrate or invertebrate, gives the death-blow to the chance hypothesis of Democritus and Empedocles raised into a scientific system in the subsidiary fortuitous selection hypothesis of Darwin. Nature is observed to take no chances, either in the transformation of existing mechanical organs or in the origin of new mechanical characters and inventions. New parts of the organic machine arise in rudimentary condition but perfect order out of the germ-plasm when the demand for them arises; they do not arise automatically without an antecedent bio-mechanical stimulus. They play their continuously adaptive service; when no longer useful they subside and sink back into the germ-plasm, where the power of reproduction is ultimately lost.

Every single one of hundreds of bio-mechanical characters of which the evolution has been observed follows the nine principles enunciated above.

10. *The loss of bio-mechanical organs* in the vertebrates is never sudden, as if due to the presence and absence principle of Mendelism. Organs evolved through a long process of continuity show remarkable heritable stability, like longheadedness in man or in the hoofed mammals when crossed with broadheaded types. In the horse-ass hybrid, for example, most of the bio-mechanical skeletal characters transmitted are those of the horse, all of which have evolved over a very long period of time—hundreds of thousands of years. Certain of the bio-mechanical characters and most of the psychic characters are those of the ass. Thus a continuity in bio-mechanical evolution may give rise to Mendelian discontinuity in hybridising, exactly as it does in the matter of bio-chemical evolution.

11. *Every race will more or less rapidly lose its typical form* in any one of four ways consistent with the tetraplastic and tetrakinetic principle of Osborn: (*a*) by alteration of its internal energies of heredity (phylogeny); (*b*) by alteration of the external energies of environment; (*c*) by alteration of the external energies of the biota of plant and animal environment; (*d*) by alteration of the internal energies of habit or ontogeny. Any one of these four energetic changes will immediately precipitate a new action of selection, and as a secular process will alter the germ-plasm.

It appears from these eleven observations that palæontology is a two-edged sword which is equally ruthless in the Darwin-Weismann and the Lamarckian fields of speculation.

In conclusion, what really happens in the natural origin of species in bio-mechanical characters is this: *Whenever all the four energetic conditions of heredity, of environment, of biota, of habit or ontogeny, and the non-energetic condition of the struggle for existence (selection) are the same, there will arise similar ascending mutations, species, genera, families.* New similar or parallel species of hoofed animals actually arise at approximately, if not at precisely, the same rate, whether we observe them in France, Mongolia, or the Rocky Mountain region.

My rejoinder to Bateson's statement[6] that "the origin and nature of *species* remains utterly mysterious" is that thirty-six years of intensive palæontologic exploration and research have so clearly and repeatedly revealed how new bio-mechanical species arise that we can safely predict not only what the species is, but also where it is most likely to be found and in what stage of evolution it will be found. Such prediction has recently been fulfilled in a most brilliant manner in our discoveries of the Titanotheres in central Mongolia. Whatever may prove true as regards species founded on bio-physical or bio-chemical characters, the research is nearly closed on the modes of origin of bio-mechanical species, because we have little more to learn.

The *causes* of these origins is quite another matter. Some day we may be able to work out the separate contribution of each of the four energetic factors, heredity, environment, ontogeny, biota to germinal evolution. We palæontologists observe exactly how the process of germinal evolution of bio-mechanical characters goes on, adaptive in every stage, just as the embryologists observe how the process of adaptive development goes on whereby the invisible germ turns gradually into the adult and perfected skeleton and teeth. There is no accident in either mode of transformation, evolutionary or developmental, nor is there anything that we can comprehend. On the whole, the order of evolution imitates the order of development; both processes, to our mind, are equally inexplicable, and will probably remain so.

[6] William Bateson's observations on discontinuity in the origin of species first appeared in his "Materials for the Study of Variation," 1894. More recent are his British Association address in Australia and his address at the Toronto meeting of the American Association quoted from above.

Accuracy of Weighing in the Eighth Century.

TWO recent papers in the *Numismatic Chronicle*[1] contain interesting information on the remarkable accuracy of ancient weighing. Dr. G. F. Hill mentions that in a hoard of 20 gold staters of Lysimachus (*c.* 355–281 B.C.), in mint state, the extreme weights were 8·62 and 8·42 grams, *i.e.* the maximum variation was 2·3 per cent. Eleven of the coins, however, had weights with a much smaller range, namely, 8·57 to 8·52 grams, a variation of only 0·58 per cent. Dr. Hill considers this degree of accuracy to be no greater than might be obtained by cutting a bar of uniform thickness into equal lengths with an ordinary measure. The smallest weight about which the Greeks cared seems to have been not less than 0·05 gram.

Much greater accuracy is shown in certain Arabian glass coin-weights of the eighth century which are described by Sir Flinders Petrie. The average error of dinar and dirham weights of this century is 0·004 gram; in the early weights the accuracy is

[1] G. F. Hill, "The Frequency Table," Fifth Series, vol. 4, p. 76, 1924; W. M. F. Petrie, "Glass Weights," Fourth Series, vol. 18, p. 111, 1918.

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even finer. Thus in 780 "the astonishing result of three weights is 32·662, 32·665, and 32·667 grains," or all within a third of a milligram. As Sir Flinders says, "to reach such accuracy it was needful to use the finest chemical balance, with closed case, double weigh the glass weights against each other, and read a long series of swings of the balance. How such accuracy was reached in the manufacture is incomprehensible. Nothing known of any other age at all approaches the fine weighing of the eighth century."

That the Arabs made an intensive study of the balance from both the theoretical and the practical sides, is well known. There is, indeed, a wide literature on this subject, which was considered to be a distinct branch of science. The celebrated mathematician Thābit ibn Qurra (836–901) wrote on the Roman balance or *qarastūn* (χαριστίων) a treatise ("Kitāb fi'l-Qarastūn") which is still extant (MSS. Berlin, 6023; India Office, 767, No. 7). Other authors who dealt with the theory or practice of weighing are Al-Farabi, Avicenna, Qusta ibn Luqa, and Ibn al-Haitham. Most important of all, however, is the treatise written by Al-Khazini in 1121 for the Sultan Sinjar. "This is not confined to the description of various balances but includes also geometrical and physical considerations on everything connected with weight. Notably, it gives theorems on centres of gravity according to Ibn al-Haitham and Al-Kuhi; it mentions an instrument for measuring liquids, after Pappus; it touches on philosophical problems and, with Thābit, seeks for the 'different causes of heaviness.'"[2] Al-Khazini's book, which is entitled "The Book of the Balance of Wisdom," contains an excellent description of the hydrostatic balance and gives tables of specific gravities which differ in general very little from the values accepted at the present day—that of lead, for example, is given as 11·33, which compares very well with our value of 11·35.

In spite of this attention to the science of the balance, it appears that accuracy in weighing deteriorated after the eighth century. Perhaps it is a mere coincidence, but it is worth noticing that the eighth century was the time in which Arabic chemistry reached its zenith. The balance continued to play an important part in chemical laboratories, however, and we find that Al-Jildaki, who died about 1360, makes the remarkable statement that "substances do not react except by definite weights."

An excellent picture of a medieval chemical balance, in a closed glass case, is given in the British Museum MS. of Thomas Norton's "Ordinall of Alkimy."

E. J. H.

[2] Baron Carra de Vaux, "Les Penseurs de l'Islam," vol. 2, p. 181.

University and Educational Intelligence.

ABERDEEN.—Prof. R. W. Reid has intimated his resignation from the chair of anatomy, which he has held since 1889.

BRISTOL.—On Tuesday, June 9, their Majesties the King and Queen visited Bristol, where they opened the new buildings of the University, as recorded in our issue of June 13, p. 913. Before proceeding to the University, the King received an address from the civic authorities, and in his reply, referring to the great generosity to the University shown by the Wills family, said that it "is a convincing proof that the race of pious founders and benefactors did not become extinct with the passing of the Middle Ages." At the University, the Chancellor, Lord Haldane, presented an address in which he pointed out clearly the significance of the university in modern life. "It is our happy lot and duty," he said, "to cultivate and encourage learning both by imparting knowledge to those who seek it, and not less by providing facilities for its development through maturer study and research. . . . We are conscious, too, that it is incumbent upon us to bring science to the aid of industry." In his reply, the King enlarged upon this theme. The duties of the universities are: "To hold in trust for the common use the treasures of past thought, to provide for the creative minds of the present a congenial and stimulating home, to give to all the opportunity of a liberal education in the arts and sciences. . . . Their responsibilities are heavy, as their opportunities are great; and they can only rise to the full measure of their task if they be strong in public sympathy and support."

Honorary degrees were conferred on June 10 upon a few distinguished representatives of the Church, arts, and science who are natives of Bristol, or have been associated with the city or the neighbouring districts through education or public service. Among these were Lord Bledisloe, Sir Richard Gregory, and Sir J. Herbert Parsons, each of whom received the degree of D.Sc.

CAMBRIDGE.—Dr. A. B. Appleton, Downing College; Mr. D. G. Reid, Trinity College; Mr. A. Hopkinson, Emmanuel College; and Mr. V. C. Pennell, Pembroke College, have been reappointed as demonstrators of anatomy.

The Council of the Royal Agricultural Society has notified the University that it is prepared to grant the interest on the money given to the Society in 1896 by the late Sir Walter Gilbey to the University of Cambridge to assist the University to maintain the Gilbey lectureship in the history and economics of agriculture.

LEEDS.—Dr. W. H. Maxwell Telling, who has occupied the chair of therapeutics for the past two years, has been elected University professor of medicine and head of the Department of Medicine, as from October 1, on the retirement of Dr. T. Wardrop Griffith.

LONDON.—The Johnston-Lavis Geophysical Collection, which was bequeathed to the University of London by the late Dr. Henry James Johnston-Lavis, will be formally opened at University College on Thursday, June 25, at 4 P.M. After the opening ceremony has been performed by Sir Henry A. Miers, Vice-Chancellor of the University of Manchester, in the main college buildings, visitors will have an opportunity of inspecting the Collection in its temporary quarters at 134 Gower Street. Those who would care to attend are requested to communicate with the Secretary of the College.

THE Liddle triennial prize, value 120*l*., of the London Hospital Medical College is being offered for an essay on "The etiology and treatment of primary high blood pressure." Competing papers should be sent by at latest January 30 next to the dean of the college, Turner Street, E.1.

APPLICATIONS are invited for the Gull studentship in pathology and allied subjects, including bacteriology, at Guy's Hospital Medical School. The studentship is open to candidates who have studied at the medical school of Guy's Hospital. It is of the annual value of 250*l*. and is tenable for three years. The latest date for the receipt of applications, which should be sent to the Secretary of the Board of Electors, at the School, is July 4.

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