AD STIMULANDUM

Diminishing Gravitation - a Hitherto Underrated Factor in the Evolution of Organic Life

More than 30 years ago, DIRAC[1] was the first to present the theory that the gravitational constant G may in fact be a slowly decreasing quantity. His hypothesis was taken up by JORDAN[2] who, with a number of collaborators, introduced the concept of a variable gravitational 'constant' into EINSTEIN's theory of relativity. The decrease in value of G seems to be extremely small, of the order of 10^{-10} to 10^{-9} of its actual value per year; the effect may be thus most easily seen over large periods of time. When applied to the history of the Earth, this diminution of G leads to a slow expansion of the Earth. This has been shown by JORDAN[3] to be the underlying explanation to the apparent drift of the continents for which much observational evidence has been accumulated[4], also to other geological and tectonic phenomena.

Now, both the decrease of the gravitational constant G, and the increase of the radius of the Earth (with a rate between ca. 0.5 mm per year in Silur up to 5 mm in the Cretaceous) act in the same direction so that the value of the gravitational acceleration g on the surface of the Earth was greater in the past. Thus, from the data presented in JORDAN's book[3] (figure 33) it follows that the gravitational acceleration g in the Jurassic exceeded by ca. 50% its present value; it is possible that in the Palaeozoic the value of g was twice as large as now. Since the effect of diminishing (with time) values of G and g has not been considered up to now in biological sciences (in contrast to the earth sciences), some speculations will be presented thereon which may provide the starting point for future quantitative analysis.

1. When life originated, the conditions on the primeval Earth might have differed from the present state not only with respect to the UV-irradiation, oxygen abundance etc., but also with respect to gravity. The same amount of mass had a larger weight than it has today; certain physico-chemical properties might have been affected, and the rate of abiogenic life formation could be different from that which is estimated assuming the value of G to be the same. Also the rate of metabolism in successive generations of organisms could be slightly modified.

2. Special caution is commendable with respect to the estimations of the weight of fossil animals. From the fossils of the vertebrates, we estimate the shape and mass of these animals. Now, in case of e.g. Jurassic dinosaurs, we have to multiply the weight (not mass!) we estimate in this way by a factor of 1.5 in order to obtain their weight in the period when they lived. This 're-evaluation' of the weights is not merely arithmetic; it may provide us with a proper estimation of the internal tensions and muscle strength of prehistoric animals, the compression resistance of the vertebral column of vertebrates etc. In view of the large Jurassic gravity, we cannot wonder at the large internal support mechanisms of the dinosaurs.

3. May the rather clumsy shapes of the first land animals, in the periods when the gravity was larger than now, be at least in some part related to the relatively larger weight, tending to squash these organisms?

4. The weight of a given amount of mass may be looked upon as slowly diminishing during the history of the Earth. Could this influence the internal elastic mechanisms of the organisms, being responsible for mechanical endurance of their internal structure? This phenomenon might be related, in part perhaps, to the well-known feature of evolution: replacing smaller forms of a given species by larger ones. Other factors of a higher importance might act in this direction; nevertheless the effect of a diminishing gravitation upon evolutionary pattern might provide an additional stimulus. This point may be subject to an experimental verification in the near future; the only difficulty seems to be to find sufficiently swift-breeding and large-sized organisms. An artificial simulation of the conditions of diminishing gravity might consist either in breeding successive generations in slowing-down centrifugal machines, or in breeding them (with other conditions being the same) on other planets (successive generations on celestial bodies of diminishing masses). While the first type of experiments may probably now be performed by microbiologists, the latter type is related to advances in exobiology of our solar system.

May these speculations of a gravitation theoretician stimulate a discussion among biologists and palaeontologists. In these days of narrowing specialization, the impact of developments in one scientific discipline upon another may be of some value.

Zusammenfassung. Einige Folgerungen der DIRAC-JORDANschen Hypothese, dass die Gravitationskonstante im kosmologischen Zeitmass in langsamer Abnahme begriffen sei, werden für die biologischen Wissenschaften aufgeführt. Die einst grössere Schwerkraft konnte sich insbesondere zu Zeiten, da das Leben entstand, auswirken und auch die biologische Evolution beeinflussen.

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[1] P. A. M. DIRAC, Nature, Lond. *139*, 323 (1937).
[2] P. JORDAN, *Schwerkraft und Weltall* (Vieweg and Sohn, Braunschweig 1955); also D. BRILL in Proc. Int. School of Physics 'E. Fermi', Varenna 1961 (Academic Press, New York 1962), p. 50.
[3] P. JORDAN, *Die Expansion der Erde* (Vieweg and Sohn, Braunschweig 1966).
[4] A. G. SMITH and A. HALLAM, Nature, Lond. *225*, 139 (1970).

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