creases more rapidly than the net expenditure of energy; those perish in which the total quantity of evolutionary transformation increases less rapidly than the net expenditure of energy.

These laws of evolution and of survival are exemplified in biological evolution both in the constitution of organic matter itself and in the paleontological series.

In all organic matter we find marvelous strength, and marvelous capacity to store and to transform energy, in proportion to weight and volume.

In the paleontological series we see the termination of the line of monster organisms, and the rise and survival of organisms of less weight and bulk, but of higher biological quality.

In psychological evolution the superimposition of reason upon instinct is correlated with an increasing complexity of nerve and brain structure, the marks of which are a finer and finer cell mechanism, of enormously high energy-conveying and converting capacity in proportion to weight and volume.

In the competition of human races one with another, and of population aggregates one with another, those of high energy-storing and converting capacity per individual have occupied the superior environments, and have most vigorously multiplied.

In the evolution of social organization superior corporate forms displace inferior forms only if with a differentiation of departments, a multiplication of officials and a specialization of functions, there is a corresponding improvement in individual efficiency.

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ALTERNATION OF GENERATIONS IN ANIMALS.

In Science of April 28, 1905, Professor Harold L. Lyon attempts to criticize my paper on 'Alternation of Generations in Animals from a Botanical View-point' (*Botanical Gazette* 93: 137–144, 1905). My theory, stated briefly, is this: The egg with the three polar bodies constitutes a generation comparable with the female gametophyte in plants; similarly, the primary spermatocyte with the four spermatozoa constitutes a generation comparable with the male gametophyte in plants. All other cells of the animal constitute a generation comparable with the sporophytic generation in plants, the fertilized egg being the first cell of this series.

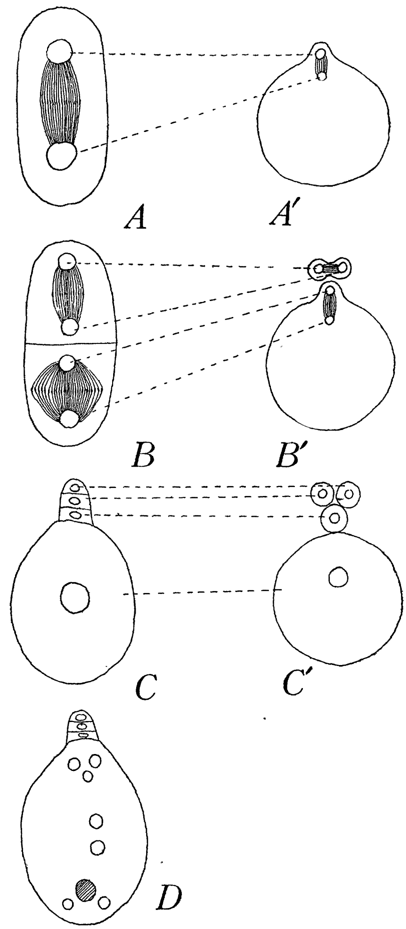

Fig. 1.

According to Professor Lyon, my diagrams indicate "that the animal egg by itself and each spermatozoid is comparable to a plant gametophyte. His statements are not consistent, not in accordance with the facts or even with his figures, and it appears that just where he wishes to draw the homology is not quite clear in his own mind."

Such a positive and dogmatic criticism should be accompanied by some proof, but the proof does not appear. Fig. 1 is the diagram which Professor Lyon fails to reconcile with the statement just made in the first paragraph of this note. Just why he failed to grasp the situation will be evident to any morphologist. He simply failed to distinguish between a *gametophytic generation* and an *individual gametophytic plant.* According to Strasburger[1] the spore mother-cell is the first cell of the gametophytic generation. This spore mother-cell usually produces four spores, each of which, with or without germinating, is an individual gametophytic plant. In Fig. 1, *C* and *C′*, this condition is compared with the egg and the three polar bodies. In the same figure, *B* and *B′*, and *A* and *A′* show previous stages in the development. A stage preceding *A* and *A′* might have been added to compare the spore mother-cell with the primary oocyte. The diagram is intended to indicate not only that the entire gametophytic generation in plants is comparable with the entire gamete-producing generation in animals (this generation beginning with the primary oocyte and ending with the egg and three polar bodies), but also that each of the four megaspores is comparable with an animal egg, the three polar bodies, of course, being regarded as eggs. I am aware that some cytologists, notably investigators of the Grégoire school, are questioning whether the gametophytic generation does not begin with the spore rather than with the spore mother-cell, since it is not until the spore is reached that the reduced number of univalent chromosomes is found. This, however, is a minor detail which does not affect essentially the theory presented in Strasburger's paper on periodic reduction or the theory advanced in my paper on alternation of generations.

The remark 'That zoologists recognize an alternation of generations in Hydrozoa and Scyphozoa is a common statement of their text-books,' coming from a teacher of botany, is rather surprising. We shall take a charitable view and hope that it was ignorance of zoology rather than of botany that allowed the remark, for the condition in Hydrozoa described by zoologists as an alternation of generations is not an alternation of generations in the botanical sense, but is only a case of polymorphism, the relation of the medusa form to the parent plant being somewhat like the relation of the leafy moss plant to the protonema. Since my paper appeared, several zoologists have called my attention to this alternation of generations in hydroids, but they have recognized at once that the term, alternation, is used in a totally different sense by botanists and zoologists.

[1] Strasburger, Ed., 'The Periodic Reduction of Chromosomes in Living Organisms,' *Annals of Botany*, **8**: 281–316. 1894.

The general criticism that there is no evidence in favor of my theory, would require a long answer. In replying to zoologists who have written to me and in explaining my theory more fully to zoologists whom I have met, the series of diagrams shown in Fig. 2 has been useful. The diagrams and explanations are given, not as a reply to Professor Lyon, but as a general answer to those who have asked about the progressive reduction of the gametophyte. While the series does not prove that the egg with its polar bodies constitutes a reduced generation comparable with the gametophytic generation in plants, it does indicate how a condition quite strictly comparable with the animal egg and polar bodies has been reached by the gametophytic generation in plants.

In Fig. 2 the smaller diagram at the right in each case represents the egg and the three polar bodies.

In an homosporous fern (Fig. 2, *A*) each of the four spores derived from the mother-cell may form an independent plant. Four gamete-bearing plants are shown. Professor Lyon's confusion probably arose from his failure to recognize that the gametophytic generation could include anything more than just one of these four plants. According to Strasburger's theory, which is more generally accepted than any other, the gametophytic generation includes not only all four plants with their eggs and sperms, but also all preceding stages back to the mother-cell.

The water ferns (Fig. 2, *B*) are heterosporous and only one of the four megaspores produces a mature plant, the other three becoming abortive. The plant is largely confined within the spore. The protruding portion may develop more or less chlorophyll and, consequently, is not completely dependent.

sporal and the resulting plant is entirely parasitic. Further, the spore, with its contained plant, is never shed from the enclosing structures. At the beginning of germination there

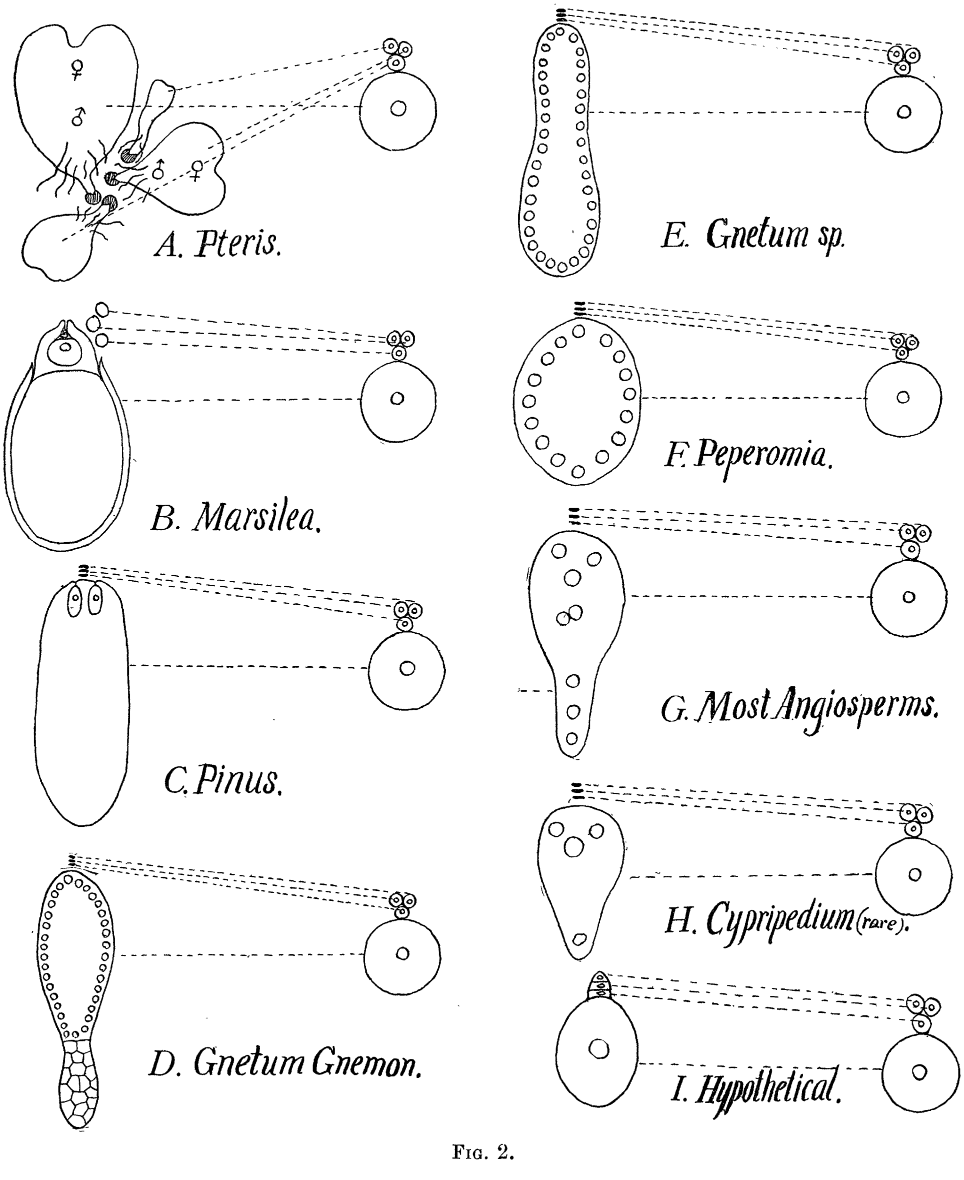

Fig. 2.

The gymnosperms (Fig. 2, *C*) are heterosporous and, as a rule, only one of the megaspores germinates, the other three becoming abortive.[2] The germination is entirely intra-

is a prolonged period of free nuclear division, but later, cell walls are formed and at the stage shown in the diagram the plant consists of a solid cellular tissue.

[2] The three abortive megaspores are represented in C — H of the diagram by three heavy lines, although they disappear completely before the stage shown in the diagrams has been reached.

In *Gnetum Gnemon,* a gymnosperm (Fig. 2, *D*), cellular tissue is formed only at one end of the female gametophyte, the end nearest the micropyle remaining in the free nuclear condition. Any one of these free nuclei may become an egg nucleus.

In other species of *Gnetum* (Fig. 2, *E*) no part of the female gametophyte gets beyond the free nuclear condition. The number of nuclei is likely to be smaller than in *Gnetum Gnemon.*

Peperomia, an angiosperm (Fig. 2, *F*), shows a still more reduced condition, the mature female gametophyte containing only sixteen free nuclei. A somewhat similar condition is found in *Gunnera,* where the number of free nuclei varies from sixteen down to eight.

Most angiosperms (Fig. 2, *G*) have eight nuclei in the female gametophyte, one of these nuclei functioning as an egg nucleus. This is the most reduced condition yet described for an angiosperm. We have found, quite recently, in *Cypripedium,* a mature female gametophyte containing only four nuclei. The antipodal polar nucleus had not divided and was disintegrating. One mitosis in the micropylar end had also failed to take place. One might reasonably hope to find still greater reduction in the tropical orchids, so that while the stage shown in Fig. 2, *I,* is still hypothetical, it is not at all impossible that it may exist. The megaspore would then function directly as an egg and the four spores would correspond strictly with the egg and the three polar bodies.

The series, as a whole, shows a gradual reduction of the gametophyte from an independent plant to a parasite; then a reduction from a cellular condition to the free nuclear condition; and finally a reduction in the number of free nuclei, until (admitting the hypothetical case shown in Fig. 2, *I*) the condition shown by the animal egg with its three polar bodies is reached. The behavior of the chromosomes during the formation of the four megaspores is essentially identical with their behavior during the formation of the egg and its polar bodies.

It was only by the investigation of forms below the angiosperms that the true nature of the female gametophyte of angiosperms became known. Perhaps a more thorough examination of animals below the Metazoa may aid in interpreting the egg and its polar bodies.

Since there would be much repetition in a discussion of the male gametophyte, this subject is omitted.

I regret that Professor Beard's work was overlooked. In this one particular Professor Lyon's criticism must be accepted. The fact, however, that Professor Beard relies strongly upon apogamy to support his theory will indicate to botanists a view-point somewhat different from mine.

It is gratifying to note that Dr. Lotsy's[3] recent paper on the x and $2x$ generations is directly in line with my theory.

CHARLES J. CHAMBERLAIN.

PRELIMINARY NOTE ON A GIGANTIC MAMMAL FROM THE LOUP FORK BEDS OF NEBRASKA.

DURING the summer of 1904 the writer was fortunate in locating an important fossil quarry in the upper series of the Loup Fork formation on the Niobrara River, four miles east of Agate P. O., Sioux County, Nebr., upon the property of Mr. James H. Cook, the Agate Springs Stock Farm. The existence of fossil bones in this locality was known to Mr. Cook as long ago as the year 1890, but he regarded the fragments of bones, when he first found them, as merely proving that the spot had been occupied by the Indians as a burying ground, they having frequented the locality in early days and frequently camped there. In August, 1904, I was guided to the spot by Mr. Cook's son, Harold J. Cook, and made some preliminary investigation. The work has been continued throughout the spring and summer of the current year under my direction. An interesting feature of the deposit is the great number of water-worn fragments of bone found in the quarry, clearly indicating that the remains were subjected to the action of a

[3] Lotsy, J. P., 'Die x-Generation und die $2x$-Generation, eine Arbeitshypothese,' *Biol. Centralblatt,* **25**: 97–117, four text diagrams, 1905.