Magnitude, Strain Release, and Earthquake Mechanics

Hugo Benioff has applied the magnitude scale to a systematic investigation of the succession of aftershocks which follow almost every important earthquake. A great earthquake represents a readjustment of local strains, involving release of potential energy over distances of the order of a hundred miles or even more. The principal fracturing runs its course in a minute or two, but it is an obvious impossibility for large blocks of the earth's crust to readjust completely in so short a time. The readjustment continues over a period of hours, days, or months, by a process closely allied to what is known in testing laboratories as elastic afterworking. The process is not continuous, because of the frictional resistance to displacement along the original line of fracture; local strains due to afterworking must rise to a certain threshold level before the original displacements can continue. The magnitude scale makes it possible to estimate the strain released in each minor event and to plot the strain release against time. In this way curves are obtained analogous to those observed in laboratory specimens. It is possible to estimate the maximum magnitude of an expectable aftershock during the process of any given sequence, and to decide whether a large following shock is a true aftershock or represents the beginning of a new event.

Markus Båth has found that in many aftershock sequences the largest aftershock has a magnitude about 1.2 units lower than that of the principal shock. Deviations from this occur in identifiably abnormal sequences, usually characteristic of particular regions. Such sequences include earthquake "swarms" such as are common in the region of Imperial Valley, California—sequences of earthquakes, small and large, with no one outstanding principal shock. Such swarms appear to be commonest in areas of structural complexity, where the crust is broken up into blocks of comparatively small size. Earthquake swarms are common in volcanic regions, especially in association with eruptions; here the fundamental mechanism is of another sort, attributable to subterranean movements of molten rock.

It was noted that small shocks contribute relatively little to energy release. In terms of strain release, the relationship is less definite; thus, the strain released in a series of aftershocks may be comparable to that occasioned by the main shock. This is due to the fact that strain release increases with the square root of the energy. Benioff has pointed out that, on this basis, small earthquakes may operate to delay or inhibit the accumulation of a major strain and so act to postpone a large earthquake. However, once a large strain has actually accumulated, the "square" factor comes into play; a major strain can be released only in a major earthquake, or in a great number of small shocks that greatly exceed in frequency those normally observed in a given seismic region. The idea, born chiefly of wishful thinking, that small earthquakes may act as a "safety valve" is thus justifiable only in a restricted way and should not be allowed to affect deliberations in connection with precautionary measures and regulations.

Notes and Bibliography

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On "The New Cell Theory"

Two Soviet authors critically review recent Soviet work on the origin of the cell.

L. N. Zhinkin and V. P. Mikhaĭlov

The discovery of the cell and the formulation of the cell theory were considered by F. Engels to constitute one of the most important stages in the development of natural science. Since the time of the creation of the cell theory, more than a century has passed. During that period the cell theory, constituting one of the fundamental elements in contemporary biology, has had its meaning intensified and enriched by a mass of new facts.

Quite recently the cell doctrine has been subjected to radical revision by O. B. Lepeshinskaya, who, on the basis of her own experimental findings, has built up a "new dialectic-materialist cell theory," in which it is asserted that every cell develops from living substance.

The views of O. B. Lepeshinskaya received complete approval at the conference on the problem of living substance and cell development of the Division of Biological Sciences of the Academy of Sciences of the U.S.S.R., held 22–24 May 1950. The conference carried a resolution in which it was affirmed that "the works of O. B. Lepeshinskaya and her co-workers opened a wide avenue for the investigation of acellular forms of life and the most delicate processes of cell development within and outside the organism. . . . The conceptions developed by O. B. Lepeshinskaya must be widely publicized and must be used to the utmost advantage in the practice of medicine and agriculture" (*1*). By a decision of the Presidium of the Academy of Medical Sciences of the U.S.S.R. of 14

May 1950, revision of the timetables of higher educational establishments and of the contents of textbooks in the light of the "new cell theory" was foreshadowed. The findings of O. B. Lepeshinskaya, as if proved absolutely, were explained in a number of books and brochures. They were inserted in higher education textbooks on biology, histology, and cytology, and in the school textbook, *Essentials of Darwinism*. Special works were devoted to explanation of the philosophical significance of the "new cell theory."

It should be mentioned that from 1950 the development of the "new cell theory" was proceeding in the unhealthy atmosphere of excessive general adulation. The theory as a whole was not assessed critically. There was no expert discussion of questions of cytology. More than this, all who earlier had come forward with criticism of the views of O. B. Lepeshinskaya were reckoned among the reactionaries in science, among the metaphysicists, idealists, and so on. And so it was forgotten that no science can develop without conflict of opinion, and that critical appraisal of the views advanced by O. B. Lepeshinskaya was the more necessary in that her findings contradicted a great many well-established facts which were almost completely ignored by her and her commentators.

Recently a number of works have been published describing the results of control examinations of the experimental material of O. B. Lepeshinskaya and her co-workers. An analysis of these works is very essential to an assessment of the theory as a whole. It is exactly such an analysis that we shall try to make in this article.

Chick Embryos

In her study of the development of the chick embryo, O. B. Lepeshinskaya described the development of entodermal cells and blood islands from the yolk spheres (*2, 3*). The formation of crystal-like structures which, through a number of stages, became reorganized into "true living cells," was described by O. B. Lepeshinskaya in cultures of the white of hen egg (*4*). Recently certain facts have emerged which compel the belief that these descriptions of the formation of cells from the yolk and white of hen egg are erroneous. V. N. Orekhovitch, M. I. Leviant, and T. P. Levchuk-Kurokhtina have published the results of their work with the inclusion of labeled amino acids in the proteins of the albuminous envelope and yolk of the incubated hen egg (*5*). They demonstrated quite convincingly that in the process of incubation of the fertilized hen egg and of embryo development, no new regeneration of the proteins of the albuminous envelope and yolk occurs. The labeled amino acids were, however, observed in the albuminous envelope and yolk of the egg, when they were introduced into the body of the hen while still carrying the egg, that is, at the time when it was being formed in the egg tube. On the basis of their findings that, during the period of incubation, dynamic exchange between the proteins of the albuminous envelope, the embryonic disc, and the yolk is absent, the authors drew the conclusion that "the hypothesis on the possibility of the development of cell elements from the white and yolk of hen egg would appear to be improbable" (*5*, p. 612). A direct reexamination of O. B. Lepeshinskaya's data on the development of cells from the yolk spheres has been carried out by A. G. Knorre by various cytological and histochemical methods and by ultraviolet microscopy. According to his findings, "the yellow and white yolk spheres of the hen egg are not moner-like living structures, and are not transformed into cells" (*6*).

A reexamination of these experiments of O. B. Lepeshinskaya was carried out over a period of two years at the Biological Institute of the Academy of Sciences in Czechoslovakia. The Czechoslovak scientists "carefully reproduced the conditions of the experiment as described by O. B. Lepeshinskaya, but were only able to follow differentiation in the yolk to the stage of yolk spheres, while in no single instance was the formation of cells from the spheres observed" (*7*).

Blood Plasma

M. G. Kritsman, A. S. Konikova, and Ts. D. Osipenko, employing the method of labeled amino acid incorporation, observed vital regeneration of the proteins in blood plasma freed from cells (*8*). These data were used by adherents of the "new cell theory" as confirmation that the blood plasma is one of the variants of the acellular living substance.

On the strength of these data, M. D. Skobel'skii, working in the laboratory of O. B. Lepeshinskaya, investigated the progress of visible structural changes in the cell-free plasma of the hen. He described peculiar structures ("plasmospheres") which were formed in the plasma during incubation (*9*). The "plasmospheres," in the view of M. D. Skobel'skii, should be regarded as "representatives of the living world." O. B. Lepeshinskaya considered that the "plasmospheres" represented cells being formed from the living substance of the plasma (*10*, p. 15).

A reexamination of the findings of M. G. Kritsman, A. S. Konikova, and Ts. D. Osipenko was carried out by V. N. Orekhovitch, T. P. Kurokhtina, and N. D. Buianova with labeled amino acids; this demonstrated that, under sterile conditions, vital regeneration of the proteins of incubated plasma did not occur (*11*). In other words, in the plasma there is no metabolic exchange, and to regard it as the representative of living substance is impossible.

A check of M. D. Skobel'skii's data was made by G. N. Voronin and V. P. Mikhaĭlov (*12*). They confirmed that "plasmospheres" are formed in hen blood plasma during incubation. But, according to their findings (the work was carried out in consultation with the crystallography specialist, S. M. Ansheles), the "plasmospheres" were radially arranged aggregates of acicular crystals (spheroliths), the process of formation and growth of which proceeds in exactly the same way as has been established for all crystals. "There is little serious evidence on which it is possible to approximate 'plasmospheres' to 'representatives of the living world,' and none to justify regarding them as 'cell-like structures,' still less as cells" (*12*, p. 631).

Hydras

O. B. Lepeshinskaya's experiments with mutilated hydras played a very important part in the creation of the "new cell theory." A repetition of these experiments was carried out by V. E. Kozlov and P. V. Makarov (*13*). In the course of the investigation on mutilated, living hydras, the appearances which were regarded by O. B. Lepeshinskaya as constituting the new formation of cells and their subsequent conversion into cell conglomerates (moruloid stage) were reproduced. Essentially the same result, however, was obtained by these investigators with ground, fixed hydras. Consequently there are no grounds for speak-

The authors are on the staff of the Moscow Oblast Scientific Research Institute of Obstetrics and Gynecology. This article was first published in *Arkhiv Anatomii, Gistologii i Embriologii* [32, No. 2, 66 (1955)]. It was translated by the Pergamon Institute for the Russian Scientific Translation Program of the National Institutes of Health, U.S. Public Health Service.

ing of the isolation from hydras of living substance and its subsequent transformation. In no single one of the experiments was anything resembling cells observed, and the authors speak rather of progressive changes in the spherical structures, their shriveling, vacuolization, and so forth (*13,* pp. 58, 59). The authors conclude that the plastic processes observed by O. B. Lepeshinskaya and by them in the substance separated from the hydras were in the category not of biological but of physicochemical processes. A repetition of the Lepeshinskaya experiments on the formation of cells from mutilated "living substance" of the hydra was also made in Czechoslovakia in the laboratory of F. Grechik, and gave negative results (*7,* p. 1433).

Sturgeon Eggs

According to O. B. Lepeshinskaya, the eggs of the sturgeon during the period of their maturation lose the nucleus, which later is again formed afresh from the cytoplasmic granules. The ova without nuclei pass through a stage of acellular structure; the process of formation of the female pronucleus, as represented by the author, reflects stages in the phylogenetic development of the cell from the acellular living substance. These observations of O. B. Lepeshinskaya were carefully reexamined by B. N. Kazanskii (*14*) and by T. I. Faleeva (*15*). The latter showed that, in the egg cells of the stellated sturgeon and the sturgeon, the nucleus, in one of its own several stages, is present at all periods of their development. Every roe was examined by her in a series of more than 200 sections, 7 mμ in thickness, and only in one or two of them was the nucleus observed to be of small size.

B. N. Kazanskii, who made a detailed examination of the processes of egg cell maturation, ovulation, and fertilization in sturgeon, showed that the nuclei in the ovocytes maintain their line throughout the period of maturation.

The investigations of B. N. Kazanskii and of T. I. Faleeva have revealed an error on the part of O. B. Lepeshinskaya (*16, 17*).

Connective Tissue Cells

The new formation of connective tissue cells from acellular living substance (with a fine granularity, formed as a result of the breakdown of rich cells which have phagocytized "blood granular substance") was described by O. B. Lepeshinskaya in relation to the healing of skin wounds in mice (*3*). Developing her hypothesis, L. V. Polezhaev tried to prove that the cells of the regenerated blastema arose without mitotic or amitotic multiplication, as a result of accumulation from undifferentiated tissues and by neoformation from acellular living substance in the region of the wound (*18*). It must be emphasized that the descriptions by O. B. Lepeshinskaya are by no means convincing. She saw, in fixed, stained preparations, in a microscope field, granules of various sizes, some sort of degenerating cells, and cells of lymphocyte type. Such pictures [for example, Fig. 24, Table 29, of her monograph (*3*)] will convince no one that here a process of cell formation is actually taking place. With considerable justification they could be regarded as various stages in a process of cell breakdown. O. B. Lepeshinskaya understands this excellently herself. It is for this reason that she cautiously writes that the conclusion as to the development of connective tissue cells in the wound from acellular living substance has been formed by her as a hypothesis, based on indirect considerations (findings on the formation of cells from cytoplasmic spherules separated from disrupted cells of the hydra; a sharp increase in the number of cells in an inflammatory focus unaccompanied by any significant number of mitotic figures).

"Such a hypothesis," she writes, "must be put forward in view of certain facts known to us, and we must try by all the most modern investigational means to confirm it" (*3,* p. 169). Ultimately, without carrying out the supplementary experiments which she had mentioned, O. B. Lepeshinskaya altered this cautious formulation to a categorical statement (*19,* p. 133).

The findings of L. V. Polezhaev were reexamined by V. P. Mikhaĭlov (*20*), who showed that in the regeneration blastema which formed after removal of the tail of a tadpole (L. V. Polezhaev had worked with tadpoles) there were numerous mitoses at all stages of the regeneration. In the fibrin covering the stump, degenerating elements and granules of varying size could be seen together with cells of normal appearance. All these elements can, at will, be arranged in an unbroken series. To reach the conclusion, however, on the basis of the appearances observed (in exactly the same way as in the case of the appearances described by O. B. Lepeshinskaya during regeneration of the skin in mice), that in such a case the development of cells from living substance of acellular structure is going on, is hardly possible. From an analysis of the data of O. B. Lepeshinskaya and L. V. Polezhaev, it is right to reach the conclusion that "as yet there are no convincing proofs of the neoformation of cells, during regeneration, from acellular living substance" (*20,* p. 55).

N. N. Anichkov, Iu. M. Zhabotinskii, and T. A. Sinitsina made a special study of the process of origin of cells and fibers in rabbits in the course of aseptic inflammation (*21*). The work was carried out, just as was that of O. B. Lepeshinskaya, on the regeneration of the skin, with fixed material. The authors "failed to obtain any clear proofs or evidence in favor of the origin of any types of cell elements from any extracellular formations" (*21,* p. 42). They emphasized that the ordinary current methods of cytological examination of fixed preparations were unsuitable for the solution of this problem.

Conclusion

Thus, the basic material underlying the "new cell theory" does not stand reexamination. The "new cell theory" is not founded on solid, firmly established facts and, consequently, does not reflect any laws actually existing in nature. The hypotheses advanced by O. B. Lepeshinskaya can only claim to depict the personal, subjective views of her and her supporters.

We have been obliged to come to this conclusion despite the fact that in 1950 a number of authoritative scientists acknowledged the factual material on which the "new cell theory" was based as authentic.

From lack of space we cannot dwell on the numerous works published since 1950, the authors of which were endeavoring, with different types of experimental material, to demonstrate the development of cells from acellular living substance. This has been done by us to a certain extent in another paper. Some of these works have been executed at an unusually low technical level. The authors, starting with a preconception, arbitrarily treat the various visible stages in the process of cell breakdown in fixed and stained preparations as stages in their new formation. In most works the conclusion on the development of the particular type of cell from acellular living substance is drawn with reservations, and in conjectural form ("appar-

The following excerpt from the Soviet Monitor *of 4 June 1950 is pertinent as background information. The English translation is reprinted, with permission,* from Occasional Pamphlet No. 10 *of the Society for Freedom in Science, dated November 1950. For the work described here, Professor Lepeshinskaya received a Stalin prize, first class.*

New Research Work on the Origin of the Cell

Olga Lepeshinskaya, professor of biology, is conducting interesting research on how the cell originated from living matter and on the part played by such matter in the organism. This research work of the Soviet scientist marks a new stage in providing a materialist theory of the cell and opens up broad prospects for establishing the principal laws of the organic world.

Lepeshinskaya has succeeded in proving that the formation of new cells in the living organism occurs not only through multiplication of cells themselves but also through their development directly from so-called noncellular matter, which is always present in the organism.

A few days ago Professor Lepeshinskaya reported on her work at a conference at the U.S.S.R. Academy of Sciences. She proved the possibility of the development of biological organisms and cells from the nonstructural albumen of eggs of various birds. This research proved that egg albumen is not merely a lifeless nourishing medium, but living matter capable of developing and forming cells.

The work carried out by Professor Lepeshinskaya and her colleagues has introduced many new elements into the study of the properties of living matter and has evoked the lively interest, and earned the acclamation, of prominent Soviet scientists who have noted the great significance of these researches for biology and medicine.

Thus Academician Trofim Lysenko said that the data obtained by Professor Lepeshinskaya in studying the origin and development of the cells of living matter constituted a major contribution to the development of the theory of Soviet Michurin biology. They help to gain a correct understanding of the phenomena of new formations in the organic world, to comprehend and to explain the emergence of new kinds of organisms within the old species.

Professor Lepeshinskaya's work was also highly assessed by Academicians Alexander Oparin, Evgeni Pavlovsky, Alexei Speransky, Nikolai Anichkov, and others. The conference recommended Soviet biologists, agrobiologists, and medical workers to start wide-scale research in the field of the development of living matter and its noncellular form and to utilize in medicine and agriculture the results achieved by Professor Olga Lepeshinskaya and her colleagues.

ently," "produces the impression," "it can possibly be assumed," and so forth).

Undoubtedly life arose in the earth in some simple form and cells were formed as a result of a long process of evolution. The problem of the evolutionary development of the cell is by no means a new one. It has already been broadly stated by the well-known protagonist of Darwinism, Ernst Haeckel. Its great importance was excellently understood by the leading Russian scientists in the '70's of the last century. A. E. Golubev, a professor at Kazan University and at the Petersburg Medicosurgical Academy, starting from the evolutionary hypotheses developed by Haeckel and his own experimental findings, had stated already in 1874 that "the study of the properties of protoplasm at its various levels of development is a matter of prime importance. Unfortunately, our knowledge in this respect is extremely scanty" (*22*, p. 8).

It is certain that, once formed, cells have traveled a long path of evolutionary development (this can be seen even in a comparison of the cells of algae and those of the higher plants). Moreover, as a result of this evolution, structures of a higher order (various symplasts, complex systems of cells and acellular material combined with them) are formed in the body of multicellular organisms. Obviously, in the complex, complete organism with its nervous integration the cells are not independent elements, as Virchow and Fervon represented them to be. From all this, however, it does not follow that the process, accomplished formerly, of the development of cells from the primitive living substance is still being effected among the representatives of the animals and plants, and that every cell, in the course of its own development, must pass through the infinitely remote acellular living substance stage. This, however, is what O. B. Lepeshinskaya has postulated, not on grounds of firmly established facts, but on speculative hypotheses, linked with a quite primitive understanding of biogenetic law.

A. A. Zavarzin, D. N. Nasonov, and N. G. Khlopin, who published a criticism of the views of O. B. Lepeshinskaya in 1939, drew attention to this point (*17*). Despite the fact that these authors had not at their disposal any factual material by which to check O. B. Lepeshinskaya's findings, their criticisms and general appraisal of the "new cell theory" were, in our opinion, fundamentally justified.

F. Engels, speaking of natural philosophy, pointed out that it "substituted links fashioned of ideas and fantasy for the true, but still unknown, connections between phenomena, and replaced inadequate facts by inventions, filling the actual gaps only in imagination" (*23*). The "new cell theory" is a classic example of natural philosophy teaching (*24*).

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Chromosome Studies of Primates

The application of new culture and cytological techniques should help solve some puzzles of evolution.

Michael A. Bender and Lawrence E. Mettler

Although the evolution of the primates is a subject which has long interested biologists, it is only relatively recently that any attempt has been made to determine their relationships through a study of their chromosomes. The main reason for this situation is the notorious difficulty of studying mammalian material, which is amply illustrated by the long dispute over the chromosome number of man. It is difficult to make accurate counts by means of the standard techniques of sectioning or by making smears of tissue removed at necropsy, while to obtain detailed karyotypes from such material is virtually impossible.

The recent development of new techniques for the culture of diploid somatic cells in monolayers on glass surfaces, as well as the development of new cytological techniques, has made it possible to determine not only the chromosome numbers but also the chromosome morphology of a great variety of animals which have not been previously studied. Making use of such techniques, Hsu (*1*) and Tjio and Levan (*2*) have published detailed karyotypes of man, while Chu and Giles (*3*) have recently published chromosome counts for five genera of catarrhine or Old World monkeys. Only one count for a platyrrhine or New World monkey is available (*4*), and so far as we know there have been no counts reported for any prosimian primate.

Karyotype analyses of other groups of animals and of plants, such as those of Patterson and Stone (*5*) on the genus *Drosophila* and those of Babcock (*6*) on the genus *Crepis,* have been extremely successful in elucidating the evolution of these groups. Within the order Primates there exist many cases in which the classical anatomical approach has been unable to clarify relationships. An example is the quandary in which taxonomists find themselves when attempting to classify the genus *Callimico.* Various authors have assigned this genus to the family Cebidae or to the family Hapalidae, or have erected a new family, Calimiconidae, to contain it. With the hope that a cytological survey might clear up such puzzles, we have undertaken to investigate the order Primates, paying special attention at present to the infraorder Platyrrhina. The work discussed here (*7*) includes study of one prosimian, three genera of Catarrhina, and four of Platyrrhina.

Materials and Methods

Primate material has been obtained from several sources. Recently dead animals have been obtained from the Bal-

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