This period and its solution of one phase of the problem of the structure of the universe is but an episode in the gradual revealing of the throbbing life of the universe. Sir William Herschel was the pioneer in recalling man's interest to the larger problem of determining the structure of our galactic system. "He pierced the barrier of the skies" and reawakened man's slumbering curiosity about the stars, a curiosity which was further stimulated by the revelations which the vibrant ether brings us in the form of light. Newton commenced the research which revealed the composite nature of white light and the possibility by its analysis of learning something of its nature. He was only prevented from going further by the imperfection in the art of glass making. Fraunhofer immensely improved said art and his curiosity, stimulated by the discovery of nature's marvelous hieroglyphics, which in deference to his great genius we have named the Fraunhofer lines, made vast strides in their interpretation. Together with this, the further leap made by Kirchhoff opened up vast new vistas, not only into our galactic system, but into the marvellous beauty and order revealed in the vibrant atom, that infinitesimal little galaxy of electrons and perhaps of even still smaller units. The discovery of the principles of spectrum analysis and the new conceptions which it has opened before our vision make clear other relationships than merely dynamical which are undermining the vicious hold and influence which the conception of the universe as a vast machine or an assemblage of intricate mechanisms has had upon the human race. It has been one of the profoundest facts revealing to us the unity of the universe and at the same time enormously extending our conception of it.

That some at least of the nebulae were distant galactic systems was conjectured by Herschel, and later, when the spectroscope made possible a scientific classification of these objects, many keen-visioned souls conjectured yet more confidently that the spiral nebula are distinct galactic systems.

The discovery of novae in the spirals and the ability to recognize them as a distinct class of celestial bodies further confirmed this conjecture and raised it to the rank of a hypothesis. The telescopic and spectroscopic revelations of systems of stars among the vast assemblage of our galactic host, has made possible a more complete solution of the problem of its structure, possibilities greatly increased by the discovery of those marvellous pulsating suns known as cepheid variables. Study of these variables in globular systems of stars, together with spectroscopic evidence as to intrinsic brilliance of stars, made possible to Shapley, a decade ago, the means of determining the distance of these globular clusters whose inner structure may be divined through observations combined with deduction from dynamical principles. By the aid of great telescopes and spectroscopes, made possible by the tremendous advances in engineering and optical skill, Hubble and others have partially resolved the nearer spirals into stars. Among these stars are cepheid variables and just as they have been the plummet which has enabled us to sound the depths of our own galactic system, so now they confirm still more certainly the conception that the spiral nebulae are distant galactic systems. A million of these are now within our ken by using to the full our present means of exploring them.

What wonders and marvels await the seeing eye and the understanding mind no man can tell, but certain it is that when the history of our own epoch is written in some far distant day, it will be justly regarded the most interesting time before 1925 in which to live, the one in which the finest opportunities are open to the intellectually curious who also develop to the full the mental capacity with which they are endowed.

Initiates, your election to this society is in itself evidence that you have this intellectual curiosity and have at least partially developed the mental capacities with which you are endowed. See to it that you let not this torch slip from you—develop your research capacity to the full and carry on the torch of science to light the new world which is to be. So live, in the light of what biological science is revealing, as to have strong and healthy bodies, the abodes of spirits sensitive to receive impulses over the widest possible range of notes from the vibrant, throbbing life of the universe.

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DROSOPHILA AND THE MUTATION HYPOTHESIS

FOR two decades the hypothesis of mutation or the saltatory origin of species has enjoyed a large vogue in American biological laboratories. In its present form, it was first formulated on the botanical side as the result of the investigations of the Dutch physiologist, De Vries, on Lamarck's evening primrose, *Oenothera lamarckiana.* In this species De Vries, as is well known, observed the appearance of a relatively small number of forms from seed, which differed in marked degree from the parent species. This author gave names to these variants and considered them to be elementary or inchoative species. Subsequently it was observed that many of the species of the genus Oenothera were capable of acting in the same manner as *O. lamarckiana,* in cultures and in a few cases the number of aberrant individuals differ-

ing from the parent form reached enormous proportions. It is now very generally conceded, even by geneticists and physiologists, that the species of the genus Oenothera often present strong evidence of hybrid origin, and the mutability frequently found in their offspring receives its obvious explanation as the result of previous crossing.

In 1906, shortly after De Vries introduced his hypothesis of mutation to the United States, in a course of lectures delivered in the University of California, Castle called attention to the extraordinary variability of the offspring of the fruit of pomace fly, *Drosophila melanogaster*. Later, Morgan, who had previously given much attention to the development of the cells of sex, particularly in insects, put forward a theory of mutation parallel to that of De Vries, based on the conduct of the minute dipterous fly, Drosophila, in cultures. A very large number of so-called mutants were isolated from the wild *D. melanogaster*, and these have presented a fertile field for the study of Mendelian ratios, when crossed with one another. So convenient have the so-called elementary species or mutants of Drosophila proved in this respect that they are now almost universally kept under culture in our biological laboratories in connection with the illustration of general principles of heredity. The ease and rapidity with which the pomace fly can be bred has doubtless largely led to this situation.

A notable feature of the genetical study of the pomace fly is the establishment of the so-called chromosome theory of heredity. In this connection, extensive studies of the chromosomes in Drosophila have been made by the geneticists of the Morgan school. It may be truly stated, in fact, that American genetics is mainly based on the experimental study of the fruit fly and this appears to be equally true of the subject both on the botanical and zoological sides, for it is in universal use in biological laboratories for genetical purposes.

The general impression doubtless is that the genus under discussion has been very thoroughly studied both in its genetical and cytological aspects and that a close correlation has been established between these two lines of activity. When the present writer had occasion to look into the cytological literature, however, he discovered to his surprise that no account or rather no adequate account had been given of the all-important reduction, meiotic or maturation divisions, in *Drosophila melanogaster*. The only author who has really dealt with the matter at all is Stevens.[1]

[1] N. M. Stevens, "A study of the germ cells of certain diptera, with reference to the heterochromosomes and the phenomena of synapsis," *Journal Exp. Zool.*, Vol. 5, 1907–1908.

This author refers to the technical difficulties connected with the study of Drosophila and after having examined some two thousand individuals in the course of a year expressed the opinion that the subject was not yet cleared up. The procedure mainly employed by Miss Stevens was teasing out in Schneider's aceto-carmine, a method which Metz later characterized as producing both distortion and displacement of the chromosomes. Certainly Miss Stevens's figures of the reduction or meiotic division of *D. melanogaster* must rank as the most bizarre which have ever been published of meiosis in the spermatocytes of insects. Later, Metz[2] attacked the same subject and after criticizing the unsatisfactory results reached with the aceto-carmine smear method, as indicated above, states that the maturation (meiotic, reduction) divisions in Drosophila are difficult to study. He gives no figure of meiosis in the species *D. melanogaster*. Thus we have no adequate information as to the critical meiotic mitoses in a genus upon which, in recent years, a whole theory of evolution has been established. This is truly a remarkable state of affairs and one as will be shown in the sequel of the deepest significance.

The difficulties connected with the cytological investigation of the all-important meiotic or maturation divisions in the genital glands of Drosophila depend mainly on the small size and extremely tortuous configuration of the organs. This condition makes it almost impossible to secure longitudinal sections of any considerable length. The proper fixation of the material is a less serious matter, as the use of highly penetrating preservatives such as Carnoy's absolute alcohol, chloroform and acetic acid, in conjunction with a quickly acting and powerful air pump, largely obviates indifferent preservation. The small size and contorted form of the testicles has been overcome by the development of quantity methods for sectioning. Forty to fifty pupae are attached to blotting paper by means of glycerine albumin fixative and the whole lot sectioned at once by the nitrocellulose method, which has the advantage of obviating the shrinkage resulting from the use of paraffine.

During several years past much attention has been given in my laboratories to the study of the cytology of hybrids, the importance of which was first clearly emphasized by Rosenberg in his epochal investigations on a hybrid Sundew (*D. ovata, D. anglica* of authors). It has since become increasingly obvious on the botanical side both that large numbers of species of plants are of hybrid origin and that these hybrid species, as well as known hybrids, give rise

[2] Charles W. Metz, "Chromosome studies on the diptera," II., *Journal Exp. Zool.*, Vol. XXI, 1916.

to phenomena in cultures, exactly similar to those found in Oenothera and Drosophila.

An investigation of the meiotic divisions in the reproductive organs of *Drosophila melanogaster* by the quantitative methods indicated above has resulted in the securing of large numbers of mitoses. These are throughout thoroughly abnormal and of the hybrid type. The normal simultaneous movement of the chromosomes (metaphase) to the equator of the cell, to constitute the so-called equatorial plate, is conspicuous by its absence in this species. Abnormalities in the anaphase are equally obvious, as there is the same lagging of the chromosomes in their progress towards the poles as manifests itself in the earlier equatorial migration. I have examined hundreds of divisions of the spermatocytes of *D. melanogaster,* without observing a single normal mitosis in the so-called heterotypic (meiotic, reduction, maturation) division. The all-important reduction divisions of *D. melanogaster* are undoubtedly aberrant and present the identical peculiarities of those observed in known hybrids. The cytological investigation of *Drosophila melanogaster* seems accordingly to establish beyond any reasonable doubt that the species is of hybrid origin and that accordingly very large and indeed fundamental reservations must be made, in any general conclusions, regarding the origin of species, and the laws of heredity, which can be drawn from the experimental study of this species.

These erroneous results, which have apparently been reached as a consequence of too superficial study in the case of *Drosophila melanogaster,* present an excellent example of the dangers of what may be called the *in vitro* or purely experimental study in the biological sciences. A number of biologists are apparently of the opinion that studies carried on in glassware, greenhouses or laboratories have a fundamental value and transcend in importance other kinds of biological investigation. It is necessary, however, to correlate the results seen at best, but darkly, in the glass experimental houses with those obtained by the study of living matter in the open, in other words, in nature. This was essentially the method pursued by Charles Darwin, who compared the only experimental evidence in general available in his time, namely, that furnished by cultivated plants and domesticated animals, with the conditions presented by plants and animals in nature. A large part of the perennial value of the "Origin of Species" is the result of this broad and solid method.

The extreme experimentalists, moreover, have apparently forgotten a very old and extremely prudent adage, namely, that those who live in glass houses should not throw stones. Professor Morgan in his "Critique of the Theory of Evolution," which has enjoyed a tremendous vogue in recent years, has damned with faint praise or attempted to controvert many of the fundamental principles of the biological sciences and has attempted to set up in place of them an evolutionary hypothesis based on the study of a single aberrant species of Drosophila. There is an interesting contrast between the Morgan hypothesis and that of Charles Darwin. The latter was able to buttress his views with the conclusions reached by morphologists, paleontologists, embryologists and biogeographers. In spite of the strong support supplied by the general biological situation in Darwin's time his hypothesis met with the bitterest opposition. The Morgan hypothesis of mutation based on the study of *Drosophila melanogaster* by contrast runs counter to practically all the inductive conclusions of the biological sciences. In contrast to the Darwinian hypothesis, moreover, it has been acclaimed at once by almost the entire body of biologists. The history of science appears to warrant no expectation of long life for the mutation hypothesis. It is, moreover, inconceivable that a science which has reached as its supreme achievement the theory of evolution should itself progress by unreasoning revolution and the subversion of the fundamentals of the biological sciences. It is in fact not impossible that before many years have elapsed the doctrine of mutation will appear to the eyes of men as a fantastic Fata Morgana, appropriately staged on the exaggerated skyline of the lower Hudson.

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REPORT OF THE COMMITTEE OF THE NATIONAL ACADEMY OF SCIENCES ON FORESTRY PROBLEMS

THE Special Committee of the National Academy of Sciences on Forestry Problems in the United States appointed at the annual meeting in April, 1924, respectfully reports as follows:

1. There is urgent national need for the clearer definition and active prosecution of a sound forestry policy. (Herewith is submitted Exhibit A—a report on forestry research by a sub-committee under chairmanship of Henry S. Graves.)

2. The formulation and development of this policy must be based upon researches in the fundamentals of science underlying forestry, including plant morphology, physiology, taxonomy, genetics and pathology correlated with biochemistry and biophysics and recognizing certain aspects of economics.

3. Such researches are especially difficult because of the time element involved and therefore are to an