microscopic slide. A solution of any desired concentration of radium bromide of known activity is made in a suitable solvent, and applied to the surface of the slide near the center. When the solvent evaporates a film of the salt is left on the slide. The film is protected by a coating of a specially prepared substance. Living cells may now be mounted as on an ordinary slide, and their response, if any, to the stimulus of the rays observed. The coating has the advantage, not only of being sufficiently transparent to light, but easily transparent to the β and γ rays, and in less degree to the α rays also.

Slides of various styles and modifications have been prepared on the above principle by Mr. Hugo Lieber, of H. Lieber & Co., New York City, and their efficacy is now being tested in the laboratories of the New York Botanical Garden. Thus far only plant cells have been studied in this way, but the device could doubtless be used in studying the cleavage of eggs, and other activities of animal cells.

To Discharge Electrified Paraffin Ribbons.—Every user of the microtome has experienced the annoyance arising from the electrification of the paraffin ribbons. The trouble may be easily avoided by any device that will conduct away the charge of electricity as rapidly as it accumulates. If the air were a perfect conductor, the trouble would not arise, but its conductivity is greatly increased through ionization. This ionization may be conveniently accomplished by supporting, near the place where the microtome-knife cuts the sections, a celluloid rod, covered on one end with Lieber's radium-coating. These rods have been used with great satisfaction by the writer to avoid the difficulty mentioned.

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SPECIAL ARTICLES

ELEMENTARY SPECIES AND HYBRIDS OF BURSA[1]

The rearing of over 20,000 pedigreed specimens of *Bursa Bursa-pastoris* (L.) Britton, has demonstrated the presence of at least four elementary species, all of which breed true when self-fertilized or crossed within the limits of the same elementary form. From over thirty hybrid families the fact is derived that these several elementary forms hybridize in strictly Mendelian fashion, each form which went into the cross coming out again in the perfectly pure extracted dominant or recessive form of the parents.

The existence of elementary forms in nature within the recognized limits of the species, differing from one another as do the elementary species of *Bursa*, in the possession of definite characters that behave as hereditary units, presents a condition that is not unique, but one which has an important bearing upon some of the questions that have been recently discussed. Several atypic plants have appeared in the cultures, which have bred true to their atypic characters, when the assumption that they were due to chance crosses would have required that they split into the atypic and typic forms in the ratio 3:1. These occurred in families of which the pollination was not guarded and their status as mutants is in consequence not considered sufficiently secure to be presented in detail at present as proofs of mutation. The fact that throughout these cultures the differentiating characters behaved as units in the Mendelian sense appears to me indubitable evidence that the several elementary species have arisen through mutation and hybridization.

On the basis of allelomorphic differences between different species these elementary species of *Bursa* represent the closest possible relationship between forms belonging to distinct types, since they are seen in most cases to differ from each other by a single distinguishing unit or by two units at most. The fact that *Bursa Bursa-pastoris* is everywhere recognized as a variable species, and the presence of several distinct forms in each of the localities from which material was derived for these studies, show that these elementary species generally grow in actual contact with each other. There is neither geographical isolation nor complete physiological isolation, yet these nearly related elementary forms

[1] Extract from paper read before the joint meeting of Section F and Section G, A. A. A. S., New York City, December —, 1906.

maintain themselves absolutely distinct. This should convince any one who may still entertain any doubt regarding it that in the presence of Mendelian hybridization, no form of physical isolation is necessary for the maintenance of closely related forms. Moreover, these observations on *Bursa* show that Mendelian behavior is a strictly normal natural process and in no manner dependent upon the artificial conditions supplied by garden practise.

When a new form arises, differing from the parent in one or several unit characters, these new characters may be either dominant or recessive to the corresponding character of the parent. Less rarely they are neither dominant nor recessive. The chances of survival under these several possible conditions seem to need discussion, since, in several recent conversations, I have found the notion to prevail that recessiveness is a handicap, and allusions based upon the same idea have found their way into print. This view is quite erroneous; not only has the dominant form no advantage in the competition which the newly arisen elementary species must encounter, but it can be shown that under certain conditions the reverse is true.

If the dominant and recessive forms are equally adapted to the particular environment in which they live, there is absolutely no advantage in favor of either. The second generation of a Mendelian monohybrid contains the same number of pure recessives as of pure dominants, and the heterozygotes continue to produce in each succeeding generation just as many recessives as extracted dominants. The chances that extracted dominants will self-fertilize or that they will cross with other extracted dominants are exactly the same as the chances that recessives will self-fertilize or cross with other recessives. In like manner extracted dominants and recessives will cross with heterozygotes with equal frequency, and the quantitative results in these two cases will be exactly parallel, in one instance giving fifty per cent. of pure dominants, in the other case fifty per cent. of pure recessives. In this equal fashion the struggle will continue indefinitely so long as the premise holds, that the two forms are equally well suited to the conditions under which they must grow.

The situation is different when natural selection favors one or the other of the competing forms. A single extreme case will suffice to demonstrate: Let us suppose that the new form is dominant over its parent, but so poorly adapted to the particular habitat in which it originated that it can not successfully compete with the parent form. All the hybrid offspring resulting from crosses between the mutant and its parent will have the unadapted new form, and when the selection becomes extreme, not only will all the pure-bred specimens of the new form be destroyed, but all the hybrids as well, and in this way every vestige of the new form will be entirely lost. Assuming, on the other hand, that the mutant is recessive to its parent but that in other respects the conditions are the same as before, the extreme selection that is assumed to destroy all the recessive individuals, leaves the heterozygotes living because they have the successful form possessed by the parent species. These successful heterozygotes give rise to a progeny in the next generation including the recessive form, and also a considerable percentage of heterozygotes that may carry the form on to still another generation, and in this way the recessive mutant may be preserved indefinitely under the protection of the dominant characteristics of its more successful parent. Such prolongation of the life of a recessive may serve to tide it over times of special stress, or may continue its existence until the various distributing agents have carried it beyond the limits of the habitat in which it is a failure into others in which it may become a success.

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NEW PROCESSES OF TAKING IMPRESSIONS OF NATURAL MOLDS OF FOSSILS

ONE of the perplexing problems which confront the invertebrate paleontologist is that of finding some substance with which an accurate and permanent cast or impression of natural molds of fossils can be made. In