the significant things and has explained them in such a way that they are readily understood. And he has brought into logical form and in proper juxtaposition the work of isolated individuals so as to place before the busy worker in biology a comprehensive and readable whole.

Important papers on important biological investigations have a way of accumulating so rapidly that the average worker is confused or badly informed, until such a book as this appears in which a thoroughly competent man has digested them all into an understandable whole.

Thus, the topics just mentioned have been given a just and philosophical treatment, sufficiently condensed to be plain reading and yet sufficiently detailed to be convincing—a difficult task done in a masterly way. The fifty-page chapter on evolution, for example, will be a delight to many workers who have not followed the recent contributions of entomology to different aspects of this engrossing subject.

The plates are done from admirable photographs, and, like the text figures, are admirably chosen.

L. O. HOWARD
DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

Colorado Plant Life. By FRANCIS RAMALEY. Published by the University of Colorado, Boulder, Colorado, 1927.

THIS book of 299 octavo pages and illustrated with 133 figures and three colored plates of Colorado wild flowers has been issued as Volume II of the Semicentennial Publications of the University of Colorado. As the work is dedicated to the citizens of Colorado with presumably only a modicum of botanical knowledge, it is written in a simple style without sacrificing essential scientific accuracy. In this especially well-illustrated and printed book the author, who is professor of biology in the state university, describes in successive chapters plant sociology, life zones and altitude, the botany from a railway train or automobile, color in plants, plants of stream-sides and ditch-banks, mountain-parks, mountain-lakes, the life of a plant, the plains in springtime and autumn, mesas and foothills, plants of the true mountains, grasses and grass-like plants, forests and forest trees, the architecture of plants, flowers, fruits and seeds, and the flora of Colorado in which chapter the characteristics of the principal plant groups are emphasized. Keys are added, so that the trees of Colorado may be identified readily. A list of the early spring flowers of Boulder and vicinity, comprising 102 species, is given with a bibliography of publications dealing with Colorado vegetation. Appendix IV comprises a list of books on botany suitable for high-school and public libraries in Colorado. The author has included in the chapter dealing with the flora of Colorado a short history of the study of Colorado botany, which began with the collection of plants by Edwin James, who was historian and naturalist of Major Long's Expedition (1819–20). He has furnished a sample, which might be followed profitably by other states of the Union.

JOHN W. HARSHBERGER
UNIVERSITY OF PENNSYLVANIA

SPECIAL ARTICLES

MULTIPLE POSITIVELY CHARGED RADIOACTIVE IONS

IN a recent paper[1] the writer discusses the question of the existence of doubly charged positive ions in gases for intervals of time usually involved in gas ion mobility measurements. It is there shown that previous experiments supposed to be conclusive on this point are not so and that there is practically no evidence for the existence of such ions under the conditions above. There remains unexplained a very definite observation by Erikson[2] on the mobility of recoil atoms from active deposits of Ra, Th, and Act which if correct can not be passed over summarily. The results were not checked in recent experiments of Dee[3] in which however the data were too meager to constitute a real contradiction. Erikson observes positive ions of mobility 1.56 for these recoil atoms, which are doubtless the normal singly charged positive ions in air. He also observes in high fields with shorter time intervals simultaneously with the slower ions, ions of mobility of 4.35 cm/sec per volt cm. in each case. These apparently do not show the aging effects usually found for positive ions in other gases. This mobility is nearly three times the mobility of the normal ion. He ascribes it to a doubly charged[2] ion in air. This it can not possibly be, as doubling the charge can not more than double the mobility. Furthermore on the basis of ion theories it is doubtful if the mobility is directly proportional to the charge. It is probable that the mobility of a doubly charged ion would be between twice the mobility of a singly charged ion and the mobility of that ion. A mobility of 4.35 cm/sec might mean a triply charged positive ion. It is more likely that it would correspond to an ion with at least four positive charges. It is the purpose of this article to give reasons for believing that we may

[1] Loeb, L. B., Proc. Nat. Acad., SCI., 13, 703, 1927.

[2] Erikson, H. A., *Phys. Rev.*, 24, 622, 1924, and 26, 629, 1925.

[3] Dee, P. I., Proc. Roy. Soc., A 116, 664, 1927.

be dealing in this case with a multiply charged ion of charge at least three or greater.

Multiply charged positive ions are generated in certain cases of what one might term catastrophic ionization as directly observed by Auger[4] for photoelectric ionization of heavier atoms by high frequency X-rays using the C. T. R. Wilson cloud expansion method. In such an ionization the X-ray removes a high speed photoelectron from the K ring of a heavy atom. The L electron falls into the K ring and gives rise to K X-radiation of the atom in question. The atom in which such an X-ray pulse starts has a high absorption coefficient for its own radiation and this liberates from the atom an electron with the energy of the K radiation less the ionization energy of the emitted electron. An M electron then falls into the L ring and so on. Thus successively 1, 2, 3, 4 etc. electrons are ejected from the same atom. For heavier atoms therefore the primary photoelectron and three other secondary electrons were observed to be liberated. Now when a fast β-ray is shot from the nucleus, Ellis[5] and independently Meitner[6] have shown that similar effects probably occur in the nucleus, giving rise to the β-ray spectra. The softer of the X-rays must lead to the Auger effect. Again the α particle emission is accompanied by X-radiation of a soft sort and there seems no reason for believing that in the expulsion of an α particle internal rearrangements may not take place that lead to multiple ionization of the parent atom. Owing to the large recoil energy of these particles (at least 2×10^8 volts) and the high atomic number the recoil process with only a few collisions with gas molecules would also sometimes result in multiple ionization. Thus it seems reasonable to assume that multiply positively charged products of radioactive change must occur. Investigations which are not exhaustive and are very much complicated by impacts with gas molecules have shown that the recoil atoms are largely uncharged or singly positively charged.[7,8,9,10,11] It seems from the literature that no really careful investigations of the charge present have been made which are free from the effects of collisions with molecules and have sought for multiply charged recoil atoms.

[4] Auger, *Jour. de Physique*, 6, 205, 1925.

[5] Ellis, C. D., Proc. Roy. Soc., A 99, 261, A 101, 1, 1922, A 105, 165, 1924.

[6] Meitner, L., *Zeits. f. Phys.*, 9, 131, 1922, 11, 1, 1922, and 26, 169, 1924.

[7] Makower and Russ, *Phil. Mag.*, 20, 875, 1910.

[8] Wertenstein, L., Comptes. Rendus., 161, 696, 1915.

[9] Wellisch, E. M., *Phil. Mag.*, 28, 417, 1914.

[10] Henderson, G. H., Transact. Roy Soc. Canada, 10, 151, 1917.

[11] Briggs, G. H., *Phil. Mag.*, 41, 357, 1921.

Having now shown that such charges can occur in recoil atoms the question can be raised as to whether they can be detected as ions. The theory of Klein and Rosseland,[12] and the researches of Franck[13,14] and his pupils have led us to expect that an atom or molecule in an active state can in impact with a different inactive molecule or atom transfer its energy to that atom, causing it to be excited or ionized. This can hold as well for ionized molecules and atoms as for excited ones. The difference between the two energies in such impacts may go to other excited states, to the energy of the escaping electron, or to kinetic energies of the separating atoms or ions. The greater such energy differences are, the more involved are the relations and the less chance is there for a transfer of charge. In fact Franck assumes a parallel between probability of the ionization by a radiation and its energy content relative to the ionization energy of the ionized electron and the type of processes where transfer of energy occurs on impact as above. This has been well borne out by the experiments of Harnwell[15] on the transfer of charges from ionized atoms or molecules of higher ionization potentials to those of lower ones.

Therefore we may regard an ionized atom as a metastable state of the atom whose life is the longer the heavier the charge, but whose life is also conditioned by the ionization energies of the surrounding atoms or molecules. Thus as the ionization potential of a radioactive atom is very low for a single ionization, such ions will be stable in air and some other gases and will appear. The doubly charged ions will, however, be unstable in air, as may be the case for the triply charged ones. Those atoms with four charges with their high energies may, however, be relatively stable and should in short time intervals be detectable.

It is thus even to be expected that the chance in a gas like O_2 of some doubly charged ion losing its energy to an O_2 molecule to give a singly charged ion and O^+_2 with energy is comparatively slight. In the case of gas ion measurements at atmospheric pressure the impacts are so numerous, however, that the chance of detecting a doubly charged molecule in a few hundredths of a second is practically 0. With the energy, however, of a quadruply charged positive radioactive recoil atom the chance of loss of charge may become so small that in measurements such as Erikson's it

[12] Klein and Rosseland, *Zeits. f. Phys.*, 4, 46, 1921.

[13] Franck and Cario, *Zeits. f. Phys.*, 11, 3, 1922.

[14] Franck and Jordan, "Anregung von Quanten Sprüngen durch Stösse," Julius Springer, Berlin, 1926, p. 216 ff.

[15] Harnwell, G. P., *Phys. Rev.*, 29, 830, 1927.

could still be detected, though not under ordinary conditions. It is therefore not unreasonable to ascribe the results of Erikson to some such process.

The question is one of considerable interest and importance for the gas ion problem. It seems it should also be of some interest from the radioactive point of view. It could easily be verified by a positive ray investigation of recoil atoms of the active deposits and it is hoped some laboratory equipped to do this work will find it worth while to undertake the measurement.

LEONARD B. LOEB

PHYSICAL LABORATORY,
UNIVERSITY OF CALIFORNIA

CROSSING-OVER BETWEEN THE W AND Z CHROMOSOMES OF THE KILLIFISH PLATYPOECILUS

THROUGH the aid of a Heckscher Research Grant from the university, the writers have been conducting over the past three years a series of investigations on inheritance in certain of the Cyprinodont fishes. One of these studies has involved two sex-linked genes in the killifish *Platypoecilus maculatus:* a dominant gene for red body-color (R) and one for black spots (Sp). Bellamy[1] (22) showed that both of these characters are sex-linked and he concluded that they are members of the same allelomorphic series. He also showed that the mode of sex-determination in *Platypoecilus* is of the WZ type. Gordon[2] (27) confirmed the findings of Bellamy regarding the sex-linkage of red and spots, but believed them not to be allelomorphs since a normal red, spotted female will transmit both characters to her sons.

In the present work, crosses have been made between red, spotted fish and non-red, non-spotted (the *Gold* race of the fanciers). Two breaks have occurred in the linkage of these genes by crossing over between the W and Z chromosomes of the females. In at least one other case there is evidence that a crossover has taken place in such a way as to transfer both genes, *R* and *Sp,* from the *Z* to the *W* chromosome. The exceptional female resulting from this process was apparently of the constitution $Z_{r\ sp}\ W_{R\ Sp}$, where a normal red, spotted female is $Z_{R\ Sp}\ W_{r\ sp}$. Two different breeding tests of this exceptional female strongly support the belief that her genotype was $Z_{r\ sp}\ W_{R\ Sp}$. These tests show further that this type is best explained as the result of crossing over between the W and Z chromosomes in a female which was heterozygous for red and spots, and that such an individual can not be accounted for by non-disjunction or sex reversal. There is, of course, the very remote possibility that this fish arose by a coincidental mutation of two recessive genes to dominants. However, the fact that other crossovers have occurred between the W and Z chromosomes in the course of these studies renders the *mutation explanation* even more unlikely.

The exceptional red, spotted female was crossed to a male heterozygous for both red and spots ($Z_{R\ Sp}\ Z_{r\ sp}$). Two types of daughters were obtained from this cross: $Z_{R\ Sp}\ W_{R\ Sp}$ and $Z_{r\ sp}\ W_{R\ Sp}$. The first of these presents the unusual condition of homozygosity of sex-linked factors in the heterogametic sex. Aida[3] (21) had the same condition in the red males of *Aplocheilus latipes* ($X_R\ Y_R$). The further breeding of these homozygous females gives unusual results which might well prove confusing to one who was attempting for the first time to investigate the mode of sex determination in this fish. Crosses of such females with *Gold* (r, sp) males will give only males in the double recessive class in F_2. In this respect the cross is similar to that of a red-eyed female Drosophila with a white-eyed male, and it would suggest the XY type of sex determination. However, in the reciprocal cross of *Gold* female with red, spotted male ($Z_{r\ sp}\ W_{r\ sp} \times Z_{R\ Sp}\ Z_{R\ Sp}$), the W-Z type of sex determination is exhibited.

Another cross of the exceptional female with a Gold (non-red, non-spotted) male gave red, spotted daughters like the mother and non-red, non-spotted sons, like the father. Evidently this constitutes a case of "one-sided feminine inheritance" similar to the "one-sided masculine inheritance" observed by Schmidt[4] (20) in his studies of the *maculatus* spot in the fish *Lebistes reticulatus.* It is expected that further crosses of these red, spotted daughters with Gold males will give in turn, red, spotted female offspring, barring occasional crossovers.

Crossing over has been reported previously between the two Z chromosomes of the male fowl, and between the X and Y chromosomes of *Aplocheilus* (Aida '21) and the X and Y of the *Lebistes* (Winge[5] '23). The present work seems to involve the first case of crossing over between the sex chromosomes of an heterogametic female. A detailed report of these investigations will be published later.

ALLAN C. FRASER
MYRON GORDON

CORNELL UNIVERSITY

[1] Bellamy, A. W., *Anat. Rec.,* 24: 419–420, 1922.

[2] Gordon, M., *Genetics* 12: 253–283, 1927.

[3] Aida, T., *Genetics* 6: 554–573, 1921.

[4] Schmidt, J., *Comptes rendus des travaux du Lab.* Carlsberg 14, No. 8: 1–12, 1920.

[5] Winge, O., *Comptes rendus des travaux du Lab.* Carlsberg 14, No. 20: 1–19, 1923.