and has been succeeded by C. H. Eckles, formerly of the University of Missouri; J. S. Montgomery and T. G. Paterson have resigned as associate professors of animal husbandry, and R. C. Ashby as assistant professor of animal husbandry, to enter commercial work; W. H. Peters, formerly head of animal husbandry of the North Dakota Experiment Station, has been appointed professor of animal husbandry; P. A. Anderson has been promoted from instructor to assistant professor of animal husbandry; J. C. Cort, formerly of Iowa State College, has been appointed assistant professor of dairying.

DISCUSSION AND CORRESPONDENCE

RED RAYS AND PHOTOELECTRIC EFFECT

I WISH to call attention to an error which should be corrected as it is being repeated and found its way into such standard texts as Hughe's "Photoelectricity" (Cambridge University Press). Red light does *not* give a photoelectric effect with phosphorescent calcium sulphide, as the effect stops at the wave-length of about 4,200 Ångström, as was shown by the writer.[1] This result was later confirmed at the University of Berlin. The result is of considerable theoretical importance because the theory of the photoelectric effect which takes into account the necessity of a critical energy content before the electrons can be shot off, shows that there will be a wave-length for each element beyond which no photoelectric effect will be produced. The element which gives the photoelectric effect in phosphorescent calcium sulphide is not known, but has been supposed by the writer to be sulphur as it is photoelectric for ultra-violet light and it was shown experimentally to give a photoelectric effect for wave-lengths *longer* than 3,200 Ångström. This hypothesis could be established by showing that the photoelectric effect of sulphur ended at the same point as was shown for phosphorescent calcium sulphide.

When the writer began an investigation of the photoelectric effect of phosphorescent material in 1910 at Yale University, it was *supposed* that the result obtained in 1909 by Lenard and Saeland at the University of Heidelberg was correct. However, it was found that the photoelectric effect of phosphorescent calcium stopped at about 4,200 Ång., which is a shorter wave-length than red light. Thus the result of Lenard and Saeland is incorrect.

The error arose from confusing the effect of red light on the conductivity, which did exist, with that of the photoelectric effect which did not exist. In their paper in the *Annalen der Physik,* Lenard and Saeland described what they thought to be a new effect with red light which was called "Aktinodielektrische Wirkung." This effect differed from the photoelectric effect in that the test plate instead of charging up only positively, charged up both positively and negatively. It was thought that the long heat or red waves being more nearly comparable with the dimensions of the molecules affected them beyond the point where the photoelectric effect stopped. However, after working about a year on the effect of red rays on phosphorescent calcium sulphide, the writer came to the conclusion that no photoelectric effect could be obtained with red light and that the actinodielectric effect was nothing more than an increase in conductivity such as had previously been known to exist for selenium.

After the foregoing conclusion was reached a reexamination of the original article of Lenard and Saeland showed that on account of a faulty construction of their apparatus the plate on which the material was placed was not completely insulated from the accelerating and retarding fields, as is necessary when the photoelectric effect only is to be obtained.

In order to confirm the conclusion, my own apparatus was later reconstructed at the Massachusetts Agricultural College so as to obtain both effects separately at will. It was shown with this apparatus that sulphur was both photoelectric and actinodielectric. The photoelectric effect required a high vacuum, but the actinodielectric effect worked in addition at atmospheric pressure, the direction of the current depending upon the direction of the applied field.

[1] "The Photoelectric Effect of Phosphorescent Material," *American Journal of Science,* 1912.

The conductivity of phosphorescent calcium sulphide was later separately investigated at the University of Heidelberg, and it was shown that certain wave-lengths not in the infra-red gave a maximum effect, which was contrary to what one might have expected from Lenard's theory. Rather the effect was a maximum near the point where the photoelectric effect stopped, suggesting some relation between the photoelectric and actinodielectric effect. An investigation of the relation between these two effects (which amounts to finding out the relation between the ease with which the electrons are ejected and the increase in conductivity for different wavelengths of light) was started for sulphur, during the summer of 1913, by the writer at the Davy-Faraday Research Laboratory of the Royal Institution, London, England, but was not finished.

The relation between the photoelectric effect, actinodielectric effect and phosphorescence has been discussed by the writer and a general theory of phosphorescence has been developed which includes fluorescence, fluorescent X-rays, organic phosphorescence and self-luminous radioactive substances.[2] In the review of this theory in the "Beiblatter zu den Annalen der Physik" the difference between Lenard's theory of phosphorescence and the author's is not clearly pointed out. The author's theory takes into account resonance, Stokes's law and a critical energy content, which is not done by Lenard.

In conclusion, in respect to phosphorescent calcium sulphide, it should be said that red light does increase its conductivity, but *does not* give a photoelectric effect.

CHESTER ARTHUR BUTMAN

[2] See "The Electron Theory of Phosphorescence," *Physical Review*, 1912.

SPECIAL GROWTH-PROMOTING SUBSTANCES AND CORRELATION

THE vigor of potato sprouts bears a direct relation to the size of the seed piece, or in other words to the amount of tissue surrounding the eye. When a certain minimum is reached, the vigor of the sprouts decreases as the size of the seed piece is reduced. The weak, slender sprouts produce correspondingly weak plants which remain weak during their entire period of growth and yield a small crop of tubers.

The weak sprouts are not due to lack of usual food materials, as sprouts on pieces still large enough to contain an abundance of these substances, show considerable decrease in vigor. If a lack of sufficient ash constituents is responsible for the weak sprouts, they might be expected to approach their usual vigor if the small pieces be allowed to sprout in rich soil, as the sprouts form roots very quickly in moist soil. The sprouts from such pieces, however, do not gain any vigor under these conditions.

It seems logical to conclude that the potato tuber contains a limited amount of a special growth-promoting substance and if the amount of tissue surrounding the growing bud is too small, there is not enough of this substance available for normal growth.

Some of the experimental data is included in Bulletin No. 212 of the Maryland Agricultural Experiment Station under the following title: "Physiological Basis for the Preparation of Potatoes for Seed." While this bulletin was in press an article appeared by Loeb, in which he states that equal masses of sister leaves of *Bryophyllum calycium* produce approximately equal masses of shoots in equal time and under equal conditions, even if the number of the shoots varies considerably. He concludes that the limited amount of material available for growth and the automatic attraction of the material by the buds which grow out first, explain the inhibiting effect of these buds on the growth of the other buds.

If the correlative inhibition of bud growth on the potato tuber has a chemical basis it does not appear to be identical with the growth-promoting substance which the writer has postulated and which seem to effect the growth of sprouts only after they have started. Several facts in connection with the growth of sprouts on potato tubers could be mentioned to substantiate this conclusion but the two following experiments seem sufficient.

If a potato tuber bearing vigorous sprouts on the terminal end is cut transversely into