DISCUSSION AND CORRESPONDENCE

EXPERIMENTAL CONFIRMATION FOR SOMMERFELD-FERMI-DIRAC DEGENERATE GAS THEORY OF CONDUCTION ELECTRONS

SOME preliminary results of a study of the Compton modified line structure at this institute confirm the Sommerfeld theory of conduction electrons in metal crystal lattices.

This theory based on the Fermi-Dirac theory and the Pauli exclusion principle predicts a much broader range of velocities for the conduction electrons than is to be expected on the classical kinetic theory. A very appreciable proportion of the conduction electrons in this theory should indeed have speeds considerably exceeding the orbital speeds of the outer electrons in isolated atoms of the same metal. This is a result of the application to the conduction electron gas of the Pauli exclusion principle originally conceived to apply to electrons in single atoms. According to this principle the phase space is to be divided into cells of volume h^3 in each of which the presence of one electron precludes the entrance of any other electron. In other words for a one dimensional case the fact of an electron possessing a velocity, v, prevents neighboring electrons from possessing any adjacent velocity, the range of exclusion in velocity being inversely proportional to the separation in space of the electrons. For a completely degenerate gas (*i.e.*, one in which all the lowest phase cells are filled with electrons) it is evident that even at low temperatures this exclusion principle requires high velocities for some of the electrons. The electrons are uniformly distributed as to velocities up to a maximum velocity beyond which there are no electrons if one neglects a slight shading at this velocity boundary due to temperature. This critical velocity boundary is shown by Sommerfeld to be proportional to the cube root of the electron density in space.

The breadth and structure of the Compton modified scattered X-ray line is intimately connected with the speeds of the electrons which scatter the X-radiation in much the same way as the Doppler broadening of optical lines. A line structure can be computed for any given distribution of electron velocities. It has been found in the interpretation of our experimental results that a line structure computed on the basis of the above-mentioned Fermi-Sommerfeld theory accords with the experimentally found line structure much better than one computed on the assumptions either that the conduction electrons have classical thermal equipartition of energy or that they have the velocities they should have in the external orbits of free atoms far removed from neighboring atoms. Aluminium and beryllium have been studied, the results being most striking in the case of beryllium, where probably two out of the total of four electrons per atom are in the above-mentioned degenerate gas state.

JESSE W. M. DUMOND
NORMAN BRIDGE LABORATORY OF PHYSICS,
CALIFORNIA INSTITUTE

A READILY DETECTABLE SIGN OF OVULATION IN THE MONKEY

IT appears certain from the work of Corner[1] that a female monkey may menstruate with or without ovulating. There are, therefore, two types of menstruation: namely, one that is preceded by ovulation, the formation of a corpus luteum, and the building up of a typical "premenstrual" endometrium; and the second type (which R. Schröder wishes to designate as "pseudomenstruation") consisting of a similar periodic bleeding not preceded by ovulation or corpus luteum formation and issuing from a uterus in the resting stage. Hitherto it has been possible to differentiate between these two types only by removal of the organs and studying them histologically or by inspection of the ovaries and uterus during laparotomy.

A sign of ovulation, readily applied to the living intact animal would, therefore, be welcome—not only for differentiating the two types of menstruation and furthering the study of menstrual phenomena in other ways, but also for aid in securing timed embryological material. Such a test we believe we have found in the recovery of small numbers of red blood cells in lavages or douches made from the monkey vagina after a technique described in April, 1928.[2] The procedure consists of washing out the vagina with a pipette containing a standard quantity of physiological salt solution, diluting the lavage with six times the quantity of 1:12,000 methylene blue made up in salt solution instead of distilled water, and studying this final mixture in a blood-counting chamber under the microscope. The observations upon which this new sign of ovulation is based are the following:

For some time it was noticed that on the day after copulation in certain animals, when the vagina of the mated female was examined for spermatozoa, a few red blood cells were found among several thousand cornified cells and leucocytes recovered from the lumen of the vagina. The number of red blood cells thus recoverable are so few that they would never be discovered in smear preparations made in the usual way.

[1] Geo. W. Corner, 1923, *Contrib. to Embryol.*, Vol. 15; also 1927, *Jour. Am. Med. Assn.*, 89: 1838–40.

[2] Carl G. Hartman, 1928, *Am. Jour. Obst. and Gyn.*, 38: 61–71.

This blood was at first interpreted as due to slight trauma arising from the act of copulation. However, this explanation soon appeared faulty, since the trace of blood was sometimes found in the largest females mated to a smaller male or was absent from small females mated to a larger male. Again, the blood would be absent from a given female soon after mating and appear one or two days later. Since, finally, the erythrocytes were consistently absent in the early and late interval, present only between the eleventh and the eighteenth day of the cycle, another explanation had to be sought. The blood could hardly originate, as in dogs and cows in proœstrum, from a congested uterus, since the red blood cells were recovered only for a very short time—one or two or at the outside three days—whereas the premenstrual congestion increases progressively towards the succeeding menses. This leaves only one other important event occurring in the interval, namely ovulation.

Of twenty mature females menstruating regularly, ten showed the ovulatory bleeding during the past month. Two animals showed the sign on the eleventh day of the cycle; one of these also on the thirteenth day. Four females had a few red cells in the specimen on the twelfth day and of these one also on the fourteenth day. Three females gave the positive test on the sixteenth day and one other on the eighteenth day. Examination of the animals was made only every other day; hence it is possible that some of the other females belonged really to the ovulating class.

Theoretically the explanation here given for the appearance of slight traces of blood in the mid-interval is logical, for during ovulation there is always a hemorrhage, variable in extent though usually slight. While minute in volume, this blood may nevertheless contain millions of red blood cells, which, if distributed through the tube, uterus and vagina, should be recoverable from the vagina by an appropriate method.

To put the theory to a test, laparotomies were performed on two females (Nos. 39 and 43), both of which, judging by their brilliant sex color, the drop in leucocyte count, and the favorableness of the time in the menstrual cycle, gave equal promise of ovulation and fertile mating. Both were mated during the night of Oct. 1–2, No. 39 on the 10–11th day of the cycle, No. 43 on the 12–13th day. Active spermatozoa were recovered in both cases on Oct. 2, a few red blood cells in the case of No. 43, none in the case of No. 39. The former showed a few red blood cells also on Oct. 4, the latter none at any time. Laparotomies done on the afternoon of Oct. 4 disclosed a young corpus luteum in No. 43 that had shown the sign and no corpus luteum but only a small atretic follicle in the case of No. 39 in which the ovulatory sign had been absent.

That the test will be found to apply to women is entirely reasonable; the matter is therefore being studied in the human species also. It need scarcely be pointed out that the method may prove of use in the diagnosis of causes of sterility; for a positive test is at once a proof of ovulation and of the patency of the fallopian tubes.

CARL G. HARTMAN
DEPARTMENT OF EMBRYOLOGY,
CARNEGIE INSTITUTION OF WASHINGTON,
BALTIMORE, MD.

OCCURRENCE OF FAINT BLEEDING ON A DEFINITE INTERMENSTRUAL DAY IN MAN

KNOWING that we were at work on a study of the vaginal smear in man, notice of the preceding article by Professor Hartman was sent one of us (H. M. E.) in a personal letter under date of October 23, 1928, and prompts the following note.

We have only occasionally observed the occurrence of even slight numbers of erythrocytes in the human vaginal smear or any intermenstrual day, but one patient in whom for a year of careful study this was not seen has subsequently for almost two years exhibited with great regularity the phenomenon of sharply circumscribed faint bleeding on a definite day of the intermenstruum. The case (G. P. B., aet. 32, a graduate student at this institution) is that of an individual in excellent vigor and health save for the unexplained sudden incidence of a slight leucorrhea lasting the particular twenty months during which time the bleeding noted was detected. Coincident with the finding of traces of brownish blood on this particular day there was always an increase in quantity and in the irritating character of the vaginal secretion. The phenomenon was limited to two days at most and usually characterized a single day of the intermenstruum and occurred at times in different cycles varying between day fifteen and day nineteen of the period.

It remains, of course, to be seen whether in this exaggerated case we have had the fortune to detect for the first time in man an occurrence almost certain to be overlooked if extraordinary care to detect it be not exercised. Even in the case here noted, only the early morning lochia were blood-tinged (brown), and we would consequently emphasize the value of examinations made immediately on rising if the transitory sign is to be found.

MIRIAM E. SIMPSON,
HERBERT M. EVANS
UNIVERSITY OF CALIFORNIA,
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