

The procedure in operating the apparatus is briefly as follows: With the connections as in Fig. 1a, and the surface M previously wetted by tilting the apparatus, compress the bulb RB gently and then release it suddenly. Repeat this until (by trial) the proper expansion ratio is obtained, whereupon the tracks will appear freely, being very distinct and persisting for some moments.

When the radium salt is mounted, as was formerly done, on the inner tip of P and *not protected*, the emanation escaping soon contaminates the expansion chamber with the result that the ray tracks proceed from random points in addition to those from the original source, thus adding confusion to the picture. The radium, being exposed to the moisture of the enclosure, or at times in actual contact with the water, is in danger of being detached and lost.

Various types of protecting cavities have been tried, but all proved undesirable, since it seemed to be impossible to make a housing with a sufficiently thin window to allow the passage of the alpha particles. The solution came, however, from a suggestion made by L. P. Garner, a graduate student in electrical engineering. This mounting is of pyrex. The glass cane carrying the radium salt is inserted through the nipple P (Figs. 1a and b) and fused in position.

A protected source of alpha particles thus constructed apparently leaves nothing to be desired. The emission of alpha-rays seems to be unaffected by the thin glass window. The troublesome emanation is eliminated and with it the random ray tracks. The active salt is effectively protected from moisture and subsequent loosening. When such a mounting is used there results a clear-cut fan-shaped grouping of alpha-ray tracks, that may be reproduced at will and which seems to be unaffected by time.

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## SPECIAL ARTICLES

### FURTHER STUDIES ON ADRENAL INSUFFICIENCY IN DOGS<sup>1</sup>

#### DURATION OF SURVIVAL OF CONTROL ANIMALS NOT SUBJECTED TO ANY TREATMENT

DATA were given in previous papers<sup>2</sup> on twenty-five males and sixteen non-pregnant females. These can now be supplemented by seven more males and sixteen more non-pregnant females, making thirty-two of

<sup>1</sup> From the H. K. Cushing Laboratory of Experimental Medicine, Western Reserve University.

<sup>2</sup> Proc. Soc. Exper. Biol. and Med., 1925, xxii, 394; *ibid.*, 1925, xxiii, 190. *Journ. Pharmacol. Exp. Therap.*, Abel Memorial, sent January, 1926.

each. Of the seven additional males, one survived the removal of the second adrenal for four and one fourth days; one for six and one fourth days; one for seven and one half days; one for eight days and five hours; one for eight and two thirds days; one for fourteen days and eleven hours; and one for fourteen days and twenty hours. The average for the thirty-two males (6.97 days) was only slightly changed.

Of the sixteen additional non-pregnant females, one lived after removal of the second adrenal for three and one half days; one for four days and one hour; one for four days and seven hours; one for four days and eight hours; one for four and two thirds days; one for five days and ten hours; one for six days and ten and one half hours; one for six days and twenty and one half hours; one for seven days and two hours; one for seven days and three and one fourth hours; one for seven days and seven hours; one for nine days and one half hour; one for nine days and two and one half hours; one for ten days and eight hours; one for ten days and eighteen hours; one for eleven and one half days. Average for thirty-two non-pregnant females 6.82 days, practically unaltered.

Our object in preparing so large a series of control animals (which is still being added to) was two-fold: (1) to permit a careful study of the symptoms, blood changes and *post-mortem* appearances (macro- and microscopic) and (2) to permit definite conclusions as to the life-prolonging effect of certain methods of treatment. Further experiments on the influence of intravenous injection of Ringer-dextrose solutions have shown an even greater maximum prolongation of life, into the fifty-fourth day, after loss of the second adrenal in a male dog. Gastric and colonic lavage with hyper- and hypo-tonic NaCl solutions and other liquids were tried systematically in several animals without noticeable effect on the final result. Feeding adrenal preparations and dextrose *per os* was without result; the same was true of intravenous and subcutaneous injection of certain adrenal preparations. Cholin, which some writers have considered a substance of physiological importance associated with the activity of the cortex, was tried in a number of animals in varying doses and had no effect in prolonging life.

Blood studies<sup>3</sup> were made in a large number of animals, embracing estimations of serum proteins, specific gravity, conductivity of blood and serum, relative volume of erythrocytes and serum hemoglobin percentage, counts of erythrocytes and leucocytes, blood sugar, serum calcium, chlorides, non-protein nitrogen, urea, uric acid, creatin and creatinin and amino-acid nitrogen. Concentration of the blood

<sup>3</sup> *Journ. Pharm. Exp. Therap.*, *loc. cit.*

(with decrease in the relative volume of the serum) is very common or perhaps constant towards the end. Frequently the change is extreme. The erythrocyte count and hemoglobin percentage are increased. The conductivity of the blood is diminished. That of the serum was either unchanged or somewhat diminished. This agrees with our result for the chlorine which also remained constant, or sometimes seemed to be moderately lessened. The non-protein and urea nitrogen were markedly increased in the terminal stages. In some cases the increase began definitely before the characteristic symptoms had appeared. (In this connection it may be mentioned that in a case of typical Addison's disease recently studied by one of us (J. M. R.) a high NPN and urea were seen). The amounts of uric acid, creatin, creatinin and amino-acid nitrogen were not materially altered. The undetermined fraction of the NPN sometimes appeared to undergo a significant increase. In some of the cases the serum calcium appeared to be increased. It is only towards the end, when the symptoms have become well established, that any striking diminution in the dextrose takes place. An interesting point is that in a pregnant dog, which remains in good health fifty-five days after removal of the second adrenal, no changes in the blood were observed till three days before death, which occurred on the fifty-ninth day.

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### A PRINCIPLE OF CORRESPONDENCE

MERCURY vapor has been bombarded by electrons of homogeneous velocities (produced by magnetic analysis), revealing interesting information on the nature of the probability that an electron will ionize an atom. It has been found that the minimum ionization potential is 10.4 volts, while other critical potentials exist at approximately 10.6, 11.2, 11.6 and 11.9 volts, respectively. Presumably others of higher energies will be noted when the experiments are extended. Further, it has been observed that the probability of ionization is finite when the electron has just enough energy to ionize the mercury atom (10.4 volts) and that this probability decreases with increasing electron energies to the next critical potential, where it takes on a sharp rise to a higher value, decreasing again to the third critical potential, et cetera. The sudden increases of the probability of ionization are attributed to the setting in of various distinct types of atomic energy transitions involving ionization, each type of transition having a maximum probability of excitation for electron energies of the minimum amount able to carry through the process. Thus, the probability of ionization by electron impact

resembles in form the radiation quantum absorption probabilities observed in the X-ray region. However, a point of much vital interest is that the probability as a function of the energy is more closely of the form found by Foote, Mohler and Chenault for the probability of ionization of Caesium vapor by light quanta. This fact has suggested the following hypothesis of correspondence in the behavior of electrons and light quanta in atomic processes involving ionization:

*Electrons and radiation quanta obey the same general laws, expressed as functions of their energy, concerned with ionization of atoms. In particular, the probability that an electron will produce a given type of ionization expressed as a function of its energy is of the same form as the corresponding probability function for radiation quanta.*

This postulate correlates a range of experimental facts that heretofore have been unintelligible. For example, Foote, Mohler and Chenault found a maximum ionization probability in Caesium vapor for light quanta of minimum energy (series limit frequency), which decreased rapidly for light quanta of higher energies, though well below the series limit an anomalously large probability was observed. On the other hand, the writer found that the ionization in potassium vapor increased above the threshold frequency. On the present hypothesis the two sets of experiments are consistent with each other, and the experiments of K. T. Compton and Van Voorhis, Hughes and Klein, and others on the probabilities of ionization by electron impact. Further, it is interesting to point out that the correspondence here suggested is in harmony with the Compton effect. It has been known for a long time that ionization by electrons of large energies (beta rays) may be accounted for along classical lines, *i.e.*, conservation of energy and momentum. The principle here suggested implies, therefore, that there is a type of ionization by radiation quanta of large energy wherein the laws of conservation of energy and momentum are explicitly obeyed. The Compton effect bears out this implication. Using Bohr's theory of ionization by beta rays in conjunction with the above postulate the probability of a quantum ionizing according to the Compton effect may be evaluated and is found to agree well with experimental facts. It is needless to emphasize the utility of the principle in determining ionization probabilities in unknown regions of the radiation spectrum, and finally, it contributes one more condition in statistical theories concerned with the interaction of radiation and matter.

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