involving some thousands of eggs, were 23, 49.5 and 68.5 per cent. Obviously then the fly eggs react to doses of these very short waves in precisely the same way as they do to softer radiation. A further test at 300 KV (0.07 A. U.) demonstrates the same fact.

Another experiment with a different biological material gave similar results. A mouse tumor (Sarcoma 180) was cut into small pieces which were radiated and then inoculated into healthy animals. The criterion of effect was the failure of the radiated pieces to grow. Untreated particles always "take." A number of tests at 550 KV showed that the lethal dose was about 2750 r. This is the same as that found by Wood[4] who used much softer rays (0.20 and 0.70 A. U.).

The conclusion is that between 0.04 and 0.70 A. U. the biological effect of equal doses is the same. How far this equality extends in the direction of still shorter waves, *e.g.*, the gamma rays of radium, and of very long waves produced at a few thousand volts, is still to be determined. Since the effect is produced by secondary radiations generated when the primary radiation is absorbed, it may be expected that there will be an equality through a much wider range of wave-lengths than have thus far been used. Experiments on the action of the Grenz rays whose wave-lengths are from 1.0 to 2.0 A. U. are now in progress.

Because of the great penetrating power of the high voltage rays it is possible to deliver to deep lying tissue a much larger proportion of the incident energy than is possible with less penetrating rays. Theoretically this should be of value in therapy; whether such rays will prove advantageous in practice can be determined only by careful study of the reaction of the patients.

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THE CORTICO-ADRENAL HORMONE

AN outstanding advance in the physiology of the internal secretions has been made by the development in the past year of potent aqueous extracts of the adrenal cortex. Nearly simultaneous announcements of the maintenance of adrenalectomized animals in perfect health by the administration of cortico-adrenal extracts has been made by Hartman and his collaborators at Buffalo,[1] and by Swingle and Pfiffner at Princeton.[2] The latter observers kept several of their cats alive and in good health over 100 days; Hartman reports that three of his animals lived over 100 days, and one over 200 days. The insignificant effect of cortico-adrenal extracts which have been developed by previous workers has been dealt with at length in a recent review.[3]

In this laboratory we have recently made and tested cortico-adrenal extracts prepared according to the methods of both the Buffalo and the Princeton investigators. The method of Swingle and Pfiffner, although long-drawn-out (taking usually 10 to 14 days) and offering many possibilities for the loss of potency to occur, is simple to carry out; that of Hartman takes only a few days but offers technical difficulties, particularly in the elimination of inert lipoid substances and of adrenalin. On adrenalectomized cats we have tested to date eighteen batches of extract made according to the Swingle-Pfiffner technique, and six batches prepared after Hartman's method.

It can be said positively that the Swingle-Pfiffner extracts contain significant amounts of the cortico-adrenal hormone. On administration of the substance to adrenalectomized cats the life span is at least much prolonged, and may possibly be extended indefinitely. The animals gain in weight and look apparently normal. We have given particular attention, however, to the recovery of animals from the severe symptoms of adrenal insufficiency, and have therefore stopped administration of the extract three or four weeks after adrenal removal, and often earlier. Evidences of resuscitation of adrenalectomized cats from extreme prostration following intraperitoneal injection of the Swingle-Pfiffner extract are apparent in 15 to 30 minutes: convulsions are suppressed, the animals show an interest in their surroundings and attempt to sit up; within an hour or so they may walk about and appear practically normal, and two hours after injection they may take food. Examples of recovery are given from a few of our protocols in Table 1.

We have made up the extract to a final concentration of 30 grams of cortex per cubic centimeter—or 100 cubic centimeters of extract per 4 kilos of fresh ox glands. The injections have chiefly been given intraperitoneally. Usually it has been necessary to inject from 5 to 10 cc of extract per kilo body weight of the animal, in the course of 24 hours, to effect restoration from the pronounced symptoms of adrenal insufficiency. Twenty cc of the extract given intraperitoneally to a small (two-kilo) cat have produced no ill effects. The material is also non-toxic when given subcutaneously, intramuscularly, intravenously or intracardially. In one case injection by the latter route was strikingly effective in resuscitating a coma-

[4] Wood, F. C., *Radiology*, 1925, 5, 199.

[1] F. A. Hartman, K. A. Brownell and W. E. Hartman, *Amer. J. Physiol.*, 95: 670, 1930.

[2] W. W. Swingle and J. J. Pfiffner, *Amer. J. Physiol.*, 96: 153, 1931.

[3] S. W. Britton, *Physiol. Reviews*, 10: 617, 1930.

TABLE I

Date	Cat no.	Condition before extract was given	Results
11/21/30	257	In convulsions	Improved in 30 minutes; walking about in 1 hour; eating 2 hours after injection
12/ 5/30	273	In convulsions	Improved 30 minutes after injection; in splendid condition 6 hours later
12/ 7/30	273	In convulsions	Again rapidly resuscitated following administration of extract
12/10/30	273	Comatose	Sat up 15 minutes following injection; appeared normal 1 hour later
12/11/30	273	In convulsions	Recovery from extreme prostration in 4 hours
1/28/31	276	Comatose	In splendid condition 5 hours after injection
1/30/31	276	In convulsions	Appeared normal within 3 hours; ate salmon

tose animal. We have also used the extract subcutaneously and intramuscularly in man without ill effect.

Our extracts made according to the Swingle-Pfiffner method contain from one-in-one-million to one-in-two-million parts of adrenalin. By control experiments we have shown that the recoveries are not due to adrenalin activity, although we have frequently found the adreno-medullary hormone effective in restoring severely prostrated animals to an apparently normal condition. Much larger amounts of adrenalin than are contained in the cortical extracts must however be given. The restoration with adrenalin is, furthermore, only temporary, lasting usually from 4 to 12 hours. Similarly the recovery from prostration following the injection of glucose solution is very short-lived. We are in definite disagreement with the statement of Swingle and Pfiffner[2] that adrenalectomized animals with severe symptoms show no improvement in their condition and "derive no benefit from the injections" of adrenalin.

It may be noted that the quantity of extract it is necessary to give to prostrate adrenalectomized animals to effect complete restoration represents relatively huge amounts of cortical tissue—a thousand times or more than the amount present in the normal cat. Swingle and Pfiffner, as well as ourselves, frequently gave from 15 to 32 cc of the extract, representing up to nearly 1,000 grams of the adrenal cortex, in the course of 12 hours, to resuscitate animals with severe symptoms. And the normal cat possesses only from 200 to 300 milligrams of cortico-adrenal tissue altogether! It seems likely that previous observers may not have secured noteworthy effects with their cortical extracts because of failure to employ the heroic dosage necessary.

Our experience with cortico-adrenal extracts made according to the Hartman technique is somewhat limited, because of the difficulties of preparation mentioned above. The few batches we have prepared we have tested a great number of times on adrenalectomized cats, and in some cases we have obtained indications of the presence of the hormone in the Hartman extracts.[4]

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PREMATURE REVERSAL OF HEART-BEAT IN BOMBYX

IT is now well known[1] that in Lepidoptera as in Ascidea there is a regular alternation in the direction of heart-beat, which, in insects, begins in the prepupa and continues during the pupal and adult stages. It is understood, of course, that the direction of heart-beat in most insects is forward, toward the head.

Intermittent backward beating does not normally occur in the full-grown silkworm until it has stopped feeding, evacuated its intestine, spun its cocoon and rested about 24 hours. Then, about 48 hours before pupation, periodic reversal of direction normally begins.

Yokoyama,[2] 1927, has recently stated that this change in type of circulation can be brought on prematurely by closing the posterior pairs of spiracles with enamel paint or by injecting lactic or acetic acid into the 8th abdominal segment. His published graphs apply to the full-grown silkworm during the 5th stage, though he claims to have obtained almost identical results with larvae of the 4th. To induce reversal, according to this observer, 6 pairs of spiracles must be blocked at the beginning of the 5th stage (one day after moulting), one pair less on each successive day, until during the last 5 days (including the period of spinning) only the 3 most posterior pairs (segments 6–8) need be blocked. Similar results

[4] Grateful acknowledgment is made of aid in the above investigations by the Grants-in-aid Committee of the General Education Board.

[5] Porter Fellow in Physiology.

[1] J. H. Gerould, *Jour. Morph. and Physiol.*, 48: 385–429, 1929.

[2] T. Yokoyama, *Dobutsagaku Zachi* [Zool. Mag.], 39, No. 459, Suppl.: 45–51, 1927.