leave the testis until they have reached the posterior end of the vas deferens can be given for at least one species. Spermatozoa are believed to be carried out of the testis into the ductus epididymidis while they are functionally immature. Much of the time consumed in passing through this 9 to 9½ foot tubule is necessary for the completion of their development. Once this is attained, however, there is no influence which preserves them in an optimal functional condition and they begin to age and ultimately to become liquified. There seems to be no general escape from the posterior end of the tract except during copulations and through dissolution.

To what extent these observations can be duplicated in other mammals, particularly those which are producing spermatozoa continuously, we do not as yet know.

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Biological Effects of Temperature Variations With High Frequency Oscillations.

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(Introduced by H. H. Collins.)

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Since there is at present a premature trend toward the use of the vacuum tube high frequency generator in therapeutics, a study of certain extreme local heating effects in animals seems advisable. The following experiments were conducted in the hope of throwing some light on the exceedingly high temperatures generated in local tissues of which the general body temperature gives little or no warning.

When week old Albino rats were exposed to an electrostatic field obtained by an apparatus giving a frequency of 100,000,000 cycles per second, death was accompanied by a violent rush of blood to fore and hind limbs and tail. These appendages became severely congested and swollen, and so marked was this effect that it was believed possible to use the general macroscopic appearance as a basis for a comparative study of the effects of high frequency oscillations with external heat.

Christie and Loomis[1] in previous experiments with mice maintained that death occurred as a result of "pure" heat. They did not,

[1] Christie, R. V., and Loomis, A. L., *J. Exp. Med.*, 1929, xlix, 2.

however, give the amount of heat necessary to duplicate any given high frequency effect, but simply proved that mice were killed in an incubator whose temperature reading was identical with rectal readings of mice killed in the electrostatic field.

In the succeeding experiments, in order that the rush of blood to the limbs could be more readily observed, rats were selected before the hair coat developed, 7 days being the age of all experimental animals.

Those animals which were killed in an electrostatic field were exposed in an open glass tube between circular plates 9 cm. in diameter at 3 cm. separation. The generating circuit of the apparatus used included a 50 watt, A. C., tube and a transformer of 1100 volts secondary. The coupling to the exposure or auxiliary circuit was made by a single wire feeder, similar to the usual radio antenna feeder. The average output on the exposure circuit was about 3 amperes as measured by a radio frequency ammeter. Saline thermometer readings of this output did not reach blood temperature in the time required for lethal dosages. The rise was at an average rate of 2.1°C. per minute with a total rise in 5 minutes of not over 12°C. above room temperature.

Those animals killed by external heat were subjected until death to the following temperatures obtained in a dry oven: 45°, 55°, 65°, 80°, 95°, 145°, and 160°C. The rats were placed in an open beaker well padded with cotton in order to protect them from contact with the heat of the oven floor and of the container itself.

Body temperatures were taken on all animals at the instant of death. Since rectal readings were impossible due to the small size of the animals, a slit was made in the abdomen just large enough to admit the bulb of the thermometer. The time lapse from death to insertion of thermometer was less than 8 seconds. Temperatures thus obtained were well within the range of rectal temperatures gotten by other workers (Schereschewsky,[2] Christie and Loomis).

At severe exposures to high frequency ranging in output from 3 to 3.5 amperes the rush of blood to the appendages started almost immediately, giving them first a deep pink, then a red, and, finally, as the congestion increased, a dark purple color which persisted after death. All 4 legs became badly swollen, and, the skin being stretched to the breaking point, ruptured on both the tail and the limbs. The appendages gave the appearance of having been burned. The animals sweat profusely in the region of the rump and seemed to suffer intense discomfort before death, which occurred in about

[2] Schereschewsky, J. W., *Pub. Health Rep.*, 1926, xli, 1939; 1928, xliii, 927.

3 minutes at the higher output. At outputs of 2 amperes death occurred in from 5 to 6 minutes. The characteristic rush of blood to the limbs took place, but more slowly.

In those animals killed in a dry oven at temperatures of 45°C. there was no discernible rush of blood to the limbs and tail, nor was there any congestion. This was equally true at temperatures of 55° and 65°C.

At 80°C., during exposure, the limbs of the animals became highly flushed but this flush seemed to fade out at death. At 95°C. the first real indication of congestion in the limbs and tail was observed. Here, however, there was no swelling but the legs and tail became a deep red in color and this color persisted after death. At 145°C. the fore and hind limbs and tail became congested and swollen, but not to the degree observed in rats killed by high frequencies.

It was only when temperatures reaching 160°C. were used that the effects of external heat were fairly comparable to those effects obtained in electrostatic fields. At 160°C. the congestion was marked and the color of the legs and tail was a deep purple which persisted after death. The hind legs in particular were badly swollen.

Abdominal temperatures taken on rats killed by external heat were essentially the same as for high frequencies, the highest being 45°C. in the case of heat and 45.5°C. in the case of high frequencies.

It is evident here that body regulation is able to keep the abdominal temperature below 46°C., whether the exposure be in an electrostatic field or in "pure" heat, and that neither the abdominal thermometer nor the saline thermometer are measures of the actual heat to which the animal may be subjected when exposed to high frequencies.

Placed between the plates of the auxiliary circuit as a dialectric the animal is exposed to a rapidly oscillating field, a displacement disturbance which manifests itself as internal heat. Christie and Loomis contended that this internal heat may be very high in various parts of the body and this seems to be borne out by the duplication of high frequency effects with external heat.

The degree of external heat necessary to duplicate the high frequency effects here described was found to be not less than 160°C., and that this "pure" heat temperature is very much higher than any measurable heat generated in the electrostatic field.