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The hunger mechanism in birds. (Preliminary report.)

By F. T. ROGERS (by invitation).

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Both normal and decerebrate pigeons have been used in this study. Hunger is marked by the appearance of restlessness. This restlessness appears before the crop is completely empty. Lack of water even though the crop be distended with dry food is marked by restlessness of the bird. These things are true of birds with cerebrum intact, partially, or wholly removed.

During hunger, changes occur in the behavior of the crop. In the normal bird with "appetite"(?) satisfied or at least in the bird which does not of its own accord eat of an abundant food supply, the crop is very much distended. In this condition only occasional contractions of the organ can be detected by means of a rubber balloon; none are visible to the eye (after removal of the feathers over the crop). An hour or two after feeding there begins to appear in the crop contractions in groups of three or four at intervals of 15–20 minutes. The activity of the crop is gradually augmented and 8–12 hours later there occur groups of 8–20 contractions at intervals of 10–30 minutes. Still later in some birds (probably young) the crop is in a state of almost continuous activity. When the content of the crop has been lessened to about one third of its capacity these contractions are directly visible. At this time they may be seen to involve principally the lower part of the crop. When it is completely empty these contractions are periodic in groups of 8–16 occurring at intervals of 10–60 minutes. Each contraction may be seen to begin at the upper part of the crop and sweep as a deep constriction, preceded by a marked bulging or relaxation, over the entire crop (and probably down to the gizzard). Each wave requires a time interval of 12 to 15 seconds to complete its cycle.

This visual evidence justifies the balloon method of recording the contractions. Unless the pressure used is excessive the balloon does not initiate the contractions.

In the crop which contains plenty of food and water a sudden distension of the balloon has little effect. Sudden distension of a balloon in an empty crop initiates a group of contractions. Using too big a balloon or using too much pressure so as to cause excessive dilatation of the crop causes sideways shifting of the neck and crop (shrugging of the shoulders so to speak) evidently an effort on the part of the animal to remove the obstruction. Similar movements may be seen in normal birds which have stuffed themselves with corn. By mechanical manipulation of the crop with the fingers isolated peristaltic contractions of the crop may be caused. Mere stretching movements of the neck are not sufficient to account for these contractions for they occur when the bird is held quietly in the hand.

In the normal bird these contractions may be inhibited by external influences such as light and noise. Light and sound do not inhibit them in decerebrate birds but rough handling may do so. Such disturbances of body coördination as those following extirpation of the semicircular canals or lesions of the cerebellum inhibit the contractions of the crop. Incidentally, during the period of marked incoördination following lesions of the semicircular canals or cerebellum the crop is emptied much more slowly than in normal birds.

Tonus changes undoubtedly occur but tracings are likely to be deceptive on this point because of the close relation of the crop to the cervical muscles. Any shifting in the position of the head will be registered by the recording balloon in the crop. Hence tracings may be meaningless. But in the hungry bird the crop can be seen to be constricted into a much smaller area. It can hardly be believed that the crop is simply folded and fallen together. (Histological study of the crop distended and empty is being made.)

A small fistula in the crop does not cause any visible difference in the contractions. The contractions may be inhibited by putting water into the crop through the fistula or by feeding the bird. Water given by mouth does not immediately inhibit the contractions for the peristaltic waves from the throat spread downward over the entire crop. No visible difference can be made out between contractions of the empty crop initiated by swallowing

water or those occurring perioically without swallowing, except as to their point of origin.

Restlessness of the starved decerebrate bird may be clearly periodic or more or less continuous. If it tends to be continuous picking up the bird and holding it in the hand for a moment and then freeing it will end the restlessness, unless contractions of the crop are occurring at the same time. If the crop is actively contracting the bird will continue his fruitless wanderings.

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Oxygen consumption in regenerating tissue.

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Little knowledge has been obtained as to the rate of metabolism of regenerating tissue as compared with that of normal tissue. Child, '15,[2] has found that susceptibility or physiological resistance of organisms varies directly with the rate of metabolism. He found, in practice, that a measure of the resistance to cyanide poison was an efficient method for determining the rate of metabolism. In experiments of regenerating tissue of *Planaria* (flatworm) he concluded that immediately after operation, the rate of metabolism fell below normal, remained there for a few days, then arose above normal where it remained for some time after regeneration was complete, when it gradually approached normal. I obtained the same result with *Sagartia*, a small *anemone* (Coelenterate). In my method the rate of metabolism was measured by determining the amount of oxygen consumed by the regenerating animals as compared with the normal animals. Oxygen determinations were made by means of the Winkler method. The experiment continued for twelve days. Determinations were made every twelve hours. Table I shows percentage consumption

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[2] Child, C. M., "Senescence and Rejuvenescence," University of Chicago Press, 1915.