

correct. For instance, it was observed that tetany occurred in the three cases in which the CO_2 tension was highest. However, our results with dogs do not confirm this hypothesis. Dr. Hastings made the P_{H} determinations by the gas chain method, using all the accepted refinements. He found that it was normal until just before death, when the usual sudden ante-mortem drop occurred, proving that in this condition, death at least, is not due to an intoxication by hydroxyl ions. Moreover, as far as I know, there are no fundamental experiments to prove that nerve tissue is hyperirritable in the more alkaline solutions. Thus, since we have no direct proof we are not prepared, yet, to say that alkalosis per se, is the cause. There are other ions to be considered besides the hydrogen ion, which may affect nerve irritability. Dr. Loeb⁵ has pointed out the importance of the monovalent/divalent kation ratio or more specifically the Na/Ca ratio, and has shown differences in the anions as well. In this case, the sodium-calcium ratio seems to be normal but there is a marked disturbance in the anions which may be the important factor.

We are investigating further into the problem, and hope to be able to determine by estimating the hydrogen-ion concentration and the carbon dioxide content in the same sample of blood whether we are dealing with a condition of compensated or uncompensated alkalosis.

120 (1867)

Hen-feathering induced in the male fowl by feeding thyroid.

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It is already well known to the members of this Society that the males of certain breed of fowls—notably Sebright bantams and Campines—are feathered so like the females as to be in this respect practically indistinguishable from them; and that such hen-feathered males, following castration (especially in early life), develop plumage of the usual male type.

⁵Loeb, J., and Ewald, W. F. *J. Biol. Chem.*, 1916, xxv, 377.

This appearance of cock-feathering in normally hen-feathered males after castration is now familiar to us. It is the purpose of this paper to call attention to experiments that have led to a similar transformation but in just the opposite direction, namely, to the appearance of hen-feathering in cock-feathered males of ordinary breeds.

We had begun a series of preliminary experiments upon the physiological correlations of certain of the ductless glands. Eighty Rhode Island Red chicks were under observation. They were of the same hatch. They had been divided into four lots of twenty each.

All the birds in two of the lots, both males and females, had been castrated between two and four weeks after hatching. Those in the other two lots were unaltered.

Four weeks after hatching, one lot of castrated birds and one lot of normal birds had begun to receive daily doses of dried thyroid (Armour and Company, containing 0.2 per cent. I) by mouth. The initial individual dose was 50 mg. It was increased from time to time. At the end of fifteen weeks it had become 330 mg.—a dose the birds were able to take without any disturbance of their normal health.

There is a striking difference between the sexes of this breed of fowls with regard to the time at which the tail coverts make their appearance. These feathers began to show themselves in some of our birds six weeks after hatching. Five weeks later, they were well developed on the normal females, in both thyroid and control lots. But they had not yet appeared on the control males, either normal or castrated. This absence of tail coverts provided a ready recognition mark of the male. Less conspicuous at this time, but nevertheless unmistakably present on the neck, were the hackles characteristic of the male bird only.

In sharp contrast with these hackled and tailless males were the thyroid-fed normal males. Though the latter were upstanding birds with well-developed comb and wattles, and unquestionably male in carriage and instincts, they were as unquestionably female in plumage, owing to the absence of hackles and the presence of well-developed tail coverts. All doubt as to the sex of these birds was removed when they were killed four weeks later. At

this time the control males were typically marked by long hackles, saddle feathers and definite sickles. The thyroid-fed males resembled females in each of these respects. In behavior, comb, wattles and spurs, they were male, in feathering female.

It was clear that the addition of thyroid to the diet of unaltered males was somehow responsible for this condition. Turning to the castrated birds that had been fed thyroid, it was equally clear that the gonad was a necessary factor in the result. For not a single castrated bird of either sex showed the least evidence of thyroid feeding in any of the characters previously enumerated. The thyroid-fed castrated females like their castrated controls, approximated males in feathering. The thyroid-fed castrated males exhibited the ultra male plumage characteristic of capons.

The facts thus far considered relating to the secondary sex characters are arranged for convenience in the accompanying table.

	Plumage.	Comb and Wattles.
Normal male.....	Male	Male
Normal female.....	Male	Female
Normal and thyroid male....	FEMALE	Male
Normal and thyroid female...	Female	Female
Castrated male.....	Male	Female
Castrated female.....	Male	Female
Castrated and thyroid male..	Male	Female
Castrated and thyroid female	Male	Female

Males with hen-feathering induced by thyroid feeding are indicated by capitals. All normal males thus fed were hen-feathered without exception. In two instances, however, sickle feathers began to appear among the tail coverts toward the end of the thyroid-feeding period, suggesting a certain degree of escape from the influence of the thyroid. This was possibly connected with the fact that the birds were then getting less than the maximum dosage of thyroid compatible with their health.

Search for the portion of the gonad through which thyroid feeding achieved its effect led at once to the luteal cells originally demonstrated by Boring and Pearl¹ in the ovary of the hen and later in the testis of the hen-feathered Sebright, by Boring and Morgan.² The latter stated their belief that the secretion of these cells

¹ *Anat. Rec.*, 1917, xiii, 253.

² *Jour. Gen. Physiol.*, 1919, i, 127.

suppresses in the hen and in the Sebright male the characteristic cock-feathering.

This view seems highly probable, although not, to our knowledge, completely demonstrated as yet. However, if it could be shown that as a consequence of thyroid feeding the luteal interstitial tissue had increased in our hen-feathered male birds, the fact would contribute strong support from a new direction. Our preparations, however, indicate no such hypertrophy. There seems to be little doubt of the complete or nearly complete absence of luteal cells from the normal testis of R. I. R. cockerels at the age of ten to fifteen weeks. The same appears to be true of the thyroid-fed birds, but we are not so confident of the facts in this case because of poor fixation of the tissues. New preparations from experiments now in progress will probably clarify the situation.

The following series, however, adds some significance to the luteal tissue in the present connection.

1. In R. I. R. cockerels, ten to fifteen weeks of age, luteal cells appear to be entirely lacking, and these birds fail entirely to develop tail coverts of the female type.

2. In White Leghorn cockerels of the same age, luteal cells are present and tail coverts of the female type are present also. In W. L. adult males, however, these cells are lacking, as in adult R. I. R. and correlated with their absence, the full male plumage is present.

3. In Sebright males, hen-feathering and luteal cells are present together in young cockerel and in adult as well.

R. I. R. males do not pass through a juvenal plumage, at least so far as tail coverts are concerned. This is a rather exceptional fact, contrasting sharply with what we have found to be true of the White Leghorn cockerel, and the Sebright, both cockerel and adult. Juvenal plumage would thus appear to be determined, not by age, but by cells whose presence, regardless of age or of sex, leads always to plumage of one type. According to this view, juvenal plumage is female plumage, and female, juvenal—or neither, as in the Sebright adult male. This problem has large implications, consideration of which would carry us outside the proper limits of this paper.

If the appearance of hen-feathering in normal males as a consequence of thyroid feeding is dependent on the presence of luteal cells, it remains to consider the nature of the relation between thyroid and luteal tissue. The former might lead to an augmentation either of the mass or the activity of the latter, or both. There is no evidence as yet of an increase in the mass or number of luteal cells in the testis of thyroid-fed males. The second alternative, for which direct evidence is far less easy to obtain, may yet prove to be the correct one.

121 (1868)

The relation of the diffusion constant to mountain sickness.

By GEORGE HARROP (by invitation).

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In connection with the recent physiological expedition to Peru, a series of determinations were made of the gas diffusion constant by the CO method described by Dr. Marie Krogh.¹ A series of preliminary determinations made at sea level agreed in the limits of error (5 per cent.) with those made at Cerro de Pasco, at 14,300 feet. It was found that the severity of the symptoms of mountain sickness, or seroche, exhibited by the eight members of the party were in direct proportion to the value found for their diffusion constants, those having values of over 40 suffering very little, or practically not at all.

TABLE A.

DETERMINATION OF DIFFUSION CONSTANT—CO METHOD.

Cerro de Pasco, Dec. 27-Jan. 10, '22—14,300 Feet.

Subject.	K.	Do ₂ .	Clinical Phenomena.
H.	5.50	25.4	Severe seroche, 3 days, symptoms chiefly nervous.
Bo.	6.03	31.8	Severe seroche, 6 days, symptoms gastric and nervous.
Ba.	8.44	36.0	Moderately severe seroche, 2 days in bed.
Bi.	9.3	38.3	Moderately severe seroche, 2 days in bed.
D.	5.91	41.5	Practically symptom free throughout stay.
R.	6.85	42.9	Some headache; otherwise symptom free.
F.	6.01	43.8	Practically symptom free.
M.	9.80	45.6	No effects from seroche.

¹ *Jour. of Physiol.*, 1915, xlix, 271.