

is in accord with the findings of Mitchel and Miller.² On the other hand in practically every group reported in Table I some of the rats failed to survive the experimental period of 8 weeks, which is in agreement with the observations of the Wisconsin investigators.

Summary. The influence of glutamic acid in the remission of milk anemia in rats was investigated and the efficiency of this substance as a vehicle for the administration of metals as hemato-poietic agents tested. The effect of inorganic salts and of metallic glutamates was essentially the same and the further addition of glutamic acid did not alter this result.

7254 C

Pigmentation and Growth Rate in Gray Breast Feathers of Adult Mallard Drakes.

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Before the physiology of sexual dimorphism in birds can be completely understood the normal change from the male winter plumage to the female-like summer plumage in the Mallard drake must be explained. This report embodies certain facts regarding feather pigmentation and growth rate in Mallard drakes which must be considered in future studies of the physiological basis for this "eclipse" or "summer plumage" change of the adult male duck.

The males used in these experiments are semi-domesticated Mallards, the majority of which are genetically "dark-phase mallard" (*M Li*).¹ These drakes are very uniform in breeding, and in adult body weight, between 980 and 1160 gm. The males are left in outside yards until they are to be used in an experiment, when they are brought indoors and kept in artificially heated and lighted pens, the hours of illumination being approximately the same in all trials. At the beginning of the experiment, 50 to 60 feathers are plucked from the middle of the ventral surface on either side of the keel, the plucked area being in the same location on each drake. All trials

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¹ Jaap, R. G., *J. Her.*, 1933, **24**, 467.

were conducted between the months of September and the following April. At any time within this period the growing feathers normally show no detectable variation in pigmentation or growth rate.

The depth of color in the growing gray breast feathers may be increased artificially by 2 different treatments, oral administration of desiccated sheep thyroids (Armour & Co. preparation, 0.2% iodine), or subcutaneous injection of an extract of the urine of young men, prepared according to the method of Funk, Harrow and Lewja² for male hormone. The thyroid increases the pigmentation and the growth rate of the feathers, and the urine extract augments the pigment increase stimulated by the thyroid. The increase of pigmentation in the partially-grown gray breast feathers is recorded in the tables by direct comparison of the normal and modified feathers of each drake. Each plus symbol indicates a definite intensification of the melanic pigment. Feathers with 5 plus symbols, in addition to being very dark in color, have a definite edging of light brown and in this respect resemble the feathers of the eclipse (summer) plumage. Each drake was killed at the termination of the experiment and, in parts B and C of Table I, a certain number of growing feathers were removed for measurement. At

TABLE I.

Drake No.	Exp. started	Daily thyroid dose gm. per kilo body wt.	Mean length of feathers Cm. P.E.	Wt. of testes Gm.	Pigmentation change
A.—Treated six weeks					
WB22	Dec. 29			4.08	0
357	" "	.25		9.98	0
774	" "	.50		18.13	+
WB14	Feb. 9			7.72	0
WB13	" "	.50		32.52	++
6938	" "	1.00		67.52	++++
B.—Treated 18 days (30 feathers)					
2W	Sept. 1		2.26 ± .05		0
2N	" "	.50	2.87 ± .08		+
2.1	" "	1.50	3.06 ± .03		+++
2R	" "	3.00	3.07 ± .04		+++++
C.—Treated 17 days (10 feathers)					
79B	Oct. 5		2.03 ± .10	2	0
51C2	" "	.1	2.66 ± .04	6	0
2.6	" "	.2	2.83 ± .04	3.51	+
49C2	" "	.4	2.70 ± .10	1.52	0
2.5	" "	.6	2.84 ± .05	7	++
49G2	" "	.8	2.74 ± .08	18	+++
46T2	" "	1.0	2.79 ± .05	15	++++
24C	" "	2.0	2.72 ± .03	33	+++++

¹ Left testis, 0.5 gm.; right testis, 3.0 gm.

² Testes dark color, microscopically showing pronounced regression.

² Funk, C., Harrow, B., and Lewja, A., *Am. J. Physiol.*, 1930, **92**, 440.

this time the testes were weighed, and pieces from these and from the thyroids saved for histological study.

Table I shows that levels of desiccated thyroid above 0.2 gm. per kilo body weight increase the pigmentation of the gray breast feathers of the Mallard drake. The weight and spermatogenic activity of the testes of treated animals increase over those of the non-treated controls in almost direct proportion to the amount of thyroid fed. It will be noted that the testis weights of non-treated birds vary according to the time of the year in which the trial was concluded. This phenomenon has been recorded by many previous investigators.

Growth rate, as measured by the mean lengths of the immature feathers plucked, shows an increase on the lower thyroid levels, but fails to respond further on the higher doses. A marked and significant increase in growth rate is obtained on a 0.1 gm. level of thyroid, without any quantitative change in pigmentation of the feathers. Thyroid, therefore, has two distinct and separable effects, (1) increasing the growth rate and (2) increasing the pigmentation. Lillie and Juhn³ found in the Brown Leghorn fowl that the feathers in certain sections of the plumage grow more rapidly than in others. Also, they have shown that such feathers require a higher concentration of hormone to increase their pigmentation than those in areas of lower growth rate, demonstrating that more rapidly growing feathers have a higher threshold for pigmentation. Since thyroid feeding increases the growth rate of the feathers in the breast area of the Mallard drake, it is assumed that levels of 0.1 to 0.2 gm. of thyroid are not sufficiently high to overcome this pigmentation threshold. A higher dose (0.6 gm.) fails to stimulate further increase in the growth rate and intensifies the color of the feathers by overcoming the threshold for pigmentation. The growth rate remains more or less constant on levels over 0.6 gm., while the increase in feather pigmentation is then roughly proportional to the amount of thyroid administered.

There is evidence from the foregoing experiments that the size and corresponding activity of the testes are, in some manner, related to increased pigmentation of the feather. This association occurs under normal conditions, for the drake exhibits the ability to produce the more deeply pigmented summer plumage feathers at a time when the testes are large and active. While there is considerable disagreement in the literature, the majority of authors find that complete gonadectomy inhibits the summer plumage change.⁴ Three

³ Lillie, F. R., and Juhn, Mary, *Physiol. Zool.*, 1932, **5**, 124.

completely castrated drakes have been given 0.25, 0.5 and 0.75 gm. levels of thyroid respectively. None of these has produced any feathers darker than normal, while non-castrated drakes under similar treatment show an increase in feather pigmentation on the 2 higher levels. It appears, therefore, that there may be a quantitative relationship between testis and the thyroid which increases the pigment-forming action of the latter. A trial was conducted in an attempt to further modify the pigmentation by increasing the "male hormone" concentration in both normal and thyroid-fed drakes. This trial was then repeated with higher levels of thyroid. The results of both trials on non-castrated drakes are presented in Table II.

TABLE II.

TABLE 1.					
Drake No.	Exp. started	Daily treatment		Wt. of testes gm.	Pigmenta- tion change
		Thyroid gm.	Urine extract cc.*		
A.—Treated 26 days					
453	Nov. 12	-----	-----	7.02	0
426	" "	-----	1.0	4.25	0
421	" "	.5	-----	4.92	+
452	" "	.5	1.0	34.08	+++++
B.—Treated 30 days					
252	Dec. 23	-----	-----	5.25	0
305	" "	-----	1.0	23.78	0
313	" "	1.0	-----	25.78	++++
308	" "	1.0	1.0	51.62	+++++

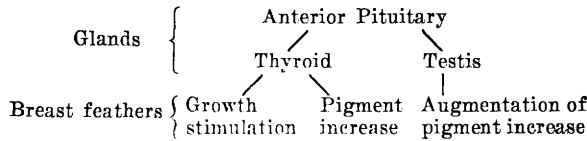
* One cubic centimeter of extract is equivalent to 200 cc. of urine.

It will be noted that, although this urine extract when administered alone has no detectable influence on the feathers, it produced a much greater pigmentation in combination with thyroid than did the thyroid substance itself. An even more surprising result is that in both of these trials the testis is larger and more active when both thyroid and urine extract are administered together. It is certain that the testis secretion in some manner augments the pigment deposition initiated by the thyroid substance. The cause of the increased testis activity under the combined treatment is being investigated further.

Since Tallent⁵ has shown that injection of an anterior pituitary suspension produces feathers similar to those of the eclipse plumage, we may illustrate what appears to be the essential glandular interaction in the production of the intensely pigmented summer plumage of the gray breast area by the following diagram:

⁴ Allen, E., *Sex and Internal Secretions*, Williams & Wilkins Co., 1932, 584.

⁵ Tallent, Violet K., *Nature*, 1931, **128**, 672.



7255 C

Growth of Bone Shafts in the Human Fetus.

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If individual bones differ in their rates of growth and if each of the major long bones is the product of 3 to 8 centers of ossification one may feel surprised at the linear relationships reported by Scammon and Calkins¹ between diverse *external* dimensions of the human fetus. We need assurance that the simplicity of these gross observations does not mask a greater complexity in the constituent tissues.

In this fetal series we report the lengths of the bone shafts alone, before the appearance of osseous epiphyses, from dried preparations in the Department of Embryology. The observations are well distributed through fetal life, their variability is small, and the error of measurement is less than 2%, but we do not know what change took place in drying.

The rectilinear relationships in Fig. 1 demonstrate our confirmation, by a different technique, of Scammon and Calkins'¹ belief that the relative growth of human fetal long bones is approximately linear. This interpretation applies also to fetal skull growth in the horse² but fetal limb growth in the horse (to be published) required a second degree equation. We have also replotted the data of Schmalhausen and Stepanowa³ concerning bone growth in the chick embryo. Here we find that lengths, as well as weights are inter-related as power functions and thus exhibit growth partition.^{4, 5} The chick humerus length is a function of femur length with exponent 0.87, and approximately the same exponent, 0.88 describes

¹ Scammon, R. E., and Calkins, L. A., *Growth in the Fetal Period*. 1929. U. of Minn. Press.

² Robb, R. C., *Proc. Sixth Internat. Cong. Gen.*, 1932, **2**, 166.

³ Schmalhausen, I., and Stepanowa, J., *Arch. Entw. d. Organ.*, 1926, **108**, 721.

⁴ Huxley, J. S., *Problems of Relative Growth*, 1932. Dial Press, New York.

⁵ Robb, R. C., *Brit. J. Exp. Biol.*, 1929, **6**, 311.