centimeters on the horizontal axis. Figures on the left ordinate refer to barb frequency, *i. e.*, the number of barbs per millimeter rhachis length. Figures on the right ordinate apply to barb lengths.

Barb frequency of the control and modified feathers are given by the curves $f_{(c)}$ and $f_{(m)}$ respectively. Curves $l_{(c)}$ and $l_{(m)}$ are contour lines of the control and modified vane margins respectively. The length of barb at any point on the rhachis is the distance from the contour line to the base of the figure.

The diagonal line, D-V, is the line of pigment deposition; the segment of barb lying between D-V and the contour line $l_{(m)}$, is the length of barb above the collar at the time of pigment deposition. Lengths between D-V and the rhachis (abscissa) are barb segments laid down following pigment determination in the collar.

The numbers "43" and "75" refer to identical barbs on the modified and control rhachises. The region of pigment deposition extends from barb 43 to barb 75. Due to the modified barb distribution along the rhachis of the feather treated with thyroxin, these and all intervening barbs—which in at least this number were in the collar at the time of thyroxin injection—must be compared with corresponding barb number in the control feather.

Both barb frequency and barb length are modified by thyroxin over a considerable range anterior to the first barb showing pigment deposition. This effect is possibly due either to failure of thyroxin to effect melanin deposition in all barbs in the zone of determination, or to interference with the normal expansion (ballooning) of barbs and rhachis after they have passed beyond the zone of determination.

The significance of these results in relation to events in the germ will be taken up in a forthcoming paper; at that time we shall consider also the action of thyroxin over a wide range of concentrations.

7496 P

Pattern Analysis in Plumage. IV. Order of Asymmetry in the Breast Tracts.

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In experiments with female hormone in this laboratory it was found that when the mark due to the hormone was restricted to one vane-half in the definitive breast feather, other feathers were occa-

sionally found in the same tract bearing a similar mark on the opposite vane-half. There are nine feathers in a transverse row across each breast tract; counting laterally from ventral mid-line of the bird. we shall designate the feathers of such a row by the numbers one to 9. Ordering the various feathers in which the asymmetrical mark was found according to this notation, it could be shown that feathers one to 5 bore the female hormone mark predominantly on one vane-half; feathers 7, 8 and 9 carried the mark predominantly on the opposite vane-half. Feather number 6 in this composite row showed little if any asymmetry in distribution of the female hormone mark, *i. e.,* both vane-halves were marked to about the same degree. Finally, the degree of asymmetry increased from feather to feather in the order of distance from number 6: the greatest asymmetry of marking thus occurred in those feathers nearest the ventral and lateral margins of the breast tract, but of course on opposite vane-halves.

These observations pointed to a true reversal of asymmetry within each breast tract with respect to a secondary antero-posterior axis of symmetry. The position of the secondary axis was apparently given by the sixth feather of each transverse row. The precision of response occasionally observed indicated, moreover, that the relations of asymmetry of feathers ventrally and laterally from the assumed secondary axis of symmetry were of an exact quantitative order.

An examination of the order of appearance of feather papillae (Anne Holmes, in preparation) has shown that the first line of papillae to arise in the embryo corresponds with the line of follicles of most symmetrical reaction pattern, which in the breast is the line of follicles numbering 6 in the transverse row.

In this note we give the results of measurements of barb lengths of definitive breast feathers which demonstrate that, in respect of barb length the order of asymmetry in the breast tracts is essentially in accord with that deduced from our observations on response to female hormone.

Barb lengths are measured at 0.5 cm. intervals on both sides of the rhachis from one cm. below the tip of the feather to within one cm. of the end of the fluff. The relative asymmetry of each feather of a transverse row is calculated by 3 procedures. 1. The differences in lengths of barbs on opposite sides of the rhachis are averaged for all measurements made. 2. The maximum difference in length of barbs found down the axis of the feather is taken as the index of asymmetry. 3. The average difference in barb lengths over the cm.

showing the greatest differences in barb lengths. In practically all cases the 3 "indices" are in agreement, although of course differing in absolute magnitude.

The relations of asymmetry in the breast tracts, as established by these results, are given in the chart. A′—A′ represents the mid-ventral line of the bird. Passing laterally to right and left from the ventral mid-line, figures 1′, 2′, . . . 9′, give the positions of the feathers in right and left transverse rows.

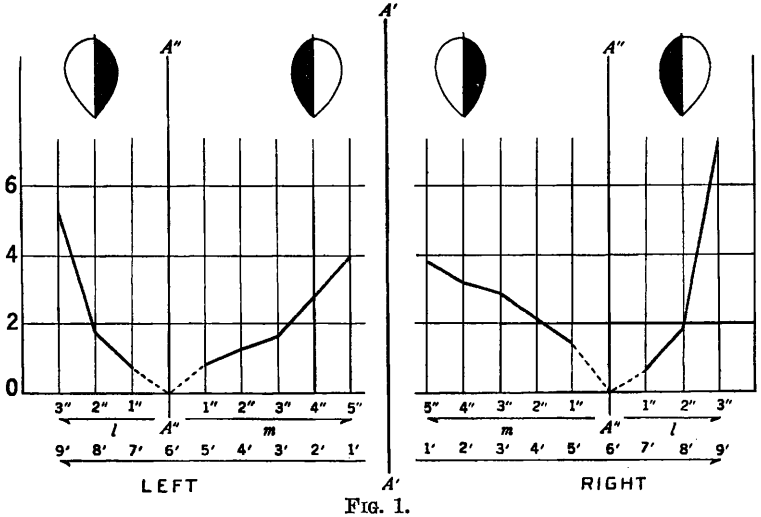

FIG. 1.

The index of asymmetry chosen is the average difference in barb lengths over the cm. of greatest difference in barb lengths. The feather showing the smallest absolute difference in length of barbs determines the secondary axes, A″—A″, right and left. This is the feather number 6 of the primary order. From the secondary axes, A″—A″, the feathers of the transverse rows are re-ordered as shown in the chart; m and l refer to feathers medially and laterally respectively for each breast tract.

The "indices" of the remaining feathers of each tract are now ordered with respect to the secondary axes. Ordinates in the chart refer only to the differences in barb lengths taken with respect to these axes, *i. e.*, with the feather viewed from the ventral surface, base up, the length of barbs in the vane-half adjacent to the secondary axes is subtracted from the length of barbs in the vane-half away from the secondary axes. These vane-halves may be spoken of as adaxial and abaxial respectively.

Abaxial barb lengths, then, are greater than adaxial barb lengths

over the cm. of greatest differences by the amounts shown in the chart.

We have some evidence that the sixth feather of the primary order is not necessarily the feather of least asymmetry in all instances. But once having established the secondary axis for a right or left breast tract, we have found no exceptions to the order of adaxial-abaxial relationship. Also, the absolute value of differences in barb lengths is subject to considerable variation; the general nature of the relations shown in the chart, however, remains the same, with extreme asymmetry at the lateral boundaries of the tract.