spiral arms wind around the center when followed outwards from the nucleus.

Dr. S. Chandrasekhar, of the Yerkes Observatory, presented a new theory of stellar motions which is applicable to various types of stellar systems, and which will doubtless revolutionize stellar dynamics.

Professor E. A. Milne, of the University of Oxford (England), gave a lecture on "Cosmological Theories," in which he begins,

> with a logical analysis of the large-scale universe of matter and motion as it appears to observation, avoiding any appeal to laws or concepts derived from smaller-scale phenomena. . . . Starting from the individual's awareness of the passage of time, it is possible to set up a system of congruent timekeeping in different places, to construct in turn a kinematics and a dynamics, hence to give a logical meaning to "uniform time," to give accounts of gravitation and electromagnetism, and finally to show how to identify the various logical constructs so encountered in the physically observed universe. . . . The stimulus for the development of this logical structure has arisen from the great American discoveries of the phenomena associated with the extragalactic nebulae. Such discoveries have justified us in formulating our deepest questionings, and have helped to separate questions which are genuine questions from those which have merely conventional answers.

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# SPECIAL ARTICLES

## LINKAGE OF PEA COMB AND BLUE EGG IN THE FOWL

RECENT studies in this laboratory show that the dominant gene causing blue shells on eggs of the domestic fowl is closely linked with that for pea comb. During the last two decades a number of fowls that lay blue eggs have been introduced into this country and to Europe from South America. These vary considerably in color of plumage and in structural characteristics. In most cases they resemble Dark Brown Leghorns in color but have pea combs. They are generally called "Araucanas" after that region in Chile in which they are most abundant.

Unlike the brown pigments of hens' eggs, which are applied on the surface only, the blue color is found all through the shell and is quite evident on the inside. When the blue is combined with varying shades of brown (as in egg-shells of Rhode Island Reds and other breeds) the result is a series of green and olive colors, varying with the intensity of the brown color. The ability to lay blue eggs results from a unifactorial dominant autosomal mutation.[1]

In February, 1938, the writers obtained a male Araucana descended from stock imported from South America and mated it with a number of females, including "testers" for two autosomal linkage groups. This male had a pea comb, and all but one of the females had single combs. Among 35 laying daughters from single-combed dams, the following combinations were found:

| | |
|---|---|
| *Parental combinations* | |
| Single comb, white egg: | 18 |
| Pea comb, blue egg: | 15 |
| *Cross-overs* | |
| Single comb, blue egg: | 0 |
| Pea comb, white egg: | 2 |
| | 35 |

[1] R. C. Punnett, *Jour. Genet.*, 27: 465–470, 1933.

Such a distribution could not occur by chance. The possibility that one gene is responsible for both type of comb and color of egg-shell seems very unlikely, because Brahmas, Sumatras and Cornish Indian Games, all pea-combed breeds, do not lay blue eggs. Evidently the Araucana male was heterozygous for pea comb and for blue egg, carried in the coupling phase. Since in 35 gametes only two cross-overs occurred, the amount of crossing over between the two genes is apparently not more than 6 per cent. Tests to measure this figure more exactly are in progress.

Hertwig[2] found 32.8 per cent. crossing over between pea comb and marbling (a pattern in the down of chicks) and 45.6 per cent. between marbling and naked neck. Confirmation of the latter association is desirable because of the long map distance involved. Though the gene for blue egg is now added to this group, its usefulness for further mapping of the chromosome is likely to be somewhat limited because it is manifested only in one sex and even there not until the birds lay. Moreover, its close linkage with pea comb would necessitate large numbers in any linkage test where these two genes were to be separated.

A tentative map[3] for chromosomes of the fowl, published in 1936, showed 18 genes in five linkage groups. Since then the "naked" gene has been added to the sex chromosome[4] and the addition of blue egg makes a total of 20 genes in the five groups. Some of these, as well as one or two other loose linkages that have been suggested, need further study.

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[2] P. Hertwig, *Verhandl. Deutschen Zoolog. Gesell.*, pp. 112–118, 1933.

[3] F. B. Hutt, *Neue Forschungen in Tierz. u. Abstammungslehre (Duerst Festschrift)*, Bern, pp. 105–112, 1936.

[4] F. B. Hutt and P. D. Sturkie, *Jour. Hered.*, 29: 370–379, 1938.