quite unlikely that if *al* lies between *S* and *k* all the cross-overs would have occurred between *al* and *k* and none between *s* and *al*. If *al* occupies a locus separate from that of *s*, but closer to it than Hutt's data would suggest, then the existence of two separate loci might not be established even with the analysis of more than 600 suitable gametes.

The original albinotic females obtained by Mueller and Hutt and by Cole both showed ghost barring and were probably sired by Barred Plymouth Rock males. In each case the sex chromosome, coming from a Barred Plymouth Rock, would have included the gene *S* closely linked to *al*, if it were not in fact an allele of *al*. However, in the case of the more recent mutation, all albinos tested (8) proved not to carry *S*. While these were 2 or 3 generations removed from the original albinotic dam, it seems highly improbable that *all* would have been derived by crossing-over and show now a very close linkage of *s* to *al*.

On the basis of our present evidence we must conclude that Werret *et al.* were correct in their interpretation that *S*, *s*, and s^{al} form a series of three alleles on the sex chromosome of the fowl.

R. K. Cole
T. K. Jeffers

Department of Poultry Husbandry,
New York State College of Agriculture,
Cornell University,
Ithaca, New York.

[1] Werret, W. F., Candy, A. J., King, J. O. L., and Sheppard, P. M., *Nature*, **184**, 480 (1959).
[2] Mueller, C. D., and Hutt, F. B., *J. Heredity*, **32**, 71 (1941).
[3] Hutt, F. B., *Heredity*, **15**, 97 (1960).
[4] Hutt, F. B., and Mueller, C. D., *Amer. Naturalist*, **77**, 181 (1943).
[5] Cole, R. K., *J. Heredity*, **52**, 47 (1961).
[6] Jaap, R. G., *Poultry Sci.*, **35**, 490 (1956).

PSYCHOLOGY

An Ante-natal Determinant of Intelligence

Reliable investigations of intelligence suggest that at least 75 per cent of individual variations in ability are determined by inheritance[1]. The distribution of intelligence appears to be best described by a Pearson type IV curve[2] determined mainly by polygenic factors.

It would appear now that much of the remaining variance of intelligence can be attributed to factors operating during the embryonic development of the individual. One such factor appears to be that of season of birth as a reflexion of climatic conditions during pregnancy.

There have been in the past a number of investigations reporting small but consistent associations between psychological performance and seasonal changes, including season of birth[3]. Such investigations often involve more average ranges of ability than those to be described here. It seems unlikely, therefore, that the latter results are only applicable to the basically low level of this sample.

I have examined[4] a group of 188 adult subnormal patients with intelligence quotients ranging from 40 to 69 (the third and fourth standard deviation ranges below the mean). It was found that birth in summer and autumn was significantly advantageous to subsequent intelligence performance compared with birth in winter and spring.

Further examination revealed that this association between season of birth and subsequent intellectual performance was probably a reflexion of the trend of climatic temperature during the whole of pregnancy. Thus, relatively high intelligence quotients were significantly associated with the number of embryonic months possessing a mean monthly temperature above that month's mean temperature over the years. Table 1 summarizes the intelligence quotient and climatic temperature data for this sample.

Table 1. Seasonal Temperature and Intelligence Quotient

	Summer	Autumn	Winter	Spring
No. of subjects	46	45	47	50
Mean intelligence quotient	57·1	54·6	51·7	53·1
Mean °F	56·5	55·5	40·9	42·3
Mean diurnal variation °F	14·9	12·6	8·3	10·8

The following example highlights the results obtained. Out of the total sample of 188, 10 subjects had an embryonic development with 8 or 9 months all above the respective mean monthly temperature. Of these 10 subjects, 8 fell in the 55–69 intelligence quotient range (third standard deviation below the mean) and only 2 in the 40–54 intelligence quotient range (fourth standard deviation below the mean).

From Table 1 it can be seen that between summer and winter births there is an average difference in intelligence quotients of more than 5 points. It is possible that if appropriate weighting be given to: (1) variations in climate from year to year; (2) individual differences in exposure and susceptibility, then the effect of climate during pregnancy on subsequent intelligence might be more than 5 points of the intelligence quotient.

With chromosomal abnormalities, a somewhat similar result has been recently reported[5]. This investigation revealed a significant relationship between climatic temperature at the approximate time of conception and the incidence of mongol births to younger mothers.

From a survey of a number of investigations[6], a relationship has been claimed between season of birth and the incidence of psychosis (especially schizophrenia). However, in a relevant examination[7], I have produced evidence to suggest this might be an artefact of the noted association between intelligence and the season of birth. Nevertheless, one author[8] has found indications that factors during pregnancy, apart from climatic change, might be a determinant of future deviant behaviour.

It is not known how climatic temperature precisely affects the embryo. Further work is required on the precise nature of the temperature effect. This is presumably a matter of relative changes rather than absolute levels, but investigations in parts of the world with differing modes of temperature variation to the British Isles would be of great interest. For example, it can be seen from Table 1 that the amount of diurnal temperature variation is positively associated with the mean temperature-level. It is conceivable that the association between climatic temperature and intelligence is a result of diurnal changes rather than seasonal ones. There are, in fact, parts of the globe where the diurnal range is greater in winter. Such variations of climate clearly offer ready-made experimental designs for investigations into human performance and their determinants. The work recorded here offers one application of such a conceptual framework.

J. E. Orme

Middlewood Hospital,
Sheffield.

[1] Burt, C., *Brit. J. Educ. Psychol.*, **25**, 158 (1955).
[2] Burt, C., *Brit. J. Psychol.*, **48**, 161 (1957).
[3] Fitt, A. B., *Season Influence on Growth, Function and Inheritance* (Oxford Univ. Press, London, 1941).
[4] Orme, J. E., *Brit. J. Psychol.*, **54**, 273 (1963).
[5] Greenberg, R. C., *Med. Offr.*, **109**, 62 (1963).
[6] Barry, H., and Barry, H., *Arch. Gen. Psychiat.*, **5**, 292 (1961).
[7] Orme, J. E., *Dis. Nerv. Sys.*, **24**, 489 (1963).
[8] Stott, D. H., *Amer. J. Psychiat.*, **118**, 781 (1962).

Number of Items presented and recalled as Determinants of Short-term Recall

The percentage of items correctly recalled from a sequence of items decreases as the number of items in the sequence increases[1,2]. Two factors normally vary directly with increasing sequence length: number of items presented and number of items to be recalled. When a twelve-item sequence was presented, Anderson[3]

©1963 Nature Publishing Group