shows that the periodic occurrence of maximum, far from being clock-like in its precision, is distinctly irregular in phase and in other details.

[1] *Mt. Wilson Contr.* No. 92; *Astrophys. J.*, **40**, 448 (1914).

[2] A Study of the Light Curve of XX Cygni, *Mt. Wilson Contr.* No. 104; *Astrophys. J., in press* (1915).

[3] *Potsdam, Publ. Astrophysik. Obs.*, **22**, Part III (1912).

THE FEEBLY INHIBITED. III. INHERITANCE OF TEMPERAMENT; WITH SPECIAL REFERENCE TO TWINS AND SUICIDES

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Mood or emotional tone depends largely upon temperament; and temperament, it is commonly recognized, has a constitutional basis—is hereditary; the temperament is as little alterable as stature. However, there is a great diversity in temperaments; some persons are prevailingly gay; others prevailingly somber; and still others pass through alternating cycles of elation and depression. Of so complex a phenomenon the explanation cannot be simple. It must account for the following three states:

(*a*) the hyperkinetic state—i.e., a state of overactivity. Of this it will be convenient to distinguish two grades, a lesser and a greater. Following the terminology of an old psychology we may call the lesser grade of hyperkinesis *nervous*. The nervous person is active, energetic, irritable, excitable, ambitious, given to planning, optimistic; usually talkative and jolly. The greater grade of hyperkinesis is the choleric. A choleric person is apt to start a new line of work before he completes the old, brags, is usually hilarious, hyperotic, often profane, liable to fits of anger, brutal, destructive, assaultive, and even impulsively homicidal and suicidal.

(*b*) The opposite state is the hypokinetic or depressed. Here too we may distinguish two grades. The phlegmatic person is quiet, serious, conservative, pessimistic. The melancholic person is unresponsive (often mute), lachrymose, given to worry, weak and incapable, feels life a burden, often longs for death as a relief.

(*c*) The normal mood is shown in that the possessor is cheerful without being boisterous, calm, well balanced, and *en rapport* socially; he works and plays moderately, laughs quietly, does not weep easily, feels little drive, and is always responsive and coöperative. This

state may be due either to the absence of excitation or the absence of depression.

Now each of the three states of hyperkinesis and its absence may be combined with any of the three states of hypokinesis and its absence, making nine combination-states. And since there are two parents in any mating the number of different matings possible will be the sum of the series 9 + 8 + ... + 1, or 45.

To account for this variety of temperaments, hyperkinetic, hypokinetic, normal and mixed, various hypotheses were tried and finally the following selected as most fitted to explain the facts on an hereditary basis. *There is in the germ plasm a factor E which induces the more or less periodic occurrence of an excited condition (or an exceptionally strong reactibility to exciting presentations) and its absence, e, which results in a calmness. There is also the factor C which makes for normal cheerfulness of mood, and its absence, c, which permits a more or less periodic depression. Moreover, the factors behave as though in different chromosomes, so that they are inherited independently of each other and may occur in any combination.*

What the nature of these factors is, whether they affect primarily the development of certain parts of the nervous system or the secretions of certain glands, is not known and is not involved in the hypothesis. It is even conceivable that each state may be due to more than the pair of factors here suggested; but if the hypothesis fits the facts it would indicate that in the factors *E* and *C* we have the predominating influences that control mood.

For the test of the hypothesis 89 carefully described family histories were available, and these afforded 147 matings in which the mated pair, their parents (usually), and certain of their offspring were sufficiently described for the purposes of the test.

The test of the hypothesis is found in a comparison of the expected and actual distribution of temperaments in the children of each sort of mating. Of the 45 possible matings 29 were realized. The relations of the sums of the observed to the sums of the expected distributions among the nine classes of temperaments is shown in the following table.

choleric cheerful	*choleric phlegmatic*	*choleric melancholic*	*nervous cheerful*	*nervous phlegmatic*	*nervous melancholic*	*calm cheerful*	*calm phlegmatic*	*calm melancholic*
36	25	30	128	149	63	77	79	46
41–6/8	46–7/8	19–5/8	98–4/8	154–6/8	72–6/8	51–4/8	97–3/8	49–7/8

There are several reasons for not expecting a very close relation between observed and expected; but the chief one is that there are sometimes several 'expected' results; and in these cases the most varied result was taken as the 'expected.' Nevertheless, the relation between

the two series is fairly close—the greatest difference being an unexpected excess of choleric-melancholics and corresponding deficiency of choleric-phlegmatics; also an excess of calm-cheerful and deficiency of calm-phlegmatic. These discrepancies imply a rather slight error in the classification of the observed cases.

We conclude, then, from our own data that the hypothesis is confirmed. In addition, an examination of the literature reveals clear evidence that a difference in the inheritance of extreme hyperkinesis (a dominant) and extreme hypokinesis (a recessive) has unconsciously been observed. And the differences in the conclusions of Rosanoff and Orr[1] and Rüdin[2] concerning the inheritance of manic-depressive insanity—one regarding it as recessive and the other regarding it as *sometimes* dominant—are easily explained on the ground of its complex hereditary nature.

The hereditary nature of temperament is demonstrated by the facts of the personal history of identical twins, as given by Galton.[3]

There is reason for thinking that the different zygotic combinations of temperamental factors occur with different frequencies. A comparison of the relative number of matings in equally frequent kinds of zygotic combinations shows that some are much more common than expected, others much less. The mated pair rarely have the same zygotic temperamental formula. Two choleric or 'nervous' persons frequently do not marry each other. Two melancholics rarely intermarry. There is, in marriage, a selection against similar temperaments, i.e., a preference for those of more or less markedly dissimilar temperaments.

An analysis of the temperaments of suicides shows that they fall into the two types of the hyperkinetic (or impulsion) suicides and the hypokinetic (or depressed) suicides. Also, a family tendency to suicide by the same method is evident; but it is uncertain whether this is due chiefly to subconscious suggestion or to an hereditary bias.

This study throws light upon the nature of the 'functional insanities' and lends strong support to the view that they are syndromes whose elements are separately inheritable.

Finally the study throws light upon the 'springs of conduct.' Just what we shall, in any situation, do is determined by numerous factors, but the general nature of our reactions, whether violent or repressed—this is determined by the hereditary nature of our temperaments. The romantic and the classic type of reacting, the hyperkinetic and the hypokinetic, the radical and the conservative, the feebly inhibited and the strongly inhibited constitute a dualism that runs through our whole population.

It is expected that the complete paper will appear as a publication of the Carnegie Institution of Washington.

[1] Rosanoff, A. J., and Florence Orr, A study of insanity in the light of the Mendelian theory, *Amer. J. Insanity*, 68, 221–261 (1911), also *Eugenics Record Office Bull.*, No. 5.

[2] Rüdin, E., Einige Wege und Ziele der Familienforschung, mit Rucksicht auf die Psychiatrie, *Zs. ges. Neurol. Psychiat.*, 7 (Hft. 5), 487–585 (1911).

[3] Galton, F., History of Twins, in *Inquiries into human faculty and its development* (1883), reprinted in 'Everyman's Library,' London, Dent, N. Y., Dutton.

SECOND TYPE STARS OF LOW MEAN DENSITY

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The rôle played by stellar densities in the theories of the order of stellar evolution is easily recognized. If the development of a star uniformly follows the spectral sequence B, A, F, G, K, M, that is, if in contracting through the agency of its own gravitation its light changes in color steadily from bluish white to red, then the mean density of the B and A type stars must naturally be less than that of the redder stars. But, on the other hand, if the earlier as well as the later stages in a star's evolution are characterized by the second and third type spectra (F, G, K, M), the density of the redder stars should have both small values and large values relative to the bluer stars.

There are two principal lines of observational evidence that indicate the existence of two orders of densities for second type stars:

1. The recognized existence of enormous differences in the absolute brightness of red or yellow stars of essentially identical spectra leads immediately to the conclusion that the volumes also differ greatly. Now since stellar masses so far as known have not very greatly differing values, we are lead to believe that the disparity in size must be accounted for by large differences in mean density. For instance, the density of our sun, which on this interpretation must be considered a body relatively advanced in age, may be from a thousand to a million times greater than that of a star of great intrinsic luminosity, such as Alpha Aurigae, which has a similar spectrum and presumably therefore a comparable suface temperature. An objection to this argument in favor of very low densities for some of the redder stars may be that our information relative to stellar masses is insufficient to prove that the large volumes are not to be attributed to large masses with normal densities.

2. The densities of eclipsing binaries, however, can be determined directly, independently of the unknown masses; and recent studies of