fibrils as consisting of fibrils embedded in sarcoplasm. The contractile fibrils may be disseminated throughout the sarcoplasm, or may be collected into a peripheral zone⁶.

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¹ Heilbrunn, L. V., "Outline of General Physiology" (London, 1937).

² Winton, F. R., *J. Physiol.*, **69**, 393 (1930).

³ Singh, I., *Proc. Ind. Acad. Sci.*, **17**, 13 (1943); *NATURE*, **152**, 132 (1943).

⁴ Astbury, W. T., and Dickinson, S., *Proc. Roy. Soc.*, **B**, **119**, 307 (1940).

⁵ Roskin, G., *Z. f. Zellforsch.*, **11**, 768 (1925).

Origin of the Planets

THE development of planets from a filament of material formed between two separating stars may not prove so great a difficulty in the theory of the origin of the solar system as is suggested in Dr. Jeffreys' recent letter¹. It has generally been maintained that the filament would be of such small mass and at such high temperature that its immediate dispersal would occur by lateral expansion. But this view neglects the force field of the two stars transverse to their line of centres, which in the early stages is enormously in excess of the gravitational field of the filament and of enough strength to control thermal velocities due to stellar temperature.

In the lengthwise development, the residual differential attraction of the two stars opposes the self-gravitation of the filament, and to begin with may slightly preponderate, though the two effects are of the same order. At first, pressure differences must urge the matter towards the neutral point, while later the transverse force field of the stars may also be concerned, since during the orbital motion after closest approach their line of centres rotates through more than 90°. The possibility of tidal disruption would not be a fatal objection however, since it is not required that the filament should collect into a single mass. At least three primitive planets must have remained captured by the sun, and possibly others may have escaped, so there seems to be a need for some tendency for the filament to break into a number of masses. But the only worked-out cases of tidal action by stars refer to steady equilibrium forms, and the various forces have unlimited time to operate; such examples do indicate that tidal forces may affect the filament, but they do not enable us to go so far as to say that tidal forces will prevent its gathering into planets.

The situation is in any case much improved as compared with the earlier ideas in that it is sufficient if aggregations form with masses of the order of those of the present great outer planets. There is no necessity for bodies as small as the terrestrial planets to form initially; indeed, the differences of composition of the four inner planets, now ascertained, could scarcely have resulted from simple condensation in the original filament.

There are of course difficulties in the theory, but they are chiefly analytical in nature and are not fundamental inconsistencies involving serious order of magnitude discrepancies. Moreover, the initial hypotheses that lead to material being removed from a star by collision with another, or by rotational instability, have valid observational and theoretical warrant, whereas most proposed alternative starting points are very gravely deficient in this respect. The nebular hypothesis, the planetesimal hypothesis with its bolts shot from the sun, the meteoric swarms, and

the lately revived hypothesis of a distended primeval star, all picture initial conditions for the sun that have no support in theory or observation. This is not to say that such hypotheses must be incorrect (though experience shows that they usually are), but they could not be regarded as satisfactory until their connexion with accepted hypotheses had been made clear: that is, until the omitted stages of the theory had been filled in, and this may as well be attempted first as last. Such hypotheses should be preceded by the essential astrophysical investigations demonstrating their legitimacy.

One further point. The central situation of the sun in the solar system is settled by its mass and is not a consequence of the mode of origin of the system. Accordingly, it is not valid to infer from its central position that the sun is necessarily the parent body.

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¹ *NATURE*, **153**, 140 (1944).

Rate of n -fold Accidental Coincidences

THE time-rate of an accidental coincidence (resolving time t) of n Geiger counters with time rates $N_1, N_2 \dots N_n$, is most easily obtained by classifying the coincidences according to the counter which goes off first. The time rate of each class is obviously $N_1, N_2 \dots N_n t^{n-1}$, and hence the total time-rate is

$$R_n = n N_1 N_2 N_3 \dots N_n t^{n-1}, \quad (1)$$

as indicated by Jánossy¹. The present derivation shows that the formula is *exact* on the understanding that any two groups fulfilling the requirements are counted separately, even when they differ only by one of the n constituent pulses. But physical counting will as a rule distinguish at best such coincidences as differ with regard to all n constituents. That is how the terms of higher order in t mentioned by Jánossy come in. They are sort of a 'correction for overlapping'.

Let us compute the next approximation. The most frequent kind of 'overlapping' (order t^n) occurs when $n+1$ pulses (two of them from the same counter, say, from No. 1) crowd, so as to contribute *two* coincidences to (1). There are two possibilities. All the $n+1$ may fall within an interval t . The time-rate of *this* event is, analogously to (1),

$$n N_1^2 N_2 N_3 \dots N_n t^n. \quad (2)$$

But, in addition, the two No. 1 pulses are allowed to have an interval $t + \tau$, greater than t , provided that the others fall in an interval $t - \tau$, situated midway between the two No. 1 pulses. The time-rate of *this* type of event is easily found to be

$$N_1^2 N_2 N_3 \dots N_n \int_0^t (t - \tau)^{n-1} d\tau \\ = \frac{1}{n} N_1^2 N_2 N_3 \dots N_n t^n \quad (3)$$

The sum of (2) and (3) and of the analogous expressions, with No. 2, No. 3 ... yielding the double pulse, is the correction to be subtracted on the right-hand side of (1). Hence the *next approximation* reads

$$R_n = n N_1 N_2 N_3 \dots N_n t^{n-1} \\ \left[1 - \left(1 + \frac{1}{n^2} \right) (N_1 + N_2 + \dots + N_n) t \right]. \quad (4)$$

Note added in proof.—The factor n in (2) is a