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LETTER TO THE EDITOR

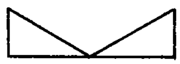
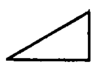
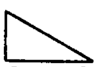
On the Random Distribution of Nucleoli in Metabolic Cells

Hasofer (1974) has studied a probabilistic model for the fusion of nucleoli in metabolic cells. The nucleoli are uniformly distributed at points in the nucleus, assumed to be a sphere. The nucleoli grow from a point to a maximum size during interphase, and fusion is said to occur if the nucleoli touch. For this model, Hasofer calculated the probability of fusion and found it much smaller than experimental data would indicate.

Experimental data of this type is taken by use of a microscope where a two-dimensional view or projection of the three-dimensional cell is obtained. Hasofer implicitly assumes that actual fusion can be distinguished from the case where the two nucleoli do not touch but their two-dimensional projections overlap. We assume, in this letter, that these two cases cannot be distinguished. The probability we obtain is larger than Hasofer's and a much better fit to the experimental data is obtained. Even if true fusion *can* be unfailingly distinguished from overlap of the two-dimensional projections, we hope that our calculations will allow someone to propose the correct (non-uniform) model.

For our assumptions, it is possible to proceed as Hasofer does for his model and to obtain the probability of fusion in terms of certain integrals. The probability, however, cannot be obtained in closed form. Thus, we proceeded by Monte Carlo techniques. The radius of the nucleus was taken to be 1 and the radius, a, of the nucleoli was chosen for a fixed probability distribution. (The ratio of the two radii is the relevant quantity.) Then, two points were chosen at random in the sphere of radius 1. If a point was not in the sphere of radius $1-a$, then the point was projected to the surface of the sphere of radius $1-a$ on a line from the original point and the center of the sphere. (This is in complete agreement with Hasofer's model of the growth process of nucleoli.) Then each point (x_i, y_i, z_i), $i=1, 2$, was projected to a plane (x_i, y_i). If $\sqrt{(x_1-x_2)^2+(y_1-y_2)^2} \leq 2a$, then fusion was said to occur.

Hasofer's experimental data were obtained by examination of 7324 cells from seeds of hexaploid wheat *Triticum aestivum* var. Chinese Spring. Fusion was observed in 4289 of the cells giving an estimate of 0·586 for the probability of fusion. Below we give five densities for a (with a slightly larger range than was observed in a sample of 70 cells) along with our results. The first two densities are the most reasonable but the remaining three are included to indicate the dependence of the probability of fusion on the density.

Density f (x) on (0·2, 0·5)	Sample Size	Number of Fusions	Estimated Probability of Fusion
Uniform:  0·2 0·5	10^5	58538	0·585
Triangular  0·2 0·35 0·5	10^5	57701	0·577
 0·2 0·35 0·5	10^5	59058	0·591
 0·2 0·5	10^5	73054	0·731
 0·2 0·5	10^5	43957	0·440

Hasofer's model results in a mean probability of fusion of 0·408 with a standard error of 0·0057. Thus, Hasofer's experimental value of 0·586 is about 31 standard deviations above Hasofer's theoretical value. Notice that, for the uniform density, our disagreement with the experimental and simulated values is closer than one standard deviation. Even if the triangular density is used, the two values are about 5·76 standard deviations apart. Therefore, we conclude that, *for our assumptions*, there is not sufficient evidence to reject the hypothesis of uniform distribution of the nucleoli.

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REFERENCE

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