Dr. F.H.C. Crick,
c/o Professor P. Doty,
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Harvard University,
Cambridge, MASS., U.S.A.

13th February, 1959.

Dear Francis,

I enclose a copy of our polio paper for any comments you might have before we submit it for publication - to Nature, most probably. I would be particularly grateful for your opinion of the general discussion at the end. I feel it is now appropriate to draw attention to the occurrence of icosahedral symmetry in 5 viruses (although I haven't mentioned Bea's result on SBMV).

I am now trying to see whether it is possible to classify the ways in which a large virus like Tipula IV might be built up out of sub-units, a problem you suggested some time ago. It seems to me that one must start off with a "point-group core", like a small virus and then try to make a "crystal" of it, by adding more sub-units to try to achieve close packing. In this way, starting off from the three Archimedean semi-regular solids with 60 vertices, one can arrive at 3 families of icosahedra, namely:

truncated icosahedron	small rhomb-icosadodecahedron	snub dodecahedron

I can see why the virus should have plane faces if one invokes the equivalent of surface energy in a crystal(density of packing perhaps? in view of our ignorance of the exact forces). But what I cannot see is what there is to determine the uniformity of size, if the nucleic acid is all in the core and there are no other components.

Incidentally I have found a fair amount of mathematical literature on external problems concerning points arranged on a sphere (densest packing, nimumum density for covering). There

P.T.O.

are a lot of gaps in the subject and some of the results are really only very plausible rather than proved, but what does seem clear, is that the solution of an extremal problem is nearly always the regular or semi-regular polyhedron, for the appropriate number of points. The maximisation or minimisation (of some relevant quantity) is nearly always more favourable for arrangements where symmetry is possible than for those in which it is not. These results are, what one might have guessed. But it does seem, though this point is not made explicit anywhere, that among the class of symmetric arrangements, those with icosahedral symmetry are the best. This is the basis of the statement made in the last paragraph of the enclosed paper.

Would you please also show the paper to Jim, if he wishes to see it.

With best wishes,

Yours ever,