ON THE STRUCTURE OF SOME RIBONUCLEOPROTEIN PARTICLES

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Received 18*th February*, 1958

A comparative study of X-ray powder diagrams indicates that the structure of the RNA in both microsomal particles and small viruses is very different from that of isolated RNA. The conclusion is that in these particles the RNA is not segregated, but takes on a molecular configuration determined by the form of the protein matrix.

The greater part of the ribonucleic acid (RNA) in cells is in the form of nucleoprotein particles in the cytoplasm. These particles are found in the microsomal fraction and so are referred to as microsomal particles. Crick and Watson [1] and Crick [2] have pointed out that the microsomal particles resemble the small viruses in size and chemical composition, and have suggested that they might be similar in structure. Since the microsomal particles are now known to be a principal site of protein synthesis [3] it is of particular interest to enquire in what form the RNA is present in them.

With the small viruses it is possible to obtain X-ray diffraction photographs of crystalline or liquid-crystalline preparations and from these to deduce a considerable amount of information concerning the structural arrangement of the protein and nucleic acid in the particle.[4, 5] From preparations of microsomal particles, only X-ray powder diagrams can be obtained, and these contain much less information. However, from a *comparison* of these powder diagrams with powder diagrams of other substances—in particular, of the small viruses, of isolated RNA, and of pure proteins—it is possible to draw certain conclusions.

Preparations of microsomal particles from rat liver and from yeast have one important feature in common with the three small viruses which we have investigated (tobacco mosaic, turnip yellow, and tomato bushy stunt). Their X-ray powder diagrams bear *no resemblance* to diffraction by a *mixture* of RNA and protein and, in particular, show none of the diffraction characteristics of isolated RNA. That this should be so in spite of the fact that the preparations contain about 40 % by weight of RNA can only mean that the RNA in the particles has a structure different from that of isolated RNA.

Our only direct knowledge of the *in vivo* structure of RNA comes from our X-ray studies of tobacco mosaic virus.[6] Here we have shown that the RNA, which forms only 6 % by weight of the particle, is in the form of a single strand which lies along a large and rather flat helix [4, 6] of diameter 80 Å and pitch 23 Å. It is supported in this position by the helical array of protein sub-units of the virus, and clearly could not be expected to maintain the same configuration when isolated. The virus protein, on the other hand can, in the absence of RNA, be made to take up the same structure as in the complete virus.[7] Thus, it follows that the configuration of RNA in tobacco mosaic virus must be one which is imposed upon it by the virus protein.

That this should be true in a particle consisting of 94 % protein and 6 % RNA is perhaps not surprising. But the same appears to be true of turnip yellow mosaic virus, which consists of 40 % RNA and 60 % protein. Here again the protein structure is one which can exist in the *absence* of RNA,[8] and the RNA,

when present, has a structure different from that of isolated RNA (see above) and so, presumably, one which is imposed upon it by the virus protein.

Our measurements on X-ray powder diagrams of microsomal particles suggest that in these, as in the above viruses, the structure is essentially determined by a well-defined protein matrix in the interstices of which lies the RNA. The configuration of the RNA in some way closely conforms to that of the protein. Neither the viruses nor the microsomal particles consist of a kind of protein bag inside which lies RNA. This situation may be contrasted with DNA, the *in vivo* and *in vitro* structures of which have been shown to be similar.[9] In at least some of the DNA-protein complexes [10] it is the protein which conforms to the structural configuration of the nucleic acid.

We wish to thank Dr. Mary Petermann and Dr. J. L. Simkin for fresh preparations of microsomal particles from rat liver and Dr. Schachman and Dr. Stensch for a fresh preparation of particles from yeast. The work was supported by the Agricultural Research Council and by a Research Grant, No. E-1772 from the National Institute of Allergy and Infectious Diseases, U.S. Public Health Service.

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