Polyhedral Shape of Adenovirus Particles as shown by Electron Microscopy

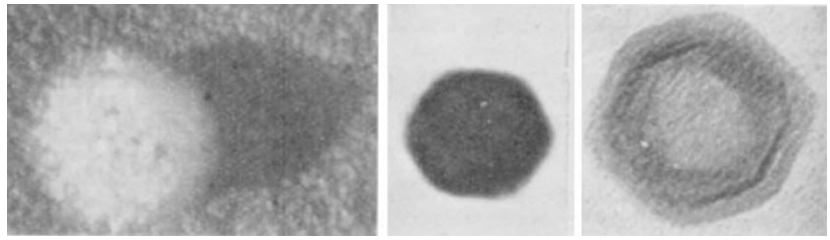
Crick and Watson[1] suggested that a small virus particle contains identical protein sub-units packed together with cubic symmetry, and they went on to predict from this that the virus particle itself might be polyhedral. Electron micrographs have since shown that various viruses do give hexagonal images. This is clearly the case, for example, for the plant virus of turnip yellow mosaic[2] and for an insect virus that infects the larvæ of the crane fly[3]. We now report finding a similar hexagonal shape for the particles of adenovirus which is a human pathogen.

Suspensions of this virus were prepared from large pools of HeLa cell cultures of high infectivity and were concentrated by differential centrifugation. The virus particles when fixed with osmium tetroxide and metal-shadowed (Fig. 1,*a*) gave images which did not clearly differ from those of spherical objects apart from a suggestive angularity in the shadows. Similarly, the virus particles in sections of infected HeLa cells shown in the excellent electron micrographs of Morgan, Howe, Rose and Moore[4] were described as round. On the other hand, Brandon *et al.*[5] have reported that the images of some of the particles found in their suspensions appeared to be five-sided. When we increased the electron density of the osmium tetroxide fixed virus particles by treating them further with 1 per cent phosphotungstic acid, it was seen that in fact the particles have a clearly hexagonal image (Fig. 1,*b*). This appearance was confirmed by making carbon replicas of the surface of formalin fixed particles (Fig. 1,*c*) using the method of Bradley[6]. In this latter procedure the particles themselves were removed from the replica with concentrated sodium hydroxide.

As judged from the electron micrographs of phosphotungstic acid treated preparations, the virus particles have a uniform size of about 700 A. and each gives a similar six-sided image however it happens to be orientated on the supporting film. We therefore assume that the particles have a symmetrical polyhedral form. Of the possible shapes, only two are consistent with the hexagonal appearances seen in our electron micrographs, the rhombic dodecahedron (a solid with twelve identical rhombic faces) and the icosahedron (twenty faces, each an equilateral triangle).

By metal-shadowing the phosphotungstic acid treated preparations, it was possible to obtain clear shadows without masking the hexagonal outline of the virus; the shadows varied from pointed to flat-topped, depending on the orientation of the particles. Models of the rhombic dodecahedron and the icosahedron were then used in an attempt to identify the shape consistent with these appearances, but it was found that neither model threw a shadow so characteristic that it could not be closely matched by a suitable orientation of the other. Thus it was not possible to draw a precise conclusion from the metal-shadowed preparations as to the exact shape of the virus. So far, replicas have also failed to show unequivocally whether the faces are rhombic or triangular.

The regular shape of the particles is allied to a remarkable resistance to attack with proteolytic enzymes (trypsin, pepsin and papain) and both nucleases, procedures that almost entirely digest vaccinia[7], influenza and similar viruses[8,9].



a *b* *c*

Fig. 1. Electron micrographs of adenovirus particles (type 6) from infected HeLa cell cultures. *a*, a particle shadowed with platinum (× 280,000); *b*, a particle treated with phosphotungstic acid (× 250,000); *c*, a particle replicated with carbon (× 280,000)

Technical assistance with the electron microscopy was given by Mr. O. Green and Miss Janet Lawrence.

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July 16.

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The Polyhedral Virus of *Heliothis armigera* (Hbn.)

With reference to the communication by Dr. G. H. Bergold and Dr. W. E. Ripper on the polyhedral virus of *Heliothis armigera*[1], it has evidently escaped their notice that the virus of this nuclear polyhedral disease has already been isolated and characterized on the electron microscope. Furthermore, experiments in the use of this virus in the control of the American cotton bollworm in Uganda are now actively in progress in collaboration with Mr. T. H. Coaker, of the Empire Cotton Growing Corporation[2].

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