responsible for the suppression of growth of the corpora allata observed in this work. Indeed in nymphs of *L. m. migratorioides*, small denervated corpora allata grow if placed in contact with the corpora cardiaca[4]. However, median cell neurosecretion has not been identified within the corpora allata of locusts. Furthermore, Girardie has shown that destruction of the cerebral neurosecretory cells causes activation of the corpora allata in nymphs of *L. migratoria*[5].

There is another explanation for the suppression of corpus allatum growth after removal of the frontal ganglion. In *Calliphora erythrocephala* the activity of the corpus allatum can be regulated by varying concentrations of metabolites in the haemolymph[6]. If a similar mechanism exists in locusts, the corpora allata of the operated insects may be expected to remain small since the concentrations of haemolymph metabolites are low following removal of the frontal ganglion[7].

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## VIROLOGY

### Small Deoxyribonucleic Acid-containing Viruses (Picodnavirus Group)

THE picornavirus group was established in accordance with the decision of the International Subcommittee on Virus Nomenclature for classifying the major groups of viruses on the basis of common biochemical and biophysical properties[1]. Picornaviruses contain ribonucleic acid and protein, are insensitive to ether, and are extremely small in size (15–30 mμ in diameter). The capsids of those members of the group the symmetry of which has been studied appear to display cubic symmetry of the icosahedral pattern[2]. Members of the group derived from humans and lower animals are recognized. Certain plant viruses and the recently isolated RNA-containing bacteriophages have properties which suggest that they might be classified as picornaviruses. The cubic symmetry of the picornaviruses which have been studied is consistent with a capsid constructed from thirty-two morphological sub-units positioned at the vertexes of a rhombic triacontahedron[2] (Fig. 1*a*).

A number of DNA-containing viruses of the same size as the picornaviruses have recently been found, which by analogy might be considered as 'picodnaviruses'. The capsids of one of the small DNA animal viruses appear to be structurally similar to those of the picornaviruses. Vasquez and Brailovsky[3] recently proposed icosahedral symmetry for the Kilham rat virus (RV) based on a hexagonal outline in the electron microscope and a probable capsomere count of thirty-two. The structural symmetry of this virus with a 20 mμ diameter was best represented by the Archimedean dual solid, the pentakis dodecahedron (Fig. 1*b*). Vasquez and Brailovsky believed that the closely related hamster osteolytic *H* viruses (*H*1, *H*3) in all probability presented a similar fine structure.

Members of the hamster osteolytic group of viruses (*H*1, *H*3) are again of very small size (about 20 mμ in diameter). All serotypes produce intranuclear inclusions containing DNA demonstrable by cytochemical staining techniques. Recently Cheong *et al.*[4] have studied the nature of the DNA of the *H*1 prototype virus after purification in a caesium chloride density gradient. They concluded from their biochemical data that the virus consisted of a protein capsid containing a DNA core making up 25 per cent of the complete virion. Green and Karasaki[5] have partially purified *H*1 virus by precipitation at *p*H 4 and have detected evidence of sub-unit structure on the 23 mμ diameter capsid in the electron microscope.

The rat virus *X*14 is serologically related to the *H*3 group of hamster osteolytic viruses. Payne *et al.*[6] banded *X*14 virus at a density of 1·40–1·43 in caesium chloride and examined the virus particles in the electron microscope. The particles were polyhedral in shape and approximately 20 mμ in diameter. The replication of *X*14 was inhibited by 5-fluoro-2′-deoxyuridine[7], thus suggesting that the virus contained DNA, and it has been shown recently by acridine orange staining that the DNA of *X*14 virus occurs in the single-stranded form[8]. This would seem to be the first animal virus to be reported to contain DNA of this type. The fine structure and morphology of the *X*14 virus (Fig. 1*c*) are indistinguishable from RV and from human picornaviruses.

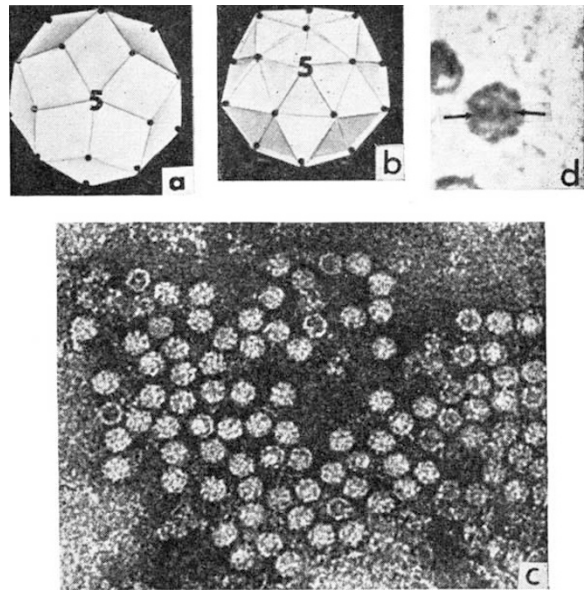


Fig. 1. *a*, Model of a rhombic triacontahedron viewed along a five-fold axis of symmetry. This convex polyhedron belongs to the icosadeltahedral class with triangulation (*T*) number equal to 3. *b*, Model of a pentagonal dodecahedron viewed along a five-fold axis of symmetry. This polyhedron also belongs to class $T=3$ but demonstrates concavities. *c*, Group of *X*14 virus particles negatively stained with 2 per cent phosphotungstic acid (× *c.* 150,000). *d*, Photographic reversal of a favourably oriented ASV particle from adenovirus *SV*15 negatively stained with 2 per cent ammonium molybdate. Particle is viewed along a two-fold axis of symmetry. Two five-fold axes (black arrows) and six peripheral sub-units are seen. (× *c.* 455,000)

Small 20-mμ particles containing DNA and morphologically similar to *X*14 have recently been observed in preparations of a number of adenoviruses of man and animals[10–13]. Detailed investigation of the particles prepared from simian adenovirus *SV*15 stocks by genetron treatment and density gradient centrifugation revealed that the small particles did indeed possess icosahedral symmetry with as few as twelve morphological sub-units on the capsid[10] (Fig. 1*d*). Under certain conditions, these 20-mμ particles are able to replicate when inoculated into susceptible cell cultures. Both mature adenovirus particles (70 mμ in diameter) and 20-mμ particles are recovered in the material collected. The 20-mμ particles do not occur in the absence of the adenovirions. The particles were banded in a caesium chloride density gradient at 1·43 g/cm³. The band, when fixed and stained with acridine orange, yielded a yellow-green fluorescence consistent with the presence of a double-stranded DNA. The staining reaction was prevented by prior digestion with pepsin and DNase. However, subsequent experi-

Table 1. PHYSICAL AND CHEMICAL PROPERTIES OF SMALL DNA VIRUSES (PICODNAVIRUSES)

| Virus | Nucleic acid | Particle diameter (mμ) | Ether resistance | Capsomere diameter (Å) | Buoyant density in caesium chloride | Refs. |
|---|---|---|---|---|---|---|
| RV | DNA | 20 | + | 20 | 1·38 | 3 |
| *X*14 | Single-stranded DNA | 22 | + | ? | 1·40 | 6,7,8,9 |
| *H*1 | DNA | 23 | + | 40 | 1·39 | 4,5 |
| Adeno satellite virus from *SV*15 | Single-stranded DNA | 20 | + | 35–45 | 1·43 | 11,13,19 |
| Adeno satellite virus from human adeno 7 | DNA | 20 | + | ? | 1·41 | 10,12,19 |
| φ*X*174 | Single-stranded DNA | 22 | + | 70 | 1·43 | 16,17,18 |

ments have shown that the reaction is readily susceptible to DNase digestion even without fixation or pepsin treatment. This is indicative that in addition to the 20-mμ particles a very accessible DNA, possibly even free, but inactive, double-stranded adenovirus DNA, was captured and banded with the small particle fraction. The presence of many degraded adenovirions and free capsomeres in the *SV*15 stocks from which this material was prepared is consistent with this interpretation. When freshly prepared *SV*15 material was monitored in the electron microscope and when only material free from morphological evidence of adenovirus degradation was used, the subsequent bands at 1·43 g/cm³ gave clear 'flame red'-staining and the DNase susceptibility characteristic of single-stranded DNA.

Atchison *et al.*[13] have investigated similar small DNA-containing particles with hexagonal profiles associated with the simian adenovirus *SV*15. These particles were not related antigenically to the adenovirus, but replication of the particles in tissue culture was achieved only when they were inoculated simultaneously with adenovirus. The particles were insensitive to ether.

Similar small virus-like particles containing DNA have been found associated with human adenoviruses[10,12,19]. Again these particles do not appear to be able to replicate unless adenovirus is present. Staining reactions with acridine orange indicate that these particles, like the *X*14 virus, contain single-stranded DNA. The particles, like the *H* viruses, are insensitive to ether but, unlike them, appear incapable of autonomous replication.

Atchison *et al.*[13] suggested that the small particles should be referred to as 'adeno-associated' virus. However, since they behave like the previously described satellite virus of plants[14,15] (in that they are unable to replicate autonomously and their replication is dependent on the presence of a larger virus), the particles should be more fittingly referred to as 'adeno-satellite' virus (ASV). The numerous recent reports on the occurrence of 20-mμ particles containing DNA have prompted us to comment on their structural similarity to the picornaviruses. Certain plant viruses have properties similar to those of the picornaviruses of man and lower animals. Turnip yellow mosaic virus is an example of a small RNA plant virus capable of autonomous replication in a susceptible host. The satellite tobacco necrosis virus (TNSV) is a defective small RNA virus of plants[14,15]. The adeno-satellite viruses are defective DNA viruses of human or monkey origin. Many of their properties are analogous to those exhibited by the satellite tobacco necrosis system.

Selected biophysical and chemical properties of some small DNA virions are shown in Table 1. It should be noted that the buoyant densities of these viruses (approximately 1·40 g/cm³) are greater than those of picornaviruses (1·34) and papovaviruses (1·32).

The staining reactions with acridine orange and relevant enzyme susceptibility patterns of selected DNA virus preparations are shown in Table 2. The yellow-green staining reactions of the purified adenoviruses free from satellite particles are consistent with a double-stranded DNA. On the other hand, the staining reactions of the adeno-satellite viruses and of the *X*14 virus are consistent

Table 2. STAINING REACTIONS OF CARNOY-FIXED SMEARS OF SELECTED DNA VIRUS PREPARATIONS

| Virus | Staining reactions with 0·01 per cent acridine orange | Enzyme susceptibility | |
|---|---|---|---|
| | | RNase | Pepsin + DNase |
| φ*X*174 | flame red | – | + |
| *X*14 | flame red | – | + |
| ASV from simian adenovirus *SV*15 | flame red | – | + |
| ASV from adenovirus 7 | flame red | – | + |
| Simian adenovirus (*SV*15) | yellow-green | – | + |
| Human adenovirus 7 | yellow-green | – | + |

with a single-stranded molecule. Similar staining reactions were demonstrated by a purified preparation of the well-defined single-stranded bacteriophage φ*X*174. It is probable that the DNAs of RV and of the *H*1 viruses will also be found to exhibit a single-stranded secondary structure.

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## Inhibiting Effect of Increasing Body-weight on the Lethal Response of *DBA*/1 Mice to Vaccinia Virus Infection

IN a previous publication[1] I considered the response of mice of different ages to experimental vaccinia infection: the high degree of resistance of adult mice to this virus, as well as the fact that vaccinia is highly lethal for new-