Crick and Watson – Structure of Small Viruses

Hypothesis – “a small virus contains identical sub-units, packed together in a regular manner.” – 473 C 1 P 1

Note this was not a new idea, but previously suggested by Hidgkin, D.C. *Cold Spring Harbor Symp*. Low, B. in “The Proteins.” Schramm, G. Z. *Naturforsch*

Study was restricted to plant viruses since the most evidence existed here at the time.

§ Plant Viruses

Plant viruses are very regular. Each particle of a particular virus looks the same. “Spherical” viruses show to be closer to polyhedra.

Regularity with which they form crystals suggests a very high degree of order exists within them. This ability means that each virus particle must be identical to its sister particles – 473 C 1 P 4

Structure – All viruses consist of protein and RNA (now do we know some with DNA?) with RNA on inside (only established for 2 viruses at this time)– 473 C 2 P 1

Turnip yellow mosaic virus – Sphere (Markham) and tobacco mosaic virus – rod (Tubingen and Berkley)

Hypothesis – “these shells are constructed from a large number of identical protein molecules, of small or moderate size, packed together in a regular manner” - 473 C 2 P 1

§Tobacco Mosaic Virus

94% protein and 6% RNA – Knight, C.A. “Advances in Virus Research”

Early X-Ray work showed the characteristic particle is made up of sub-units of some sort. “recently” realized the structure is helical. – “The protein part of the virus is constructed from a large number of structurally equivalent sub-units (small globular proteins) set in a helical array about the central axis.

Length of rod is controlled by length of RNA core (rods of indefinite length are produced when undenatured protein subunits are aggregated in absence of RNA) – 473 C2 P5

So TMV has a screw axis – symmetry axis – which means all protein sub-units exist in the same environment. Each has the same contact points with its neighbors– 473 C2 P6

Claims this feature can be applied whenever a structure of definite size and shape has to be built up from smaller units – that the subunits will be related by symmetry elements.

§Spherical Plant Viruses

“question… whether the protein shell of the spherical viruses is likewise constructed by a regular aggregaton of one type of small protein molecule” (at time of writing no chemical search for presence of such a sub-unit)– 474 C1 P4

For bushy stunt virus and turnip yellow mosaic virus, they crystalize in a unit cell which has shape of a cube. Dr. Dorothy Hodgkin and Dr Barbara Low – if the lattice possesses true cubic symmetry so must the virus particle, since there is only one particle in the primitive unit cell. – 474 C1 P 5

Established by Caspar that unit cell of bushy stunt virus has cubic symmetry, and virus has even higher symmetry than the unit cell. Expect this for many spherical viruses - 474 C1P6

From previous, the virus is made up of asymmetric building blocks due to asymmetric carbon atoms of one particular hand only (so they cannot be “flipped” think each one has an inside and an outside.) Thus there are only rotational axes. For cubic symmetry this limits us to 3 possible symmetry groups. 474 C2 P0

All possible point groups have minimum number of asymmetric units as multiple of 12 – 474 C2 P1

Three things. 1)Possible to arrange subunits in other ways to produce a spherical shell but symmetry will not be cubic. 2)The asymmetric unit may consist of identical sub-units joined in some unsymmetrical fashion. 3)Predictions concern the symmetry elements, not exact shape. So shape may be polyhedral not spherical – 474 C2P2

The limited number of ways to build a spherical shell from identical subunits is a topological problem (not covered in paper) – 474 C2P3

§Animal and Other Viruses

No X-Ray evidence at this time, but it is becoming clear that the small one are spherical

Assume it will still hold if DNA

§Conclusion

Virus is shell around nucleic acid. Shell is made of large number of identical sub units. Spherical virus the number of sub-units should be multiple of 12 (wrong)