

Virus

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29 June 2004

<http://web.me.com/whitby>

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<http://web.me.com/whitby/Octahedron/Welcome.html>

Reference

Octahedron1stEd.pdf–bookmark VIRUS–pages 393-410

Introduction

This material is excerpted from *Octahedron*. It shows how viral capsids are formed of octahedral panels composed of proteins.

VIRUS

A number of viruses have icosahedral enclosures which house the molecules which encode their construction. Their octahedral structure is similar to that of the fivefold quasi-crystals. The depictions herein are based on electron micrographs and their descriptions which are available over the internet or from print sources.

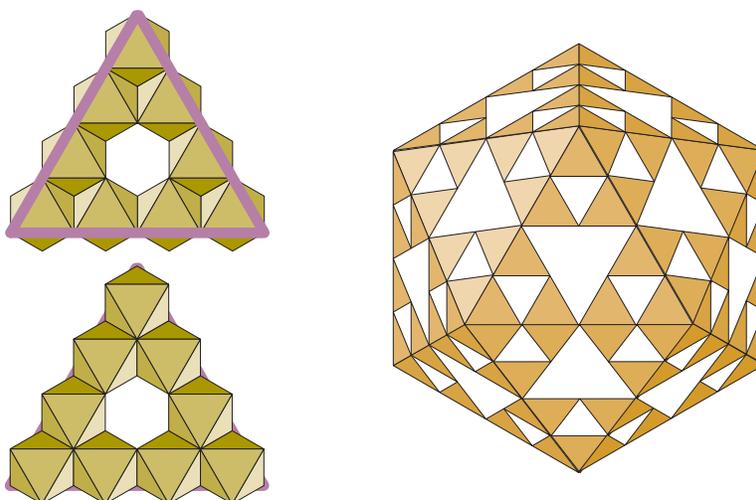
Capsid with sixty capsomers

An icosahedral facial panel can be formed by a structural assembly consisting of three triplets of identical octahedra. The top view on the

left side of the next figure shows the panel as viewed along the facial radius from the centroid of the icosahedron. The perimeter of the face of the icosahedron is superimposed upon the octahedral panel. The view beneath it is of the panel from outside and along the facial radius towards the centroid of the icosahedron. Here, the panel is superimposed upon the face of the icosahedron.

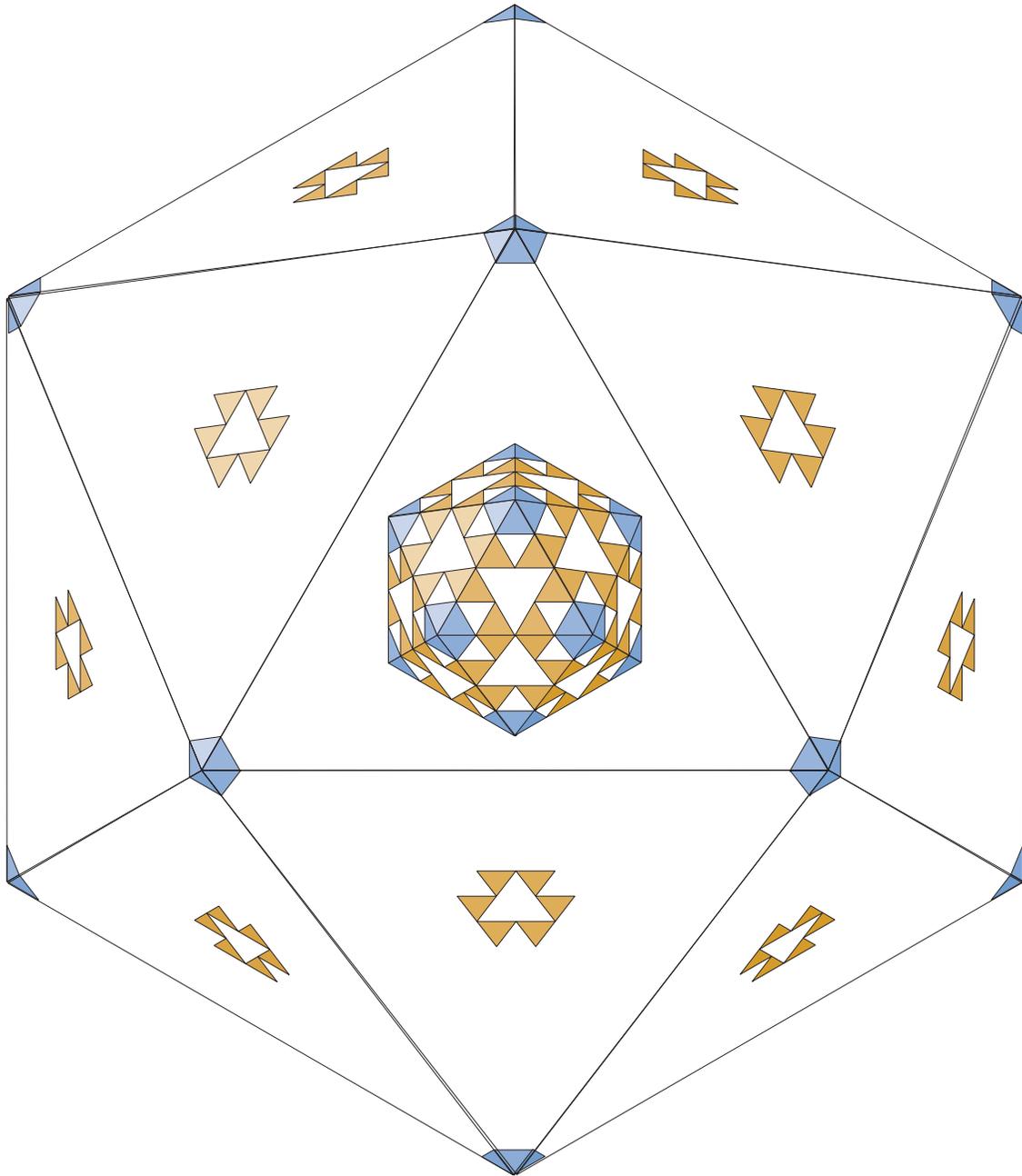
The icosahedron defined by the octahedral panels is on the right side of the figure. The view here is parallel to a facial diameter. Each of the octahedral faces which define the visible faces of the icosahedron is shown in orange.

The next six pages are devoted to illustrations of the relationship of spokes to the icosahedral enclosure.



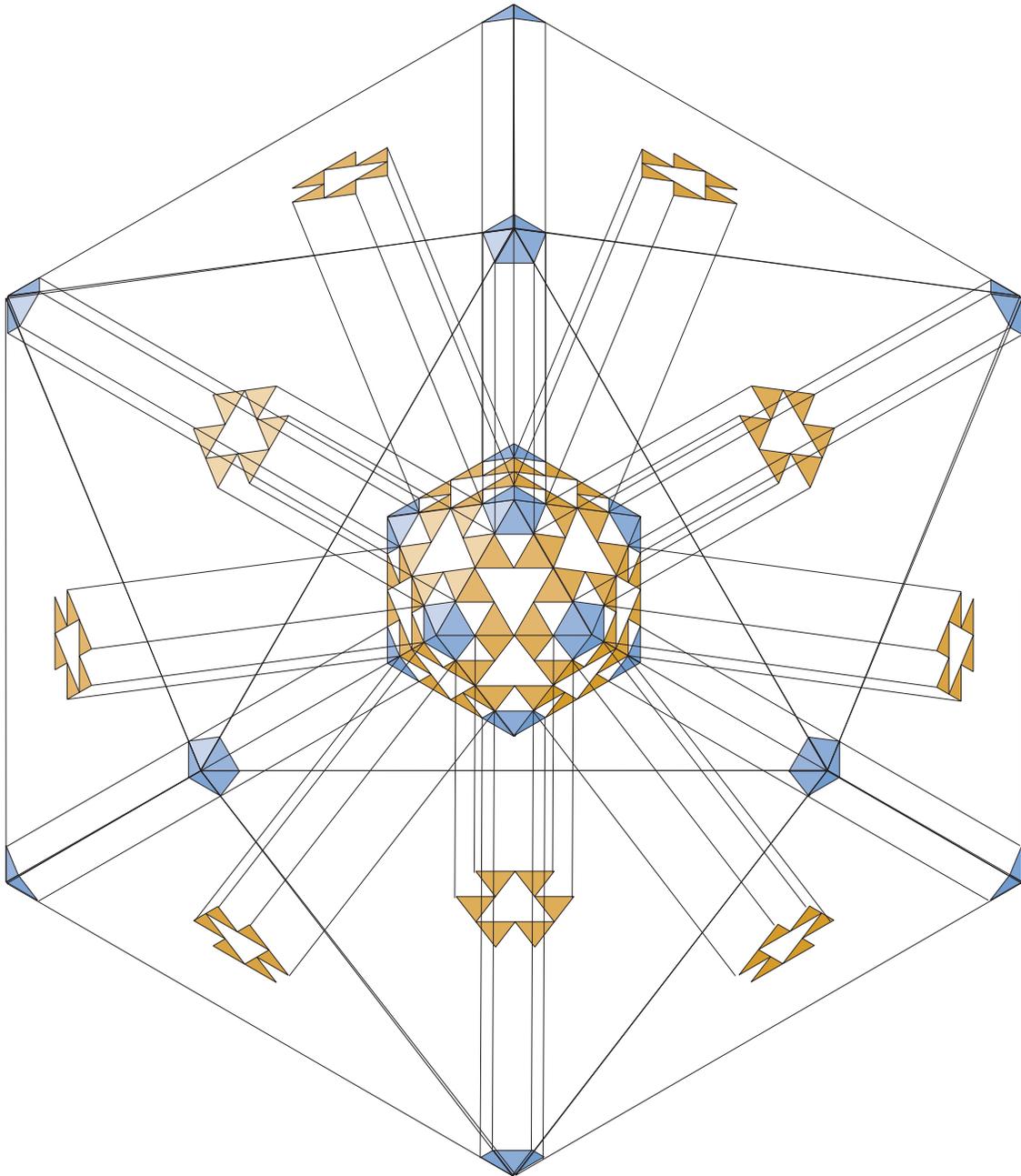
Viral capsid: sixty capsomers.

On the left, the figure shows the octahedral panel from in two views relative to the centroid of the capsid. The violet triangle represents the icosahedral face defined by the octahedral panel. The locations of the octahedra which define the icosahedral faces are shown in orange on the right.



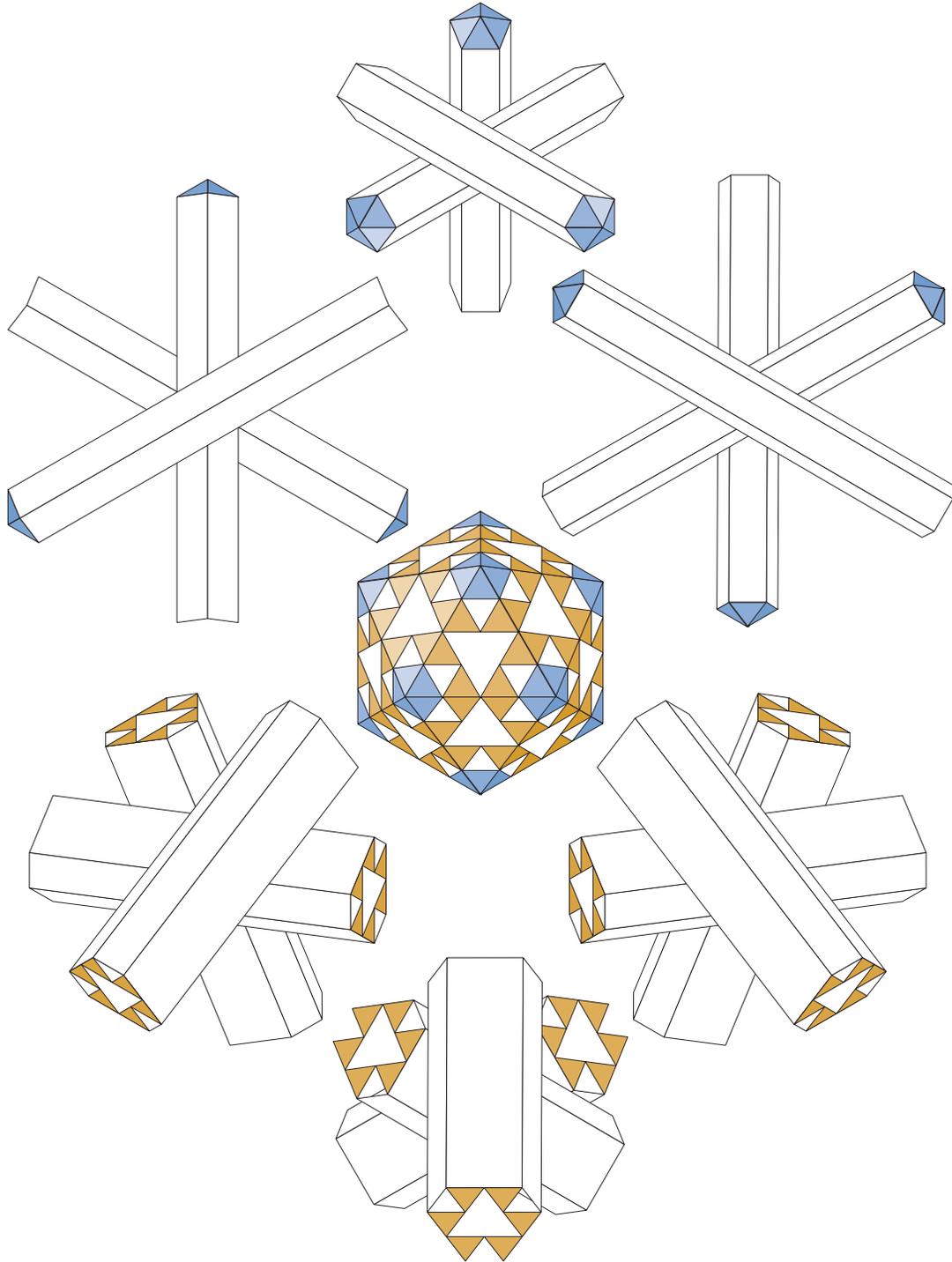
Viral capsid: Spoke distribution, figure A

The octahedra can be divided into two sets—twelve groups of five each at the icosahedral vertexes and twenty groups of six each on the icosahedral faces. Each of the groups is the foundation for a spoke assembly. This is shown in the next figure where the octahedral faces are projected radially outward upon a larger icosahedron which is concentric with the base icosahedron and of the same orientation.



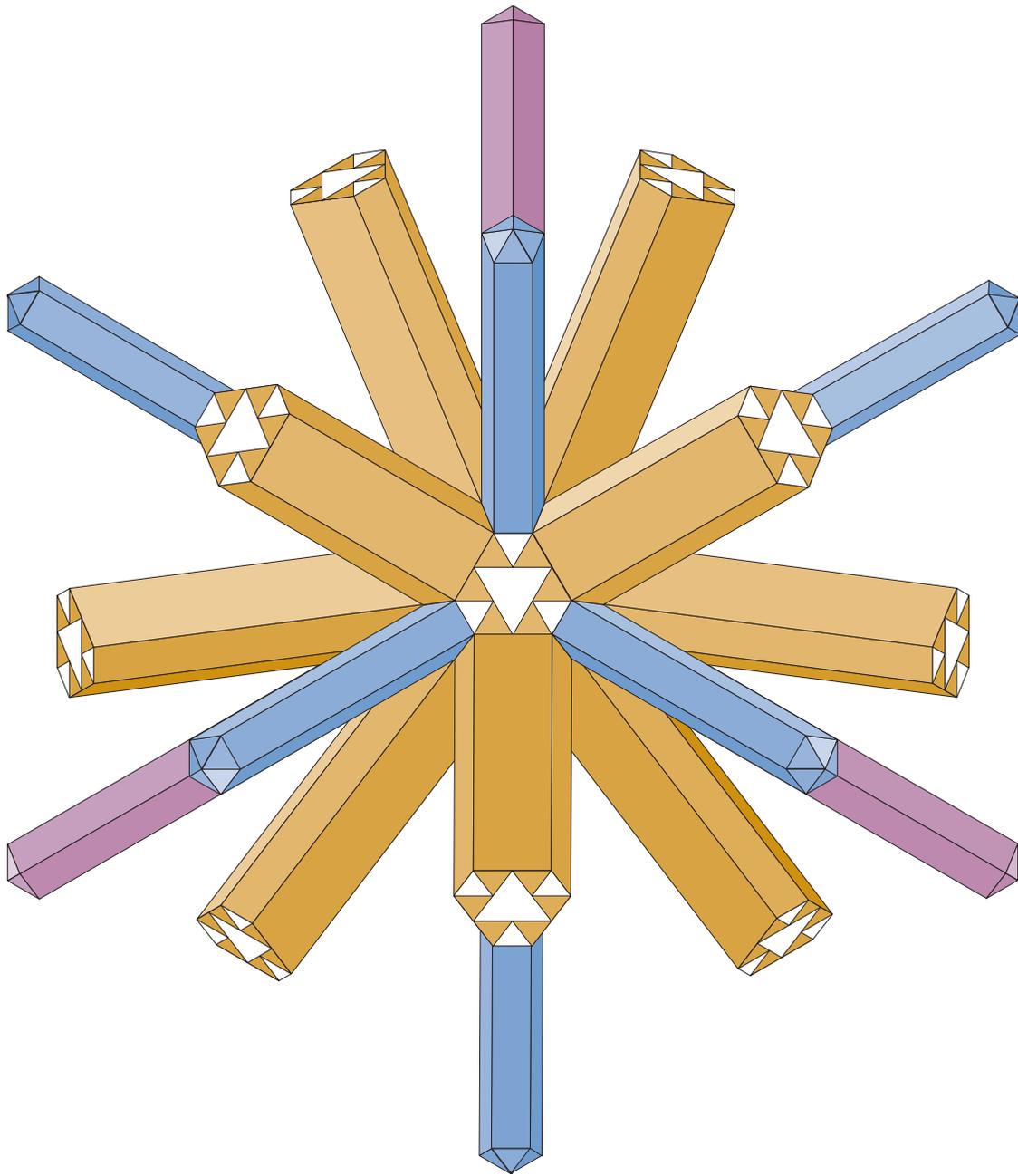
Viral capsid: Spoke distribution, figure B

The pentagonal groups are colored blue and the hexagonal groups are colored orange. The octahedral facial groups are connected by lines which represent the prism faces of spokes extending from the inner icosahedron to the outer icosahedron.



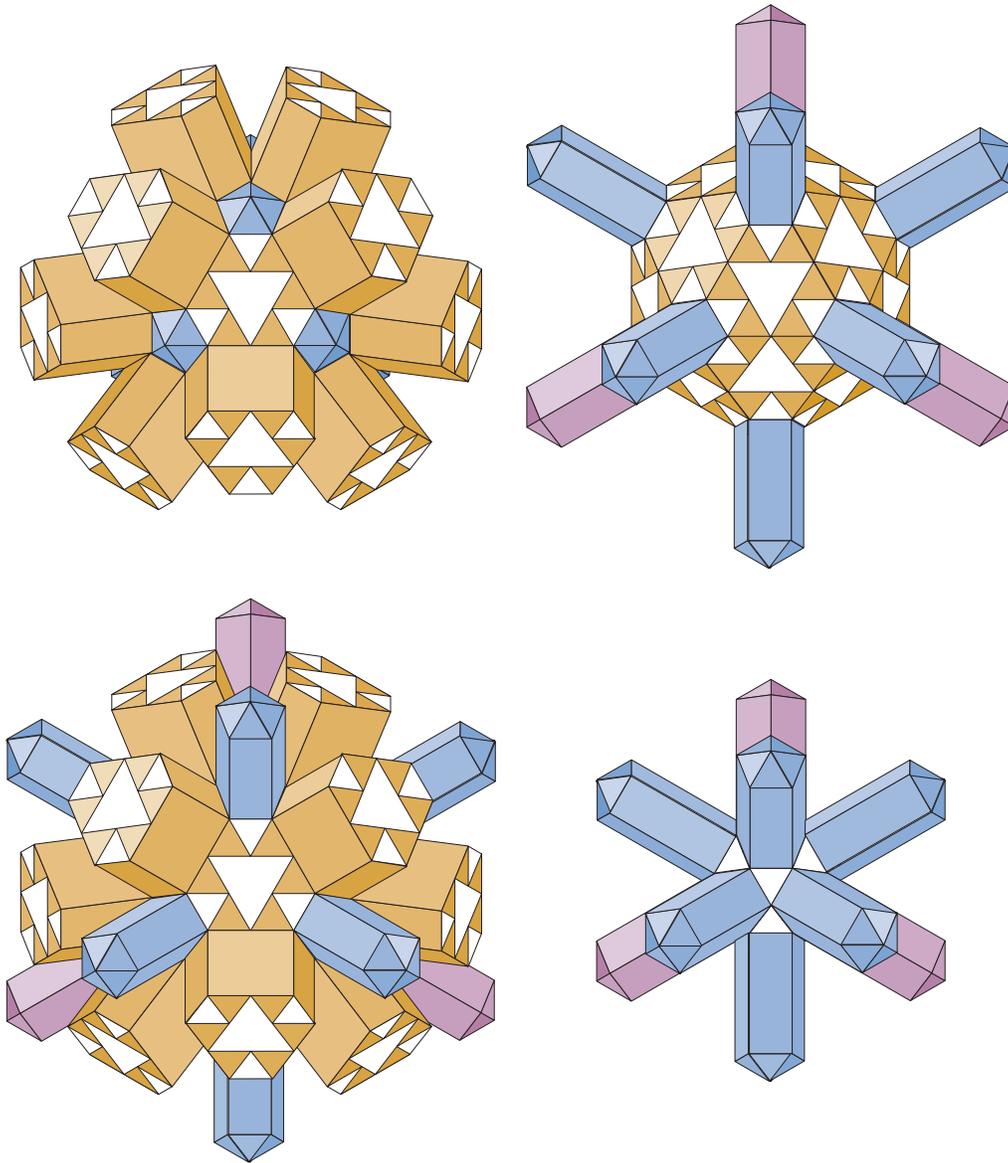
Viral capsid: Spoke distribution, figure C

The spokes which are formed are shown in groups of three, according to their projected appearance, surrounding the base icosahedron. The pentagonal spokes are identical and the hexagonal spokes are identical.



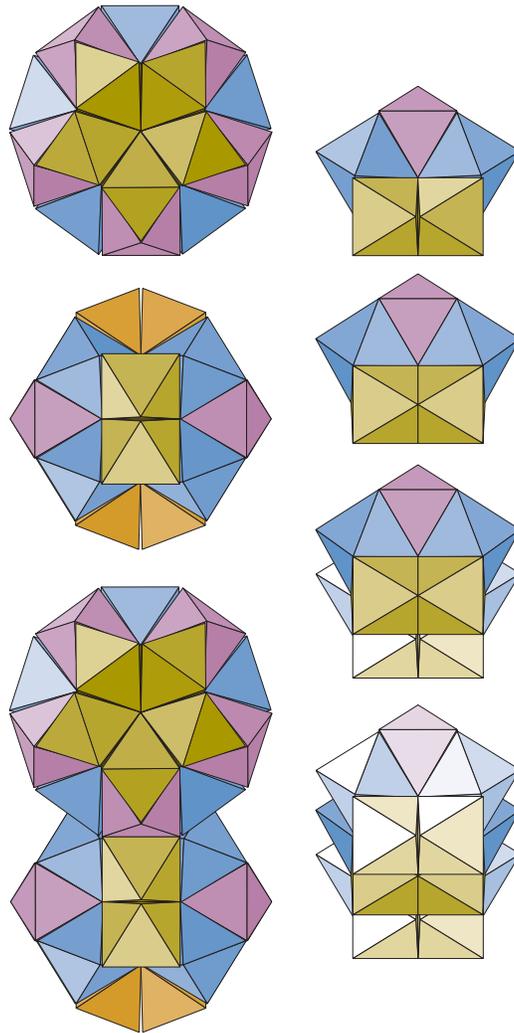
Viral capsid: Spoke distribution, figure D

The spokes are mounted on the base icosahedron and the prisms are colored.



Viral capsid: Spoke distribution, figure E

The spokes which appear in this figure are shorter. The assembly in the upper left has only hexagonal spokes. The assembly in the lower right has only pentagonal spokes. The assembly in the lower left has both hexagonal spokes and pentagonal spokes. The assembly in the upper right has the same spokes as the assembly in the lower right mounted on a smaller icosahedron.



Pentagonal spokes: Icosidodecahedral assemblies of octahedra
Rotation of octahedral units in pentagonal spokes due to joining requirement of the icosidodecahedral units.

Spoke assemblies.

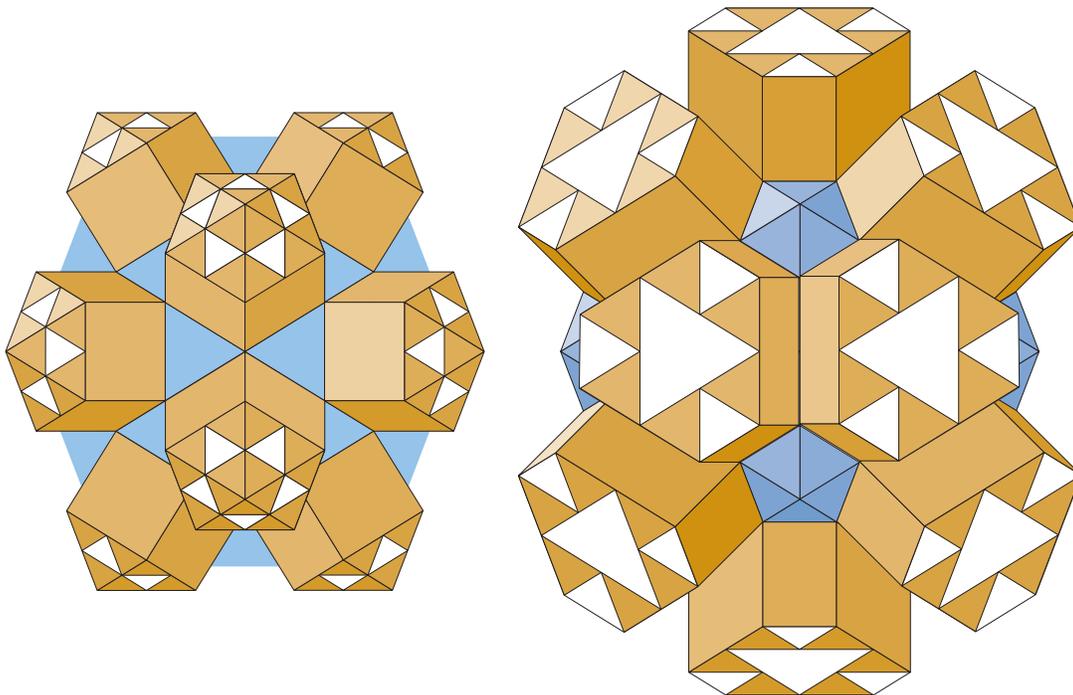
Octahedral assemblies which produce hexagonal prisms have been shown in the section on hexagonal crystals. Pentagonal prisms formed by icosidodecahedral assemblies of regular octahedra have been shown in the section on fivefold quasicrystals. These methods of assembling prisms could produce the spokes of viral capsids.

Each of the icosahedral assemblies of regular octahedra which form fivefold spokes is rotated by one-tenth of a revolution about the join axis relative to the two assemblies adjoining it. This is shown in the next figure. The top assembly and the one below it are oriented for joining along a pentagonal axis. The joined pair is shown at the bottom.

Another method of pentagonal spoke construction using regular octahedra is depicted here. The top two units are identical assemblies of five regular octahedra. Each is inverted relative to the other. They are shown joined in

the third view of the column. An additional five octahedra unit has been added in the bottom view of the figure. Alternate units in this type of assembly are identically oriented. Adjacent units are inverted relative to one another.

The five octahedra unit has two sides. Each of the octahedra provides a face of a regular icosahedron on one side. The octahedra are edgially joined by the edges of these faces. The only point of contact between the octahedra on the obverse side of the assembly is at the central vertex. The unit is not structurally stable on its own. When two opposed units are joined, the resulting assembly is structurally stable. Each octahedron on one assembly shares an edge with an octahedron of the opposed assembly. Since there is no rotation of the joined assemblies about the join axis, the octahedra are in columns parallel to the fivefold axis.



Icosahedral spokes, edgial view.

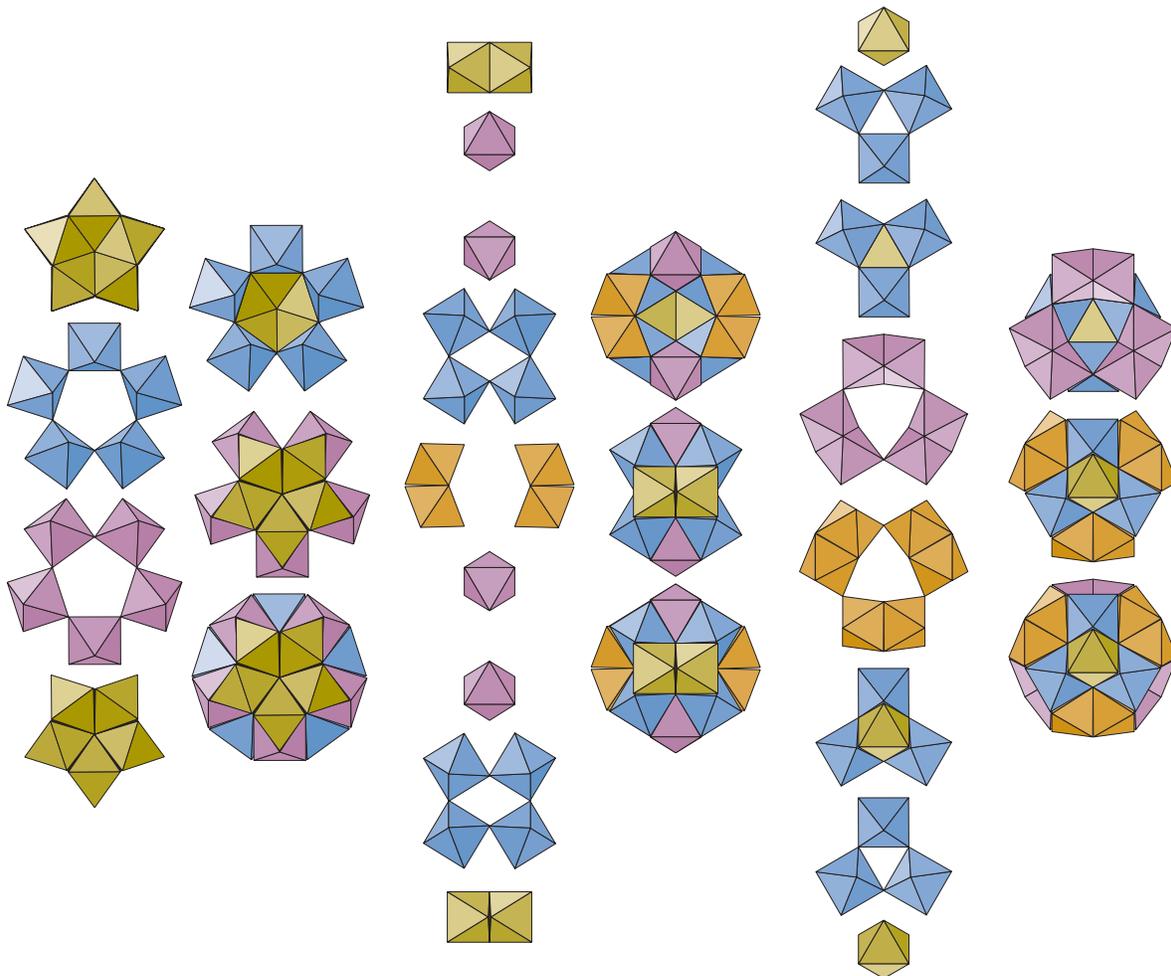
The top assembly shows the arrangement of the pentagonal spokes in a view which is parallel to an icosahedral edgial diameter. The bottom assembly shows hexagonal spokes in the same viewing direction.

Capsid with twenty capsomers

An icosahedral assembly of twenty octahedra is shown in three different views in the figure at the bottom of the page. The view on the left is parallel to a vertexial diameter of the icosahedron. The view in the middle is parallel to an edgial diameter of the icosahedron. The view on the right is parallel to a facial diameter of the icosahedron.

Within each view, the octahedra are colored

according to the layer they occupy. The octahedra within each colored group differ by a rotation about the viewing direction. In the lefthand column of each view, the octahedral groups are shown in the order of joining from farthest to nearest. In the righthand column of each view, the assembled units which form the bottom are shown first, then the assembled units which form the top, and the complete assembly.

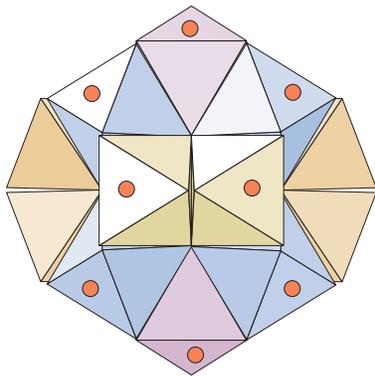
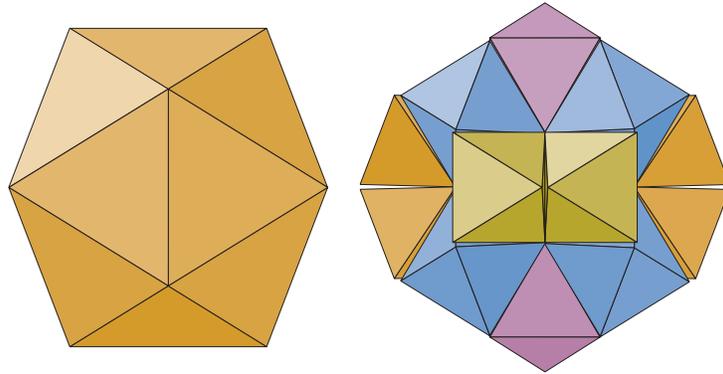


Icosahedral assembly of twenty octahedra: three views

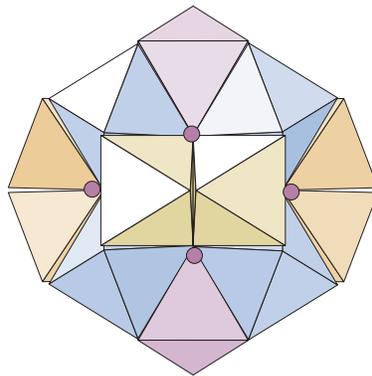
The three figures show the assembly of an icosahedral group of twenty regular octahedra from three different viewing directions. On the left the view is parallel to a vertexial diameter of the icosahedron, the middle view is parallel to an edgial diameter, the view on the right is parallel to a facial diameter.

Relating peaks to octahedral capsid

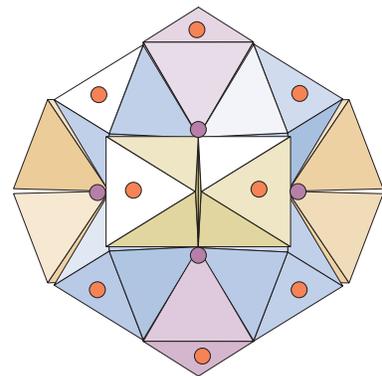
Relation of electron micrograph peaks to an icosahedral assembly of octahedra



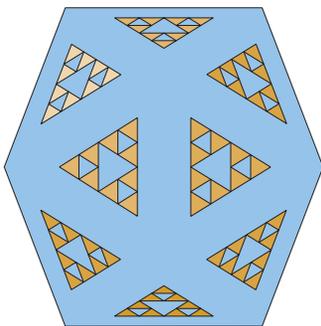
Hex spokes only



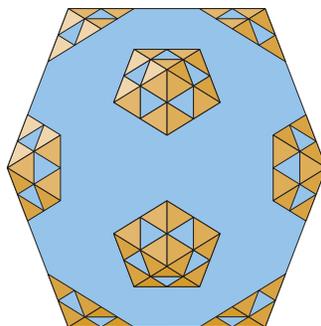
Pent spokes only



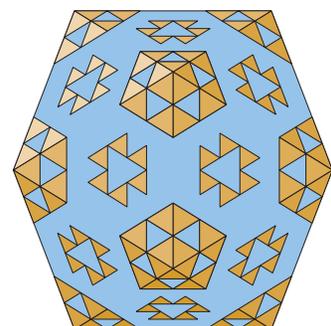
Hex & pent spokes



Red clover mottle virus
Murine minute virus.

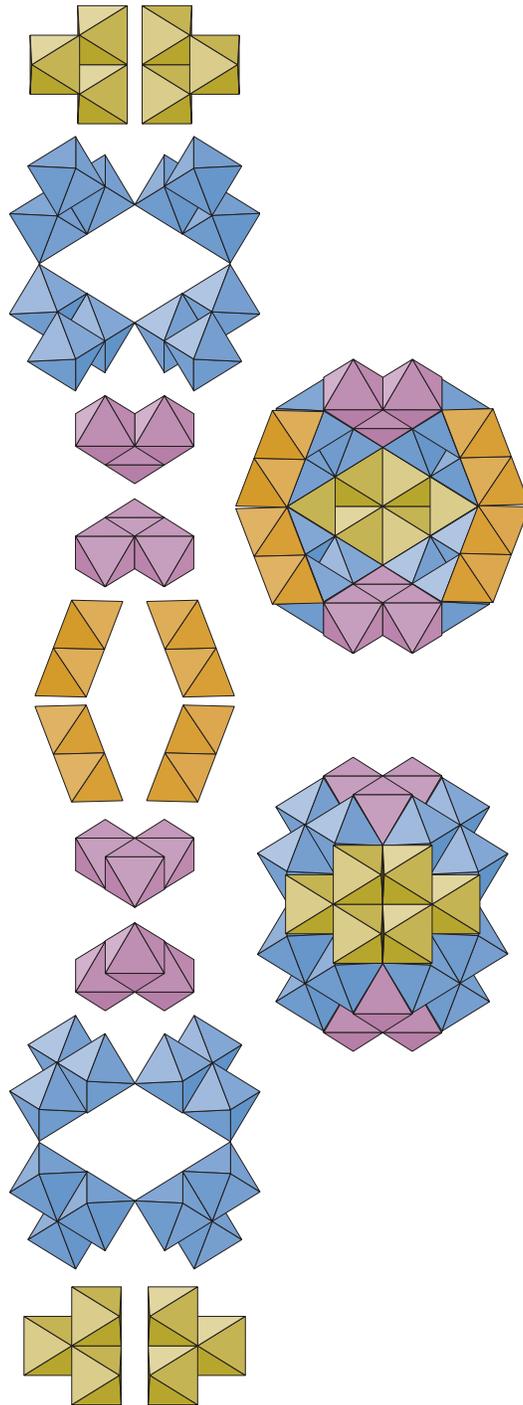


Bacteriophage G4
Bacteriophage ϕ X174
Bean pod mottle virus
Cowpea mosaic virus
Mengo encephalomyocarditis virus
Satellite panicum mosaic virus



Cowpea chlorotic mottle virus
Turnip yellow mosaic virus

Icosahedral assembly of triplets

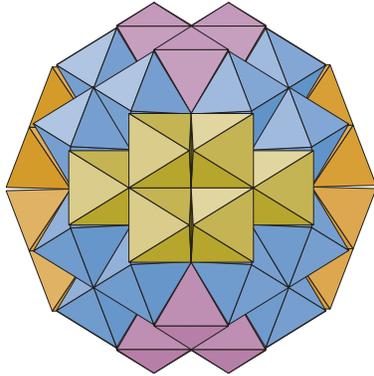


Icosahedral assembly of octahedral triplets.

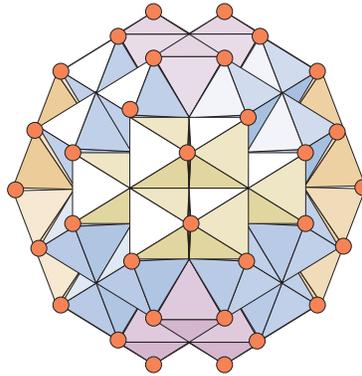
The triplets are arranged in groups according to layer. They are assembled into two groups in the right hand column. The completed assembly is in the next figure.

Relating peaks to capsid of triplets

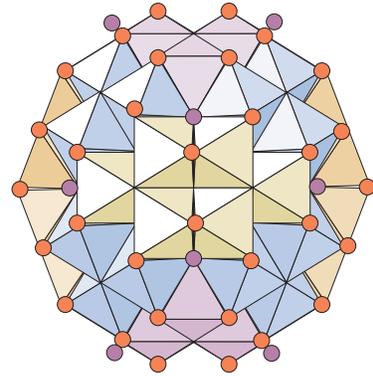
Relation of electron micrograph peaks to an icosahedral assembly of octahedral triplets



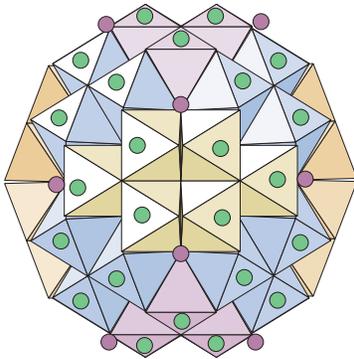
Icosahedral assembly of octahedral triplets, edgial view.



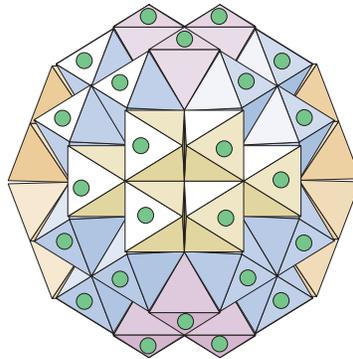
Peaks at icosahedral edge.
 Nodamura virus
 Black beetle virus
 Flock house virus



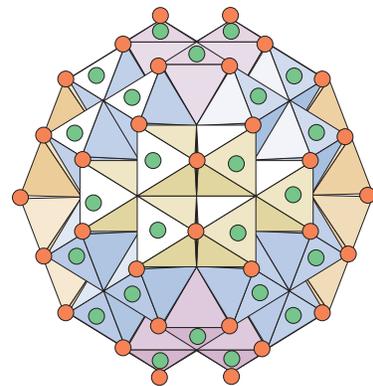
Peaks at icosahedral edge and vertex.
 Tobacco necrosis virus



Peaks at icosahedral vertex and outer face of octahedron
 Hong Kong virus.
 Echovirus 1

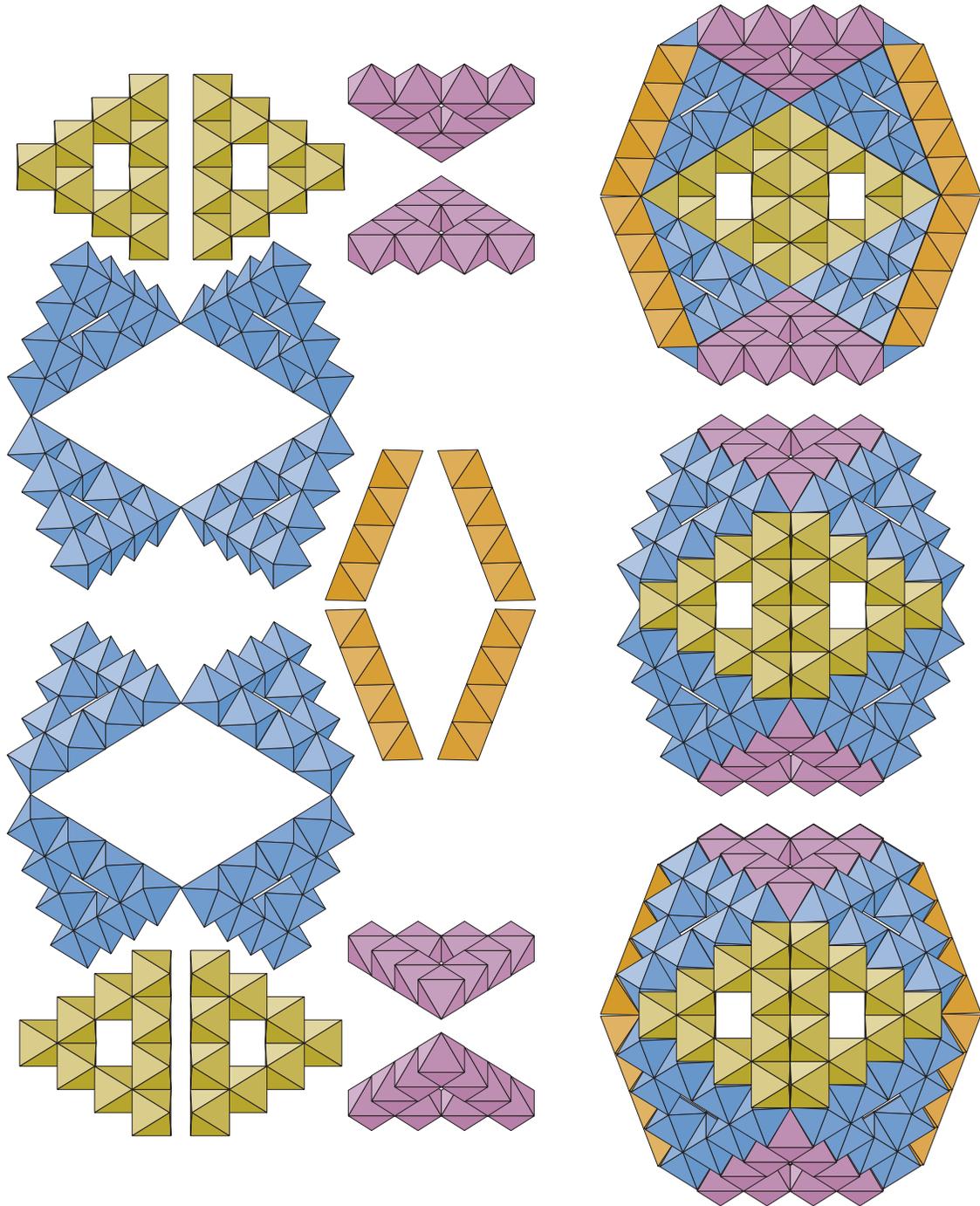


Peaks at outer face of octahedron
 Nudaurelia w Capensis virus
 Alfalfa mosaic virus
 Foot and mouth disease virus
 Human rhinovirus 16
 Theiler's murine encephalomyelitis virus (DA strain)

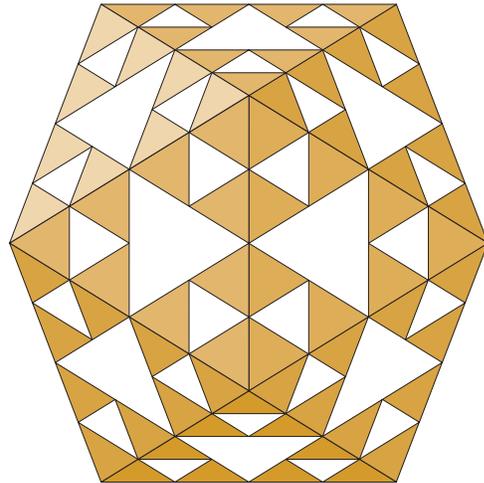
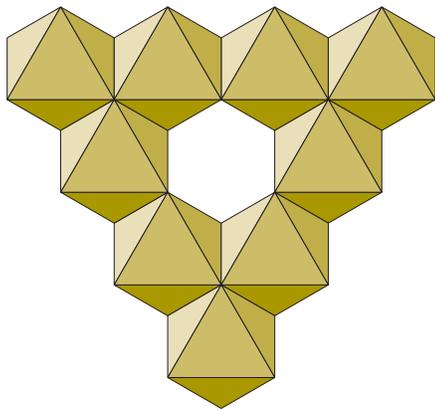


Peaks at icosahedral edge and outer face of octahedron.
 Hepatitis B virus.

Icosahedral assembly of tri-triplets



Icosahedral assembly of octahedral panels consisting of three triplets.

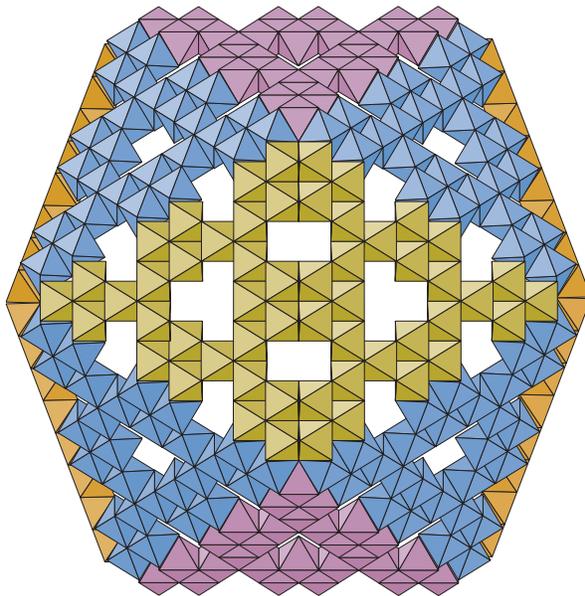
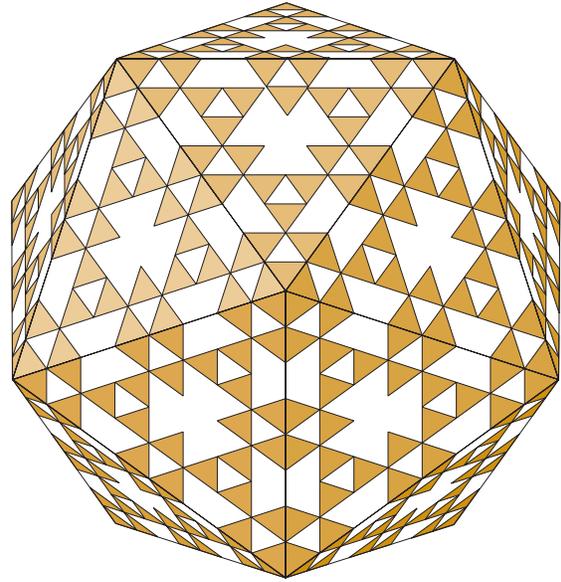
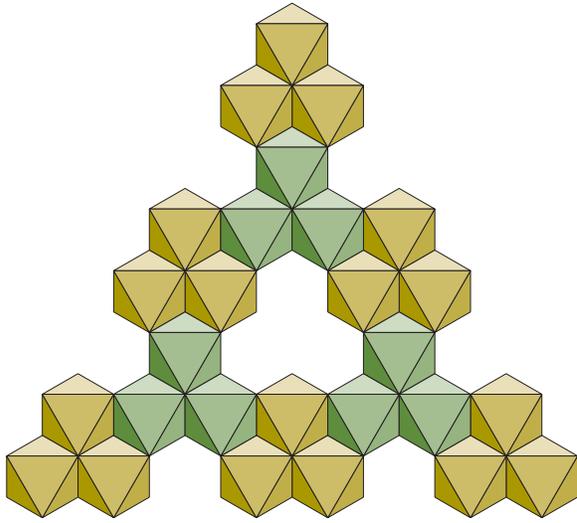


Viral capsid with three triplet facial panels

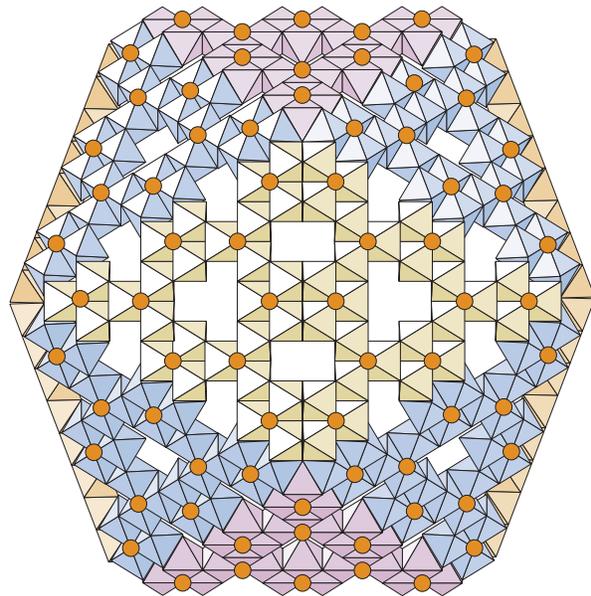
Relating peaks to nine-triplet capsid

Viral capsid with 180 capsomers

The facial panel of the inner capsid of the rotavirus is shown in the figure. The view is toward the centroid of the icosahedron. This is the minimal structural representation of the capsomer arrangement which is derived from electron microscopy. Each of the capsomers is shown as a triplet of octahedra. The yellow colored triplets at the edges of the panel are linked by the green colored triplets.



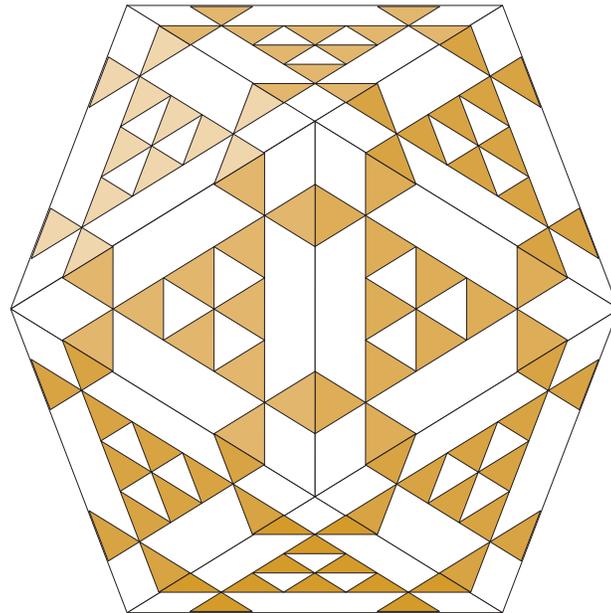
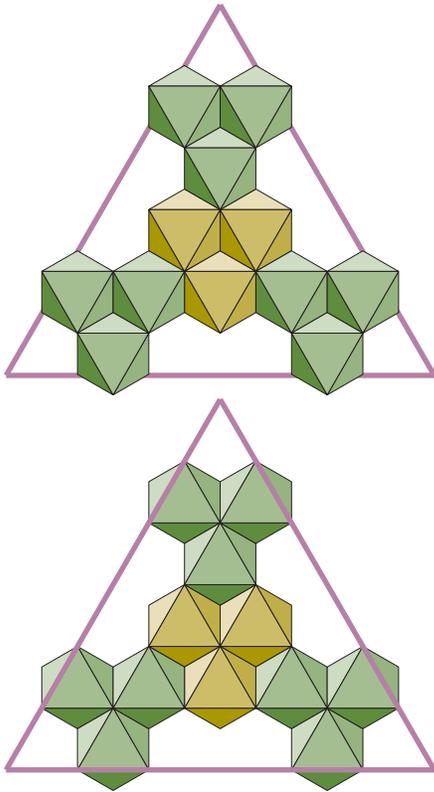
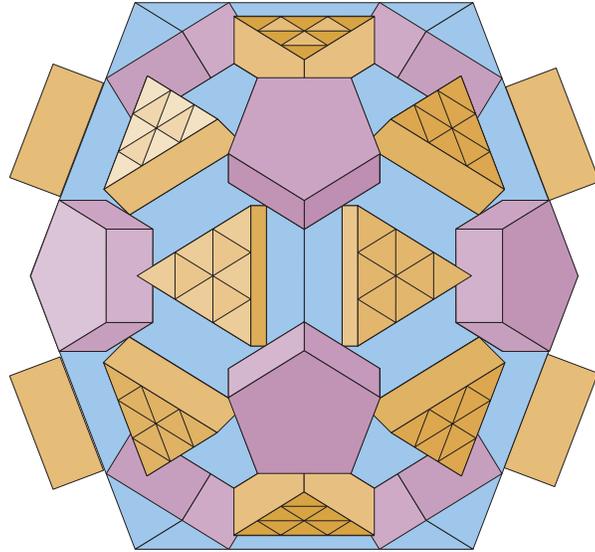
Icosahedral assembly composed of 9-triplet panels.



Bacteriophage GA peaks.

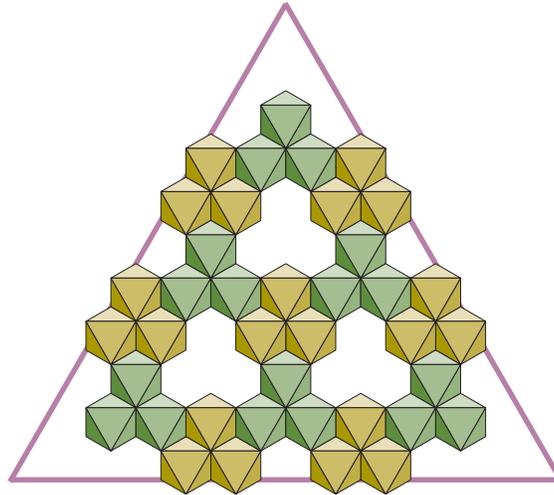
Capsid of 240 capsomers

Physalis mottle virus type capsid.
 Cowpea chlorotic mottle virus
 Cucumber mosaic virus
 Turnip yellow mosaic virus

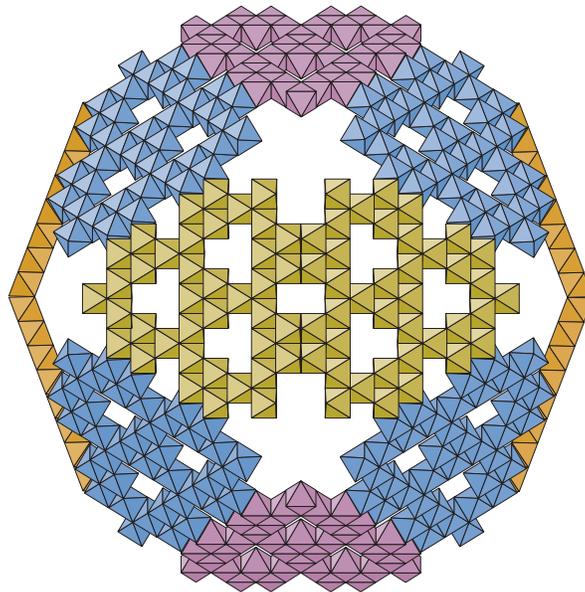


Viral capsid with 240 capsomers

A capsid consisting of 240 capsomers can be modeled using twelve octahedra per facial panel. The octahedra are structurally connected as four triplets.

Capsid of 780 capsomers

Icosahedral panel of thirteen octahedral triplets.



Viral capsid with 780 capsomers

