Mathematics and influenza virus capsids

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Anything mathematics can do, we can do (virus proverb)

Abstract
Compositions of simpler pentagonal capsid structures are used to describe the complicated influenza capsids with extended Hermite mathematics. The conical HIV capsid is also described with this method.

Introduction
We have shown that pentagonal virus capsids are built with exact geometry using simple summation of exponentials, Hermite mathematics, and FTA mathematics (ref 1-7). This to an extent that seems unique for living matter.
We show here that the unique viruses of swine influenza and HIV have structures that can be derived from the geometry that describes the simpler viruses. We use the five structures of Adeno 5, Herpes, Coxsackie, Bact phi 174 and Bean PodMottle.

Background
A description of pentagonal virus capsids structures from the Hermitians of m=1-5 and eq 1 is shown below in fig 1a (ref 2-3). The observed pictures from cryo-electron microscopy are in fig 1b. The geometrical accuracy is extraordinary.

\[-4(x^2+y^2+z^2)H[m,(\tau x+y)]H[m,(\tau y+z)]H[m,(\tau z+x)]H[m,(\tau y+z)]H[m,(\tau z+x)]H[m,(-\tau x+y)]H[m,(-\tau y+z)]H[m,(-\tau z+x)] = \text{const}\]

The constant varies between .1(m=1) and 1000(m=5).

Fig 1a 5 Numbering after m 4 3 2 1
Fig 1b Adeno type 5 Herpes Coxsackie Bact phi 174 Bean Pod Mottle
Influenza virus capsids

The extraordinary mathematics above have stimulated us to search for similar descriptions of the influenza virus capsids in fig 2a from Harris et al (ref 8). Fig 2b shows Herpes capsids from Newcomb et al (ref 9).

In fig 2a capsids are numbered 2, 3, 4 which we propose are similar to the capsids of Herpes, Coxsackie and Bact phi 174. These are compared in fig 3 also with a capsid 2+3, which we propose is described as a mathematical addition of the Bact phi 174 and Coxsackie capsids. The same type of addition is used for the capsids 2+2, and 2+2+2 also given in fig 2a and described below.

Fig 2a The capsids numbered 2, 3, 4 from fig 1 (ref 8) are here used with corresponding numbers in fig 2a.

Fig 2b Herpes capsids (ref 9)
From above we select the calculated structures for the capsids numbered 2, 3, 4 in fig 4 also with a calculated 2+3 using the mathematical addition after eq 2.

![Calculated capsids](image)

Fig 4 Calculated capsids

\[ \begin{align*}
2 \text{ eq 1} \\
3 \text{ eq 1} \\
4 \text{ eq 1} \\
2+3 \text{ (mathematical addition after eq 2)}
\end{align*} \]

We show the capsids 2+2, and 2+2+2 as row arrangements in fig 5. The remarkable kidney shape from (ref 10) also shown in fig 5 we claim is a triangular arrangement of three Coxsackie capsids described as (2+2)/2.

![Electron microscopy image](image)

Fig 5 2+2 2+2+2

(2+2)/2 An electron microscopy image of the flu virus. Ref 10: Rob Ruigrok/ UVHCI. Grenoble

Calculated shapes are in fig 6 with eqs 3 and 4 below.
We also give a description of the kidney shape capsid in eq 5 and fig 7—one part is spherical with positive curvature, which is gradually shifted to negative Gaussian curvature—the saddle. A remarkable structure in geometry, and also among capsids.
Fig 7 A spherical saddle- a kidney.

Finally we have added the calculated capsids 2+3+4 from above into a grand calculation after eq 6 and shown in fig 8. This is a candidate for a description of the HIV structure, as there is a conical shape with no Gaussian curvature and the structure will easily adopt higher concentrations of six-rings. As above for the cylindrical structures.

\[ e^{-4(x^2 + y^2 + z^2)} \sum_{n=0}^{3,6} H[m,(\tau x + y)]H[m,(\tau y + z - n)]H[m,(\tau z - n)]H[m,(\tau y + z)]H[m,(\tau x + y)]H[m,(\tau z - n)]H[m,(\tau y + z+n)]H[m,(\tau x + y)]] = 3 \]

Fig 8
2+3+4, description of HIV

**Deviations in structure**
We see deviations in fig 2 with the influenza capsids as loss in symmetry and change in size. We say this is a way of evolution to develop changes in structure that only seems to occur for the influenza capsids. Instead of creating new capsids with perfect symmetry this influenza style must be extraordinary to achieve change in evolution. Examples are 2+2 and 2+3 types of capsids.

Much smaller deviations are easily obtained by a small changes in mathematics. We show the examples below, tau is changed to unity in the first term of eq 7.

\[ e^{-4(x^2 + y^2 + z^2)} H[2,(x + y)]H[2,(\tau y + z)]H[2,(\tau z + x)]H[2,(\tau x + y)]H[2,(\tau y + z)]H[2,(\tau z + x)] = 1 \]
The effect is considerable, all symmetry gone as shown in fig 9a

Dropping one of the variable, just x in eq 8, is dramatic as shown in fig 9c.

\[ e^{-4(\frac{x^2}{2} + \frac{y^2}{2} + \frac{z^2}{2})} H[2,(y)] H[2,(ry + z)] H[2,(rz + x)] H[2,(rx + y)] H[2,(rz + x)] H[2,(rx + y)] = 1 \]

Fig 9 a without tau        b normal for m=2        c without x

With Develop and Expand in Matematica much smaller changes can be obtained in calculating capsid structures. This to give some realistic pictures of evolution.

A change in volume can be measured with the change in the constant of equation.

References


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10 Rob Ruigrok/ UVHCI. Grenoble The deadly knife of the influenza virus made visible