Needlepoint Human Rhinovirus

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Human Rhinovirus (HRV):

Rhinovirus is the most common virus to infect humans and is the predominant cause of the common cold. Rhinoviruses belong to the genus *Enterovirus* in the family *Picornaviridae.* This class of viruses are an example of a non-enveloped virus, meaning that the protein shell is not protected by a lipid bilayer. The interior of the capsid contains RNA, which is the genome that allows for virus replication. The virus capsid is composed of 60 copies of each of four proteins (VP1, VP2, VP3, and VP4) which assemble to form a 20-sided icosahedral structure (Figure 1). VP1 is highly represented on the exterior of the capsid and contains most of the proteins involved in immune system clearance of the virus. VP4 is completely interior to the capsid and interacts with the RNA.[1,2] The icosahedral structure includes both areas of five-fold symmetry and three-fold symmetry.

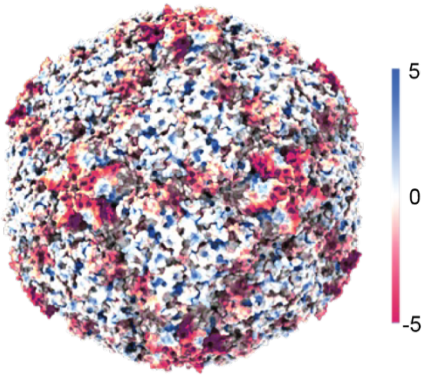

Figure 1. Surface depiction of HRV based on PDB 4RHV[2] by Dr. Pratik Joshi from Michigan Technological University using ChimeraX 1.3.[3] Residues are colored based on electrostatic charge. Blue = positive, red = negative, white = neutral.

Rhinoviruses were first discovered in 1953 by Winston Price at Johns Hopkins University. As of 2022, more than 99 different serotypes of human rhinovirus have been sequenced, but no vaccines exist against rhinoviruses because of the significant variability between the serotypes.[4]

Materials:

- 20 plastic canvas triangles. The example shown below used Youliang 75 mm/2.95 inch triangles, with 15 triangles per side.
- One yarn needle
- Scissors
- 20 strands, each approximately 24 inches long of five different colors of yarn. The design highlights the patterns of positive and negative charge on the surface. Therefore, we suggest using a gradient of colors that help to communicate this information. The example shown below used:
    - Dark red (strongly negative)
    - Pink (weakly negative)
    - White (neutral)
    - Medium blue (weakly positive)
    - Dark blue (strongly positive)

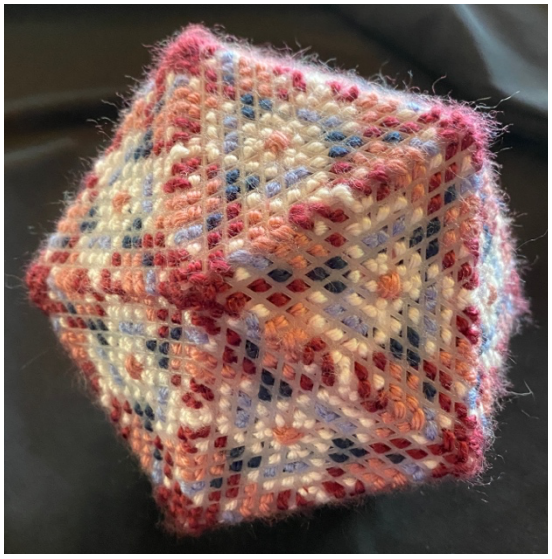

Figure 2. Finished virus, created by Dr. Sarah Perry.

Getting Started:

To begin with, start stitching by securing the yarn. While it is possible to use a knot to do this, it is recommended to sew over the loose end (Figure 3). Stitching then continues in a diagonal fashion, as indicated.

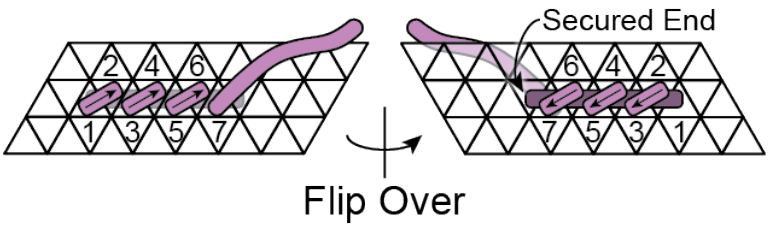

Figure 3. Schematic of how to needlepoint. Stitches go along the diagonal of the triangular lattice going from 1 to 2 to 3, and so forth. When starting a new color of yarn, the loose end can be secured by sewing over it, as shown.

Stitching:

Stitching is done along the diagonal. However, because of the symmetry of the capsid the direction of these stitches changes across the pattern (Figure 4). Each stitch covers only a single space in the canvas, with the exception of the star in the middle. The star in the middle represents the three-fold axis of the virus capsid. The colors can be stitched in any order.

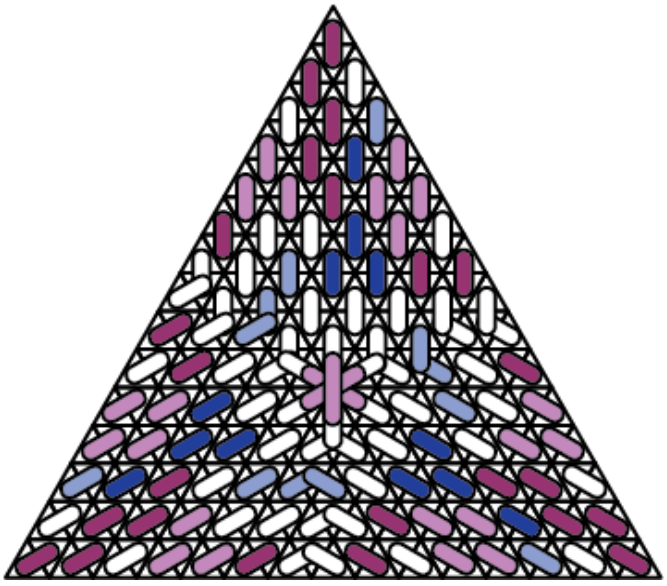

Figure 4. Needlepoint stitch pattern, developed by Dr. Sarah Perry.

Mistakes Happen:

If you make a mistake, remove the stitches by pulling them out with the needle, rather than using scissors to cut them out, to avoid damaging the canvas.

Tying Off:

To end a particular color, tie a knot close to the back of the canvas. It is not necessary to trim the long end, as these lengths can be used to help join the various triangles together without needing to secure a new piece of yarn.

Assembling:

The panels can be assembled by stitching the finished triangles together. To maintain the consistency in the color scheme, as mapped out based on the surface charge of the capsid, as suggested by the pattern shown in Figure 5. This joint represents a two-fold axis of symmetry.

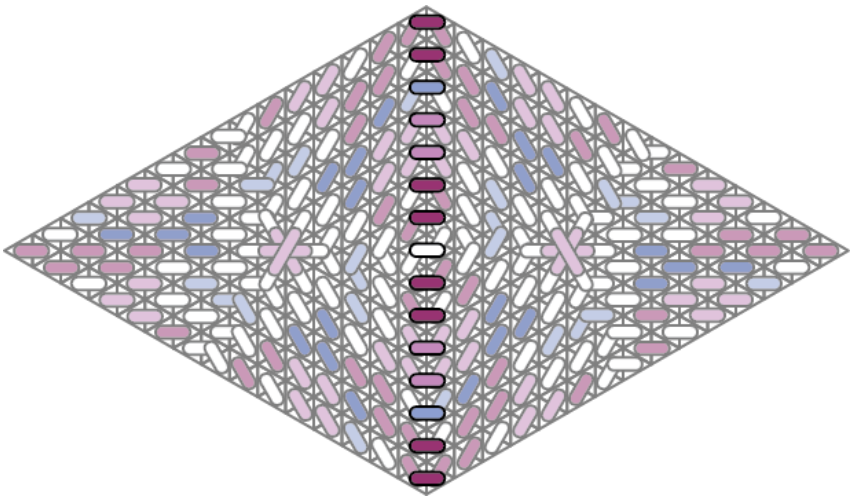

Figure 5. Stitch pattern for assembling the various panels of the virus.

Assemble all 20 triangles into the structure shown in Figure 6. The final icosahedral structure is then created by joining

together the various triangles as indicated by the colored arrows in Figure 6. Where five triangles join, this is the five-fold axis of symmetry.

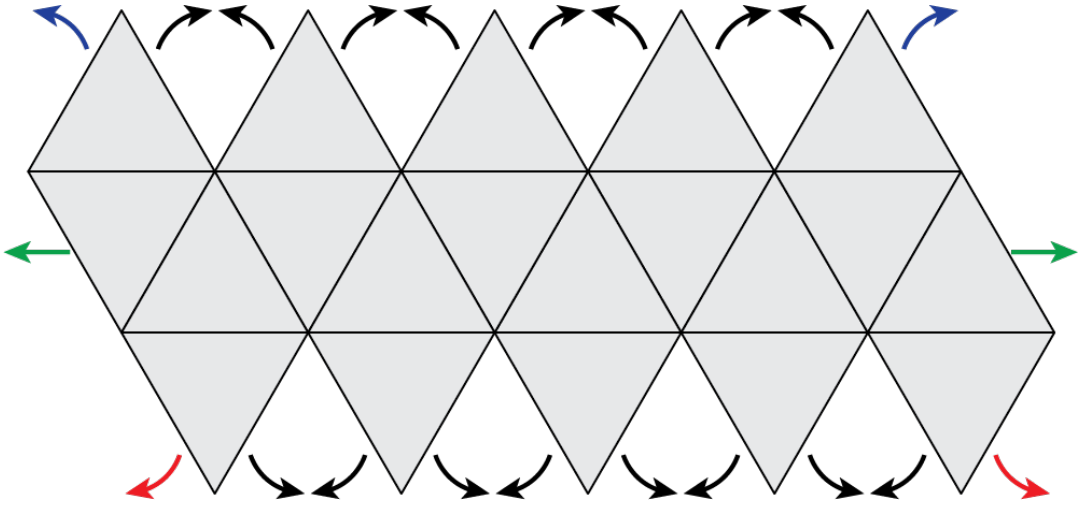

Figure 6. Pattern for assembling the various panels of the virus. All 20 triangles should be sewn together to form the indicated structure. The icosahedron can then be closed by connecting the various individual triangles as indicated by the arrows. Color (black, blue, red, green) indicates how the various faces connect.

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References:

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(2) Arnold, E., Rossmann, M.G., "The Use of Molecular-Replacement Phases for the Refinement of the Hvman Rhinovirus 14 Structure," *Acta Crystallographica Section A: Foundations of Crystallography*, (1988), *44*(3), 270-283. http://dx.doi.org/10.1107/s0108767387011875

(3) Pettersen, E.F., Goddard, T.D., Huang, C.C., Meng, E.C. Couch, G.S., Croll, T.I., Morris, J.H., Ferrin, T.E., "UCSF ChimeraX: Structure Visualization for Researchers, Educators, and Developers," *Protein Science*, (2021), *30*(1): 70-82. https://doi.org/10.1002/pro.3943

(4) https://en.wikipedia.org/wiki/Rhinovirus (accessed June 30th, 2022).