LESSON PLAN

SMART HANDS

LESSON TITLE: "Architecture of a Virus"

HOSTED BY: Miruna Batin (Romania)

LENGTH IN TIME: 20min.

THIS LESSON COMBINES ELEMENTS FROM THE FOLLOWING SCHOOL SUBJECTS:

Molecular Biology, Mathematics and Crafts

LESSON OBJECTIVES

This lesson takes on one of the biggest Scientific Problems today: the understanding of a virus. It shows how observing and modeling can help scientists understand their subject better and how the collaboration between different sides of science can lead to great breakthroughs.

The pupils will have time to model a virus and discuss what makes its structure so stable and efficient. They will also learn concepts of modeling, structure, patterns, scale and symmetry.

SUMMARY OF THE LESSON

5 min - Intro viruses: When Scientists first heard of the novel coronavirus their first reaction was to model it. All it took them was 12 days, a super powerful microscope and some heavy computational power. This is what they came up with:
https://analyticalscience.wiley.com/do/10.1002/was.00020069

Now let's try to model our own little virus and see what we can learn from it.

15 min - The workshop: Cut the shape and fold the triangles to make a packaging to enclose the yarn and the cotton balls. Hands-on Icosahedron making.

What's going on: Viruses are composed of nucleic acid genomes (RNA/DNA) - which tell the virus what to do (something like a computer program), surrounded by a protective protein "skin" called a capsid - which protects it. Instead of making the capsid out of one giant protein, viruses typically utilize many identical copies of the same protein that combine together to form this outer shell. This way, the virus can be economical, using one gene repetitively to make many small proteins instead of devoting a large portion of its genome to making a large protein coat. Most viruses are thought to be composed of triangular sub-units that associate to form an icosahedron—. This shape helps the virus to minimize its surface-area-to-volume ratio, which allows it to carry the most genetic material inside a given protein shell. The icosahedral structure is one way of doing that, another one is the helical structure (SARS-COV-2) but there are also viruses that use both or are more complex.

Free Discussion: Pupils are encouraged to reflect on what they did and share information. What did we do? Was it easy to make the icosahedron? How many sides does it have? How many edges does it

have? How many vertices? What do you think makes this shape unique? Is it symmetrical? How many ways can you rotate it, without seeming to change appearance. What does it resemble to? What do you think makes it so stable?

These icosahedral structures exhibit rotational symmetry: 5-fold symmetry at the vertices, 2-fold through the edges and 3-fold through the center of each triangular face. It can be rotated in 60 different ways without seeming to change in appearance.

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5 min Going Further: Model Comparison

Some viruses have an extra lipid membrane, meaning the virus is encased or enveloped. The infectivity of these viruses is mostly dependent on the envelope and it's proteins. But the lipid membrane also makes the virus sensitive to soap. Sound familiar? Do you know a virus that is killed by soap?

What can we learn from this 2 models? How is it different from ours? How can we make our model better? What do scientists concentrate on? Can a model be dependent on what the scientist is looking for?…

*Note even if not seen in this model the inner structure of SARS-COV-2 is helical shaped

<u>MATERIALS/EQUIPMENT/ICT NEEDED BY STUDENTS:</u>

- attached template printed on A4 heavy paper (120gr)
- some cardboard support for cutting and glueing
- ruler
- (60–90 centimeters) of yarn
- six extra-large cotton balls
- scissors
- double sided tape or paper glue (tape works best)
- plastic foil
- (optional) a screw or something pointy
- (optional) colored pens, markers, permanent marker

<u>PREPARATION TASKS / KNOWLEDGE NEEDED IN ADVANCE BY STUDENTS:</u>

Print out the model on a thick A4 paper (we used 120gr.)

REFERENCES OR WEBLINKS:

Based on: https://www.exploratorium.edu/snacks/viral-packaging

More Ref

https://www.quantamagazine.org/the-illuminating-geometry-of-viruses-20170719/

https://viralzone.expasy.org/8577#:~:text=The%20Caspar%2DKlug%20Theory%20

https://morgridge.org/outreach/teaching-resources/virology-immunology/virus-structure/

https://news.ucr.edu/articles/2018/11/02/physicists-explain-how-large-spherical-viruses-form

https://www.scientificamerican.com/article/are-viruses-alive-2004/

https://dfw.cbslocal.com/2020/10/16/covid-cure-14-year-old-frisco-girl-national-award/

https://learn.genetics.utah.edu/content/cells/scale/

FOLLOW UP AFTER ASSIGNMENT:

Explore more about the symmetry of viruses by building these models at home: https://pdb101.rcsb.org/learn/paper-models/quasisymmetry-in-icosahedral-viruses#:~:text=Viruses%20come%20in%20many%20shapes,protein%2C%20arranged%20in%20icosahedral%20symmetry

You can start drawing the “skin” of your virus, make sure to keep it symmetrical :).